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WHEAT CULTIVATION.

Factors for Success.

Mr. A. E. V. Richardson, M.A., D.Sc., Director of the Waite Agricultural Research Institute, deals with the question of factors for success in wheat cultivation in the April issue of the "Victorian Journal of Agriculture." While the article deals almost wholly with Victorian practices and conditions, the contentions are of considerable importance to South Australia, where conditions are similar.

In considering the factors for successful wheat culture in Victoria, says Mr. Richardson, it is well to remember that nearly 90 per cent. of the wheat produced there is grown north of the Dividing Range, in a region of relatively low rainfall. The three great wheat districts of the State are the Mallee, the Wimmera, and the Northern areas. During recent years the Western District has become an important wheat area, and is destined to produce in the future an increasing proportion of the wheat of the State.

The average annual rainfall of these areas may be taken as follows:—Mallee, from 10 to 14 inches; Wimmera, from 14 to 17½ inches; Northern, from 14 to 21 inches; Western District, from 18 to 25 inches. The greater part of the rain falls from April to October, and the late spring and summer months are invariably hot and dry. What are the factor for success in wheat cultivation under such conditions? From the point of view of maximum production of wheat per acre we may say that the following are essential:—(1) Conservation of soil moisture by early fallowing and thorough working of the soil. (2) Liberal manuring. (3) Regular crop rotation and association of sheep with wheatgrowing. (4) Rational use of seed. The observance of these principles will make for the production of good crops and the maintenance of soil fertility. They are the foundation of successful wheatgrowing from the cultural standpoint. But more than this is required to make a successful wheatgrower. Business methods and executive ability are quite as important as production methods, for if the wheat and sheep are produced at too great a cost, or marketed unwisely, the farm may bring in but little profit.

An effort must be made to cheapen production at every possible point by good business management and the use of efficient plant and labor.

The wheatgrower must try to discover the point at which increased labor and fertility applied fails to produce more than a corresponding increase in the crop return, and endeavor to reach this point but not pass it. We may add, therefore, two additional factors which make for success:—(5) Efficient implements and plant. (6) Good management and business ability.

Conservation of Moisture.

It is a matter of common observation that well-fallowed land in our wheat districts will grow bushels more wheat per acre than land that has been merely stubble-ploughed. Various experiments in the drier parts of the wheat belt, as well as the practical experience of farmers, have both conclusively demonstrated that more wheat can be grown over a period of years on a given block of land by cropping it every other year than by growing wheat continuously on the same land every year. In these days of costly labor it is becoming more and more necessary to carry out a thoroughly efficient system of cropping. It does not now pay under Victorian conditions to raise small crops. The most profitable system of agriculture under existing economic conditions in the wheat belt is to grow the largest crops possible on those parts of the farm as are reserved for grain. The way to do this is to raise such grain crops less frequently, precede the wheat with a bare fallow, and either pasture occasionally or use forage crops for feeding down with sheep and lambs in a rotation with wheat. This is the keynote of successful wheat-farming in these areas.

It is often stated that the continual practice of bare fallowing deprives the soil of organic matter—the soil's most valuable constituent—and therefore it may be supposed that bare fallowing will gradually impoverish the land. If the land is impoverished, the fault lies not so much with the practice of bare fallowing as in growing too many grain crops and carting them off the farm instead of growing them in rotation with forages and pasture for feeding down by sheep and lambs.

With the adoption of judicious rotation there need be no fear that the practice of fallowing will ultimately result in soil depletion.

The advantages of the practice of bare fallowing have already been emphasised.

(1) The fundamental principle underlying the practice is that it conserves soil moisture—the limiting factor for successful agriculture in an arid country, and it enables a considerable portion of the rainfall of one year to be conserved in the soil through the summer, and thus to augment the supplies which fall subsequent to the sowing of the crop. It places at the disposal of the wheat crop the rainfall of two seasons.

(2) It distributes work of the farm evenly throughout the year, and enables the wheat-grower to have ready in autumn large areas of land in the best possible state of tilth to receive the seed as soon as the weather conditions are favorable to seeding. This is a matter of considerable importance in the drier parts of the State, where the normal seeding season is so restricted. When favorable conditions for seeding exist, it is necessary for the farmer to concentrate his energy, not on the ploughs, but upon the drills. If the ploughing has to be done at seed time, the subsequent seeding must be delayed, and danger arises from the ill-effects of a non-consolidated seed bed.

When it is realised that the main object of fallowing is to conserve moisture, it will be obvious that the sooner fallowing is commenced, the more the moisture that can be conserved, and the better the ultimate prospects of success. It has been repeatedly demonstrated that land fallowed early gives, in normal years, heavier crops than land fallowed late, whilst in dry seasons the crop grown on early fallowed land is worth bushels per acre more than that raised on land fallowed late.

Summer Fallowing.

Summer fallowing has become a common practice in the Wimmera. The black clay loams, which constitute so large a proportion of the Wimmera, are well suited to the adoption of this practice. The land to be prepared for fallowing is skim-ploughed in February or March, or in some cases it is disced. A loose mulch is thus formed on the surface, which not only conserves the moisture, but assists the rapid germination of the weeds with the first rains. In July and August, after seeding is completed, this summer-fallowed land is re-ploughed or scarified. Such land as is ploughed late in spring is immediately worked down with a scarifier or harrows to conserve moisture and eliminate weeds. From spring until the following autumn the land is kept in a friable condition by scarifying or harrowing as often as is necessary to preserve the mulch. On the better lands in the Wimmera from eight to twelve operations are included in this summer working.

In other districts the number of scarifyings or harrowings is much less. The essential point is to keep the top layer of 2½ in. as loose and friable as possible throughout the summer. Fixed tined scarifiers are very popular in the Wimmera, as they can be relied upon to loosen the hardest soil and suppress weeds. Disc cultivators are less frequently used, though in other districts, especially where the soil tends to set very hard, the disc cultivator does effective work.

No set methods can be recommended for all districts, but the principle of maintaining a loose shallow surface mulch on the soil throughout the summer months must be adhered to if heavy yields are to be obtained. No good purpose is served by merely cultivating the soil when the surface mulch is loose and dry. Cultivation is needed only to break up the surface crust after rain or to destroy weeds. Sheep are very useful on the wheat farm for this latter purpose. They consume weeds on the fallow and assist in consolidating the seed bed.

Thorough tillage, which has as its aim—(1) Preservation of a loose mulch; (2) tining and firming the seed bed; (3) destroying weeds; (4) promoting aeration and bacterial activity—is essential for successful cultivation in regions of low rainfall. In the Wimmera, tillage operations have become more or less standardised, and the methods are well adapted to meet the soil needs and the peculiarities of the climate. In other districts much investigational work is necessary to determine the best combination of tillage methods to suit the soil needs.

The wheatgrower must ever bear in mind that the next season may be a dry one, and the tillage methods adopted should be such as will ensure a successful crop if the rainfall is below the average.

The methods which will secure a favorable crop in a dry year will be suitable also for a normal season. In excessively wet seasons the differences between well-worked and neglected fallows are to some extent levelled down because both types of fallows have sufficient moisture to mature a heavy crop. Such seasons occur but infrequently in the wheat belt, so that on the whole the farmer must adapt his practice to meet the exigencies of normal seasons and years of low rainfall.

The importance of early fallowing and summer fallowing is obvious, but neither early fallowing nor summer fallowing will be of much avail if the fallows are neglected through the summer. A neglected fallow is little better than stubble-ploughed land for raising wheat crops.

There is an old saying that "tillage is the best manure." Very little is known of the changes which take place in the soil constituents as a result of tillage. We do know, however, that nitrates are rapidly formed in well-worked fallows, and that by seed time sufficient is available in the soil to bring the heaviest wheat crop to maturity.

There is reason to believe that other mineral nutrients are made available for the use of the crop, though it would doubtless be very difficult to show this by chemical analysis. The soil contain enormous reserves of dormant plant food, and the aim of the farmer should be to render as much of this available as possible by thorough and frequent cultivation. The more thoroughly the soil is tilled, the more available plant food will be formed, and the less will be the manure bill. It is in this sense that "thorough tillage is a substitute for manure." Jethro Tull recognised this fact over 150 years ago, and founded his "Horsehoeing Husbandry" on it.

A fine illustration of the value of thorough tillage is shown in the results of the manurial tests at Longerenong. The unmanured plot at Longerenong for a ten-year period average 20½ bushels. For the past decade a well-worked fallow, without fertiliser, has averaged at this centre nearly 30 bushels per acre—a yield more than double that of the State.

Finally, apart from conservation of moisture, extermination of weeds and production of available mineral nutrients, there is one other important advantage from thorough tillage, namely, the consolidation of the seed-bed.

Every experienced wheat-grower knows how important it is to have a firm, finely divided, consolidated seed-bed for his wheat crop. Oats or barley will thrive on loose open seed-beds, but for wheat a firm, finely divided seed-bed is essential for success.

The consolidation of the seed-bed cannot be secured in a week or a month. Time is a necessary factor for the process, and the consolidation is brought about by the packing action of the rain and the frequent stirring of the soil. Such a seed-bed, resting on a moisture-laden subsoil, is in the very best condition, not only for resisting dry spells, but also for yielding heavy crops.

The advantage of a fine, firm seed-bed in a dry season is very marked. The finely divided soil particles act as an unbroken series of force pumps on the storage reservoir below, and keep the roots rapidly and constantly supplied with moisture.

With a loose, open, cloddy, seed-bed capillary action is slow and irregular, and in time of stress the crop will suffer. Such a seed-bed is the invariable result of hasty preparation of the soil. The best preparation for a wheat crop in districts with a limited annual rainfall, the bulk of which falls between April and October, is to fallow early and well, to keep the soil thoroughly cultivated through the summer, and to be ready to concentrate the whole strength of the farm on the drills and cultivators when the first favorable autumnal rains fall.

Example of Benefits.

The benefits of preceding the wheat crop with a bare fallow are shown by the results of field tests at the experimental farms:—

	Bushels per acre.
1. Werribee—Average of nine years:—	
Wheat continuously	7.0
Pasture, fallow, wheat	17.1
Oats, pasture, fallow, wheat	17.7
2. Longerenong—Average of six years:—	
Wheat continuously	11.17
Wheat after bare fallow	34.03
Wheat, pasture, bare fallow	35.32
Wheat, oats, bare fallow	38.05
Wheat, oats, pasture, fallow	37.08
Rutherglen Experimental Farm—Average of five years:—	
1. Ploughed 5 inches in July and worked through the summer	17.5
2. Ploughed 5 inches in July and not worked through the summer	12.8
3. Ploughed 5 inches in autumn, just before seeding	7.4

Use of Manures.

The guiding principle in the use of manures is to encourage the formation of soluble mineral nutrients by thorough tillage, and supplement any deficiencies with fertilisers. Actual experiment is the best means of determining those soil needs. The problem for the farmer is to discover the most economical and profitable way of supplying these needs. Speaking generally, the chief deficiencies of Victorian wheat soils are organic matter and phosphoric acid. Increasing the organic content of the soil is a very difficult problem for the wheatgrower on account of the large area of a wheat farm and the very limited supplies of organic matter available for this purpose. Indirect means, e.g., crop rotations and pasturing, may possibly counteract the great losses of organic matter which result from bare fallowing. The rate at which organic matter is lost and may be replenished in Victorian wheat soils is a matter for investigation.

Except in wet seasons and in districts of heavy rainfall, the use of stable manure does not materially increase wheat yields. Though the organic content of Victorian wheat soils is low and the amount of nitrogen present much less than in European soils, experimental work has shown that nitrates are unnecessary in all but the wetter areas. Adequate reasons have been furnished for this lack of response to nitrates. So far as phosphates are concerned, practical experience and the results of numerous experiments have not make up for deficiencies in cultural methods. With the adoption of thorough tillage methods, the full benefit of liberal fertilising is obtained.

The average amount of superphosphate used per acre in 1911 in the wheat districts of Victoria was as follows:—Mallee, 47 lb.; Wimmera, 59 lb.; Northern, 61 lb.; North-East, 71 lb.; Western District, 95 lb. Since then the quantity used per acre has been steadily increasing. Notwithstanding the conclusive results obtained on departmental farms and on farmers' experimental plots throughout the State of the value of liberal dressings of phosphate, wheatgrowers as a whole have been conservative in applying the lessons from the experiments.

During the past few years the manufacturers of superphosphate have been conducting extensive propaganda work with the object of increasing its consumption.

The following table shows results of tests with light and heavy dressings of superphosphate:—

	Longerenong (10 years' average).	Rutherglen (6 years' average).	Werribee (10 years' average).	All centres.
	Bush.	Bush.	Bush.	
No manure	29.2	9.8	7.8	15.6
½ cwt. super	33.3	14.8	13.6	20.6
1 cwt. super	34.3	15.7	15.6	21.9
2 cwt. super	36.9	16.3	16.8	23.3

These results demonstrate that heavy dressings of superphosphate give a higher yield and a more profitable yield than the ½-cwt. application.

Valuing the wheat at 4/6 per bushel, its approximate average value for the period under review, and superphosphate at 5/ per cwt., the net profit from each application works out as follows:—

	Yield.	Increase over unmanured plot.	Value of increase at 4/6 per bushel.	Cost of fertiliser.	Net profit per acre.
	Bush.	Bush.			
No manure	15.6	—	—	—	—
½ cwt. super	20.6	5.0	22/6	2/6	20/0
1 cwt. super	21.9	6.3	28/4	5/0	23/4
2 cwt. super	23.3	7.7	34/8	10/0	24/8

Even if the heavier dressings gave no greater net profit than the ½-cwt. dressing, there is the indirect effect of the liberal dressings to take into consideration. Heavy dressings of superphosphate lead to increased growth of pasture when the land is left in pasture. This is a common experience in the wheat belt. The indirect effect of heavy dressings on the growth of grass on stubbles is very marked at Werribee during winter and spring. Thus the stock-carrying capacity of a wheat farm may be gradually increased by a policy of liberal dressings with phosphate. Not only is the maximum wheat crop obtained from liberal dressings of superphosphate, but the quantity, and certainly the quality, of the grass is greatly improved.

Experiments have shown that the application of liberal dressings of phosphate result in the economical use of the water supply and a low transpiration ratio. This does not mean that a manured crop requires less water than an unmanured crop. In fact, a manured crop generally uses more water, because it grows vigorously and usually has a greater leaf surface from which transpiration takes place. But transpiration is a physical phenomenon depending mainly on the evaporating power of the atmosphere (i.e., air temperature, relative humidity, and wind velocity) and the water-content of the leaf.

With a liberally manured crop the plant grows vigorously without check, and is increasing in dry matter economically throughout the whole period that it is transpiring water. But on an unmanured soil or an infertile soil, or a soil in which soluble phosphate is wanting, the plant is transpiring water continuously (as a resultant of the physical environmental factors), but owing to lack of phosphates, growth, i.e., increase in dry matter, may be suspended, with the result that the transpiration ratio for the unmanured crop may be excessively high.

Any factors which assist a crop to grow in a normal or a vigorous manner will bring about a reduction in the transpiration ratio for the same reason.

Summing up, we may say that there can be no doubt as to the value of soluble phosphates for the whole of the wheat belt, but the quantity of phosphate to apply will vary with the rainfall, the soil, and with the standard of the cultural methods employed, and that the tendency will be for more liberal dressings of fertiliser to be used. The best quantity to use under any given set of circumstances can be determined only by actual field experiments over a series of years.

Liberal dressings are justified, especially if cultural methods are thorough, to give the maximum yield possible on the rainfall, and to stimulate the subsequent growth of grass on the stubbles and increase the stock-carrying capacity of the farm.

Sheep and Wheat-growing.

The outstanding weakness in our system of wheat culture is that in many cases little or no provision is made for the restoration of organic matter. It is well known that the losses of organic matter due to fallowing in an arid climate are very considerable. The fertility of the