11

DEPARTMENT OF AGRICULTURE, SOUTH AUSTRALIA

Agronomy Branch Report

Agricultural Research in the South-East of South Australia and adjacent areas of Victoria

PASTURE PRODUCTION

P. S. COCKS and E. D. HIGGS

Report No. 11

October, 1969

AGRICULTURAL RESEARCH IN THE SOUTH-EAST OF SOUTH AUSTRALIA AND ADJACENT AREAS OF VICTORIA

PASTURE PRODUCTION

P.S. COCKS Research Officer, Agronomy

and

E.D. HIGGS Senior Research Officer, Pastures

AGRONOMY BRANCH REPORT

October, 1969

FOREWORD

The following paper was prepared as a background paper for the Workshop held at Naracoorte on 14th to 16th October, 1969 to discuss the problems of the agricultural areas of South Eastern South Australia and adjacent areas of Victoria, and to pinpoint the research needed to overcome these problems.

This workshop was attended by officers of the South Australian and Victorian Departments of Agriculture, the South Australian Department of Lands, C.S.I.R.O. Division of Soils, C.S.I.R.O. Division of Nutritional Biochemistry, the Waite Agricultural Research Institute, and the Victorian Soil Conservation Authority.

A final list of research requirements, as determined by the workshop, is also included.

AGRICULTURAL RESEARCH IN THE SOUTH-EAST OF SOUTH AUSTRALIA AND ADJACENT AREAS OF VICTORIA

PASTURE PRODUCTION

INTRODUCTION

The early agricultural development of the area consisted almost entirely of the development of pastures. However, because the soils of the whole area were deficient in phosphorus and nitrogen, there was little chance of development apart from the clearing of trees and the installation of drains. This was done extensively, and at the turn of the century large numbers of sheep grazed the pastures of the region.

The next and most significant development came in about 1920 with the advent of the use of superphosphate and the introduction of subterranean clover (Trifolium subterraneum). Sheep carrying capacities trebled, farmers prospered, and the annual use of superphosphate became an accepted practice, so much so that in many people's minds it is regarded as an elixir to cure all pasture problems.

More recently other fertilizers have been used, and other pasture plants introduced. Trace elements are widely applied, some potash and lime is used, and very recently, because some farmers are dissatisfied with responses to superphosphate, other fertilizers, particularly other forms of phosphate, have been tried. Of new pasture plants introduced, the most acceptable but generally not widely accepted have been the perennial grasses Phalaris tuberosa, perennial ryegrass (Lolium perenne), and Currie cocksfoot (Dactylis glomerata), and the perennial legumes, lucerne (Medicago sativa) and strawberry clover (Trifolium fragiferum).

The following paper summarizes the developments in the pastures of the region since the publication by CSIRO of 'Agricultural Research in the South-East of South Australia and Adjacent areas of Victoria' (Jackson, 1968). Further, this paper indicates the lines of current research, outlines problems which have arisen, and suggests the direction in which future pasture research should proceed.

RECENT DEVELOPMENTS AND CURRENT RESEARCH

Fertilizers and Soil Fertility

(a) Phosphorus and sulphur - With the possible exception of the volcanic soils near Mount Gambier the soils of the region were grossly deficient in phosphorus. As noted above, this deficiency is corrected by the use of superphosphate. Thus except in some newly developed areas, recent research with phosphorus has been concerned with the question of whether application rates of superphosphate can be reduced, and indeed whether there is any need for any further additions of superphosphate.

The reasons for this great interest in reducing the application rates of superphosphate are obvious enough. In parts of the region superphosphate has been applied continually since the early 1920s, and total applications as high as 4 tons per acre have been recorded. The farmer's superphosphate bill is often one of his most significant annual debts, so the possibility of helping him to reduce this debt must be seriously investigated. However, the problems involved in research in this field are complex. Firstly, there is the great variation of pasture response to phosphorus from site to site. Secondly there is the problem of relating relatively small increases in pasture production to wool, meat, and milk production. Thirdly there is the whole sulphur question; that is, whether the continued application of superphosphate has concealed a sulphur deficiency, and if so whether the residual effect of sulphur is as great, greater, or less than the residual effect of phosphorus. Finally there is the possibility of harmful effects of the continued use of superphosphate due to a lowering of pH.

The question of site to site variation can best be approached by relating a measurement of soil phosphorus (available phosphorus) to pasture response, at the same time accounting for differences in botanical composition. An early attempt to do this in the region was that of Cocks (1966) who related the pasture response in winter and spring to ammonium fluoride-hydrochloric acid soluble phosphorus (Bray and Kurtz, 1945), two other categories of phosphorus (Williams, 1950), and total phosphorus at eight sites on solodized solonetz soils from Frances in the north to Penola in the south. A correlation was obtained between winter response and Bray and Kurtz phosphorus, provided that only annual pastures were considered. If Bray and Kurtz phosphorus was above 20 p.p.m. in the top two inches of soils there was a response to superphosphate of less than 10%, but if Bray and Kurtz phosphorus was less than this amount the response rose steeply so that at 15 p.p.m. the response was 75%. An interesting feature of the results was that there was no response in spring pasture growth to superphosphate application.

This kind of work has been continued by Clarke - at two locations (Kybybolite and Wattle Range); he applied phosphorus at rates of from 0 to 80 lb per acre on sites which had received varying amounts of superphosphate in the past. (There were three sites at Kybybolite and two at Wattle Range). The soils were sampled six weeks after application in 1967 and again in June 1968, and analysed for available phosphorus (using the method of Bray and Kurtz). Available phosphorus in 1967 was related linearly to phosphorus applied in that year, and at Kybybolite there was a strong residual effect of available phosphorus in 1968. At Wattle Range however, there was a substantial drop in availability by 1968 of superphosphate applied in 1967 at the low phosphate site.

The pastures responded to phosphorus to a level of 20-30 p.p.m. of available phosphorus in the top three inches of soil at all sites but one. At this site (Wattle Range, high phosphorus) there was no response to phosphorus even though available phosphorus in the control plots was less than 20 p.p.m. However, Clarke found that a build-up of available phosphorus had occurred at a soil depth of 12 inches, and the pasture was apparently making use of this phosphorus.

The question of the relative residual effects of phosphorus and sulphur is being examined by Clarke and Brown at Kybybolite Research Centre. The work was commenced in 1968 on sites which are part of a long-term grazed superphosphate trial. Three sites were selected which had received zero, 56, and 112 lb of superphosphate per acre annually since 1958. All sites had previously received 3,500 lb of superphosphate over a period of 40 years. The soil was analyzed for total phosphorus, available phosphorus (Bray and Kurtz) and total sulphur, subterranean clover was sown, four rates of phosphorus and three of sulphur were applied, and the plots were harvested twice. The pasture at sites which had received 56 and 112 lb of superphosphate annually did not respond to additional phosphorus or sulphur, but the pasture at the site which had zero superphospahte for 10 years responded to both nutrients, especially phosphorus. The results did not suggest that there was any additional need for sulphur above the basic phosphorus requirements. This was in marked contrast to the work of Burford, in the higher rainfall areas of Penola and Kalangadoo reported in the previous study of the region (Jackson, 1968). The work of Clarke and Brown is continuing and is expanding to include work on different forms of sulphur fertilizer.

An experimental programme which sould yield interesting information on the distribution and seasonal variation of phosphorus and sulphur in a number of South-Eastern soils is being undertaken by Clarke and Matthews. They intend measuring total phosphorus, available phosphorus (Bray and Kurtz), total sulphur, and sulphate sulphur at three times during the year and at various positions down the soil profile. These measurements will be correlated with measurements of plant root distribution. It is hoped that the experiments will provide a background for a more complete study of phosphorus and sulphur maintenance requirements in these sandy soils. It was commenced in 1969.

The question of relating the small increases in pasture production due to a current application of superphosphate to wool production has been attempted at two sites in the area and is being attempted at a third site. The first site, which had received 3,500 lb of superphospahte over a 40 year period, is at Kybybolite, and the early results have been discussed in Jackson's booklet. Although small increases in pasture production occurred in winter (about 17%), these were not reflected in wool growth at the stocking rates used in the trial, namely four sheep per acre, although there was some response in sheep live-weight.

The third site at which the application of superphosphate is being correlated with wool production is at Struan where work is being conducted by Clarke and Deland. However, the more important aim of this experiment is to determine the residual value of phosphate fertilizers applied to a perennial pasture growing in ground water rendzina soils, as measured by pasture responses under grazing conditions, and to relate such responses to measured available soil phosphorus. The experiment began in 1969, and as yet no results are available.

The question of the acidifying effect of superphosphate and its possible correction with lime is being studied at Kybybolite, in an experiment which also examines the possibility of using rock phosphate. Superphosphate and rock phosphate have been applied annually at two application rates, whereas lime was applied in one large dressing at the beginning of the 10 year period. To date superphosphate has been superior to rock phosphate, and there has been a significant increase in pasture yield due to the application of lime.

Douglas is studying the use of lime, phosphorus, and sulphur in a series of experiments in the Shire of Kowree. No results are available yet, but the programme should give valuable information on the use of lime and sulphur in this region.

(b) Potassium - Work on potassium fertilizers is assuming considerable importance in both the South Australian and Victorian parts of the region (particularly the Victorian parts). Potassium deficiency has been known to occur in the Victorian Little Desert (Newman, 1959), in the Mount Gambier-Glencoe area (Lines, 1964, personal communication), and at Dartmoor (Margetts et al., 1961) for some time, but the extent of the deficiency and the techniques necessary to overcome it are only in the process of being worked out.

The work of Margetts is of particular relevance to this discussion. He has conducted a large number of experiments in the Shire of Portland. The magnitude of the response to potassium in this area can be seen in Table 1 which shows the results of an experiment on new pasture sown in an acid sandy soil at Mumbannar. Note that the response is in the second year following the application of the fertilizer, indicating that there is a considerable residual effect of potassium.

TABLE 1

Potassium applied (cwt per acre of potassium chloride)	Yield (cwt per acre) First year spring	Second year spring
Nil	3.1	3.5
$\frac{1}{4}$	5.1	23.5
$\frac{1}{2}$	6.8	29.3
1	6.7	32.3

From the results of this and a number of other experiments in the area Margetts has drawn several conclusions. Firstly, he concludes that potassium is of special importance in sandy textured soils where the intensity of fodder utilization is high. Secondly, autumn applications are quite satisfactory even under sandy soil conditions. Thirdly, heavy application rates are quite unnecessary except in hay paddocks.

Rates as low as 20 lb per acre can produce valuable increases in pasture production. Fourthly, in older pastures, cultivation can frequently improve the potassium situation. Finally, except in areas of acute deficiency, the response is limited to the legume fraction of the pasture sward.

On the South Australian side of the border, work on potassium is being conducted by Meissner. The overall aim of his programme is to correlate soil potassium with the level of pasture response. At twelve sites on sandy soils, from north of Bordertown to Kalangadoo in the south, pasture response to potassium, the residual effect of potassium, and the fate of applied potassium in the soil is being examined. Six of these sites were studied in 1968, and on four of them, a linear response of pasture yield to 250 lb of fertilizer was obtained. The greatest increase in yield was a doubling of the yield of the control plots, indicating that in South Australia, as in Victoria, the potential for the use of potassium fertilizers is very high indeed.

(c) Nitrogen - The use of nitrogenous fertilizers has received very little attention in the region. The reason, of course, is that complete reliance has been placed upon pasture legumes for the supply of this nutrient. The work of Russell (1960) at Kybybolite indicates that a considerable build-up of nitrogen has indeed occurred. However, there are several questions that remain to be answered. Firstly, how much of this nitrogen is actually available for plant growth; that is, what are the mineralization rates of organic matter and the leaching rates of mineral nitrogen at the various times of the year? Secondly, have legumes the same potential for high yield as grasses when the latter are adequately supplied with nitrogen? Thirdly, is it really possible to maintain a legume dominant pasture sward, and if it is not, are non-legumes adequately supplied with nitrogen at all times in the growing period? Finally, what response will be obtained in terms of animal product?

One of the authors is attempting to answer a few of these questions at Kybybolite. An examination of the response of three annual pasture grasses (Lolium rigidum, Vulpia myuros, and Hordeum loporinum) to four levels of nitrogen at three densities is being made. Sward harvests are being made at fortnightly intervals in an attempt to measure maximum growth rates through the growing season. Initial results suggest that the three species do vary in their response to nitrogen, and that the response varies with density. One tentative conclusion is that it will not be worth topdressing pastures with nitrogen fertilizers if the plant density is low, but it may be very worth-while if the plant density can be made to be very high.

The response to both superphosphate and urea of Phalaris tuberosa - strawberry clover pasture growing in ground water rendzinas at Struan, has been studied by Ellis. The experimental areas had been developed for some years and had received a considerable amount of superphosphate

Nevertheless the pasture responded to both urea and superphosphate in the winter, but only to urea later in the year. Total pasture yield was almost doubled by the application of $1\frac{1}{2}$ cwt of urea per acre.

(d) Lime and magnesium - The most common reason for using lime as a fertilizer is to aid pasture establishment. This will be discussed later. Very little research has been carried out on the use of lime as a fertilizer in the region apart from that mentioned in connection with superphosphate at Kybybolite. However, in the work of Douglas, applications of both lime and magnesium have been made to establish pastures in the Shire of Kowree. As yet there are no results available from this work.

(e) Trace elements - Although the region has been the centre of a considerable amount of research activity into the use of trace elements, this has diminished in recent years as the development of the problem areas proceeded. The only work at present in progress is in the Shire of Kowree where Douglas has established a series of experimental plots. This work is interesting in that it is looking at trace element requirements in developed pasture, an area which has been neglected in the past.

Pasture Plants

(a) Establishment - The consideration of pasture establishment falls into two areas, firstly pasture establishment in newly cleared ground, and secondly pasture renovation; that is, pasture establishment in ground which has been used as pasture for some time, but where the quality of the pasture has deteriorated and thought to be capable of improvement by resowing.

In large parts of the region there were very few problems in initial pasture establishment. Subterranean clover often volunteered after superphosphate had been spread. However, in other parts of the region pasture establishment has proved as difficult as anywhere else in the world. Nevertheless, even in these areas techniques for establishment were worked out more than 10 years ago. Current research is really an extension of these results into further similar areas. The largest area concerned is in the Shire of Portland where the work is under the direction of Margetts.

The work of Margetts has shown that the key to the development of these problem areas is in the use of lime. He has found that if the soil is acid but that the pH is greater than 5.6 then pasture legume seeds need to be lime-coated. If, however, the pH lies between 5.6 and 5.2, then 2 cwt of lime per acre needs to be drilled with the seed, as well as the lime coating. If the pH is less than 5.2 it is advisable to broadcast $\frac{1}{4}$ to $\frac{1}{2}$ ton of lime per acre as well as lime coating the seed, and drilling 2 cwt of lime into the soil at seeding. These techniques ensure that the legume plants grow and reproduce as well as germinate and establish.

Renovation of old pastures is a relatively new problem. Following the establishment of legumes, a phase of legume dominance is followed by a phase of diminishing legume importance during which the legumes are increasingly replaced by other annual species, generally considered to be less productive. The reasons for this change in botanical composition are not clear, but the phenomenon is widespread throughout southern Australia. One approach to the problem is the establishment of perennial grasses, which seems to give a pasture of rather more botanical stability.

The use of perennial grasses is widely recommended throughout the region, both in Victoria and South Australia. However, in general, farmer's have not responded to the recommendations, the reasons being firstly, that the economic benefit of renovation has never been satisfactorily demonstrated, and secondly, that the techniques of establishment are not reliable. Some research into the second point is being undertaken, particularly into the establishment of Phalaris tuberosa.

The establishment of Phalaris tuberosa into an acid soil at Mumbannor has been shown by Margetts to be markedly improved by the use of lime. Further, Margetts' results suggest that mixing the seed with superphosphate has a deleterious effect on establishment (Table 2, page 8). Although this work was done in new ground its real significance lies in the possible explanation of the difficulty of establishing Phalaris tuberosa in old pastures. Similar work, though in greater detail, is under way in the Adelaide Hills in an area of sandy soils with 25 inch rainfall similar to much of the South-East and adjacent Victorian districts. This work, under the direction of Saunders, is confirming the toxic effects of superphosphate in Phalaris tuberosa establishment and the partial mitigation of this toxic effect by lime. A wide range of other trace elements and sulphur have failed to produce further significant improvements. The majority of phalaris on this site is still unthrifty, suggesting further deficiencies or toxicities.

There have been two approaches to the problem of how to renovate old pastures without incurring a year's loss of production.

TABLE 2

The effect of fertilizer treatment on the establishment of Phalaris tuberosa in an acid sand (pH about 5) at Mumbannar

Fertilizer Treatment	Phalaris establishment (plants per unit area)
Seed only	25
Superphosphate 1 cwt per acre	22.5
Superphosphate 2 cwt per acre	14
Superphospahte 4 cwt per acre	3.5
Lime 2 cwt per acre	37
Superphosphate 8 cwt per acre	1.5
Lime 2 cwt per acre plus Superphosphate 2 cwt per acre	37

The first is to sod seed perennial grasses into an annual pasture following the removal of competition from the annuals by spraying with a herbicide. Perennials have been successfully established using this technique (Cocks, 1965), but its success has varied from year to year and site to site depending on the type of opening of the season and on botanical composition. Work by Cocks (subsequent to that published in 1965) suggests that the technique works well if the opening of the season is not followed by a long dry period and is not too late, and that it works well if the competition from existing species comes mainly from one particular species. Nevertheless the technique has some promise.

The second approach is to sow the perennial grass with a cash or fodder crop. In this way the year's loss in production is made good by the value of the accompanying crop. The work of Margetts is of particular interest. He has found that the survival of perennial ryegrass is hardly affected by a companion crop of oats, even if the oats are sown at the rate of 40 lb per acre, but that it is suppressed if the companion crop is 40 lb of barley. Survival of Phalaris tuberosa is more severely affected by competition from the cereal, but is quite adequate in company with oats sown at 20 lb per acre.

Margetts has done similar work using Chou moellier as the companion crop. Table 3 (page 9) shows his results. Note that not only did he get good establishment of Phalaris tuberosa, but that fodder production was not depressed in the year of establishment.

These results are of great interest in that they show that it is possible to establish a perennial grass without incurring a year's loss in pasture production. Another significant development, which while having only a minor effect on pasture establishment at the moment, could become a very significant means of minimizing cost of pasture establishment. This is the harvesting of a seed crop for the first year or two of the pasture before it reverts to a full time pasture. Early indications are that worthwhile yields of grass seed can be obtained from perennial grasses at least in the higher rainfall regions of the district in the year of establishment if appropriate cultural treatments are followed, followed after harvest by a high grazing potential until the stand is shut for the second seed harvest in August or early September. Many pastures in the South Island of New Zealand are established with a similar purpose in mind.

(b) New pasture species and strains - Work in this field has been confined in recent years to the examination of various perennial grass and lucerne cultivars. However, in new programmes, the nutritive value of various pasture species to sheep is being compared, and a closer look is being taken at the various volunteer annual species.

TABLE 3

The establishment of Phalris tuberosa when spring sown in company with Chou moellier

Seed mixture (lb per acre)	Phalaris plants established (plants/sq yd)	Total Yield in 1965 (cwt per acre)	Total Yield in 1966 (cwt per acre)
Phalaris 1	57	7.4	37.2
Phalaris 2	81	6.8	31.0
Phalaris 1 + Chou ½	44	40.1	28.5
Phalaris 1 + Chou 1	47	40.7	29.4
Phalaris 2 + Chou ½	50	31.4	27.9
Phalaris 2 + Chou 1	53	36.7	30.6

An experiment at Kybybolite, under the direction of Crawford, has compared 10 strains of Phalaris tuberosa, two sterile hybrids of Phalaris tuberosa and Phalaris arundinacea, and four strains of Cocksfoot (Dactylis glomerata). Establishment, survival, and seasonal production have been measured. With the exception of some of the Cocksfoot strains, all grasses have survived five seasons, including 1967, a very severe drought.

Currie Cocksfoot performed well, but the outstanding results were obtained with the Moroccon Phalaris tuberosa strains, 19305 and 19331. It is interesting that in this trial, and in other trials conducted throughout the region, 19305 has tended to yield better than 19331, though a selection of the latter for better seed retention was later released as 'Sirocco'.

Experimental work with lucerne is assuming high priority, as farmers and professional agriculturalists realize the value of lucerne in extending the period of nutritious fodder production. Previously lucerne growing has been restricted to problem soils where subterranean clover would not persist, and in the rest of the region it has been confined to house paddocks. It is now being sown much more widely, and is very prominent under irrigation. Present work is confined to the testing of new strains, but three problems which need to be tackled in the future are firstly, the use of lucerne-grass mixtures to boost winter production and secondly, the possibility of breeding new strains to extend the growing of lucerne into wetter areas and thirdly, a study aimed at developing improved establishment techniques.

Work on the introduction of new lucerne cultivars is being done by Hagerstrom and Crawford, in the high rainfall districts around Mount Gambier. Although they have several sites, their most comprehensive work is at Allendale south of Mount Gambier. Six cultivars of lucerne are being compared, establishment and survival counts made, and harvests made at intervals corresponding to commercial grazings. At present the highest yielding cultivars are Du Puits and Cancreep, best summer yields being recorded by Du Puits, and best winter yields by Siro Peruvian. The cultivar Rhizoma is yielding very poorly, and the widely grown commercial cultivar Hunter River has outyielded only African and Rhizoma. Nevertheless it would be dangerous to draw conclusions from this experiment at this stage, as only one complete year's results are available.

A similar trial, but with in addition some newly introduced strains from the Mediterranean region, has been sown at two sites near Mount Gambier by Higgs using seed provided by Leach. As these trials were sown in 1969, there are no results available at this date.

Several other legumes and lucerne are being compared in experiments in the Little Desert. This work, done by Douglas, has yielded no results at this stage. Included in these experiments are eight subterranean clover strains, several lucernes, two other medics, three lupins, and Serradella.

A completely new approach to the assessment of pasture plants is being undertaken at Kybybolite and Struan. At Kybybolite pure cultures of various grasses (all perennial) and legumes have been established in small paddocks. This work, under the control of Dunstan, is aimed at finding out whether the different species have different nutritive values as a feed for sheep. Each paddock is grazed by young lambs at a stocking rate so that feed is non limiting, and the growth rate of the lambs recorded.

It is expected that this work will be the preliminary of a comprehensive study of the nutrition of sheep grazing pasture.

The Struan work is different in that it is looking at various perennial grasses growing in company with strawberry clover. However, in this work, differences in nutritive value between the grasses may well be masked by the presence in all plots of strawberry clover. Amongst the grasses being tested at both Kybybolite and Struan is Demeter fescue (Festuca arundinacea) which has shown some promise in the higher rainfall parts of the region on a variety of soils and situations.

A comparison of some annual grass species is being undertaken by Cocks. This work was discussed under the heading of 'nitrogen' earlier in this paper.

PASTURE MANAGEMENT

It is not our intention to review the effects of different management systems on sheep production. However, it is important that some notice be taken of the effect of management on the pasture, especially on botanical composition.

The first management practice to be considered is that of deferred grazing. Deferred grazing is that practice where livestock are yarded and fed for the first few weeks after the opening rains. This allows the pasture to develop sufficient leaf area index so that poor light interception does not limit pasture growth. An experiment is under way at Kybybolite to test the value of deferred grazing against normal continuous grazing. The work, controlled by Brown, involves eight stocking rates from five sheep per acre to twelve sheep per acre as well as the two management practices. Monthly pasture harvests have been made, and the herbage hand separated into grass and clover. The pasture results so far show that firstly, deferment has resulted in greater grass dominance at the lower stocking rates, secondly, that at higher stocking rates (greater than nine sheep per acre), both subterranean clover and annual ryegrass (Lolium rigidum) have been replaced by Poa annua, thirdly, that total pasture growth has been greater under deferred grazing in at least one year out of three, and finally that the pasture has remained green longer under continuous grazing and this fact has been reflected in sheep liveweights.

A second management practice which has had some effect on botanical composition is that of hay making. In a trial at Edenhope, managed by Douglas, seven stocking rates from three to six sheep per acre were compared, and in four of them one third of the land area was conserved for hay. The results of this experiment suggest that subterranean clover is favoured by higher stocking rates, and that barley grass (Hordeum leporinum) is temporarily controlled by a combination of high stocking rate and hay cutting.

Other grazing management systems being compared by this group are the effect of deferred grazing and stocking rate on perennial based and annual based pastures. As yet few results are available.

FUTURE RESEARCH PROGRAMMES RELATED TO INCREASING PRODUCTION

The planning of future research programmes in the region under discussion must be related to the anticipated future world economic climate. It would appear to us that if the present political status is maintained in the economically advanced nations, the nations which buy the majority of our agricultural exports, then these countries will become increasingly self-sufficient in their basic food requirements and also become less reliant on Australian wool for their fibre requirements. This trend is likely to proceed even beyond self-sufficiency in these economically advanced nations, to the stage where an increasing number of agricultural commodities traditionally imported will be available in increasing volume for export to fewer remaining importers.

This of course means that unless subsidies are provided to the Australian farmer on a massive scale there will be little profit in farming for most people producing most products for a long time to come. This in turn must lead to a lack of finance for investment in agricultural production for the exploitation of the results of scientific research.

It may seem then that under the envisaged future economic circumstances most research effort should be directed at trying to maintain existing production levels while progressively reducing input costs. This would seem reasonable for the region under discussion if we were to believe that current levels of output or current enterprises could be changed only marginally and that our current efficiency were about average.

We do not believe that this is so.

We believe that this region is sufficiently unusual in its geology, meteorology, and physiography, that quite radically different types (from those practised generally in Australia) of agriculture can be successfully practised, and because of this the prime objective of future research programmes should be aimed at constructing entirely new farming systems for the area, which are radically more profitable than existing enterprises and which will therefore attract the necessary capital for effective exploitation.

While in general the price outlook for the major agricultural commodities produced in Australia is quite gloomy there are always likely to be opportunities for entering the production of particular commodities where the level of demand is such as to favour the producer in particular favoured regions.

The Australian farmer, unlike his counterpart close to the major markets of North America and Europe, is not at the moment generally geared for adjusting his production to closely match changing demand. In Europe and U.S.A. necessary knowledge for a very wide range of particular enterprises is already available and if not immediately known by the farmer is accessible to him, sought when required, and accepted by him.

The farming skill required for rapid shifts in production is in part traditional, but very largely developed from the large amount of production-orientated research conducted in these regions.

If we are to meet this challenge of finding viable new farm enterprises we need to conduct research aimed at developing new production techniques, concurrently with convincing farmers that they must be prepared to change from their traditional enterprises when more profitable enterprises become available, and teaching them how to produce profitably these new products.

This work must be done quickly otherwise the demand may shift again, rendering the work of little or no immediate value. If we are to think truly in terms of a radical increase in agricultural production in the region we must discard all our prejudices, which have generally been built on a series of earlier prejudices and think out from the basic resources currently available what might be reasonable production objectives for the region.

What are the outstanding physical features of the region?

The land surface has extremely low elevation being generally under 300 feet above sea level and of low relief.

With its particular latitude range, low elevation, and proximity to the sea, the region enjoys a temperature regime which is generally very favourable for plant growth.

The light regime, though not remarkable for Australia, compares favourably with many if not most of the intensively farmed regions of the world.

Black (1964) suggests the potential production of subterranean clover in the region would, in conditions of water and nutrients being non limiting, be approximately 25,000 lb of dry matter per acre.

The rainfall of the region is one of high reliability in that an extended period of each year receives sufficient rainfall for unrestricted plant growth. Quantity of rainfall and length of growing season does vary from year to year and district to district within the region, but it is rare indeed that an uninterrupted period of growth is shorter than five months.

The soils of the region are variable in the extreme in almost all attributes.

While they were initially poor in most nutrients, excessively winter wet, or subject to complete flooding each winter, the construction of drains and the use of species that exploit soil moisture more effectively than the native species, has resulted in the problems of inundation and winter wetness being radically modified. There has also been a marked increase in soil organic matter closely related to amount of superphosphate applied. In general the soils are improved on what they were; generally, to a dramatic degree.

The geology of the area (porous limestone underlies the region with few exceptions) coupled with low altitude, low relief, and a period of each year during which rainfall greatly exceeds evaporation, has resulted in a vast amount of high-quality water being stored at convenient depths below the surface which can cheaply be exploited for domestic, livestock, and irrigation purposes.

We consider that when all these factors of the physical environment are taken into consideration it is reasonable to initiate investigations aimed at producing a more intensive form of land use than is generally practised at the moment.

If we are to plan for a many fold increase in production in this region we need to set out our objectives clearly. We will not be planning for a subsistence agriculture whose attractions are basically an attractive way of life producing commodities more for the satisfaction they give than their monetary worth, with the only major long-term financial hope one of a substantial capital gain. We will be planning for a strictly commercial approach to farming, when profit is the motive and interest earned on capital employed the measure of success.

We must not in our research be content in establishing biologically interesting principles. Our research must not be considered completed until the enterprise we are researching has been tested on at least a semi-commercial scale and carefully costed out to the last cent.

Apart from permanent forests and tree and vine plantings of a long-term nature there are three basic agricultural systems each with considerable possibilities for further variety. These are:

(a) Permanent arable - a system practised somewhat in the distant past in a few isolated fertile areas of the Mount Gambier and Millicent districts.

(b) Ley arable - a system which is comparatively rare in the district but not completely unknown.

(c) Permanent pasture - the overwhelmingly dominant farming system. While continuous arable farming will eventually become important and perhaps dominant in the very long-term it is not a subject of this paper. It is only important in so far as it reduces the area of land available for pastures.

We will be concerning ourselves in the future research programmes with the leys of the ley arable, the permanent pastures, and the particular types of production possible from them.

The types of animal production that appear possible in the district are:

(a) Intensive dairying based on feeding at a level approaching adequacy for the full production potential of the animal.

(b) Dairying based on low inputs with production per animal allowed to fluctuate with feed quality and quantity.

(c) Intensive beef production where liveweight gains are kept high from birth to slaughter.

(d) Extensive beef production.

(e) Intensive prime lamb production

(f) Extensive prime lamb production.

(g) Breeding for wool producing or prime lamb mothers.

(h) Wool production on a closed ecosystem basis.

(i) Wool production based on wethers bred off the property.

Types (b), (d), (f), (g), (h), and (i) are carried on to varying degrees of success throughout the region. In the regions where prospect of intensification does not extend beyond these types of production we feel that research should be restricted to a minimal level and limited to problems that are likely to occur irrespective of the level of intensity of production practised. The particular needs for these types of production will be discussed later in this paper.

The majority of grassland research, which must be at a greatly expanded level of intensity, should be concentrated on projects aimed at intensive dairying and intensive beef production and perhaps to a lesser degree to intensive fat lambs production.

What are the needs of these industries?

Ideally there should be a supply of highly digestible herbage with energy, protein, and minerals in proper balance available in appropriate quantities to meet the seasonal requirements of the animals.

At the moment, apart from deficiencies in the breeds available and in animal husbandry, the reason why intensive animal production is not practised in the region is that fodder production, with the limited fodder conservation practised, does not meet the fodder demands of the animal, for high levels of performance for more than brief periods of the year.

The deficiencies of fodder production are of quantity during the cooler months of the year, and of quality and possibly also quantity during the drier months of the year.

How can these deficiencies be met?

Prospects of increasing supply of fodder during winter months occur in several areas.

While winter temperatures place some restriction on plant growth in the region the major restriction is due to inadequate interception of available light. Better light interception is likely to occur in winter if defoliation is less severe, if seed or root reserves are greater, coupled with a growth rhythm that allows rapid growth during short cool days following onset of autumn rains, and if mineral nutrition, particularly nitrogen nutrition, more closely approximates the biological optimum.

Prospects of increasing the quality and quantity of herbage during the drier months of the year rest largely but not entirely on the exploitation of plants with growth rhythms that allow growth at the time of year with long days and moderately high temperatues, and with root systems that allow a more complete exploitation of the summer showers and water stored during the period of winter surplus, with or without supplemental irrigation.

The alternatives to growing out of season fodder are the breeding of pasture plants which retain quality at maturity, or the use of chemicals to kill herbage and prevent normal maturation, and conventional fodder conservation.

The role of conservation needs complete re-definition. If the fodder conserved needs to be of a specific quality, which seems likely, it will more likely be met by using plants for conservation which reach an appropriate nutritive stage in a growth form and at a time of the year which allows cheap highly mechanized conservation with minimum loss.

What experimentation needs to be done to develop production in these two areas of deficiencies in production and in the alternative solution, the more effective conservation and supplementary feeding?

It appears as if the solution to all three areas will involve resowing of pasture areas to plants of different kinds from those currently occupying pastures, or at least increasing the population of the plants at present colonizing the area.

The first step in developing new production techniques must therefore involve the development of more effective and reliable methods of pasture establishment. This appears to be a straightforward problem, which with properly organized research, should be capable of solution in a short period of years. The problem appears to involve proper placement of the seed in the soil of appropriate current and anticipated future moisture status, adjacent but separate from fertilizer appropriate to the soil fertility and using herbicides and cultivation as proves to be most economical to control unwanted competing plants.

Filling the winter production shortfall

We feel that this will be solved primarily by the fertilization with sufficient nitrogen of dense pastures consisting of nitrogen-responsive species. A programme of systematic testing of the species already colonizing the region and the now commercially available varieties of promise for nitrogen responsiveness is an urgent need. A wider search for species and breeding within promising species may be justifiable later. A start has been made by one of the authors (Cocks) and this may well indicate the volume of effort needed and justifiable to reach commercially acceptable recommendations for the whole district. It is quite apparent that a vast amount of careful plot work of a relatively unsophisticated nature will be needed - preferably concentrated into a few years and extended over as wide a range as possible of soils and climates of the region.

It is already apparent that dense stands of annual plants heavily fertilized with nitrogen can produce winter growth rates of a very high order. The possibilities of perennial grasses with a strong winter growth rhythm such as Sirocco phalaris can only be guessed at. However, visual indications from cultures established for seed production and fertilized with some nitrogen suggest again that winter production of the order of many times the levels currently achieved in commercial practice is biologically possible with these plants.

Increasing quality and quantity during the drier months of the year

The most obvious and so far rather neglected plant to consider in this area is lucerne. The reasons for neglect of lucerne are not obscure. It is simply that lucerne establishment requires more effort than has been generally applied to establishing pastures in this region in the past. The dominant pasture species, the annual grasses and the annual legumes have generally volunteered or thickened up from sparse stands. Strawberry clover likewise is quite capable of spreading from sparse populations. Lucerne, at least Hunter River lucerne, rarely thickens and requires careful management to maintain a steady plant population.

While lucerne will have a definite limit in wet situations, these cover much less area than previously. Even some of the really inundated areas of water table rendzinas have been so heavily drained that strawberry clover is unable to persist and these areas now appear to be quite ideal lucerne sites.

The breeding of types of lucerne better adapted to the various sites in the region offers great prospects and will be actively pursued in the year to come. The creeping types may be able to colonize areas from very low initial population of types adapted to winter wetness or soil acidity.

Of the perennial grasses Demeter fescue, Siro 1146 hybrid phalaris, Aries and Montpellier cocksfoot, and other as yet not commercialized varieties based on the combination of winter productive Mediterranean types and summer productive types offer distinct prospects for increasing summer production with or without irrigation.

The role of irrigation is a special one. Some irrigation is currently practised in the district but no quantitative data have yet been gathered on input-output relationships on irrigated pastures and fodder crops. The simultaneous study of the effects of quantity and frequency of watering, species composition and density, and the use of nitrogen fertilizers is an urgent need. Over much of the district the water resource appears adequate for a modest proportion of every property to be irrigated without over-exploitation of the resource (CSIRO Annual Report, 1969).

Fodder conservation

Shortly grazed actively growing fodder plants where most of the fodder on offer is less than four or five weeks old are generally of an acceptable level of digestibility, adequate for highly productive animals. As plant tissues age they become less digestible. As fodder conservation, if it is to be economical, has to start with a large volume of herbage, it is customary in growing fodder for conservation to allow uninterrupted growth for a much longer period than four or five weeks, which results in the material used for conservation being of lower than adequate digestibility from the start. Further losses of digestibility may occur during the conservation process, particularly if poor weather conditions occur during conservation.

Taller growing plants which retain a suitable level of digestibility at a time of the year not plagued by unsettled weather appear to be needed for conservation purposes. Lucerne already fits this bill tolerably well although leaf shattering presents difficulties in haymaking, and silage made from lucerne is not always very satisfactory.

The use of tall growing Italian ryegrass is widespread in Europe for early season conservation, followed by a variety of successively late flowering pasture plants -all of which retain digestibility levels of an adequate order until particular date of the year known with precision to within a few days.

We need to examine plants specifically for their attributes in relation to conservation.

Techniques of conservation need to be examined.

Great advances in silage making and self feeding have taken place in Britain in recent years. Silage made from chopped wilted grass, kept in plastic-lined bunkers and covered with plastic, is cheap to make and can be easily self fed. The initial capital investment is high but running costs very low.

Low cost haymaking techniques (fodder rolls) are currently increasing in popularity in the district. More critical evaluation of the technique and perhaps further development of the method involving (i) better storage and (ii) subsequent feed out of the rolls seem to be needed.

Although not common in Australia automatic equipment for gathering and stacking bales of hay is available and widely used overseas.

The use of lucerne hay wafers is fully commercial in California. One 2200 cow feed lot seen by one of the authors (Higgs) was relying almost entirely on the use of this form of fodder, which is easily handled mechanically, although rather expensive machinery is needed to form the wafers.

CONCLUSION

It seems to us to be reasonable to gamble on large advances from revolutionary changes to farming systems and to minimize research efforts directed at minor improvements to existing systems.

We do not deny that research leading to further improvements in fertilizer technology applied to existing pastures and farming systems will yield some benefits. We would urge rapid completion of existing research aimed at producing fertilizer predictions and, if found feasible, the introduction of a soil testing service.

We question the need for investigations relating to obscure mineral deficiencies in both plants and animals where they are of limited distribution, if this work is done at the expense of work related to developing new enterprises of radically greater output.

We would strongly urge that the initiation of research directed at bringing the limited amount of unfarmable country into production cease immediately. We feel that if it is reasonable that areas close to the densest population centres of the world are left unfarmed as in Britain and Holland on their poorer soils, it must be reasonable in our economic situation to think that some areas of this region should not be farmed, nor should efforts be expended on learning how they could be farmed.

I think our main plea regarding future research can be sumed up as follows. Let us think in terms of producing much greater amounts of fodder before we get too deeply involved in work relating to livestock production on existing fodder resources.

When we learn how to produce this extra fodder, which should be quite rapidly, it will be soon enough to worry about pasture utilization and animal production problems of the region. These always rest on fodder production. Research in these areas on current fodder production can hardly be meaningful in the future, with its envisaged radically higher herbage production.

REFERENCES

ANON. (1969) - CSIRO Annual Report.

BLACK, J.N. (1964) - J. appl. Ecol. 1: 3-18.

BRAY, R.H. and KURTZ, L.T. (1945) - Soil Sci. 59: 39.
COCKS, P.S. (1965) - Aust.J.Exp. agric. Anim. Husb. 5: 203-7
COCKS, P.S. (1966) - The residual effect of superphosphate on solodized solonetz soils at Kybybolite, South Australia. M.Ag.Sc. Thesis Univ. of Adelaide.

JACKSON, E.A. (1968) - Agricultural research in the south-east of South Australia and adjacent areas of Victoria (CSIRO Melbourne).

MARGETTS, S.W., STUBBS, A., NEWMAN, R.J. (1961) - J.Dept.Agric.Vic. 59: 225-31.

NEWMAN, R.J. (1959) - J. Dept. Agric. Vic. 57: 1-9.

RUSSELL, J.S. (1960) - Aust. J. Agric. Res. 11: 902-6.

WILLIAMS, (1950) - J. Agric. Sci. 40: 233.

APPENDIX

List of pasture production research requirements determined by the workshop at Naracoorte, 14th-16th October, 1969:-

1. To increase fodder production through the use of Nitrogen and increased plant density:

   (a) Selection of the most responsive species.

   (b) The interaction between nitrogen, density, species, defoliation, temperature and other fertilizer requirements.

   (c) Application of the above findings to the livestock situation.

   (d) Study of the soil nitrogen levels with relation to distribution in the profile and seasonal variations.

2. Phosphorus:

   (a) Development of a diagnostic soil test.

   (b) The relationship between stocking rates and phosphorus requirements.

   (c) Studies on specific problem soils.

   (d) The use of slowly available and less mobile forms of phosphorus.

3. Sulphur:

   (a) Pasture requirements for growth.

   (b) Animal requirements.

4. Potassium:

   (a) Economic evaluation under grazing, including investigations of recycling and transfer. (trial, stocking rate x potassium).

   (b) More accurate delineation of areas of response, and development of a soil test suitable for South Australian conditions.

   (c) Investigation of plants which may use available potash more efficiently e.g. deeper rooted plants.

5. Lime Magnesium and trace elements:

   (a) Study of requirements in relation to stock health.

(b) Trace element requirements for pasture maintenance.

6. New pasture plants:

(a) Establishment problems, specieal equipment for establishment, application of high fertilizer rates.

(b) In relation to environmental conditions selection of new pasture species and cultivars. Special attention to be applied to research on plants with different growth rhythms from current species.

e.g. (1) Lucerne - breeding and use in mixtures.

(2) Fodder crops for summer and winter production especially with high soil nitrogen.

(3) Winter growing pasture species.

7. Soil physical factors affecting pasture growth:

Efficiency of water availability to plants:

e.g. (a) Compaction.

(b) Water repellance.

8. Pests, diseases and weeds of pastures:

e.g.

(a) Red-headed cockchafer.

(b) Rhizoctonia in lucerne.

(c) Noxious and toxic weeds.

9. Effect of drainage and water table control on pasture growth