FALLOW MANAGEMENT & CROP ROTATION

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KEY POINTS:

- **Modern fallow management practices have a strong impact on improved long term average yields**
- **Rotation crops impact both positively and negatively on the following cotton crop. Consider the choices carefully.**

Wherever dryland cotton is grown, the amount of stored soil moisture at planting time is the critical agronomic factor influencing the decision to plant. In those areas with higher summer rainfall and / or soils with better water holding capacity e.g. Central Darling Downs, Liverpool Plains, 60cm of wet soil is considered to be the minimum requirement. For most dryland cotton growing areas, 90cm of wet soil is the minimum required. This would translate to 140-180mm stored plant-available water, depending on soil type.

TYPES OF FALLOWS

Long fallow

One practice has been to grow dryland cotton every second summer, without any rotation crops, giving a fallow of approximately 18 months duration.

While optimising the potential for soil moisture storage, this fallow system has a number of negative aspects. Mycorrhizal problems frequently occur because of the absence of growing plants for such an extended period. Ground cover is almost negligible, contributing to water run off and erosion problems. This system has a very low fallow efficiency, a measure of crop produced per mm of rainfall during fallow. Maximising fallow efficiency is a major consideration in dryland crop production.

Standard fallow

Dryland cotton is commonly planted after a 10-11 month fallow from a winter cereal. The following are important considerations for the practice:

- it allows for the retention of high levels of cereal stubble on the soil surface until planting, and even beyond, to maximise rainfall entry and storage in the soil
- standing stubble reduces run off and soil movement on both sloping and floodplain areas
- retention of cereal stubble on the soil surface after planting protects vulnerable young seedlings from sandblasting
- timely control of weeds and volunteer cereals will preserve soil moisture
- delaying cultivation in the early part of the fallow will help retain post harvest soil cracking patterns which aids soil profile wetting from the bottom up. Less soil disturbance slows moisture loss from the surface layers and reduces weed germination.

Short fallow

Quite satisfactory yields have been obtained from cotton grown after a short (6 months) fallow from sorghum, millet or mung beans in years of above average autumn or winter rainfall. Management practices such as pre-harvest crop or post-harvest stubble spraying of sorghum with glyphosate, will help to maximise the potential amount of soil moisture stored. Early planting the previous spring, a timely dry harvest and minimal soil and stubble disturbance post-harvest will improve the chances of the system being successful.

If the country has to be cultivated, operations should be light and as few as possible. Heavy operations which create a rough, open surface will require an excessive number of subsequent passes to fine down, with potential compaction problems in wet winters.

SEEDBED PREPARATION

Obtaining a satisfactory plant stand can be a challenge in dryland cropping. Two major requirements for cotton planting are surface and deeper stored moisture to be well joined up and a suitable seedbed tilth. Some growers furrow out fields late in the fallow in the hope of creating a more favourable planting microenvironment in the furrow if planting rain is marginal. Some heavier clay soils may require cultivation(s) late in the fallow to obtain a desirable tilth. Adding nitrogen fertiliser in bands in tramlined fields helps minimise soil disturbance in no-till fields. Care needs to be taken in cultivated land, not to 'shallow up' the seedbed too early. Every grower needs to develop a system which suits his particular soil type and planting equipment.

Managing soil compaction

Cotton growth can be badly affected by compacted zones in soil. Tramlining the paddock in its planting configuration early in the fallow will reduce the chance of this occurring. Avoid working if the soil is too wet and use the minimum tyre pressures on all wheeled equipment. If wheel tracks have come through from the previous harvest, nurture them early. Fill and level track marks by light cultivation with either light offsets or a cultivator. During the planting operation, avoid planting into wheel tracks.

If soil compaction problems are suspected, take a shovel and physically check the soil profile. If dense layers are found, cultivation at a depth just below the damaged areas is the most effective means of amelioration. Subsequently, management strategies should be adopted to minimise re-occurrence.

Weed control

Weed control is important both in the fallow and during the crop. Many of the residual herbicides used in grain cropping systems are damaging to cotton. These include the sulfonyl ureas and atrazine.

The residual life of many of these herbicides (in the soil) is unpredictable, being dependent on climatic conditions and soil pH. As a general rule, if it is likely that cotton will be the following crop, use of these groups of chemicals should be minimised during the previous crop, and most importantly during the fallow.

Trifluralin is one of the cheapest and most effective herbicides for use in cotton. In areas where the planting window is narrow, its application pre-plant can rule out most other crops as a substitute should cotton not be planted, or be hailed out early. Its requirements for incorporation into a relatively stubble free seedbed also creates some problems in minimum till situations.

Diuron is another residual herbicide that can restrict later planting choices if used late in the fallow. The practice of banding herbicides requiring minimal incorporation, at planting, is an alternate. However, in dry years, these are often not activated very effectively, resulting in poor weed control.

A clean weed free start is essential for a cotton crop as early weed competition can seriously impact on yield. The application of a knockdown herbicide(s) immediately pre-plant or post-plant, pre-emergent helps ensure such a start. Weeds at this stage are normally young, fresh and very susceptible to relatively low rates of herbicide. The availability of Roundup Ready® cotton allowing over the top application of Roundup up to but not including the 5th true leaf greatly extends the window for this control.

When selecting knockdown herbicides for pre-plant application, note that 2,4-D products have a 10-21 day plant-back interval with cotton. **Table 20** provides information on plant back for cotton from fallow herbicides while **Table 36** gives plant back periods for other crops after herbicide use in cotton. **Table 33** gives herbicide selection for various weeds. NSW Agriculture's *Cotton Pest Management Guide* contains current herbicide registrations.

Nitrogen application

In dryland cotton, nitrogen is normally incorporated in a pre-plant application. This application should occur late in the fallow to reduce the likelihood of denitrification, yet early enough so that any concentrated band of fertiliser does not reduce germination. The use of 'cold-flo' anhydrous ammonia or granular products reduces the need for deep application and accompanying seedbed damage.

In tramlined no-till fields, application of fertiliser in bands can help maintain standing stubble cover over the majority of the field beyond planting. Applying the bulk of the crop's N requirements as an in-crop sidedressing is not recommended. It is likely to become tied up in dry soil, and only become available later in the growing season, causing potential regrowth problems.

Nitrogen Rate

The amount of nitrogen fertiliser required to be added will depend on the amount of stored water i.e. the crop potential and the soil N level. High yielding environments will need more available N. A cotton crop removes about 12kg/ha of N per bale and requires about double this amount to grow the crop. A field expected to produce 4 bales/ha would need at least 96kg of available N in the profile. The amount of nitrogen in the profile is measured well before planting, and a decision made if N needs to be topped up.

Strip trials and experience can also assist in determining the fertiliser requirement. In general, fertiliser should be applied to a level that will produce a better than average crop as the opportunity cost of having insufficient N is considerable. However excessive amounts of N can create management problems with insect control, defoliation and regrowth difficulties.

CROP ROTATION

Factors that need to be considered when looking at developing rotations involving dryland cotton include:

- fallow soil moisture accumulation
- provision for influencing Heliothis population dynamics
- potential for disease build-up
- influence on VAM (Vesicular Arbuscular Mycorrhizae
- influence on fallow nitrogen
- residual herbicides

Only in years of above average autumn / winter rainfall would back-to-back cotton be a consideration in a dryland situation. **Table 19** outlines a number of possible rotational options currently being used in the dryland cotton areas.

Rotation 1 can experience VAM problems, and generally has lower water use efficiency due to more runoff, during a longer fallow. N movement to depth and denitrification are more likely to occur with this system.

Rotations 2 and 3 are commonly practiced rotations in dryland cotton areas. They maximise the chances of high levels of stored soil moisture at planting. Use of reduced or no tillage practices will help maintain standing stubble to lessen soil erosion and runoff. Low VAM levels in the soil with consequent nutrient unavailability is generally not a problem, especially where sorghum is grown. The winter cereal component is grown primarily for cover considerations.

Rotations 4 and 5 are dependent on good rainfall occurring during Autumn, as the cotton finishes. Rotations involving winter cereals provide better surface cover during the following summer fallow than winter legumes, usually resulting in better soil moisture storage and erosion control. While *Rotation 4* has the potential to reduce artificial nitrogen inputs, the winter legume option can potentially contribute to later season Heliothis control problems. Similarly sorghum in rotation in adjacent strips can reduce Heliothis control options due to drift concerns. Late sorghum can however, act as a sink for Heliothis, and prove an excellent tool too assist in their control.

Rotation 6 increases the frequency of cropping, and the level of ground cover. To maximise the chance of re-wetting the soil profile before cotton, the alternative summer crops must be planted as early as possible in spring. A high level of N management is necessary under this system.

Table 17 outlines the yield and return from a dryland cropping system trial conducted at Warra since 1993. The trial includes some of the rotations outlined in **Table 19**. The results to date indicate that judicious choice of rotational crops in dryland cotton systems can provide major soil sustainability benefits without detriment to gross return.

Figure 11: Aerial view of the dryland farming systems trial at Warra in Queensland (see Table 17)

Table 17: Summary – Seven year gross margins.

Years		Rotation 1 Cotton / cotton	Rotation 2 Cotton / sorghum	Rotation 3 Cotton / dc W.cereal	Rotation 4 Cotton / W.legume	Rotation 5 Cotton / W.cereal
1993/94	Crop	Fallow	Sorghum	Barley	Barley	Fallow
	Yield		2.1 t / ha	0.22 t / ha	0.22 t / ha	
	Price		$164	$155	$155	
	Income		$344	$34	$34	
	Var.Costs		$92	$52	$52	
	Gross Margin	$0	$252	($18)	($18)	$0
1994/95	Crop	Cotton	Cotton	Cotton	Chickpea	Wheat
	Yield	3.73 b / ha	3.05 b / ha	4.05 b / ha	0.66 t / ha	1.43 t / ha
	Price	$529	$529	$529	$320	$142
	Income	$1,972	$1,612	$2,141	$211	$203
	Var.Costs	$913	$837	$815	$96	$94
	Gross Margin	$1,059	$775	$1,325	$115	$109
1995/96	Crop	Fallow	Sorghum	Wheat	Cotton	Cotton
	Yield		5.77 t / ha	0.42 t / ha	4.45 b / ha	4.50 b / ha
	Price		$160	$242	$510	$510
	Income		$923	$102	$2,244	$2,295
	Var.Costs		$178	$68	$889	$927
	Gross Margin	$0	$745	$37	$1,355	$1,368
1996/97	Crop	Cotton	Cotton	Cotton	Wheat	Wheat
	Yield	3.35 b / ha	3.21 b / ha	3.80 b / ha	2.7 t / ha	2.70 t / ha
	Price	$460	$460	$460	$143	$143
	Income	1541	1476.6	$1,743	$386	$386
	Var.Costs	$782	$793	$871	$65	$65
	Gross Margin	$759	$684	$873	$321	$321
1997/98	Crop	Fallow	Sorghum	Wheat	Chickpea	Cotton
	Yield		3.05 t / ha	3.05 t / ha	2.57 t / ha	2.70 b / ha
	Price		$130	$130	$300	$450
	Income	$0	$397	$397	$771	$1,215
	Var.Costs	($63)	$142	$117	$166	$854
	Gross Margin	($63)	$255	$279	$605	$361
1998/99	Crop	Cotton	Cotton	Cotton	Cotton	Wheat
	Yield	3.8 b / ha	2.92 b / ha	4.41 b / ha	3.04 b / ha	3.79 t / ha
	Price	$480	$480	$480	$480	$153
	Income	$1,824	$1,402	$2,117	$1,459	$580
	Var.Costs	$1,005	$993	$1,018	$1,008	$107
	Gross Margin	$819	$409	$1,098	$451	$473
1999/00	Crop	Fallow	Sorghum	Wheat	Chickpea	Cotton
	Yield		5.78 t / ha	1.99 t / ha	1.03 t / ha	2.9 b / ha
	Price		$115	$180	$370	$450
	Income	$0	$665	$358	$381	$1305
	Var. Costs	($40)	$201	$155	$183	$792
	Gross Margin	($40)	$464	$203	$198	$513
7Yr Rotation Gross Margin		**$2,534**	**$3,584**	**$3,797**	**$3,027**	**$3,145**

Table 18: Possible rotational programs for strip cropped areas.

Year	1997	97/98	98	98/99	99	99/2000	2000	2000/01	2001	2001/02	2002
Season	**W**	**S**	**W**	**S**	**W**	**S**	**W**	**S**	**W**	**S**	**W**
Strip No											
1	Wh-dc	Wh-st	Wh-st	Cot	Cot-st	S-late	S-st	S-st	S-st	Cot	
2	S-st	S-st	S-st	Cot	Wh-dc	Wh-st	Wh-st	Cot	Cot-st	S-late	
3	Cot-st	S-late	S-st	S-st	S-st	Cot	Wh-dc	Wh-st	Wh-st	Cot	
4	Wh-st	Cot	Cot-st	S-late	S-st	S-st	S-st	Cot	Wh-dc	Wh-st	Repeat
5	S-st	Cot	Wh-dc	Wh-st	Wh-st	Cot	Cot-st	S-late	S-st	S-st	1997
6	Wh-dc	Wh-st	Wh-st	Cot	Cot-st	S-late	S-st	S-st	S-st	Cot	'W'
7	S-st	S-st	S-st	Cot	Wh-dc	Wh-st	Wh-st	Cot	Cot-st	S-late	
8	Cot-st	S-late	S-st	S-st	S-st	Cot	Wh-dc	Wh-st	Wh-st	Cot	
9	Wh-st	Cot	Cot-st	S-late	S-st	S-st	S-st	Cot	Wh-dc	Wh-st	
10	S-st	Cot	Wh-dc	Wh-st	Wh-st	Cot	Cot-st	S-late	S-st	S-st	
11	Repeat Strip No 1										

Wh-dc = Wheat Double cropped
Cot = Cotton
Wh-st = Wheat Stubble
Cot-st = Cotton Stubble
S-late = Late Sorghum
S-st = Sorghum Stubble

EROSION CONTROL IN DRYLAND COTTON

Floodplain Areas

A large proportion of Australia's dryland cotton is grown on flood plains, where erosion from overland flood flow is a serious potential threat at any time of the year. Strip cropping is a tried and proven method of controlling erosion and spreading flow in these area. The basic principle is to 'always have one foot on the ground' i.e. at any time of the year, to have standing well anchored stubble or well established crop in at least 1/3 of strips, lying across the direction of flood flow. Land levelling along fence lines and in gullied areas will improve the evenness of floodwater spread through the strips.

The stubble management practices applied within the stripcropping system are the core of its success. Because of the low level of stubble remaining and the length of fallow often associated with cotton, special challenges occur in systems involving dryland cotton. Stubble provided by other crops in the system has to last a considerable time, and remain well anchored. Sorghum and canary stubbles are the most effective in this regard. There is no doubt, that systems involving only cotton in long fallow, without other rotational crops are non sustainable. **Table 18** outlines a stripcropping program which addresses most agronomic and soil conservation requirement of a sustainable cotton production system.

Sloping Lands

On sloping land, cotton presents special challenges from a soil conservation perspective. Contour banks and contour cultivation have been the traditional way to reduce soil erosion. However, without the support of ground cover, banks are little more than silt traps.

Dryland cotton grown in a skip row configuration means that a low level of ground cover is present during the summer. If frequent inter row cultivation is carried out, this further increases the likelihood of soil erosion. Planting the crop into standing wheat or sorghum stubble, and using shielded sprayers for weed control throughout the life of the crop has the potential to greatly reduce soil erosion on sloping fields.

Research has been conducted to investigate a system where cotton is grown on beds running up and down slopes in fields tramlined to provide traffic control. Erosion can be minimised provided runoff is confined to its own bed furrow, and does not accumulate in depressions as it moves downslope. Obviously, intensive stubble management practices on the beds to reduce run off volume and peak flow rates is the key to the system being successful.

Pupae Control Conflict

One aspect of cotton production which potentially causes conflict with soil conservation practices in cotton rotations is the need for full soil disturbance to 10cm depth soon after cotton picking for control of potential overwintering pupae in the soil. Researchers, extension officers and farmers are developing practices which satisfy both requirements. These include:

- use of modelling to identify likely level of diapausing pupae
- more detailed field sampling for pupae
- late season inter row cultivation
- specialised planting equipment to give 10cm deep full disturbance
- post picking aggressive inter row cultivation in standing cotton stubble.

Table 19: Possible rotational options for dryland cotton

S	W	S	W	S	W	S	W	S	Soil H20	Surface Cover	Heliothis	Disease	VAM	Nitrogen
1.Cotton	Fallow	Fallow	Fallow	Cotton	Fallow	Fallow	Fallow	Cotton	++	--	++	++	--	+
2.Cotton	Fallow	Fallow	Winter Cereal	Fallow	Fallow	Cotton	Fallow	Fallow	++	+	++	++	+	+
3.Cotton	Fallow	Sorghum late	Fallow	Fallow	Fallow	Cotton	Fallow	Sorghum late	++	+	-	++	++	+
4.Cotton	Winter. Cereal opp	Fallow	Winter Legume	Fallow	Fallow	Cotton	Winter . Cereal opp	Fallow	+	-	-	+	++	+
5.Cotton	Winter . Cereal opp	Fallow	Fallow	Cotton	Winter Cereal . opp	Fallow	Fallow	Cotton	++	+	++	++	+	+
6.Cotton	Fallow	Sorghum Early	Fallow	Cotton	Fallow	Sorghum Early	Fallow	Cotton	-	++	-	++	++	-

Table 20: A guide to Plant–Back periods. (Please refer to current product labels).

CHEMICAL	PRODUCT	ACTIVE CONSTITUENT	APP. RATE PER HECTARE	PLANT BACK PERIOD	COMMENTS
sulfonylureas	GLEAN SIEGE	750g chlorsulfuron/kg	15-20g	18 months with a minimum of 700mm rainfall 24 months with a minimum of 700mm rainfall Glean is not recommended where soil pH is above 8.5	where soil pH is 6.6-7.5 where soil pH is 7.6-8.5 where soil pH is above 8.5
	ALLY	600g metsulfuron/kg	5-7g	15 months with a minimum of 700mm rainfall 18 months with a minimum of 700mm rainfall 18 months and then a further 700mm rainfall	where soil pH is 5.6-8.0 where soil pH is 8.1-8.5 where soil pH is above 8.6
	HARMONY M	682g thifensulfuron + 68g metsulfuron/kg	40g	15 months with a minimum of 700mm rainfall 18 months with a minimum of 700mm rainfall 18 months and then a further 700mm rainfall	where soil pH is 5.6-8.0 where soil pH is 8.1-8.5 where soil pH is above 8.6
	LOGRAN	714gt triasulfuron/kg	30-35g	12 months 22 months 24 months	where soil pH is up to 6.5 where soil pH is 6.5-7.5 where soil pH is above 7.6
	AMBER POST	20g triasulfuron + 600g terbutryn/Kg	250-500g	14 months	
2,4-D	2,4-D AMINE	500g 2,4-D amine/L	up to 0.7L 0.7-1.4L above 1.4L	10 days after at least 15mm rainfall 14 days after at least 15mm rainfall 21 days after at least 15 mm rainfall	Breakdown of 2,4-D is dependent upon microbial action under warm, moist conditions. Nominated plant back periods only commence after there has been in excess of 15mm rainfall. Extreme caution needs to be exercised under very dry conditions
	2,4-D ESTER	800g 2,4-D ester/L	up to 0.35L 0.35-0.7L 0.7-1.1L	10 days after at least 15mm rainfall 14 days after at least 15mm rainfall 21 days after at least 15 mm rainfall	
	TILLMASTER	180g 2,4-D amine + 90g glyphosate/L	up to 2.0L 2.0L–4.0L 4.0L–6.0L	10 days after at least 15mm rainfall 14 days after at least 15mm rainfall 21 days after at least 15mm rainfall	
	SURPASS	225g 2,4-D IPA salt/L	up to 1.5L 1.5-3.0L 3.0-4.6L	10 days after at least 15mm rainfall 14 days after at least 15mm rainfall 21 days after at least 15 mm rainfall	
Imidazolinone Imazethapyre	SPINNAKER	240g imazethapyre	200-400ml	22 month + minimum of 800mm rainfall	
Sulfonamide	BROADSTRIKE	800g/kg flumetsulam	25g	3-9 month on permeable soils 24 months on impermeable soils	

CHEMICAL	PRODUCT	ACTIVE CONSTITUENT	APP. RATE PER HECTARE	PLANT BACK PERIOD	COMMENTS
dicamba	DICAMBA 200 BANVEL	200g dicamba/L	up to 0.6L 0.7-1.4L	7 days 21 days	Breakdown of dicamba occurs by microbial activity under moist soil conditions. The nominated plant back period should only commence after there has been in excess of 15mm rainfall
picloram	TORDON 75-D	300g/L 2,4-D 75g/L picloran	300ml-1L	12 months	
	TORDON 242	26g picloram + 420g MCPA/L	1.0L	12 months	
fluroxypyr	STARANE	300g fluroxypyr/L	up to 500ml 500ml-1.5L 1.5-4.0L	14 days 28 days 60 days	Fallow Spray. Mainly used at lower rates of 250-500ml/ha. either alone or in tankmixes with glyphosate.
Triclopyr	GARLON 600	600g trichlopyr/L	80-160ml	7 days	Fallow Spray. Used in tankmixes with glyphosate for the improved control of paddy and camel melons
Clopyralid	LONTREL	300g clopyralid/L	70ml 150ml 300ml	7 days 14 days 56 days	Fallow Spray. Used in tankmixes with glyphosate for improved control of milk thistle.
Oxyflurorfen	GOAL CT	240g oxyflurorfen/L	75-100ml	No plant back period required at the rates specified.	Fallow Spray. While Goal does have soil residual action, the spike rates of 75-100ml used to tankmix with glyphosate should present no soil residue problems in cotton when used as a pre-plant treatment. The chemical provides improved control of prickly lettuce, mallow, medics and stinging nettle.
Atrazine	Various Products	500g atrazine/L	2.5L/ha 2.5-6.5L/ha	6 months 18 months	Damaging residues from high rates of atrazine may persist for up to 18 months depending on weather conditions and soil type. Atrazine is more persistent under the following conditions: - increasing soil pH (alkaline soils) - increasing clay content of the soil - low soil temperatures - low soil moisture levels. Residues persist for considerably longer on alkaline clay soils, and extreme caution needs to be exercised on clay soils where the soil pH is above 8.0. Atrazine breakdown is also strongly influenced by seasonal conditions. Rates of breakdown slow considerably under dry conditions and can stop altogether under extreme conditions such as drought.