A REASSESSMENT OF THE ECOLOGY OF BARLEY GRASS IN AUSTRALIA

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Summary. Barley grasses (*Hordeum leporinum* and *H. glaucum*) have generally been considered to be high fertility weeds, invading pastures as a result of an increase in soil nitrogen produced by the legume component. During a series of experiments in South Australia, it was found that whilst the proportion of barley grass increased with successive years of the annual pasture, this was not related to soil nitrogen levels or to the presence or absence of a legume component in the pasture. It appears that the important edaphic factors influencing the invasion of barley grass are soil consolidation and soil pH. It is suggested that soil consolidation was overlooked as an independent factor, being unintentionally confounded with soil nitrogen levels. The importance of soil pH has also been overlooked.

INTRODUCTION

Two species of barley grass (*Hordeum leporinum* and *H. glaucum*) are very widespread in Australia (Cocks *et al.* 1976). They appear to occupy similar agricultural niches, the former being generally found in southern high rainfall areas ($>$ 425 mm per annum) and the latter in northern areas and in southern low rainfall areas. The species are difficult to separate vegetatively but may be distinguished at flowering (Cocks *et al.* 1976; Humphries 1980). Earlier workers, unaware of the distinction, referred to both species as *H. leporinum* or even *H. murinum*.

Herbarium collections reveal the presence of these species in Australia soon after settlement, and their weediness was recognized early (Francis 1859). In pastures they are unpalatable to stock after the awned spikelets form in spring. Stock injury is common, the awns penetrating the soft tissues of sheep and lambs and the spikelets contaminating wool and ruining hides by penetrating the skin. The plants are also host to cereal diseases (Cocks 1975) and compete with pasture seed crops and contaminate hay. In contrast, some writers have drawn attention to the benefit of high fodder production during winter, compared for example with ryegrasses (*Lolium* spp.). Barley grasses are seen as reliably filling a need at a time of critical feed shortage (e.g., Smith 1968b; Southwood 1971; Smith 1972).

Because of their agronomic importance in Australia they have been investigated intensively. Some major references are Smith (1966), McGowan (1967), Cocks (1969), Smith (1972), Cocks and Donald (1973a, 1973b), Cocks (1974) and Cocks *et al.* (1976). There are many other papers, some of which will be noted in the course of this paper in which the important edaphic factors in the ecology of barley grass are reassessed.

CURRENT VIEWS OF THE ECOLOGY OF BARLEY GRASS

In the literature, the barley grasses are generally seen as weedy invaders of perennial and especially annual pastures since these are inherently unstable and hence prone to invasion (e.g. Trumble 1935; Smith 1965; Oram 1972). The invasion is seen largely as a response to rising soil fertility caused by legumes, or in localised patches by dung on sheep camps or similar causes (e.g. Tiver and Crocker 1951; Day and Michelmore 1952; Tiver 1954; Squires 1963; Moore 1966; Paton and Hosking 1970; Reed 1972; Doing 1972). Soil fertility is stated, or is implied to be, synonymous with soil nitrogen level, a notion that antedated but was supported by Donald and Williams (1954) in which straight line relationships were found between levels of applied superphosphate and levels of soil phosphate, nitrogen and sulphur. For example, Rossitter (1964, 1966) lists barley grass as a weed of soils with high phosphate levels, but the relationship with high soil nitrogen levels is implicit in his papers.

Pasture management influences barley grass invasion, although in the literature it is mainly discussed as a control method. Grazing management (e.g. McGowan 1967; Hagerstrom 1970; Myers and Squires 1970), hay cutting or silage making (e.g. Smith 1968d; Walter 1974), mowing (e.g. Smith 1968d) and herbicides (e.g. Campbell 1961; Squires 1963; McGowan 1970; Southwood 1971) are all seen as methods of managing pastures to reduce barley grass content.

The success of barley grass in pastures was succinctly summarised by McGowan (1967) as being due to: (a) good seedling vigour, (b) ready penetration of dry overburden by emerging seedlings, (c) barley grass being able to benefit more than other species from high levels of organic nitrogen, (d) the seed heads being unpalatable to sheep, and (e) the seeds being too big for removal by ants. Subsequent workers have confirmed one or more of these points in their own studies, but in contrast to McGowan's work these have been undertaken in simplified systems and the overall picture has become clouded. Thus at the end of one of the more recent projects, Cocks (1974) concluded that the success of barley grass is probably related to its ability to produce copious seed, its long bristly awns which discourage grazing animals and aid its dispersion and its ability to germinate rapidly in unfavourable conditions. Whilst the latter two factors harmonise with those of McGowan, Cocks' first point is diametrically opposed to McGowan's (1967) finding that the production of barley grass seed was only 9-fold, compared with 57-fold for silver grass, (*Vulpia* sp.) and 117-fold for ryegrass.

Within the constraints of the limited space available, a series of points will be discussed in relation to some experimental results and a critical examination of the literature.

SOIL NITROGEN LEVELS

In a series of experiments that will be reported elsewhere, the writer found that there appeared to be no relationship between soil nitrogen levels or abundance of legumes and the proportion of barley grass in volunteer swards in South Australia (Kloot, unpub. data). As an example, Table 1 presents data obtained during 1980 from the permanent rotation plots at the Waite Institute.

In many papers an increase in soil nitrogen levels was assumed or measured with increasing length of the pasture phase. My data, including those presented in Table 1, suggest that there is no relationship between soil nitrogen levels and the proportion of barley grass. Prescott (1933) mentions that barley grass was very common in the South Australian Mallee at a time when there was no planted legume and soil nitrogen levels were very low. Trumble (1935) notes that barley grass was common on land in the cereal areas of South Australia where no sown legume was present. Under those conditions, soil nitrogen levels were very low (French *et al.* 1968). A general observation is that barley grasses grow prolifically on roadsides, wasteland and other areas lacking legumes and never receiving applied nitrogen.

Table 1. The relationship between phase of the pasture rotation, the proportion of barley grass, the level of soil nitrogen and soil compaction, Waite Institute, 1980.

Year of pasture	Proportion of barley grass (%)	Soil nitrogen (%)	Soil Compaction (relative units)[1]
	(± Standard error)		
1st	0.6 ± 0.3	.139 ± .004	9.0 ± 1.08
2nd	23.5 ± 1.3	.158 ± .003	13.0 ± 0.85
3rd	30.1 ± 5.2	.137 ± .002	12.8 ± 0.75
4th	24.2 ± 7.0	.136 ± .003	15.3 ± 0.25

[1] The reading of a probe (in cm) impelled into the ground by a fixed weight falling through a fixed distance is arbitrarily deducted from 20 to give a quick and convenient measure of compaction in relative units.

Smith (1968b) found that as a result of high soil nitrogen, barley grasses are more resistant to frosts than other species, particularly ryegrass, and that this causes the dominance of barley grass. He conceded that that explanation would not account for the build-up of barley grass in frost free areas such as the peninsular regions of South Australia.

SOIL pH

The invasion of barley grass proceeds more rapidly on alkaline soils than on acidic soils. McGowan (1967) found that a swing to 100% barley grass took 6 years in north-eastern Victoria, whereas on highly alkaline soils (pH 8.4) at Avon, South Australia the swing takes only 2 to 3 years (Kloot, unpubl. data). McGowan (1967) found that liming (approx 5 t ha^{-1}) increased the proportion of barley grass in the sward from 35 to 68%. Davison (1970) noted that in Great Britain the closely related species *H. murinum* was favoured by high pH, and locally Moore (1965) states that *H. leporinum* is of greater importance on calcareous soils than on podsols.

It is possible that there is a species difference which is confounded with soil pH, *H. leporinum* being found on soils of lower pH than *H. glaucum* which in southern Australia, at least, is largely associated with highly alkaline soils.

However, the results of McGowan's liming experiment where a single population was involved suggests not.

GRAZING

Under practical farming conditions the heavier the grazing pressure the greater the swing to barley grass dominance in succeeding years because of the selective grazing of the other species. Results given in Table 2 show a reduced swing to barley grass dominance where grazing was very light in spring. McGowan (1967) and Smith (1968d) present similar results.

Table 2. Percentage of barley grass in swards in two consecutive pasture years, South Australia.

Year	Grazing Intensity: Heavy				Light
	Location				
	Waite (1978, 1979)	Lenswood (1979, 1980)	Hamley Bridge (1979, 1980)	Waite (1979, 1980)	Rosedale (1979, 1980)
First	9	<1	4	3	<1
Second	15*[1]	24**	14**	20**	5**

[1] Indicates level of significance between years.

SOIL COMPACTION

The longer a pasture remains undisturbed the greater is the degree of soil compaction, although my observations suggest that the rate of increase in compaction is lower after three or four years. At the Waite Institute, the soil under fourth-year pastures was as compacted as that under pastures undisturbed for over 50 years. It was noticed that barley grass tended to dominate on compacted soil, whether in paddocks, on roadsides, in reserves or gardens. The data presented in Table 3 show that barley grass dominated in a rotation where there is minimal disturbance, as in direct drilling, but not where conventional cultivation was used. Data presented in Table 1 show a similar relationship between barley grass abundance and soil compaction as measured by a probe modelled on the dynamic cone penetrometer used by civil engineers.

Soil compaction has not been previously examined as a specific factor affecting barley grass. However, re-examination of data from earlier experiments does show a relationship. Thus, McGowan (1967) found that barley grass established significantly better on a compacted soil than did other grass species, particularly ryegrass. Smith (1968a) found likewise, attributing an advantageous anchoring effect to the awns. Cocks and Donald (1973a), who obtained similar results, considered that barley grass germinated very rapidly before the soil surface dried out.

Table 3. Effect of previous cultivation treatments on soil mineral nitrogen levels and the proportion of barley grass in a wheat crop at Avon, South Australia, 1980 (after Rovira 1981).

1978 rotation	Wheat		Wheat		Wheat		Wheat	
1979 rotation	Wheat		Medic		Pasture		Peas	
1980 rotation	Wheat		Wheat		Wheat		Wheat	
Tillage treatments each year	CC[1]	DD	CC	DD	CC	DD	CC	DD
Soil mineral N(ppm) (0 to 10 cm)	11.7	9.9(NS)	12.1	13.9(NS)	14.3	14.9(NS)	N.A.	N.A.
% of ground covered by barley grass	5.0	21.4**[2]	15.8	31.5**	11.6	33.7**	10.9	32.8**

[1] CC = Conventional cultivation; DD = Direct drilling; NA = Not available;

[2] Indicates level of significance between cultivation treatments;

NS = Differences not significant.

Conversely, soil disturbance is known as a means of controlling barley grass (e.g. McGowan 1967) although the almost complete success of cultivations timed for autumn sowing of crops is due to the restricted period of barley grass germination compared with ryegrass. However, this work confounds the effects of cultivation affecting soil compaction and its killing of growing barley grass plants. An experiment to elucidate the matter is underway.

Smith (1968d) reported that where subterranean clover seed was raked into the soil whether at 4.4 or 110 kg ha^{-1} there was a highly significant reduction in barley grass heads regardless of any management treatment subsequently imposed. It is presumed that the unseeded plots were not raked. As there was no significant difference due to the different sowing rates of clover it may be concluded that the raking i.e. soil disturbance, was more important than the sowing of the clover.

CONCLUSION

It is suggested that soil compaction is the major edaphic effect facilitating the invasion of barley grass. In any situation, the longer the period that has elapsed since a previous disturbance the greater will be the soil compaction, and this explanation applies to all situations where barley grass is found. In contrast, the increase in soil nitrogen levels with time, which occurs in legume-based pastures, is a far more restricted phenomenon than barley grass dominance.

On soils of high pH or under grazing, barley grass dominates more quickly than where either of these two factors is not operative.

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