Paper 15
SOME AGRONOMIC EFFECTS ON BARLEY QUALITY

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INTRODUCTION

There are two interpretations of the term "barley quality" depending on the purpose for which the crop is grown. This is either to contribute to the liquid refreshment of man or to be a solid supplementary food for animals, and all too often grain intended for one is suitable only for the other. For malting the raw material — the grain — should have a low nitrogen content, while high-nitrogen grain is preferred for feed. Both industries require sound, uniform grain, with a low proportion of shrivelled grain in the sample. Feed barley interests tolerate a higher proportion of screenings, and if the grain has a high nitrogen content (high protein) it is something of a bonus, although not financially rewarded at present. Digestibility has received little attention (see preceding paper).

To the maltster, malt extract is the most important quality characteristic. Malt extract and grain nitrogen content are significantly correlated and both are related to grain size; generally the larger the grain, the lower the nitrogen content and the higher the malt extract. Any agronomic practice which alters grain size will automatically affect malting quality. As these quality parameters are also closely related to grain yield, any discussion on barley quality which did not consider yield would be incomplete.

The grower's objective is to obtain the highest return on investment, and this is generally achieved by producing a high grain yield. High yields are only attainable under good fertility conditions, implying adequate soil nitrogen is available, and it would seem likely that such crops would be high in grain nitrogen, and that their quality would be more suited to the feed barley trade. However, with skilful management, high yields with acceptable screenings and grain nitrogen levels are possible.

There are surprisingly few published reports on the large amount of experimental work carried out in New Zealand on the effect of agronomic practices on the yield and quality of barley. Winchmore-based staff, in co-operation with the Canterbury Malting Company, have carried out and reported studies on light stony soil under irrigation (Thompson *et al.,* 1974; Drewitt and Smart, 1981). Another significant contribution to our understanding comes from a survey of a large number of commercial crops in Canterbury carried out by Malcolm and Thompson (1968). The only other recent work of note is that of Wauchop and Field-Dodgson (1978), who examined the effects of phosphorus and nitrogen on the yield and malting quality of barley in the south of the North Island. There have been other experiments using nitrogen fertiliser but the value of many of them has been reduced because of inadequate moisture. Some commercial firms other than the Canterbury Malting Company have carried out numerous experiments and surveys, and in making their results available have stimulated an interest in quality as well as quantity, and their contribution is acknowledged.

Agronomic practices which have the greatest effect on yield and quality of barley include seed-bed preparation, seed rate, time of sowing, nitrogen fertilisation and irrigation. Early preparation of a good seed bed is essential for the rapid development and even establishment of barley, and cultivation should start as soon as weather conditions allow. Seed rates are discussed by Millner (this symposium). The effects of sowing time, nitrogen fertilisation and irrigation are inter-related; they form the basis of this discussion after a brief comment on cultivars.

CHOICE OF CULTIVAR

The farmer must decide whether he is growing barley for malting or feed purposes, and must choose his cultivar accordingly. In the feed trade there is a wide range of cultivars to choose from. Not a great deal is known about agronomic effects on feed barley quality, especially of the finer ingredients — digestibility and so on, and suitability depends on the animal to be fed. We know we can produce grain with either high starch or high protein content, and that is important.

For malting barley, there is currently (1982) a choice of three cultivars — Zephyr, Manapou and Mata. Zephyr has been a reliable standard for several years, but it could be superceded by a new cultivar, Triumph, in the near future. The quality characteristics of malting barley are well known, and some can be influenced by management practices. However, the only quality characteristic recognised in the price to farmers is the percentage of screenings. Other desirable characteristics, also partly governed by choice of cultivar, are low grain nitrogen content and the associated high malt extract, and perhaps in the future these attributes will command a premium.

Many barleys have a strong regional adaptation, and the available information on relative cultivar yields, straw strength and disease resistance will be summarised in the Recommended List.

TIME OF SOWING AND IRRIGATION

A series of experiments examining the effects of sowing time and irrigation frequency on the yield and quality of wheat and barley was carried out by Carter and Stoker on Lismore stony silt loam at Winchmore in the four seasons, 1977-78 to 1980-81. I am indebted to my colleagues for writing up the results of the barley section of their study for inclusion in the proceedings of this symposium, and their permission to use the data in this discussion. Their work was an extension of that reported by Drewitt and Muscroft-Taylor (1978), who found that barley yields did not vary with sowing time in crops sown from late August to late October. December sowing was included to examine the feasibility of double cropping, for example an early crop of peas followed by a late crop of barley. Late sowing was also investigated as an irrigation scheduling device for easing the pressure of the heavy irrigation demand of all farm crops in November and December. The cultivar Zephyr was sown at approximately 150 kg/ha with 240 kg/ha superphosphate and 120 kg/ha ammonium sulphate (20%N) at four sowing times, mid-month from September to December. There were three irrigation treatments; nil, and irrigation applied by the border-strip method when soil moisture in the top 150 mm fell to 10% and 15% respectively.

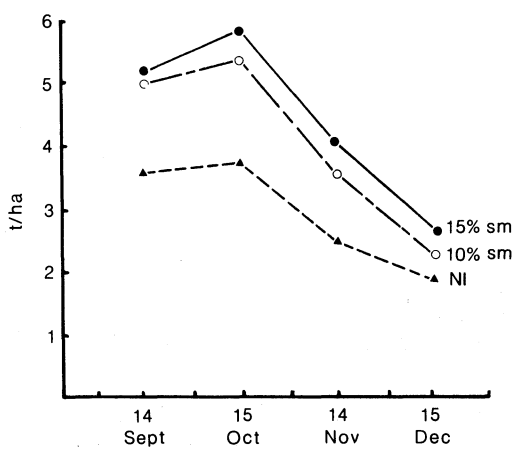

Figure 1: Barley grain yield, kg/ha, at four sowing times and three irrigation levels.

The means of four years' results are shown in Fig. 1; results from individual years are given in the associated paper by Carter and Stoker. There is probably no yield advantage in sowing before October, but yields were greatly reduced when sowing was delayed until mid-November. December sowing was clearly unsatisfactory even at the heavy irrigation level, not only because of its very poor yield but also because of the difficulties encountered when harvesting too late in the season. Both irrigated treatments were considerably higher-yielding than the unirrigated, and although there appears to be very little difference between the two irrigated treatments, yield responses to irrigation frequency vary according to nitrogen availability, and this aspect will be discussed later. Yields from September and October without irrigation were comparable to those from November sowing with irrigation. The number of irrigations required to maintain soil moisture levels increased with later sowing until November, then decreased with December sowing.

The screenings percentage increased as the sowing date was delayed (Fig. 2). In the absence of irrigation only September sowing generally graded satisfactorily for malting, while both September and October sowings with irrigation met the required standard. Crops from November sowing under irrigation were suitable only for the feed barley market.

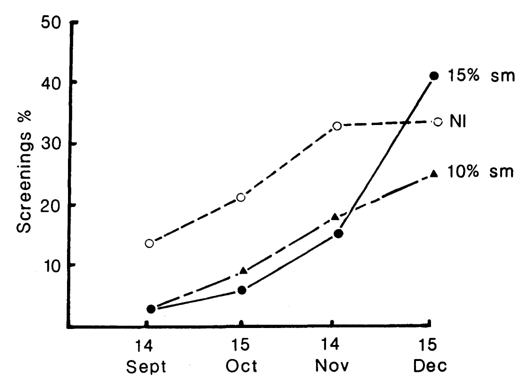

Figure 2: Barley grain screenings percentage: four sowing times and three irrigation levels.

Early sowing and irrigation were essential for good malting quality (Fig. 3). In both grain nitrogen content and malt extract there was little difference between September and October sowing, but a sharp decline in malting quality thereafter. Unirrigated barley gave very poor malt extract.

To summarise, delayed sowing reduced the yield and malting quality, while irrigation increased the yield, extended the sowing season and improved the malting quality of barley.

The optimum sowing date for both yield and quality will vary from season to season, depending on weather conditions permitting the preparation of a good seed bed and quick establishment. Malcolm and Thompson (1968) and Hunter (1962) have stressed the importance of good seed-bed condition and vigorous development, but, as Hunter also pointed out, early sowing is "only one factor in a series of complex biological reactions contributing to the high yield and low grain nitrogen".

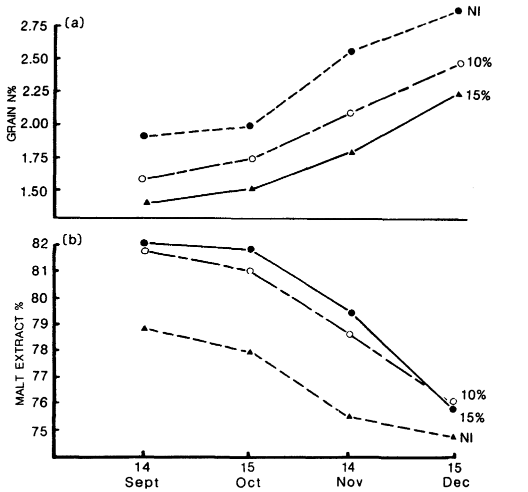

Figure 3: Effect of sowing time and three irrigation levels on grain N% (a) and malt extract % (b).

NITROGEN FERTILISER AND IRRIGATION

In another series of experiments carried out in the same period at Winchmore (Drewitt and Smart, 1981) nitrogen fertiliser was applied at 50 and 100 kg/ha N at drilling and at tillering, or split between drilling and tillering. The irrigation treatments were again nil, 10% and 15%. Two of the experiments followed pasture and two followed a nitrogen-depleting crop. Zephyr barley was sown at 145-150 kg/ha and all sowings were carried out in October. There was little or no difference in yield, screening, or malting quality with time of nitrogen application, or with splitting the nitrogen, and in the following discussion only the drilling applications will be considered. Results from the two ex-pasture experiments have been combined, as have those from the two ex-crop experiments.

The patterns of irrigation response at three nitrogen levels on ex-pasture and ex-crop sites are shown in Fig. 4. Under the high-fertility conditions following pasture, there was no response to nitrogen fertiliser but a good response to irrigation, and the increase in yield in going from 10% to 15% irrigation was equal to that between nil and 10%. Where nitrogen was depleted by previous cropping there was no response to nitrogen fertiliser in the absence of irrigation, a small response to nitrogen with irrigation at 10%, and a much larger response with irrigation at 15%.

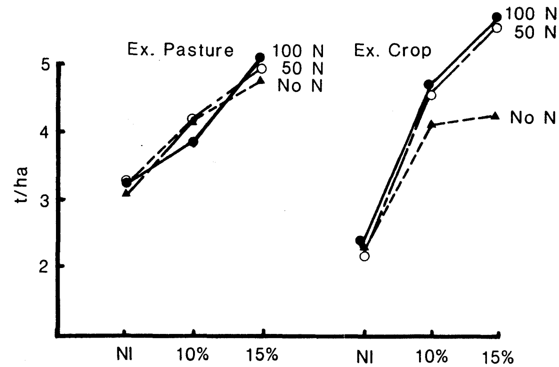

Figure 4: Barley grain yield, kg/ha: effect of N fertiliser and irrigation following pasture and a previous N-depleting crop.

There was no difference between responses to 50 and 100 kg/ha N at any irrigation level. Irrigation at 10% increased the yield by 2-2½ tonnes/ha, and on the nitrogen-treated plots irrigation at 15% gave a further response of approximately 1 tonne/ha. However, when no nitrogen was applied there was no further response to the heavier irrigation treatment. This trend of additional yield response to more frequent irrigation under more fertile conditions was also evident in the time of sowing experiments described above. Thompson *et al.* (1974) found that yields from two irrigations (at 10% soil moisture) were only marginally below those from more frequent irrigation, but their experiments followed nitrogen-depleting crops and no nitrogen fertiliser was added.

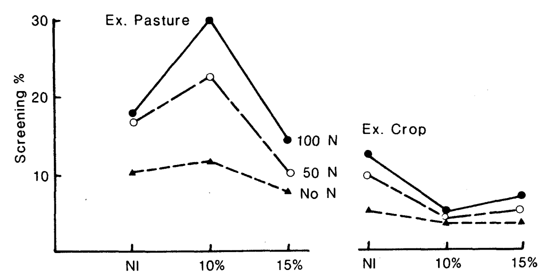

Figure 5: Barley grain screenings percentage: effect of N fertiliser and irrigation following pasture and a previous N-depleting crop.

On the more fertile sites the screening losses were higher, and losses were increased by the addition of nitrogen fertiliser (Fig. 5). In the presence of added nitrogen irrigation at 10% increased the screenings, while irrigation at the higher level decreased screenings. The adverse effect of the low level of irrigation was due to inopportune timing in one particular season, which allowed the plants to be stressed for too long in the milk/soft dough stage. On the sites sown after cropping, nitrogen fertiliser increased the screenings in the absence of irrigation, while both irrigated treatments reduced screenings in the presence of nitrogen fertiliser. Irrigation had little effect on screenings in the absence of nitrogen fertilisers in any of the experiments. Wauchop and Field-Dodgson (1978) also found that the screenings percentage increased (and malting quality decreased) with added nitrogen, a result they attributed to moisture stress in the grain-filling stage.

Malt extract decreased with added nitrogen and increased with irrigation on both high and low fertility sites (Fig. 6). After pasture, all irrigation treatments without added nitrogen gave good malting quality, but when nitrogen was added only the combination of 50 kg/ha N with heavy irrigation gave satisfactory quality. Malt extract was generally higher on the sites sown after cropping, and only the unirrigated treatments were poor in quality. In the Malcolm and Thompson (1968) survey of Canterbury crops also, malting quality was higher when the barley was preceded by a nitrogen-depleting crop.

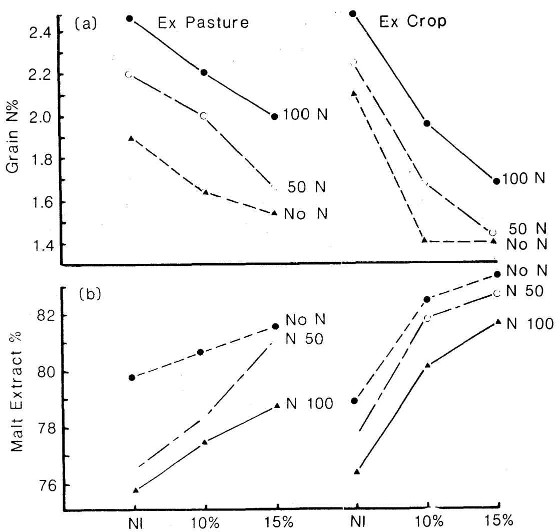

Figure 6: Grain N% (a) and malt extract % (b): effect of N fertiliser, irrigation and previous cropping.

In nitrogen-responsive conditions and in the presence of adequate moisture, nitrogen fertiliser applied by the end of tillering will contribute to increased yield without greatly affecting grain nitrogen content, while nitrogen applied later will have much less effect on yield but will lead to a higher concentration of nitrogen in the grain (Hunter, 1962). In our experiments nitrogen was applied only up to the tillering stage. On the low fertility sites the nitrogen requirement was fulfilled by 50 kg/ha N; this rate increased the yield but the nitrogen content of the grain remained unchanged. The 100 kg/ha N rate was in excess of requirement, and although it gave the same yield increase it also increased grain nitrogen content and reduced malt extract. Under the more fertile conditions of the ex-pasture experiments, nitrogen supplied from soil nitrogen reserves was sufficient, and continued to become available throughout plant growth, resulting in high grain nitrogen content. The addition of nitrogen fertiliser in these conditions only compounded the problem of high screenings and low malting quality, without contributing to the yield.

In summary, there was no yield benefit from the addition of nitrogen fertiliser to crops following a period in pasture, and quality was reduced. Where there was a yield response to added nitrogen, following a nitrogen-depleting crop, the malting quality was not seriously impaired. Irrigation increased the yield and improved malting quality, irrespective of previous land use. The beneficial effects of heavier irrigation were greater in the presence of adequate nitrogen.

The effects of agronomic inputs on the individual characteristics of barley yield and quality are less important than their inter-relationships. A sample with high malting quality is unrewarding to the grower if it comes from a two or three tonne crop, and a high-yielding crop with high screenings and low quality due to mismanagement may be equally unprofitable, even allowing for the greater tolerance of screenings in the feed trade. Fortunately, those practices which increase yield usually also increase quality. Correct management of irrigation, and to a greater extent nitrogen fertiliser, is essential for high-yielding, good quality barley. With the present proliferation of irrigation plants, it is probable that much of the barley grown in future will have the benefit of extra water.

A reliable means of determining the correct amount of nitrogen to be applied, and when, is still the most urgent requirement of cereal growers to-day. Armed with that information we should be able to produce good quality barley as well as considerably increasing the efficiency of nitrogen fertiliser use. A technique under examination at Winchmore involves the measurement of the amount of nitrogen that will become available from the soil nitrogen reserves during the life of the plant. This information is coupled with the known nitrogen requirement of the crop, and the deficit is corrected by applying nitrogen from the bag. It is anticipated that the test will be available on a small scale next season. In the meantime, there is the Ludecke/Ravensdown test which measures the level of nitrate in the soil in spring, and this coupled with previous cropping history is a useful guide to nitrogen requirements.

To conclude, high yields of good malting quality barley can be achieved by sowing early, irrigating to maintain soil moisture at a minimum of 15%, and applying the correct amount of nitrogen fertiliser. While it is true that not very much barley is grown on lighter soils, perhaps we should be growing much more, provided of course we have irrigation. With access to irrigation we have control of screenings, and some of the best malting barley in

Canterbury comes from these light soils under irrigation (Paper 4). It appears that the best prospects for exporting barley are in good malting barleys. An expansion of barley growing on the light soils is feasible, and I suggest the area available is big enough to produce large quantities of one cultivar of top quality barley for export.

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DISCUSSION

White: I think that this sort of recommendation must be related to soil type, because all this work I gather has been done on Lismore soil where only a small amount of barley is grown, and it might not apply at all if you were dealing with soils that were holding 150 to 250 mm of available water.

Drewitt: Even soils that hold that amount of water do dry out in some summers. I wouldn't be too specific about the absolute levels but I would have thought that the principle of preventing them drying out would apply whatever soil type you were on.

Thompson: If you refer to the paper with Malcolm, that does cover 5 soil types, and this same principle applies over all of these.

Drewitt: The only work that I am aware of being done on a heavier soil type is some that we did ourselves some years ago on the Templeton farm. There we found that the irrigation in fact had no effect on yield but had a small effect on quality; probably something to do with the depth of soil and the distribution of the roots.

Malcolm: To add to that, I don't have a scientific study, but an observation on the heavy Temuka silt loam in Ellesmere. This was with October sown spring barley and September sown wheat, and it showed that its moisture retention is not good enough in a normal average season. Nitrogen didn't come into the story because the crop rotation was after white clover and greenfeed prior to the spring wheat and barley. Even in a less fertile rotation I am sure that the Temuka silt loam and other tight heavier loam soils will respond to irrigation in some seasons.

Drewitt: I am not experienced on Temuka soils, but I could add a little to what I said before about the Templeton soil — I think the fact that we didn't get a response to irrigation there was related to problems associated with getting the water on — we were working under difficult conditions for experimentation. Water didn't go on quite as soon as it should have done, and we found there was much more neck break and straw break on the plots we were irrigating.

Smart: I would just like to follow on from the work at Templeton; I remember in some trials in Ellesmere about the same time there was little or no response in yield, to irrigation.

Coles: The comment has been made that there is a five tonne ceiling apparently on yield on a Lismore soil, and even providing all the nitrogen and water required this ceiling cannot be exceeded, which indicates that there are not just two factors, nitrogen and water, involved.

Scott: It goes back to the fact the Good Lord forgot to finish off the Lismore soil. Half the volume is stones; you can throw the periodic table at it and all the water you like, but it will still never produce as much as a good soil. Referring to Dr White's remarks on water, the same thing applies to the nitrogen. The lower volume of soil usually has less organic matter, and once the nitrogen gets below that top soil it doesn't stop till it gets to the sea or into a Lincoln well. With a deep Wakanui soil you could still have nitrogen down perhaps a metre and a half below the top and still available to the crop.

Drewitt: I don't accept that our yield ceiling on Lismore is in fact 5 tonnes. We have had yields of 7 tonnes, but putting all the factors together to guarantee you this 7 tonnes is something that is beyond me and I suspect beyond most farmers. That's why I say that even ensuring that you had sufficient nitrogen for this level of crop growth, so many other things come into it that will in fact limit your yield to quite a lot below what you might expect. Its not just moisture and in the trials I described it's not phosphate either. A lot of it is to do with just plain seasonal conditions.

Q: Is the injection of fertiliser into irrigation water feasible?

Drewitt: We look at this from time to time at Winchmore. Last week, an American journal was predicting that most fertilisers put on crops by the turn of the century would in fact be through irrigation water. They said it was as easy to put on by the flood method as by sprinklers. I think it is something we could look to in the future.