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TREBLING THE WHEAT YIELD.

Science Applied to Primary Production.

Address by Dr. A. E. V. Richardson.

With the application of scientific methods to agriculture, the wheat growers of South Australia might produce 40 bushels to the acre on the average, in the opinion of Dr. A. E. V. Richardson.

The director of the Waite Agricultural Research Institute (Dr. A. E. V. Richardson), delivered the third of a series of lectures dealing with the primary products of the State on Tuesday evening at the Prince of Wales lecture hall at the University. Dr. Richardson, whose lecture was illustrated by lantern slides, graphs, and tables, said the importance of agricultural and pastoral pursuits to the national welfare was reflected in the relative value which production from these sources bore to the total production. Of the £382,000,000 of new wealth created in 1923 the agricultural and pastoral industries contributed £220,000,000, or 58 per cent. of the total. During the same year, the total production of South Australia was £34,000,000, of which £22,000,000, or 64 per cent. of the total was contributed by the agricultural and pastoral interests. The principal source of revenue from the primary industries came from the 75,000,000 sheep, and 14,000,000 cattle which were maintained on the pastoral lands of Australia. The wheat crop furnished the main source of the revenue from agriculture, and wheat was relatively more important to South Australia than to any other State. Though this State normally produced 10 per cent. of Australia's agricultural and pastoral wealth, it contributed more than 25 per cent. of Australia's wheat output.

The climate of South Australia was not as favorable for intensive agriculture as some of the other States, owing to the limited proportion of high rainfall land. Moreover, the rainfall over a very large proportion of the State was too low and too uncertain to engage in profitable agriculture. Nevertheless, there was every reason to believe that the production from the wheat belt and from the pastoral lands of the State could be greatly augmented before the limits imposed by the rainfall were approached.

Wheat.

The average area sown to wheat in Australia was approximately 10,000,000 acres, of which South Australia normally contributed 25 per cent. The most important natural factors limiting the distribution of wheat were the total rainfall and its incidence, and the fertility of the soil. The rain of importance for wheat was that received during the growing period of the crop—April to October inclusive. Practically all their wheat was now grown between the lines of 7½ and 15 inches of winter rainfall—April to October. In South Australia, Victoria, and New South Wales, the 15 in. line of winter rainfall corresponded very closely with the southern boundary of the wheat belt, this line separating the dry farming areas from the closer settlement country where more intensive farming was possible. In Western Australia, however, there was a considerable area of wheat grown between the 15 and 20 in. lines of winter rainfall. The 10 in. line of winter rainfall had usually ben regarded as safe for wheat growing, but in South Australia and Victoria, wheat was grown over a very considerable area far beyond that line, even passing beyond the 7½ in. winter rainfall line. A portion of the wheat growing area of South Australia, and the newly opened mallee country in north-west Victoria, were outside the 7½ in. line of winter rainfall, and between the 7½ in. and 10 in. line of winter rainfall were the old established mallee districts of Veitch (South Australia), Ouyen and Swan Hill (Victoria) where wheat growing had been an established and successful industry for the past 15 years. It might therefore, be fairly assumed that country having a winter rainfall of 7½ in. of reliability equal to the areas indicated, was capable of being utilised for wheat under present conditions. Apart from Northern New South Wales, it would appear that the 7½-in. line of winter rainfall marked the present inland limit of the wheat belt. Transport facilities and competition with live stock industries were the main economic factors in determining the distribution of wheat. There were many million acres of land climatically suited for wheat which at present were either used for pastoral purposes or covered with mallee scrub. Under existing economic conditions, wheat-growing was unprofitable beyond 12 to 15 miles from existing railway lines, because of the cost of cartage. The factors determining the present actual limits of wheat belt were economic rather than climatic.

Sheep.

If the map showing the distribution of sheep in Australia were carefully examined,

mum sheep concentration was in south-eastern Australia on either side of the 20-in. line of rainfall. Along the moister eastern side of the continent there were no appreciable numbers of sheep close to the coast, nor in regions over the 30-in. line of rainfall. From this region of maximum concentration there was a wide belt of decreasing sheep concentration extending inland to the 5-in. line of rainfall. The main areas suggesting themselves as potential sheep country were the Victorian and South Australian mallee lands and a large tract of country in Western Australia within the 10-in. line of rainfall, bounded, roughly, by Southern Cross, Albany, and Eucla. It must be borne in mind that in most parts of Australia sheep-raising had pioneered the wheat industry. In the mallee country, however, the scrub must first be subjugated before sheep raising becomes possible, and the establishment of the wheat industry, therefore, preceded the stocking of the country with sheep. Judged from climatic considerations another potential sheep area appeared to be that portion of the Northern Territory lying between the 20-in. and 10-in. line of rainfall. The factors preventing the utilisation of this possible sheep area were lack of transport facilities, of suitable water supplies, and the prevalence of wild dogs. Apart from these areas the sheep lands of the Commonwealth appeared to be fairly well occupied. The number of sheep maintained in the Commonwealth was, on an average, between 75 to 80 millions. A large proportion of these were maintained in the areas of liberal rainfall. In these areas the stock-carrying capacity could be greatly increased by improving the pasture lands, either by sowing down artificial pastures or by stimulating the growth of native pastures with artificial fertilisers.

Cattle.

Approximately 70 per cent. of the fourteen million cattle in Australia were maintained in Queensland and New South Wales, and the influence of the big capital cities in increasing the cattle population for dairying and fattening was very marked. The influence of irrigation on cattle distribution was shown very clearly in the numbers of cattle found along the irrigated areas of the Murray Valley, but cattle were also found in considerable numbers from the arid interior, with a 5 in. rainfall, to coastal Queensland, with over 60 in. of rain per annum. Similarly, they appeared to thrive equally well with a temperature range of 85 degrees in North-West Australia to 55 degrees in the south-eastern corner. There appeared to be great possibilities for increased cattle production in the Northern Territory and North-West Australia. In both these territories were vast unoccupied areas, a large proportion of which should ultimately carry cattle in density approximating that of Queensland. Artesian and sub-artesian water and railway facilities had greatly helped the development of the cattle country in Queensland. The provision of transport facilities and water supply were the main factors which would greatly stimulate development in these undeveloped regions, and in what was known as the desert in the arid interior.

Development of the Wheat Industry.

It was a matter of common observation that a close relationship existed between the average wheat yield and the rainfall, especially the rainfall during the growing period of the crop. If they compared the average wheat yield of the State in bushels per acre with what might be termed the composite average rainfall during the growing period of the crop—April to October inclusive—a rather striking correlation was found. In order to determine the average winter rainfall for South Australia, the rainfall from April to October, at twenty typical wheat stations, was taken for a period of 35 years. The centres selected were Cowell, Streaky Bay, Fowler's Bay, Maitland, Paskeville, Orroroo, Redhill, Snowtown, Gladstone, Crystal Brook, Yacka, Saddleworth, Mallala, Balaklava, Wilmington, Coonalpyn, Bordertown, Loxton, Blanchetown, and Eudunda. Results were illustrated by a graph showing that from 1890 until 1910 the line representing the average yield of wheat for South Australia in bushels per acre was considerably below the line representing the composite seasonal rainfall expressed in inches of rain. From 1891 to 1910 the wheatgrowers of South Australia reaped little more than half a bushel of wheat for each inch of winter rainfall. From 1911 to 1924, with the exception of the drought year 1914, the two lines almost coincided, and in 1911, 1912, 1916, 1920, and 1924 the graph representing the average yield in bushels per acre was slightly above the graph representing the rainfall in inches. The

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latter were the years when the average wheat yield in bushels per acre slightly exceeded the seasonal rainfall in inches, i.e., when the wheatgrowers as a whole reaped more than a bushel of wheat for each inch of seasonal rainfall.

The increase in efficiency in wheat-growing was thus strikingly illustrated. If they left out of consideration the two abnormally dry seasons of this period—1902 and 1914—and compared the last ten years with the ten years prior to the 1902 drought, they got a striking comparison. For the ten years 1892-1901 the average wheat yield of South Australia was 4.74 bushels, and throughout this period the wheatgrowers obtained .41 bushels of wheat per acre for each inch of winter rainfall. For the past ten years the average yield was 12.45 bushels per acre, and the average rainfall 12.73. Hence the wheatgrowers reaped 0.98 bushels of wheat for each inch of rain. At the present time the average wheat yield of the State was approximately one bushel for each inch of winter rainfall received. The same general relationship held for Victoria.

For the 10 years, 1892-1901, the Victorian wheatgrowers averaged 7.65 bushels on an average winter rainfall of 11.49 in., or 0.67 bushels per acre for each inch of winter rainfall. During the last 10 years they averaged 14.58 bushels on an average winter rainfall or 12.9. Hence, for each inch of winter rainfall for the past 10 years they reaped 1.13 bushels per acre for each inch of rain received. Thus both in South Australia and Victoria the increase in efficiency, as revealed by the ratio of wheat-yield to rainfall, had been marked. This, too, in the face of the fact that during the last decade large areas of new mallee land, with a low rainfall, had been added to the wheat belt of each State. In these newer mallee areas, which now formed a considerable proportion of the wheat belt of each State, wheatgrowers had not yet been able completely to abandon pioneering methods, which in the mallee always resulted in low average yields. The average wheat yield of the State could not, therefore, be taken as representing the full or normal wheat production, but it might be expected that yields of the whole State would steadily improve coincidentally with the improvement in farming methods in the mallee aeas. For the period 1892-1901 the Wimmera wheat farmers averaged 7.08 bushels per acre on a winter rainfall of 11.92. Thus they reaped 0.59 bushels per acre for each inch of rainfall received. Throughout this 10-year period their average yields were less than the average yields of the State. During the last 10 years, however, the average yield had been 20.77 bushels per acre, on a rainfall of 12.93. Thus, during the last 10 years they had reaped 1.60 bushels of wheat for each inch of winter rainfall. The average yield was nearly three times as great as it was 20 years ago. The main factor which had brought about this improvement was the almost universal adoption of the following practices, which were demonstrated very clearly at the experimental station established by the Victorian Department of Agriculture at the Longerenong Agricultural College:—

1. The adoption of late seeding, which in the Wimmera invariably led to cleaner crops, a marked increase in the proportion of grain to straw, a reduction in the water cost of grain produced, and a substantial increase in the yield per acre compared with early sown crops.

2. The recognition of the value of fallowing, and of the thorough working of the fallows to retain soil moisture and promote nitrification. Summer fallowing, or the adoption of a fifteen-months' fallow, was very general in the Wimmera.

3. The use of heavy dressings of water soluble phosphate, especially where cultural methods were thorough. Heavy dressings of superphosphate, when supplemented by conserved soil moisture and abundance of nitrates, led to increased wheat yields at a lowered water cost.

4. The general use of a variety of wheat —Federation—which, under actual field tests, proved to be better suited to Wimmera conditions than any other variety.

Many farmers in the Wimmera were reaping bags per acre where they reaped bushels per acre years ago.

Bigger Yields.

It had been shown that at present South Australian farmers obtained 1 bushel, the Victorian farmers 1.13 bushels, and the Wimmera farmers 1.60 bushels per acre for each inch of rain falling between April and October, but what yield of wheat per acre was possible if production were pushed to the limit? There was much evidence to show that the rainfall of the wheat belt was sufficient to give yields considerably greater than those obtained at present. Investigations, covering a period of six years, were made at Rutherglen, Victoria, to determine how much rain had to pass through a crop to produce a ton of dry matter, grain, and straw, and to produce a bushel of wheat. During these investigations it was found that the water requirement of wheat was not constant but varied considerably with the season. Thus the average water requirement of wheat during the drought year 1914 was found to be double, that of the following season. It was found that the amount of rainfall required to produce, say, a ton of wheat varied considerably with the season, and was dependent on the intensity of the atmospheric conditions, i.e., air temperature, velocity of wind and dryness of the atmosphere at the stage of maximum transpiration of the crop which usually occurred in October and November. Over a period of six years, it was found that 1,067 tons of water had to pass through a crop of wheat to produce one ton of grain, and as an

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weighed 101 tons, 10.53 inches of rain has to be used by the crop in order to produce one ton of wheat, so that each inch of rain produced over an average of six seasons 3.54 bushels of wheat. Therefore, with moderate rainfalls, each inch of rain was capable of giving a yield of 3½ bushels per acre. It was evident that the whole of the rain falling between April and October could not be used by the wheat crop. Portion must inevitably be lost by evaporation from the soil. Large as the losses by evaporation might be, it was probable they were at least counter-balanced by the moisture conserved in the soil from the previous year by fallowing. Investigations showed that fallowed land in the Wimmera contained at seed time at least 4 to 5 inches more moisture than non-fallowed land, which was equal to 35 per cent to 40 per cent. of the normal April to October rains. If they assumed that the water lost by evaporation from the soil was approximately equal to that conserved in the soil by fallowing the whole of the seasonal rainfall was then available for purposes of transpiration. As the composite seasonal rainfall for the past 33 years was practically identical for Victoria, South Australia, and the Wimmera, namely 11½ inches, it would appear that the maximum possible production on the rainfall would be 11½ multiplied by 3.54, or slightly over 40 bushels per acre. South Australia secured much less than a third of this yield, Victoria is slightly more than one-third, and the Wimmera farmers about one-half of the possible yield.

On the Longerenong Agricultural College Farm the yields of wheat over an average area of 300 to 400 acres had in recent years been remarkable. On this farm the Victorian Department of Agriculture established in 1912 an experiment station to investigate wheatgrowing problems. Cultivation, variety, manurial, rate of seeding, time of sowing, and crop rotation tests had been conducted for the past 12 years. As the lessons from these tests became manifest, they were gradually put into practice on the farm area. On an average winter rainfall of 11.84 inches, the average yield of the whole farm, representing from 300 to 400 acres under crop, had been 35½ bushels per acre. Exactly 3 bushels per acre had been reaped for each inch of winter rainfall. For the past five years the results were even more striking. On an average winter rainfall of 11.1 inches, an average yield of 39½ bushels per acre had been obtained, or 3.51 bushels for each inch of winter rain. The Nhill Agricultural Society had for the past 25 years conducted crop competitions for the best crop of the district. Among the many farmers who had competed for these competitions were R. O. Blackwood, of Kiata, and W. Dahlenburg, of Salisbury, Victoria. Mr. Blackwood's crop for five years, on a winter rainfall of 11.39 inches, was 39.6 bushels per acre, an average of 3.48 bushels for each inch of rain. Mr. Dahlenburg, on lighter rainfall country, over a five-year period averaged 31 bushels on 8.5 inches of winter rain—a return of 3.6 bushels for each inch of winter rainfall. It was evident, then, that there were cases where men were securing the full wheat yield expected from the rainfall, and it was safe to say that if the many could be encouraged to do what the few were already doing, the average wheat yield of the State could be greatly increased. The composite winter rainfall for Victoria and South Australia over a 30-year period was 11½ inches. If they assumed that the water losses from the soil by evaporation were balanced by the water conserved by fallowing, thus making available the whole of the winter rainfall for transpiration, then the average rainfall of the State was sufficient to produce an average yield of 40 bushels per acre. This average had actually been obtained for the past five years by their best farmers, though the present State production was much less than one-third of that amount. Clearly, then, wheat production, both in Victoria and South Australia, might be greatly increased before the limits imposed by the rainfall were approached.

DEVELOPMENT OF PASTURE LAND.

The natural pastures of Australia supported practically the whole of the sheep and cattle of the country. Grass was nature's forage, the healthiest and most nutritious food for livestock. Though Australia had a wealth of native grasses and fodder plants, there were relatively few edible leguminous plants, and no indigenous plants of the genus Trifolium—the clover family. The clovers and trefoils greatly improved the succulence and the nutritive value of pastures, and materially assisted in improving the fertility of the soil because of their capacity to gather nitrogen from the air. The pasture plants of the drier portions of Australia were unrivalled for their grazing and wool-producing value. While, therefore, they should continue to rely on native grasses for the great bulk of pasturage, they should not hesitate to use introduced grasses, clovers, and fodder plants in the moister regions where the soil and climatic conditions were very favorable for their development.

DETERIORATION OF GRASS LANDS.

It was a matter of common observation that many of their native pastures showed signs of deterioration, and in some cases the livestock showed evidence of malnutrition. Natural pastures deteriorated through overstocking and injudicious grazing, and the continual removal from the soil of the elements of nutrition by the annual crop of wool, lambs, and fat stock without the replacement of these nutritive elements by means of fertilisers. In addition, in the heavier rainfall district mineral nutrients, e.g., nitrates and lime, were