

WATER USE BY COTTON: AN UPDATE ON STRATEGIES

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In addressing this topic I have been asked to consider the development of management strategies for farmers faced with a shortage of irrigation water, a situation that appears endemic in the Gwydir Valley. Ten years ago Greg Constable and I showed in an analysis of our experimental data that 8 MI per planted ha are needed for maximum yields in the driest years, while 7 MI/ha gives the greatest returns per MI on average by allowing a larger area to be planted with a given allocation. When the allocation is reduced, greatest returns would be obtained on average when the crop area was reduced to allow 6 to 7 MI for each planted ha. With less than 6 MI per ha the risks of obtaining yields below the breakeven point were very great and there was no advantage in delaying the first irrigation or increasing the interval between irrigations.

Our conclusions were based on the response of 31 experimental crops to water stress and the analysis of weather records for 95 years at Wee Waa and 22 years at Myall Vale. Since then data from a further 22 experimental crops are available and a more powerful method of analysis has been developed and extended to other regions.

A grower with a reduced allocation has three basic options available to him:

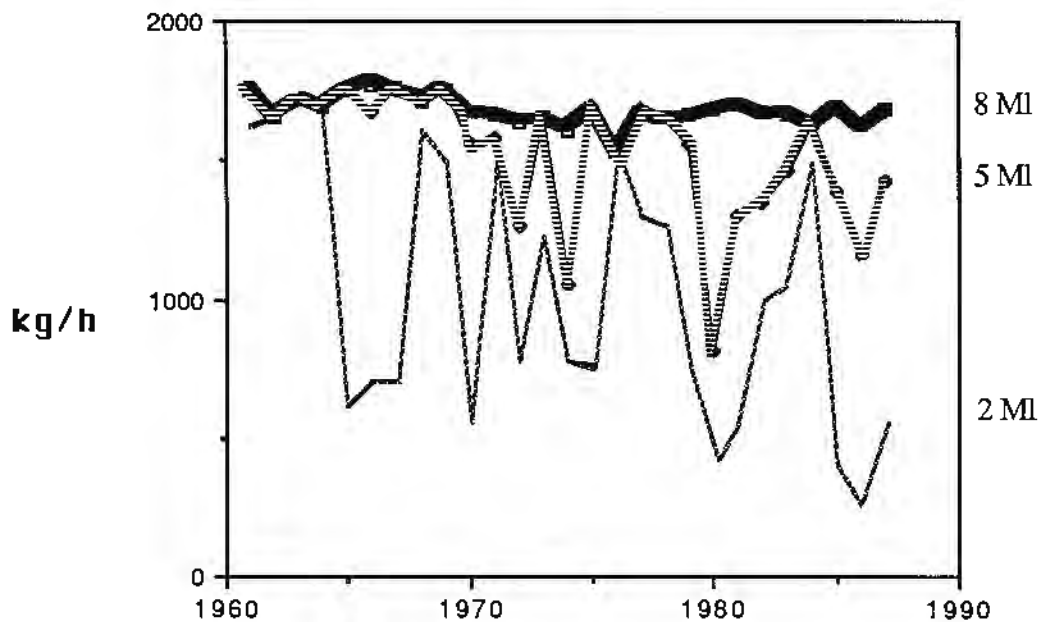
- * reduce the area of crop in proportion to the reduced allocation or
- * maintain the area or
- * make a compromise between the two.

Most growers choose the third option but may be uncertain as to how to compromise. In addition to these basic options there are supplementary options to maximise returns from the basic option selected, including delaying the start of irrigation, extending the interval between irrigations, skip row planting, paddock selection. There are risks whatever combination of options is chosen; risk of yields below break even point if the area is maintained and rainfall is inadequate to supplement the reduced allocation; risk of lost opportunity if the area is reduced and rainfall is adequate and a larger area could have been grown. However these risks can and should be taken as calculated risks

REDUCE AREA, MAINTAIN AREA or COMPROMISE.

Expected yields with supplies ranging from 1 to 9 Ml per ha were calculated for each season since 1960-61. Figure 1 shows a selection of the results as an example, with yields for 2, 5, and 8 Ml her ha. As the supply decreased, the fluctuations from year to year increased, with lower yields in drier seasons.

FIGURE 1: EXPECTED YIELDS WITH 3 WATER ALLOCATIONS AT MYALL VALE OVER 27 YEARS



While there is nothing new or unexpected in such a result, the fluctuations can be quantified and risks calculated. For this purpose the yields are listed in ascending order in Table 1 in order to assess the yield probabilities. Thus the 3rd line in Table 1 is highlighted in bold print, with yields ranging from a low of 372 kg/ha with 1 Ml per ha to 1627 kg/ha with 7 to 9 Ml. These yields are likely to be exceeded 24 years out of 27 (approximately 90% probability) with relevant water supply. Likewise the 75, 50, 25 and 10% probabilities have been highlighted, indicating the yields expected with given water supply 3 years out of 4, 1 out of 2, 1 out of 4 and 1 out of 10 respectively.

These results confirm previous conclusions. Only in two years (1979-80 and 1984-85) were more than 8 Ml in 6 crop irrigations needed for maximum yield. This does not show as a difference in yields between 8 and 9 Ml per ha. Yields started to fall sharply in dry years with less than 6 Ml per ha. However as water

available decreased below 6 MI per ha average yields were maintained by the high yields in the wetter years.

TABLE 1: EXPECTED YIELDS AT MYALL VALE OVER 27 YEARS WITH A RANGE OF WATER ALLOCATIONS

Probability	9MI	8MI	7MI	6MI	5MI	4MI	3MI	2MI	1MI
	1528	1528	1528	1356	811	536	269	269	301
	1604	1604	1558	1388	1051	604	323	408	304
90%	1627	1627	1579	1431	1156	831	457	421	372
	1634	1634	1604	1462	1264	1051	505	543	421
	1636	1636	1626	1473	1297	1085	536	546	424
	1654	1654	1627	1528	1350	1156	623	577	633
75%	1655	1655	1634	1559	1388	1226	662	623	643
	1659	1659	1636	1569	1422	1242	680	709	653
	1660	1660	1654	1579	1466	1245	709	710	669
	1662	1662	1655	1580	1528	1264	780	748	675
	1664	1664	1659	1594	1559	1297	958	768	711
	1668	1668	1660	1634	1561	1347	1242	780	722
	1674	1674	1662	1654	1575	1410	1294	806	804
50%	1679	1679	1664	1655	1634	1466	1317	1003	816
	1679	1679	1668	1659	1652	1523	1362	1051	822
	1680	1680	1674	1660	1654	1528	1426	1201	870
	1686	1686	1679	1662	1660	1549	1454	1263	1048
	1687	1687	1679	1664	1674	1552	1483	1300	1051
	1690	1690	1690	1679	1688	1561	1495	1483	1229
	1707	1707	1707	1690	1690	1621	1515	1495	1300
25%	1714	1714	1714	1714	1693	1634	1528	1497	1332
	1725	1725	1725	1725	1714	1660	1549	1543	1461
	1751	1751	1751	1751	1725	1690	1610	1610	1473
	1753	1753	1753	1753	1751	1718	1660	1629	1496
10%	1754	1754	1754	1754	1753	1725	1690	1660	1533
	1764	1764	1764	1764	1754	1753	1725	1690	1660
	1769	1769	1769	1769	1764	1754	1753	1725	1690
Mean	1680	1680	1669	1619	1527	1371	1133	1039	930

Break-even @ \$400/

With a reduced allocation a larger area can be irrigated if less water is reserved for each hectare. Thus each 6 MI allocated could be used for different areas of crop as follows:

	MI/ha	8	6	4	3	2
area	ha	.75	1	1.5	2	3
mean yield	bales/ha	7.5	7.2	6.1	5.0	4.6
production	bales/6MI	5.6	7.2	9.2	10.0	13.8
net returns	\$/6MI	1115	1380	1430	1000	1020

The average yields from Table 1 have been used and growing costs of \$1500/ha and a price of \$400 per bale have been assumed. On this basis it seems a grower with a reduced allocation will on average make more money per MI by growing an area that allows 4 MI per ha. However this takes no account of the risks involved. A glance at Table 1 shows that at 4 MI per ha in 3 years out of 27 (approximately 1 in 10) yields are expected to be below break even point (843 kg/ha or 3.75 bales/ha, assuming \$1500/ha to grow the crop and \$400/bale). By contrast, at 6 MI per ha the lowest expected yield (1356 kg/ha, 6 bales/ha) is well above the break even point. A line has been drawn in Table 1 to indicate the break even point. A grower can calculate and draw his own break even line in Table 1 based on his own growing costs and estimate of cotton price.

These results are based on experimental work done at the Research Station at Myall Vale and apply to the central Namoi Valley. How applicable are they to other regions? The analysis was repeated for Collarenabri at the western end of the Gwydir/Moomin system which is faced with severe and continuing reduction in allocations. At Collarenabri the weather is drier (20 to 30% less rainfall), temperatures are 1.2 deg Celsius higher on average and there is 2 to 3% more solar radiation. These differences affect the growth as well as the water requirement of the crop. The expected yields are given in Table 2. The analysis of options for using each 6 MI of allocation with a reduced supply has been repeated for Collarenabri as follows:

MI/ha		8	6	4	3	2
area	ha	.75	1	1.5	2	3
mean yield	bales/ha	7.4	7.1	5.5	4.7	4.2
production	bales/6MI	5.6	7.1	8.3	9.4	12.6
net returns	\$/6MI	1099	1321	1037	722	529

The case for reducing the area so that there are at least 6 MI per ha when the allocation is reduced is even stronger at Collarenabri. With only 4 MI per ha not only is the risk of yield below break even point twice as great as at Myall Vale (expected 6 years out of 27, nearly 1 in 4) but on average returns are less than with 6 MI per ha where the lowest yields expected are still well above break even point.

TABLE 2: EXPECTED YIELDS AT COLLARENABRI OVER 27 YEARS WITH A RANGE OF WATER ALLOCATIONS

	9 MI	8 MI	7 MI	6 MI	5 MI	4 MI	3 MI	2 MI	1 MI
	1581	1490	1440	1112	602	494	348	384	37
	1586	1581	1458	1290	837	563	363	385	40
90 %	1590	1586	1467	1416	1055	578	498	498	42
	1590	1590	1490	1426	1088	602	559	537	76
	1638	1590	1540	1440	1112	678	599	559	91
	1642	1638	1553	1467	1127	821	626	641	147
75 %	1645	1642	1571	1471	1306	898	648	648	220
	1648	1645	1581	1540	1394	949	652	693	255
	1651	1651	1590	1566	1415	985	678	712	348
	1657	1657	1590	1581	1416	1005	775	719	385
	1661	1661	1632	1590	1419	1088	883	740	509
	1664	1664	1645	1612	1434	1203	898	746	520
	1665	1665	1657	1619	1471	1228	949	779	620
50 %	1666	1666	1661	1632	1483	1306	985	786	648
	1669	1669	1664	1645	1549	1452	1088	800	657
	1672	1672	1666	1657	1566	1483	1161	828	658
	1673	1673	1669	1664	1590	1483	1166	855	681
	1691	1691	1670	1666	1657	1524	1203	949	726
	1700	1700	1691	1669	1668	1549	1436	1161	740
	1702	1702	1702	1680	1669	1584	1486	1269	828
25 %	1706	1706	1706	1690	1674	1625	1524	1369	843
	1715	1715	1715	1702	1680	1645	1529	1437	1122
	1747	1747	1747	1706	1702	1657	1535	1485	1216
	1748	1748	1748	1747	1706	1664	1600	1535	1407
10 %	1752	1752	1752	1748	1747	1669	1669	1600	1437
	1752	1752	1752	1752	1752	1747	1674	1669	1444
	1771	1771	1771	1752	1752	1752	1736	1674	1588
Mean	1673	1668	1634	1587	1440	1231	1047	943	640

*break even
@ \$400/bale*

DELAY START and/or LENGTHEN INTERVAL.

The rationale behind this option is that, when the allocation is reduced, delaying an irrigation by a few days results in the last irrigation occurring later thus reducing the duration of the period of stress at the end of the season after the allocation is exhausted. Furthermore it increases the probability of receiving sufficient rainfall to delay the irrigation further. In 1977/78 and 1986/87 for example heavy rain occurred early in the new year effectively taking the place of a delayed first irrigation. However rainfall probabilities are low and there is little advantage in this. The yield gained by reduction in stress at the end of the season rarely offsets the yield loss by increased stress earlier in the season. Stress early in the season produces a smaller plant with reduced potential, which may not be able to take advantage of better conditions later in the season.

SKIP ROW.

This technique originally became popular in the US to maximise production under the Federal Cotton Acreage Control Program. Only the planted rows were included in the official acreage. Yields of planted rows increased but yield over the whole paddock decreased. When considering yields quoted it is not always clear if they refer to the whole paddock or the planted rows. When evaluating the technique as an irrigation management strategy, it should be remembered that costs are still incurred on the unplanted skips so that yields must be evaluated on a paddock and not a planted row basis. In terms of irrigation management the effect of skip row is to increase the soil water storage capacity available to the planted rows. The result should be to increase the capacity to store heavy falls of rain without runoff and allow longer intervals between irrigations thus increasing the probability of rain occurring before an irrigation.

The analysis evaluated skiprow on this basis for an allocation of 2 Ml per ha. On average there was no advantage in extending the irrigation interval. Yield on the planted area increased by 20% so that overall paddock yields were down by 40%. If production costs per paddock can be reduced by a greater amount then it is an economic strategy. Costs on a paddock basis can be reduced on skip row cotton in terms of nitrogen and insect control when applied by ground rig to the planted rows. There is unlikely to be reduction in costs for aerial control, nor for land preparation and weed control. Growers will have to do their own budgeting to determine this. The general consensus to date is that it is not economic.

PADDOCK SELECTION.

Returns from a limited water supply can be maximised by selecting the most productive paddocks. These will usually be fallowed, cleanest in terms of weeds and disease with least compaction and waterlogging problems. Crops on soils with a compaction problem often require more frequent irrigation, which is disadvantageous when allocations are reduced. It is also prudent to select those easiest to supply with water. Irrigation efficiency falls when a channel system designed for a large area has to be filled in order to irrigated only a few paddocks. The analysis showed that a drop of efficiency from 75 to 65% with 5 Ml per ha reduced average yield by 8% and increased the risk of less than break even yields threefold, from 1 in 27 to 3 in 27 years in dry years.

OTHER INPUTS - INSECT CONTROL AND NITROGEN.

The interaction of insect control strategy with irrigation strategy is little understood and has not yet been well researched. Conventional wisdom is that early insect control is even more crucial for crops with a limited water supply than it is believed to be for normal crops. For crops supplied with 3 to 6 Ml per ha this is probably true. However for crops that are almost entirely raingrown insect control needs to be matched to the rainfall pattern. In 1977/78 for example, a crop that was delayed by 20 days and had only 3 Ml/ha had heavier yield than one without delay because the delay enabled it to take advantage of late season rainfall. The early crop cutout before the rain came and was unable to take advantage of it. A crop stressed early in the season will not be attractive to insects and will not have much to protect. Heavy expenditure on insect control should be avoided for crops of low potential.

When crops are grown with a restricted water supply, say less than 6 Ml per ha, nitrogen should be reduced in accordance with the reduced yield expectation.

CONCLUSION.

Given our variable climate, there is no strategy for use with reduced allocations that will always be right every season. A conservative strategy (reducing the area cropped to maintain a large amount of water per ha) may come out ahead most seasons, but there will be seasons when a less stringent strategy (growing a larger area with less allocation per ha) will prove more profitable. In looking for a decision that is the best bet, it is possible to calculate the risks. There are a number of points during the sequence of operations required to produce a crop when it is wise to review the decision about how much crop to grow with a given allocation. These points are: prior to land preparation, prior to nitrogen application, prior to sowing and prior to first irrigation.

