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A COMPARISON OF AUTUMN AND SPRING SOWN BARLEY ON LISMORE SOILS WITH AND WITHOUT IRRIGATION

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ABSTRACT

Three experiments were carried out at Winchmore Research Station from 1983 to 1985 to evaluate the performance of Autumn sown barley on a Lismore soil.

Illia and Tipper, two true Winter cultivars of barley, Priver, Goldmarker, Gwylan, Magnum and Triumph (all Spring cultivars) were all sown in Autumn. The plots were flood irrigated when the soil moisture (s.m.) in the top 150mm of soil fell to 10% (wilting point) and 15% (25% available soil moisture) or were not irrigated. As a comparison, plots of Spring sown barley irrigated at 15% s.m. were also included in this project.

An average yield of 7.2 1 t/ha was obtained from Illia, the Winter cultivar, which was approximately 1 t/ha more than the average yield of the Spring cultivars sown in Autumn. In one season, the Winter cultivar Tipper was grown and had similar yields to the Spring cultivars. When Spring cultivars were sown in Autumn, grain yields were similar to the yield obtained when the cultivars were sown in Spring.

In two seasons, one irrigation increased the yield of the Autumn sown barleys, but irrigating at 10% and 15% soil moisture made no difference to the yield. In the third season, there was frequent rainfall and irrigation did not affect grain yields.

Irrigation reduced the amount of small grain (screenings), but it appeared to increase the amount of disease and lodging.

The project showed that Autumn sowing of barley can be successfully carried out on a Lismore soil, provided care is taken to eliminate fungal diseass.

The yield advantage of Autumn sown barley in Canterbury appears to be much smaller than that of from Europe.

Additional Key Words: Winter cultivars, Spring Cultivars, flood irrigation, yield response, yield potential, crop model.

INTRODUCTION

In the United Kingdom, Autumn sown cereal cutlivars tend to out-yield Spring sown cultivars of the same species, (Russell *et al.*, 1980). During the last 15 years, the area of Autumn sown cereals has increased in England and Western Europe. In 1982, 32% of the barley grown in England and Wales was sown in Autumn.

Gallagher (1983) extrapolating from data from England, suggested that there were good prospects for Autumn sown barley in New Zealand. He developed a model predicting yields of Winter and Spring barley crops in Canterbury. His calculations suggest that Autumn sowings of Spring barleys could yield, on average, 33% more than Spring sowings. this yield advantage is increased to 38% if Winter barleys are sown and arises from the longer duration of growth of the Winter barley crop. The model predicts that on medium to light soils such as the Lismore Stony Silt Loam, the yields of Autumn sown unirrigated crops could be almost twice the yield of unirrigated Spring sown barley crops.

Autumn sowing of barley holds some attraction to farmers on medium to light soils in Canterbury. The crop fits well into arable and mixed cropping management systems and its potential yield is high. Gallagher suggests that the crop is unlikely to have a high requirement for irrigation.

The objectives of this project were to:

(a) Evaluate Autumn and Spring sowings of barley grown with and without irrigation on the light soil of Canterbury.

(b) Test the yields of Autumn sown crops predicted by Gallagher against yields of field grown crops.

MATERIALS AND METHODS

In 1983-84, 1984-85 and 1985-86, trials were carried out at Winchmore Irrigation Research Station on a Lismore Stony Silt Loam. The top 300mm of this soil has an available water holding capacity of about 60mm and work has shown the shingle substrata to be capable of holding significant quantities of plant available water (Stoker 1982). Total plant available water is between 90 and 100mm. Irrigation was applied by the border strip method according to the soil moisture (s.m.) of the top 150mm of soil.

Each trial compared currently available cultivars, sown in the Autumn and Spring under several levels of irrigation. Trial design was a split plot design, with the irrigation/sowing time factor on main plots and the cultivar factor on sub-plots.

For the Autumn sowings, three irrigation treatments were used as follows:

1. No irrigation..
2. Irrigation applied at 10% soil moisture.
3. Irrigation applied at 15% soil moisture.

For the Spring sowings, irrigation was standardised at 15% soil moisture.

On Lismore Stony Silt Loam, 10% s.m. corresponds to wilting point and 15% s.m. to approximately 25% available s.m. Sufficient water was applied at each irrigation to restore the whole profile to field capacity.

Each irrigation/sowing time treatment, occupied two out of the eight border strips within each of three replicate blocks.

For the Autumn sowings, four of the following cultivars were sown:

Illia and Tipper (Winter cultivars),

Table 1. Trial Details for Each Season

Experiment	1983-84	1984-85	1985-86
Prev. History	Pasture 3 Years	Wheat Ex Pasture	Pasture 3 Years
Sowing Rate (kg/ha)	125	125	125-130
Sowing Date – Autumn	3 June	3 May	27 May
– Spring	6 October	27 Sept.	27 Sept.
Fertiliser N (kg/N/ha)	-	40	-
Winter Barley – Drilling			
G.S. 4 (Feekes Scale) (Date)	120, (13 Sept)	115, (27 Sept)	92, (10 Sept)
Spring Barley – Drilling	103	40	-
G.S. 2 (Date)	-	115, (1 Nov)	92, (5 Nov)
Irrigation Dates			
Winter Barley – 10%	22 Nov.	24 Nov.	-
– 15%	12 Nov,1 Dec.	11 Oct,6 Nov.	18 Nov.
Spring Barley – 15%	22 Nov.	7 Nov,19 Dec	-
Rainfall (mm)			
(August to January)	417	214	395
Long Term Mean (mm)	368		
Pesticide Applications			
Winter Barley	-	-	- (excluding Illia)
Spring Barley	1	2	2

G.S. 4 and G.S. 2 = Growth Stage 4 and 2 (Feekes Scale)

Koru, Priver, Goldmarker, Gwylan, Magnum and Triumph (Spring cultivars).

All of these cultivars except Triumph were "feed" barleys. In the first year, wheat was included, though these results are not reported here.

Each border of the trials held two of the cultivars, the pairing of cultivars balancing over replicates. For the Spring sowings, only two cultivars were included, and the replication doubled.

The previous crop, sowing date, sowing rate and timing of fertiliser Nitrogen applications are given in Table 1. Fertiliser Nitrogen was drilled as diammonium phosphate in 1984-85 and as urea in other years. The 200 kg/ha of diammonium phosphate also contained 20 kg/ha of Phosphate. 250 kg/ha of superphosphate (containing 23 kgP/ha), was applied at sowing in 1983-84 and 1985-86.

The cultivars were inspected regularly and the fungicide Tilt and insecticide Lorsban, were applied at the first signs of disease or insect infestation. The advice of local Plant Pathologists was also sought. The Autumn sown crops were extremely attractive to small birds when the grain was at milky dough stage. Strips of plastic on string lines were used to deter birds. Other cereal projects at Winchmore showed that a "preventative" approach to disease and insect control could increase yields and keep screening percentages low (Daly pers. comm.).

In 1983-84, one effective irrigation was applied in mid-November. Another irrigation was applied to the 15% s.m. treatment.

In 1984-85, both irrigation treatments again received one effective irrigation. Another irrigation was applied to the 15% s.m. treatment.

In 1985-86 the Autumn sown barley irrigated at 15% s.m. received an irrigation in mid-November when passing through the ear emergence phase.

On 19 January 1984, 10 January 1985 and 17 January 1986, one strip 1.25 x 35 metres was taken from the centre of each plot by mini header for yield determinations. Grain yields included screenings and were adjusted to 12% moisture content. The percentage of screenings was determined as the percentage by weight of grain passing through an A6 (2.37mm) screen.

Malt quality was determined by micro-malting 250g samples of barley (Meredith *et al.*, 1962) and measuring the fine grind extract percentage using the European method (Pollock, 1962). Malt extract was measured on a composite sample from each replicate.

Gallagher's (1983) model was used to look at the yield of barley from this project. This model proceeds in two steps, first calculating an estimate of the maximum duration of growth and then modifiying this to allow for periods of high moisture stress when no growth occurs and from this, calculating an estimate of the yield.

Table 2. Yield (kg/ha) and Screening Percentage for 3 seasons

	Yield (kg/ha)		Screenings (%)	
	Not-irrigated	Irrigated	Not-irrigated	Irrigated
1983-84 – Autumn Sown				
Illia	7000	8190	21	4
Priver	5210	6790	15	6
Koru	6310	6480	10	5
Spring Sown				
Magnum	nt	7800	nt	5
Triumph	nt	7100	nt	10
L.S.D. 5%	570	400		3
1984-85 - Autumn Sown				
Illia	3220	7670	3	9
Goldmarker	3260	6910	15	15
Gwylan	5580	7030	10	31
Triumph	3490	6450	18	10
Spring Sown				
Triumph	nt	6830	nt	25
Gwylan	nt	5400	nt	22
L.S.D. 5%	820	660		7
1985-86 - Autumn Sown				
Illia	7660	7770	4	4
Tipper	6400	6520	4	4
Triumph	6890	6890	3	3
Magnum	6780	6630	9	9
Spring Sown				
Magnum	6400	*	6	*
Triumph	5000	*	8	*
L.S.D. 5%	400	560		

- nt = not tested.

Note: * Critical soil moisture level not reached, therefore irrigation not applied.

RESULTS

Rainfall during the August to January period varied considerably in each year (Table 1). Although there was relatively high rainfall in 1983, less than half the normal rain fell during November when the plots were at Feekes Growth Stage 10.

Grain Yield

In two of the three seasons, irrigation increased the yields of Autumn sown barley, (Table 2). There was only one instance when there was a substantial difference in the grain yields obtained from plots irrigated at 10% and 15% soil moisture, (Triumph in 1984-85). Data from the two irrigated treatments has been combined.

In 1983-84, Illia and Priver responded to irrigation while Koru did not. In 1984-85, all four cultivars responded to irrigation. When Autumn sown, Gwylan was significantly higher yielding in the absence of irrigation, but similar to the others when irrigated. Triumph was poor yielding when irrigated at 10% s.m. The 1985-86 season was one of frequent rainfall. Illia was superior yielding to all other cultivars.

The true Winter cultivars appeared more resistant to disease. Spring cultivars, Autumn or Spring sown, required regular monitoring for disease and the number of pesticide applications for each time of sowing were similar.

The differences in yield between the Autumn and Spring sown barley varied with the season. Overall, yields of the Spring cultivars sown in the Autumn, exceeded the yield of the same cutivars sown in the Spring by 15% or approximately 0.8 t/ha.

In 1983-84 when Triumph and Gwylan were sown in both Autumn and Spring, the yield from both sowings of Triumph was similar at 6.6 t/ha, while the yield of Gwylan was reduced 30% from 7 t/ha to 5.4 t/ha when sowing was delayed until Spring.

However, the the 1985-86 season when Triumph and Magnum were sown as cultivars common to both times of sowing, the yield of both crops of Magnum were similar, while the yield of Triumph was reduced by 38% when it was sowin in Spring.

Screening Percentage

The percentage of screenings in the grain at harvest varied each season, (Table 2). In 1983-84, despite relatively high yields, the percentages of screenings in the cultivars which had not been irrigated was high. Irrigation reduced the amount of screenings.

Generally, the amount of small grain in the sample at harvest is reduced by irrigation, but in 1984-85, the percentages of screenings in samples was increased by irrigation.

The percentage of screenings in Goldmarker and Triumph was not affected by irrigation or season. In 1985-86, the percentage of screenings were low for all Autumn sown cultivars except Magnum which had 9%.

The amount of screenings at harvest in grain of Spring sown cultivars also varied with the season. Triumph and Gwylan screenings were high in 1984-85.

Malt Quality

The malting quality of Triumph was not affected by time of sowing. Irrigation increased the amount of malt extract obtained and reduced the nitrogen content of the grain. However, during the years when these experiments were undertaken, all Autumn sown barley was sold as "feed" barley because contracts for malting barley specified that the barley must be sown in Spring.

Gallagher's model suggests that the maximum duration of growth is considered to be 900 photothermal units for Spring and 950 units for Autumn sown barley. In this investigation, growth units were accumulated from the time of emergence to the end of the following January. For the Autumn barley, 950 units were achieved in all seasons, but in no season did the Spring sown barley achieve 900 units, (Table 4). In this model, the product of the maximum growth duration (tm) modified by the days when no growth occurs (td), an average growth rate C (considered to be 95 kg/ha/day), (Gallagher *et al.*, 1983) and a harvest index H (0.470, (Gallager *et al.*, 1983) then gives the grain yield (Y) as in the equation:

$$Y = C^* H^* (tm\text{-}td)$$

For this investigation, a limiting deficit at which growth ceased was set at 115mm. The results of applying this analysis to the Autumn sown Illia barley yields of this projects are given in Table 5.

Table 3. Malting Quality of Triumph

	N%	Extract			Malt
		Fine	Coarse	Difference	SN%
1983-85-					
Autumn –					
Non-Irrigated	2.33	78.7	77.4	1.4	1.076
Irrigated	2.11	80.3	79.4	0.9	1.920
Spring					
Irrigated	2.46	78.3	76.7	1.6	1.955
1985-86-					
Autumn					
Non-Irrigated	1.71	79.1	77.6	1.5	1.852
Irrigated	1.56	81.0	79.0	2.0	1.776
Spring					
Non-Irrigated	2.04	79.5	75.1	4.4	1.919

Table 4. Growth Duration of Autumn and Spring Barley for 3 seasons

Sowing Date	Season	Period	Units	Days
Autumn	1983-84	2. 7.83 to 27. 1.84	954	210
Spring	1983-84	19.10.83 to 31. 1.84	695	105
Autumn	1984-85	18. 6.84 to 8. 1.85	950	205
Spring	1984-85	11.10.84 to 31. 1.85	852	113
Autumn	1985-86	27. 6.85 to 17. 1.86	954	205
Spring	1985-86	7.10.85 to 31. 1.86	754	117

Table 5. Estimated and Actual Yields of Autumn Sown Illia Barley

Season	Growth Days	Yield (t/ha) Estimate	Actual	% Difference
Non-Irrigated –				
1983-84	181	8.1	7.0	16
1984-85	139	6.2	3.2	94
1985-86	203	9.1	7.6	20
Irrigated at 10% –				
1983-84	210	9.4	8.1	16
1984-85	176	7.9	7.3	8
1985-86	203	9.1	7.8	17
Irrigated at 15% –				
1983-84	210	9.4	8.3	13
1984-85	201	9.0	7.7	17
1985-86	205	9.2	7.8	18

DISCUSSION

The eight cultivars used in the project varied in their performance. Illia, yielded 1 t/ha more than all other cultivars tested, except in a dry season when no irrigation was applied. This was less than reported for Winter barley in Europe, (Gallagher, 1983). Tipper, the other Winter cultivar included in the trials showed no yield advantage over Spring cultivars in the one season it was grown, (Table 2).

Preventative measures for the control of fungal diseases and insect pests were not used and their presence in the crops before chemical controls were applied appeared to affect final yields, (Table 2). This method of control may have been responsible for some of the unusual results obtained for percentage screenings in Illia and Gwylan in 1984-85, (Table 2).

The yield estimated from Gallagher's model is about 1 t/ha greater than the actual yields obtained, (Table 5). The biggest difference between predicted and actual yields occurred in 1984-85 in unirrigated crops, but generally predicted yields were within 13 - 20% of acutal yields.

It is possible that Gallagher's model did not estimate actual yield because:

1. The upper limit of 900 photothermal units used to determine the maximum duration of growth in the model is too high. In Canterbury, Spring sown barley crops did not accumulate more than 852, (Table 4).
2. The average growth rate and the harvest index used in the model are not valid for Canterbury conditions.
3. The soil water deficit limiting growth is too high. Winter wheat growth on a gravel soil is likely to require 115mm of water, (Jamieson *et al.*, 1984), but on a Lismore Stony Silt Loam the deficit is likely to be between 80 and 90mm, (these figures correspond to Spring barley deficit figures from Stoker (1982).

CONCLUSION

The Autumn sowing of barley can be successfully carried out on a Lismore soil.

Irrigation is necessary in some seasons to ensure good yields.

The yield advantage of Autumn sown barley over Spring sown appears much smaller in Canterbury than the advantages reported from Europe.

Winter cultivar Illia out-yielded other cultivars tested by 1 t/ha or more, provided it received some irrigation in dry years.

Gallagher's model produced estimates of yield of Autumn sown barley about 1 t/ha greater than actual yields.
However, there could be a fundamental flaw in the model as it is hard to imagine that adjustment of the above factors could compensate for differences of actual and predicted yields ranging from 8 to 94 percent.

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REFERENCES

Gallagher, J.N., Biscoe, P.V., Dennis-Jones, R., 1983. Environmental Influences on the Development, Growth and Yield of Barley. In: Barley: Production and Marketing. Wright, G.M., Williams, R.B.: Editors. Agronomy Society of New Zealand Special Publication No. 2, Agronomy Society of New Zealand. 21-49.

Gallagher, J.N., 1983. Winter Barley - Possibilities, Problems and Prospects. In: Barley: Production and Marketing. Wright, G.M., Williams, R.B.: Editors. Agronomy Society of New Zealand Special Publication No. 2, Agronomy Society of New Zealand. 89-99.

Jamieson, P.D., Wilson, D.R., Stoker, R., Farrant, P., 1984. Irrigation management - Water Budgeting for Spray irrigation AgLink FPP 274. Information Services NZ MAF, Wellington. 2p.

Meredith, W.O.S., Anderson, J.A., Hudson, L.E., 1962. Evaluation of Malting Barley. in: "Barley and Malt". Ed. A.H. Cook, Academic Press, New York and London. 234-235.

Pollock, J.R.A, 1962. The Analytical Examination of Barley and Malt. In: "Barley and Malt" Ibid: 413-415.

Russell, G. Ellis, R.P., Brown, J., Milbourn, G.M., Hayter, A.M., 1980. The Development and Yield of Autumn and Spring Sown Barley in South-East Scotland. Association of Applied Biologists 100, 167-178.

Stoker, R., 1982. Soil Wetting and Moisture Extraction on Lismore Stony Silt Loam. Report 16: Winchmore Irrigation Research Station.