Environment of the high rainfall zone of Southern Australia and implications for agriculture

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Definition

The three national zones of Australian agriculture are periodically identified and mapped by the Australian Bureau of Agricultural and Resource Economics on the basis of current land use. The high rainfall zone is distinguished from the neighbouring wheat/sheep zone by the virtual absence of cropping: like the pastoral zone it produces mainly wool and meat. Geographically, in southern Australia it covers a strip of about 160 km wide along the coast of New South Wales, eastern and southern Victoria, the whole of Tasmania, the south-east of South Australia, and the south-west corner of Western Australia.

As its name implies, most of the zone is favoured by relatively high rainfall, and its boundaries follow closely those of the region with a growing season of nine months or more (1). In New South Wales, for example, two-thirds of the State's water resource is within the zone. In this respect it is the zone with the greatest potential for intensified agriculture and high returns. Some 44% of Australian farmers live in the high rainfall zone, but their incomes are consistently much lower than those of primary producers in the other zones (2). The large number of producers and their low incomes make the raising of production and income one of the most important challenges in Australian agriculture. Whenever the price of meat or of wool slumps, so too do the incomes of high rainfall zone producers.

Climate

Rainfall

The pattern of the rainfall that can be expected in one year out of two divides the zone into three regions.

The winter rainfall region can expect 50 mm or more of rain in every month from May to October. This covers the south-west of Western Australia, which includes the largest area with monthly rainfall above 100 mm, most of Tasmania, most of southern and eastern Victoria, and the central and southern tablelands of New South Wales.

The northern tablelands of New South Wales are a summer rainfall region with an expectancy of 50 mm or more in each month from November to March.

The coastal fringe of New South Wales is both a winter and summer rainfall region, expecting 50 mm of rain in almost every month of the year.

The southern tablelands and coast of new South Wales have the least reliable rainfall (3), with coefficients of variation of 40-60%, .compared with less than 20% in the south-west of Western Australia, the western districts of Victoria and western Tasmania.

Temperature

During the growing season there is a wide range of temperatures in the zone: mean monthly temperatures vary from 5 to 25?C. Within the winter rainfall region, mean temperatures in the warmest parts of the zone in Western Australia are about 8?C higher than in the coolest parts of the southern tablelands of New South Wales and Tasmania. Temperatures alone allow a wide range of crops to be considered, though water harvesting may be needed where rainfall is erratic.

One result of high rainfall and favourable temperatures is that these encourage the production not only of plants but also of their parasites. Pests such as red legged earth mite (Halotydeus destructor), lucerne flea (Sminthurus viridus) and various aphids combine with common root rots and clover scorch (Kabatiella caulivora) to reduce pasture production in much of the zone. Crop production is often spectacularly reduced by disease. For example in wheat, stripe rust (Puccinia striiformis f. sp. tritici) has reduced yields by up to 50% (4), while similar losses have been reported for barley infected by scald (Rhynchosporium secalis). Take-all (Gaeumannomyces graminis) in cereals, Septoria diseases in wheat and oats, crown rust (Puccinia coronata) in oats and powdery mildew (Erisiphe graminis) in barley are all threats to crop production. Although barley yellow dwarf virus is still considered to be of minor economic importance in Australian wheat crops (5), it has caused yield losses of up to 40% in the high rainfall zone (T.D. Potter, unpublished data). This disease looms as a threat of particular importance to crops sown early in autumn to provide grazing as well as grain.

Terrain

While rugged terrain prevents cultivation of about two-thirds of the zone, some two million hectares may be considered arable (2). The distinction between arable and non arable land is obscured by Australian experiences of low input agriculture, low population pressures, and traditional farming practices. Helyar and Thompson (6) have estimated that on the southern tablelands of New South Wales alone, the area of land that could be cropped would increase from 0.4 to 1.2 m ha if direct drilling rather than conventional cultivation were the basis for estimates.

Soils

Development

The soils of the zone present the greatest difficulties for agricultural development. About two-thirds of these, like most Australian soils, are derived from an ancient (Tertiary) landscape which has been slowly weathered and leached, and there has been relatively little exposure of other rocks through glaciation or volcanic action to generate younger soils (7).

Following mechanical disintegration of the rocks, the action of water and carbon dioxide together can decompose them into quartz, clay and chemical compounds. Clay then moves down the profile through solonization or podsolization (8). The intensity of leaching in the zone removes not only the most mobile salts, but also the less soluble sulphates and carbonates

of calcium and magnesium (8). The net results of such weathering is that much of the zone is covered by soils with sandy A horizons overlying clay B horizons (9) generally described as "grossly infertile acid soils" (10). The coastal and subcoastal siliceous sands are particularly impoverished because they have been deposited from elsewhere and most of their soluble materials would have been washed out to sea (7).

Nutritional problems

Because of their long history of weathering from ancient rocks, most Austrlian soils are deficient in phosphorus and nitrogen. This is particularly true of soils in the high rainfall zone (11). Although the use of superphosphate to correct phosphorus deficiencies in crops has been widespread since 1882, the value of combining superphosphate and subterranean clover was first demonstrated in a high rainfall area near Adelaide by Trumble and Donald in 1938 (12); this has led to a continued increase in the phosphorus and nitrogen levels of Australian soils.

Since Anderson and Spencer (13) first demonstrated that sulphur was deficient for pasture growth on podzolic soils in the southern tablelands of New South Wales, it has been appreciated that superphosphate has been important in satisfying both sulphur and phosphorus requirements. Relatively large amounts of superphosphate are required to satisfy the requirements for these on soils in the zone. Thus, in the New England region, 1.9 t/ha of superphosphate applied over 15 years satisfied the sulphur requirement, although pastures were still responding to phosphorus (14). A bank of residual phosphorus built by the application of 1.1 t/ha of superphosphate over 10 years was found sufficient to supply some 60% of the pasture's requirements (14).

Because the nutritional problems of soils of the high rainfall zone were not overcome by the use of superphosphate alone, they stimulated further research that led to the identification of the first trace element deficiencies found in Australian soils. The first response recorded was near Mount Gambier, where manganese increased the grain yield of oats from 0 to 3 t/ha (15). Responses were later recorded for zinc on citrus in Western Australia (16), cobalt in sheep and cattle in both South Australia and Western Australia (17, 18, 19), boron in apples in Tasmania (20), copper on cereals in South Australia (21), iron on a range of trees and crops in Victoria (22) and selenium in sheep in New South Wales, Victoria and Tasmania (23, 24, 25) in the one year (1962).

The first responses of pastures to trace elements were recorded in the high rainfall zone of South Australia by Riceman and Donald to copper in 1940 (21), by Anderson to molybdenum in 1942 (26), by Riceman to zinc in 1948 (27) and by Powrie to cobalt in 1960 (28). The hopes that fertilization with superphosphate and trace elements would end the nutritional problems of the acid soils of the high rainfall zone were then thwarted by yet another major obstacle to agricultural development.

Soil acidification

In 1954 Donald and Williams (29) measured differences in pasture and soil components on yellow podzolic soils in the high rainfall zone of New South Wales following different histories of treatments ranging from untreated vegetation to 26 years of pasture improvement with applications of superphosphate totalling 1.6 t/ha. They noted that on all six sites soil pH had fallen from about 6 units on untreated pastures to about 5.2 on those with the higher levels of superphosphate: soil pH had fallen by about 0.05 units/100 kg/ha of superphosphate added. They concluded that the acidification was probably due to an increased exchange capacity of the soil associated with a build up of organic matter, and suggested that the pH might reach an equilibrium at about 5.1

In 1980 Williams (30) re-examined the same soils after up to 50 years of pasture improvement. The pH had levelled out at about 5.1 and the rate of decrease had been greatest in the early phase of improvement. However, organic matter build up and associated increased exchange capacity was not responsible for all the increase in acidity: organic matter accumulation was confined to the top 10 cm, while increase in acidity extended to a depth of about 30 cm. It was thought likely that the depletion of cations, as nitrates built up by legumes were leached from the soil, was an important contributor, as had been suggested by Helyar (31). Recently, Helyar (32) has pointed out that increasing acidity occurs across a range of agricultural conditions, usually in association with increases in organic matter and exchange capacity under pastures, and in association with decreases in these under crops. Changes in pH involve changes in the levels of different nitrogen compounds, organic and inorganic acids, and compounds that oxidize or hydrolyse to form acids or bases, and they vary with the buffering capacity of the soil (32).

Below pH values of about 5.5 soil acidity begins to inhibit the production of some crops as manganese and aluminium apparently reach toxic levels (32). The element responsible for toxicity varies with soil type. Bromfield et al. (33) found a four-fold difference in the levels of reactive manganese in three southern tablelands' soils, with the highest levels on soils derived from basalt, and concluded that levels below 80 pg/g of soil would be unlikely to produce toxicity as pH declines. Most soils contain sufficient aluminium for it to be thought toxic at low pH values (32). McLaughlan (34) reported that lime, and to a lesser degree, superphosphate, added to an infertile, acid soil made it productive for subterranean clover. Both treatments increased aluminium uptake and yield, so it seemed unlikely that aluminium toxicity was involved. McLaughlan considered that the formation of aluminium phosphates leading to reduced supplies to the plant may be a cause of aluminium problems.

Whatever the basis of increasing acidity in high rainfall soils or of its effects on plant production, its continuing course threatens to turn mildly acid soils into problem soils, and problem soils into economically irrecoverable ones (32).

Interactions of climate and soil

The combination of high rainfall and sandy topsoils presents a major problem of nutrient retention. On siliceous sands in the south-east of South Australia, averages of only 40% of sulphur and 60% of phosphorus applied as fertilizer were recovered from the pasture and top 30 cm of soil after five months (35). The production of grazed subterranean clover pastures on those soils has been estimated at only about half of their potential, due mainly to low nitrogen levels, with another 400 kg/ha of nitrogen required to achieve that potential (36).

The combination of high rainfall in winter and subsoils of low permeability leads to waterlogging problems, especially in southern Victoria, the south-east of South Australia and on some of the shallow soils in Western Australia. Prolonged waterlogging adversely affects the macro structure of fragile soils, causes denitrification that leads to nitrogen deficiency in spring, and inhibits root growth, leaving plants susceptible to water stress early in the drying cycle. It also favours the growth of certain weeds including toadrush, (Juncus bufonius), Phalaris species, and dock (Rumex crispus).

For cropping, the weed problems are worsened by the combination of high rainfall and acid soils which generally reduces the efficacy of herbicides applied to soil.

Implications for agriculture

The environmental problems of the high rainfall zone we have listed are difficulties encountered by primary producers, and challenges facing research agronomists. They must be overcome if the zone is to approach its potential productivity and assume an increasingly important role in the Australian economy.

The most obvious path to improved incomes is to increase pasture production and thereby the number of grazing animals. Another way in which agronomists can help a community of primary producers depending almost entirely on wool and meat production is to extend cropping throughout the zone. But both approaches depend upon the problems of soils being reduced.

The most visible problem is waterlogging. In the south-east of South Australia 1450 km of drainage ditches have been constructed (37), but substantial areas of land still remain subject to waterlogging. Farms in the area are, at most, being surface drained. In Victoria, the advantages of soil drainage are being investigated, along with the prospects for cropping to help recoup the costs.

Given the large quantities of fertilizer needed to satisfy demands for nitrogen, phosphorus and sulphur, and the widespread occurrence of trace element deficiencies, it seems likely that nutrient deficiencies may impose the greatest limitations to plant and animal production. Yet they may often remain unsuspected because grazing systems are generally compared by producers in vague terms of carrying capacity. The inclusion of cropping in a primarily pastoral enterprise would promote a more inquisitive approach to nutritional status, and also provide a more sensitive yardstick for detecting problems. For example, recurrent failures of rapeseed (alongside relatively stable cereal yields) (38) would now be attributed to boron deficiency (39). Throughout the zone, perhaps the most direct way of improving incomes would be to enable every producer to test paddocks for responses to applied nutrients and the economic benefits available from them. Once the phosphorus status is high, cheaper, less soluble forms of phosphate than superphosphate may be used profitably (40).

Soil acidity is probably the most insidious of high rainfall producers' problems: serious acidity is virtually inevitable in time and its effects may not be appreciated until the situation is critical. Then, there is no quick remedy: lime is but slowly soluble, and, when spread on pastures, it may take some years to improve production substantially.

Cropping offers an economical means of incorporating lime through the cultivated layers of arable soils to increase its effect. The application of lime to the surface of pastures on non arable soils may also be justified since Bromfield et al. (40) found significant effects on pH in the top 15 cm of soil six years after pastures were topdressed; they considered that **these** might have been due in part to the neutralizing of acids as they formed in the biologically active surface soil. However, others are pessimistic about lime influencing subsoil acidity (42). Yet the conclusion (33) that its use seems inevitable must be accepted. A period of high outlay and low returns from it may be unavoidable.

The approaches needed to overcome soil problems in the high rainfall zone seem obvious. The main impediment is that they may be costly and must be rewarded by profit. In the vicinity of large cities, market opportunities have ensured that environmental problems have not presented lasting obstacles to the production of high value produce (2). If high costs must be incurred throughout the zone then its agriculture must become more intensive. Provided that high yielding genotypes are made available, crops can contribute to this. High yields are also usually demanded by the absence of opportunities for economies of scale, owing to rugged, broken terrain. Fortunately, the zone's climate enables a wide range of crops to be grown and in cool regions high yields of cereals are expected (9) and have been achieved (38, 41). In the Western Australian zone, low yields of wheat that seldom exceed 1.5 t/ha reflect water use efficiency values of less than 5 kg/ha/mm, or only about half the values that apply inland (42), and indicate problems still to be solved.

Cropping will become important both for the value of its products and for its role, referred to above, in combating soil problems. So research that is aimed at developing the zone should combine crops and grazing research with economic evaluation (38). Research emphasis will vary according to local problems presented by climate, soils or terrain. The last will focus interest on establishment through direct drilling because of a widespread fear that cultivation will erode sloping land, although most erosion is caused by overstocking unimproved pastures (38). The cost to the nation of not having the high rainfall zone well developed is a matter for speculation that is heightened by the finding (38) that in 1984 in the southern tablelands of New South Wales (a significant part of the zone), 40% of properties had no improved pastures at all.

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