Paper 16
IRRIGATION AND SOWING DATE EFFECTS ON YIELD AND MALTING QUALITY OF BARLEY

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INTRODUCTION

The quality of barley grain produced on the Canterbury plains has varied considerably from year to year (Malcolm and Thompson 1968). This variation in quality was attributed to variation in amount and timing of rainfall, water availability being particularly important during grain development. In irrigation experiments using Zephyr barley on the light stony soil at Winchmore, irrigation increased grain yields and improved malting quality (Drewitt and Smart 1981, Thompson *et al.* 1974). The improvement in malting quality was due to reduced grain nitrogen content and screening percentage, and measured by increased malt extract.

Time of sowing also affects yield and quality of grain crops. At Winchmore, Drewitt and Muscroft Taylor (1978) compared three sowing dates (August, September, October) two irrigation levels (10% and 15% soil moisture) and three crops (Gamenya and Karamu wheat and Zephyr barley). They showed barley yield to be unaffected by sowing date, whereas wheat yields declined when sowing was delayed to October. Yields of August-sown Zephyr and Karamu did not differ significantly when irrigated at the higher level. In later-sown crops at the higher irrigation level and for all sowing dates at the lower level barley out-yielded wheat.

This study is a continuation of the above work, and presents barley results for four seasons. The objectives were to determine the number of irrigations required and the yield responses obtained when water was applied at defined soil moisture levels with a wide range of sowing dates. The information would be of use in irrigation systems planning, and by extending the sowing date as late as mid-December, data could be used in assessing the potential of double cropping.

EXPERIMENTAL

The four trials were carried out with Zephyr barley on Lismore stony silt loam at Winchmore Irrigation Research Station from 1977-78 to 1980-81. This soil had an available water holding capacity of about 60 mm; some typical physical properties are given by Stoker (1978). The previous crop, the sowing dates for each season, and the irrigation treatments are given in Table 1. Seeding rate was from 150 to 160 kg/ha, and 360 kg/ha of a 2:1 mix of superphosphate and sulphate of ammonia was applied with the seed. In all seasons weeds were controlled by the application of a broadleaf herbicide near the end of tillering. A fungicide was used where necessary to control leaf rust and powdery mildew. A dessicant was used in the three seasons that December grain was harvested. Irrigation was applied by the border strip method when moisture in the top 150 mm of soil fell to pre-determined levels. Sufficient water was applied at each irrigation to restore the full soil depth to field capacity. One miniheader strip, 1.25 x 35 metres, was taken from the centre of each plot for yield determinations. The non-irrigated September sown cereals were the first to be harvested, usually in the late January — early February period, and the irrigated wheat of the December sowing was last to be harvested, near the end of April.

TABLE 1: Previous crop and sowing dates.

Season	Previous Crop	Sowing Dates
1977-78	Old pasture	15.9, 13.10, 13.11, 15.12
1978-79	3 year pasture	14.9, 18.10, 15.11, 19.12
1979-80	3 year pasture	14.9, 18.10, 14.11, 14.12
1980-81	Barley and wheat	15.9, 15.10, 13.11, 15.12

Irrigation Treatments

1. No irrigation
2. Irrigated at 10% soil moisture (s.m.)
3. Irrigated at 15% soil moisture

Each trial consisted of four replicates of a split-split plot design with irrigation treatments as main plots and sowing dates as subplots, and cereal (barley and wheat) as subsubplots. This paper presents the barley results.

Grain yields were adjusted to 12% moisture content and include screenings. The screening percentage is the percentage by weight of grain passing through an A6 (2.37 mm) screen. Grain nitrogen content of unscreened samples was determined by the Kjeldahl method and expressed as a percentage on a dry basis. Malt quality was determined by micro-malting 250 g samples (Meredith *et al.*, 1962), and measuring the fine-grind extract percentage using the European method (Pollock, 1962). Grain screenings percentage and grain nitrogen content were measured and statistically analysed on a plot basis. Malt extract was measured on composite samples from each treatment.

RESULTS

Rainfall distribution from October to February varied considerably in the four seasons of the study (Table 2).

TABLE 2: Monthly rainfall (mm) October to February.

	77-78	78-79	79-80	80-81	Long-term mean
October	23	91	136	47	61
November	24	36	67	118	65
December	73	124	49	50	69
January	51	39	125	33	64
February	20	42	68	23	57
5-month total	191	332	445	271	316

Grain yield

Grain yields for the four seasons are given in Table 3. All seasons showed a response to irrigation but the sizes of the responses varied.

TABLE 3: Effects of irrigation on barley grain yields (kg/ha) at four sowing dates in four seasons. Number of irrigations in brackets.

	1977-78	1978-79	1979-80	1980-81	Mean
Non-irrigated					
Sept	1440	3530	4060	5190	3550
Oct	2560	3880	4280	4070	3700
Nov	3210	1030	2930	2630	2450
Dec	1050	—	1970	2410	1810
Irrigated 10% s.m.					
Sept	4720 (2)	3980 (1)	5470 (1)	5720 (1)	4970
Oct	5380 (2)	4710 (1)	5650 (1)	5680 (2)	5360
Nov	4690 (2)	1730 (2)	3550 (2)	4210 (2)	3540
Dec	1960 (2)	— (2)	2440 (1)	2260 (1)	2220
Irrigated 15% s.m.					
Sept	5070 (4)	3940 (1)	6090 (2)	5480 (3)	5140
Oct	6350 (4)	4600 (2)	6310 (2)	6000 (3)	5820
Nov	5980 (4)	1710 (4)	3800 (3)	4420 (4)	3980
Dec	2950 (4)	— (3)	2570 (2)	2300 (3)	2610
LSD 5%-					
For comparison of sowing dates for each irrigation level:					
	770	680	610	790	1250
For comparison of irrigations at each sowing date:					
	840	800	730	820	1150

The 1977-78 growing season was dry over-all, only December having an average rainfall. There was a large response to irrigation, the barley irrigated at the higher level of irrigation (15% s.m.) giving the greatest response. Barley sown in October and November irrigated at this high level (4 irrigations) yielded best, with all irrigated barley sown from September to November yielding well. The yield of the irrigated December-sown barley was much less, although it was as high as from the earlier-sown plots without irrigation.

In the 1978-79 season rainfall was variable; November was a dry month, December very wet and January and February dry. This resulted in an over-all small response to irrigation. The September-sown barley showed little response in yield to irrigation whereas the yield of the October-sown barley was substantially improved. November being dry, the barley sown in this month germinated unevenly and had subsequent poor growth; there was a considerable response to irrigation but the final yield was low. Severe regrowth made the December barley unharvestable.

In the 1979-80 season, which also experienced variable rainfall, October was wet, November had average rainfall, December was dry and January was very wet. The September and October sown barley showed similar good yields without irrigation, and also the largest response to irrigation. November yields were less, with a further reduction to the December yields.

The 1980-81 season was fairly dry; October was dry, November wet, with December, January and February having below-average rainfall. The September-sown barley showed a high yield and no response to irrigation, whereas the yields from October and November sowings were improved by irrigation, with little difference between the responses at the two irrigation levels. Yields from November and December sowings were once again low without irrigation, and the December-sown plots were not improved by irrigation.

Screening Percentage

Irrigation reduced screening percentages, and barley sown in September or October generally had acceptable screening percentages under both irrigation levels (Table 4). The one exception was the October barley of the 1978-79 season, irrigated (once) at the low level. At the higher level of irrigation one additional irrigation was required, and the screening percentage fell to an acceptable level although there was no yield increase. When barley is sown in November there is a risk of producing unacceptable screening percentages, even with three or four irrigations. December sown barley produced unacceptable screening percentages in all seasons, except from the non-irrigated plots in 1979-80.

Grain Nitrogen

In all four seasons irrigation significantly decreased grain nitrogen (Table 5), particularly at the higher level. In three of the four seasons irrigated barley showed an increase in grain nitrogen as sowing date was delayed. In the other season (1978-79) the October sowing had the lowest grain nitrogen levels.

TABLE 4: Effects of irrigation on barley screenings (%) at four sowing dates.

	1977-78	1978-79	1979-80	1980-81	Mean
Non-irrigated					
Sept	9	3	36	6	13
Oct	13	32	4	37	21
Nov	8	69	26	28	33
Dec	56	—	6	40	—
Irrigated 10% s.m.					
Sept	3	5	2	3	3
Oct	10	18	3	5	9
Nov	18	18	28	8	18
Dec	17	—	18	41	—
Irrigated 15% a.m.					
Sept	2	2	4	2	3
Oct	5	8	4	7	6
Nov	9	23	13	15	15
Dec	35	—	30	62	—
LSD 5%-					
For comparison of sowing dates for each irrigation level:	8	4	8	7	18
For comparison of irrigations at each sowing date:	8	5	9	8	17

TABLE 5: Effects of irrigation on barley grain nitrogen content (%) at four sowing dates.

	1977-78	1978-79	1979-80	1980-81	Mean
Non-irrigated					
Sept	2.46	1.81	2.01	2.01	1.91
Oct	2.43	1.60	1.92	1.98	1.98
Nov	1.60	2.53	2.03	3.04	2.55
Dec	3.33	—	2.63	2.60	—
Irrigated 10% s.m.					
Sept	1.84	1.64	1.53	1.31	1.58
Oct	2.03	1.51	1.72	1.66	1.73
Nov	2.32	1.87	2.02	2.10	2.08
Dec	2.56	—	2.38	2.43	—
Irrigated 15% s.m.					
Sept	1.61	1.48	1.47	1.14	1.43
Oct	1.76	1.33	1.47	1.44	1.50
Nov	1.88	1.85	1.60	1.79	1.78
Dec	2.13	—	2.02	2.52	—
LSD 5%-					
For comparison of sowing dates for each irrigation level:	0.30	0.22	0.15	0.22	0.38
For comparison of irrigations at each sowing date:	0.35	0.26	0.17	0.23	0.27

Grain nitrogen of the non-irrigated barley also increased as sowing date was delayed after October. All barley from September and October sowings irrigated at the higher level had grain nitrogen levels suitable for malting, but in the driest season nitrogens were rather high at the low level of irrigation. The November-sown barley of both irrigated treatments had grain nitrogen contents too high for malting.

Malt Extract

In all seasons irrigation increased malt extract (Table 6). The irrigated treatments had similar percentages of malt extract. This percentage decreased with the delay in sowing date, in all treatments and all seasons, in general agreement with the decreases in yield and the associated increases in grain nitrogen content.

TABLE 6: Effects of irrigation on malt extract (%) at four sowing dates.

	1977-78	1978-79	1979-80	1980-81	Mean
Non-irrigated					
Sept	76.4	80.4	76.6	81.7	78.8
Oct	75.3	78.3	79.9	77.0	77.6
Nov	74.9	75.7	77.2	74.6	75.6
Dec	71.4	—	78.2	74.9	—
Irrigated 10% s.m.					
Sept	80.3	81.9	82.0	82.8	81.8
Oct	79.0	80.8	83.4	80.8	81.0
Nov	78.0	80.1	77.2	79.5	78.7
Dec	76.8	—	75.9	74.2	—
Irrigated 15% s.m.					
Sept	80.3	81.8	82.1	83.8	82.0
Oct	82.2	81.6	82.0	81.4	81.8
Nov	79.9	80.2	78.7	78.7	79.4
Dec	77.8	—	74.1	75.3	—

DISCUSSION

The earlier findings of Drewitt and Muscroft-Taylor were that barley yield was unaffected by sowing date (August to October) and that yields were similar at the two levels of irrigation. Our results also show that the yields of September-sown barley were similar at these levels of irrigation, and grain quality seemed not to be affected by the level of irrigation.

However, the October yields and numbers of irrigations required for acceptable quality present a different picture. Barley irrigated at 15% s.m. is capable of outyielding barley irrigated at the lower level of 10% s.m. At this sowing date barley appears to have an increased water requirement, especially from mid-December to early January when the barley is growing through the critical ear

emergence and early grain-filling phases. Three or four irrigations were required in a dry season for these yields and even if the extra irrigation did not give an increase in yield it ensured the barley had acceptable malting characteristics.

The results also show that October-sown barley receiving adequate moisture is capable of outyielding the earlier sown barley. November-sown barley also needs an increased number of irrigations to yield well, but in two of the four seasons four irrigations were insufficient to lower the grain nitrogen content to a level acceptable for malting.

The sowing of barley in December is not feasible. Yields and quality characteristics are given in this report but a dessicant was needed in the three seasons that harvestable yields were taken. Plant failure, regrowth, sprouting and high screening percentages all occurred at this sowing date, even when irrigation was applied.

CONCLUSION

On the light stony soils in Canterbury, high yields of good quality malting barley can be grown with irrigation, and the practice of irrigating early-spring-sown barley twice during the season appears to be well founded. October-sown barley given adequate moisture will produce high yields with acceptable malting quality whereas November-sown barley can yield well but lacks malting quality. Barley sown in December does not grow well.

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