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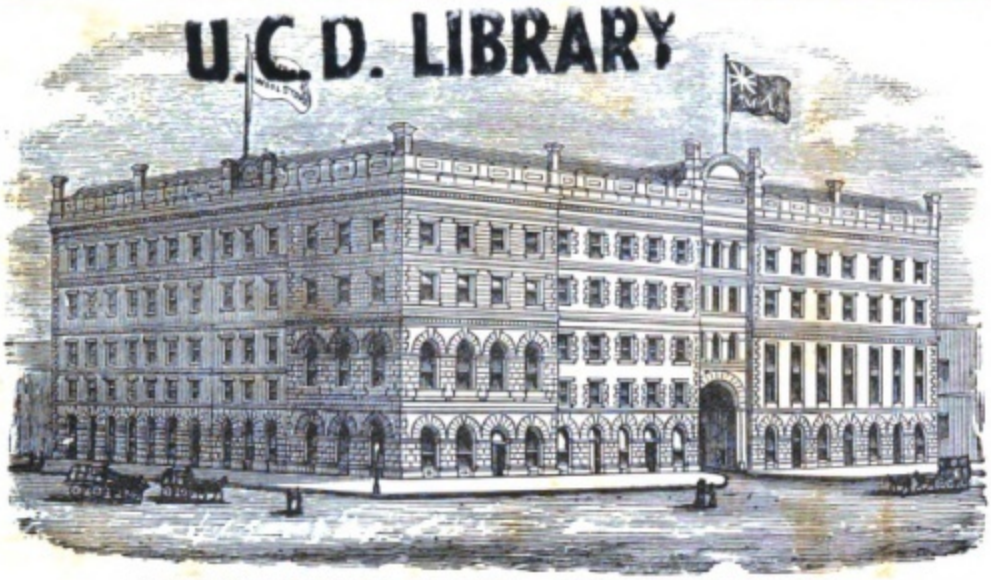

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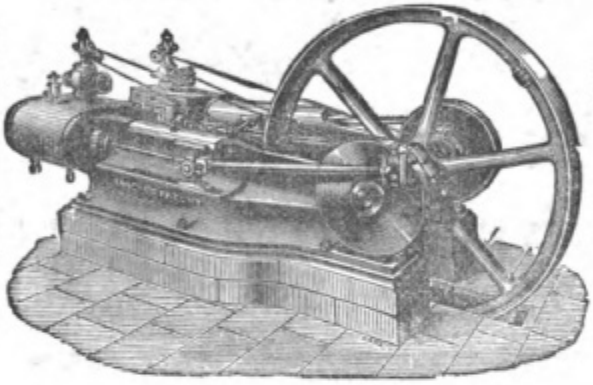

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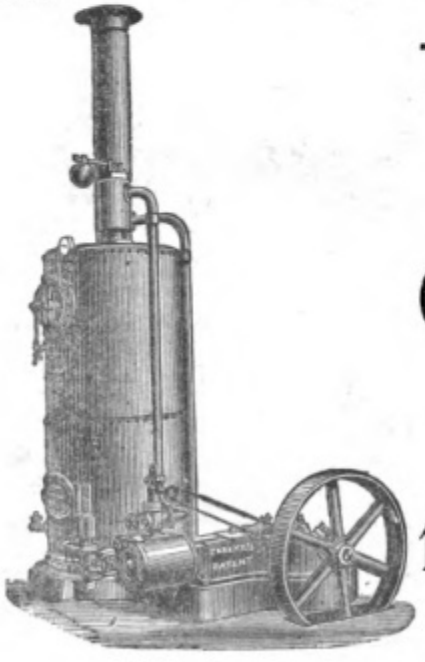

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THE

AUSTRALASIAN FARMER

A PRACTICAL HANDBOOK FOR THE FARM AND STATION

By the Agricultural, Horticultural, and Pastoral Staff of the "Australasian"

Published for

WILSON AND MACKINNON, Proprietors of the "Australasian"

BY

GEORGE ROBERTSON & COMPANY

MELBOURNE, SYDNEY, ADELAIDE, AND BRISBANE

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INTRODUCTION.

THE AUSTRALASIAN FARMER is intended to supply the occupiers of land in the colonies with that class of practical information which cannot be obtained in existing works upon agriculture. In the Australasian colonies the various rural industries connected with the cultivation of the soil and the breeding of live stock are carried on under new conditions, requiring the adoption of methods differing widely from those followed in the older countries of the Northern Hemisphere. There are peculiarities of climates, differences of soils, the higher rate of labour ruling in a sparsely-populated new country, the value of land as an element in the cost of production, the market value of products, and various other circumstances which render it necessary to carry on all branches of rural industry upon a system suited to the requirements of local conditions. Hence it is that standard agricultural treatises prepared in other countries contain but little of the practical information which the colonial cultivator or stock-breeder requires. The general principles of agricultural science are taught in English and other works upon the subject, but the directions given for applying those principles to the operations

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of the farm, the station, the vineyard, orchard, or garden cannot be taken as a guide under the altered conditions met with in the Australasian colonies. It is probably largely due to the absence of any reliable guide in these matters, and to the evident want of such information which is experienced by land-owners and occupiers, that the newspaper press in the colonies has come to devote such a large share of attention to agricultural subjects. The *Australasian*, as the leading weekly journal of the colonies, has from time to time enlarged its agricultural department, the spread of settlement and the rapid development of rural industries demanding for its readers an increasing amount of practical information of the kind unsupplied in available works upon agriculture. At first the operations of the cultivator, as well as of the grazier, were largely experimental in the new surroundings of this part of the world. As experience was gained, the results were noted and published in the newspapers, and thus the best methods of carrying on the various operations became known to those who came after the pioneers. There is still much to be learned from the results of future experiments, and the *Australasian's* work of collecting, by means of its staff of special reporters, and disseminating through its columns agricultural information as it becomes available, will no doubt have to be continued for a long time. Even in England agricultural science continues to make new discoveries, and we may, therefore, expect that in the Southern Hemisphere there is available a wide and fruitful field for investigation. A great deal has been learned, however, by the intelligent and enterprising men who have been for a generation

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or two following farming pursuits in these colonies. There is, in fact, an unwritten law of Australasian practice in regard to all branches of farming and grazing, and it is this which the present work attempts to put into collective form. The conductors of the *Australasian* have been so frequently asked to recommend their readers a suitable book upon colonial farming that the want of such a work as is now provided has been clearly shown. The weekly list of questions which are answered in the correspondence columns of the journal has also formed a guide as to the lines upon which the work should be prepared. With such a guide to the requirements of the reader before them, the members of the agricultural, pastoral, and horticultural staff of the journal have endeavoured in the following pages to provide a thoroughly practical hand-book for the farm and station. The book is not intended to take the place of more exhaustive standard works, but to apply the principles laid down in these to the practical conditions of farming in the Australasian colonies. Although confining the treatment of each branch of the subject within reasonable limits, it is believed that the directions include everything that is really essential, and the scope of the book is sufficiently comprehensive, including chapters upon all the industries connected with the occupation of land in the colonies. Directions are given concerning settling upon land, and the various operations of cultivating and harvesting cereal, root, and green crops, together with chapters upon pastures, vineyards, orchards, gardens, hop grounds, and tobacco plantations. The live stock department

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of the book deals with horses, sheep, cattle, swine, poultry, and bees, and directions are given upon dairying, the treatment of wool, the drying of raisins, the preservation of fruit, and other rural operations. The information has been methodically arranged, and a complete index has been provided to facilitate references to any department of the work.

THE "AUSTRALASIAN" OFFICE,

May, 1885.

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THE AUSTRALASIAN FARMER.

CHAPTER I.

SOILS.

THE soil is the basis of all agricultural operations, being that portion of the earth's surface which supports vegetation. Its origin is the rocks, and it has been formed by the various forces of nature, which have disintegrated the mineral particles, and produced, by chemical changes and mechanical combinations, the conditions favourable to vegetable life. Soils differ in character according to the composition of the rocks from which they have been formed, and according to the proportion in which they contain their different constituent parts, as well as according to the physical agencies which have been most potent in their formation. Owing to the numerous varieties of soils, all systems of classification are more or less unsatisfactory; but that which divides the soils into classes according to the proportion of clay and sand which they contain is popularly adopted as sufficiently accurate for practical purposes.

Pure clay, consisting of silica and alumina, is a substance in which the particles are so fine as to be perfectly soft to the touch. It readily absorbs and persistently retains water, forming, when moist, an adhesive and impervious mass.

Pure sand is the reverse in characteristics from clay. It consists of small granules of rock, which do not adhere to each other, and it is rough and gritty to the touch. Sand will absorb only a small quantity of moisture, and it possesses a very limited capacity for retaining water.

Strong clay soil consists of clay mixed with 5 to 15 per cent. of sand.

Clay loam is a soil containing clay, mixed with from 15 to 30 per cent. of sand.

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A loamy soil consists of clay and from 30 to 60 per cent. of sand.

Sandy loam is a soil in which sand predominates, the clay amounting to from 10 to 40 per cent.

A sandy soil contains over 90 per cent. of sand, and less than 10 per cent. of clay.

This classification of soils gives five divisions, but the terms *vegetable* soil, *alluvial* soil, *volcanic* soil, *marly* soil, and *calcareous* soil are also in common use, and, therefore, may be taken as convenient names for designating the kinds of soil to which they refer.

Vegetable soil contains more than 5 per cent. of decayed vegetable matter, called *mould* or *humus*. When soils of this class contain 60 or 70 per cent. of vegetable matter, they are also called *peaty soils*.

Alluvial soils are those which have been formed by the action of water, the substances of which they are composed having been carried by water, and deposited in their existing position.

Volcanic soil is the name given to soil formed directly from lava or volcanic rocks.

A *marly soil* is one which contains from 5 to 20 per cent. of lime.

Calcareous soils are those which contain over 20 per cent. of lime.

The subsoil, as its name implies, is the stratum which lies under the surface soil.

When soil is exposed to the action of fire, a portion of it is consumed and dispersed in the form of gases, and a portion remains in the form of ashes. The portion which passes off is organic matter, and that which remains is inorganic, or mineral. It is important to remember the two distinct characters of the matter of which soils are composed. The inorganic or mineral substances are derived directly from the rocks, while the organic matter has been derived indirectly through organized plants or animals, or through the atmosphere. The following are the inorganic or mineral constituents of soils :—

Silica	Lime
Phosphoric acid	Potash
Carbonic acid	Soda
Sulphuric acid	Magnesia
Chlorine	Oxide of iron
Alumina	

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The organic constituents of soils are carbon, oxygen, nitrogen, hydrogen.

The fertility of soils depends upon the proportion in which these constituents are contained, and upon the condition in which these elements exist. Thus a fertile soil not only contains a sufficient quantity of the elements necessary for the support of vegetable life, but contains those elements in a condition which renders them available as plant food. In the treatment of soils, therefore, it is essential to bring about the conditions necessary to make the constituent parts available for the use of plants, to maintain the supply of the various elements required by the crops which are cultivated, and to add any constituents that may be absent, or not present in sufficient quantities.

CHAPTER II.

THE COMPOSITION OF PLANTS.

As all vegetation is supported by the soil and the atmosphere, it follows that the constituents of plants are identical with the elements of which the soil and the atmosphere are composed. The substances of which plants are composed are divided into two classes, viz., inorganic or mineral, and organic. The mineral or inorganic parts are those which remain in the form of ash when plants are subjected to the effect of fire, and the organic parts are those which pass off in the form of gases under similar treatment. All the inorganic elements of plants are derived from the soil; but the organic constituents are obtained partly from the atmosphere and partly from the soil. In the process of vegetation chemical changes are wrought, and chemical compounds are produced, bringing into existence substances which are distinct from the elements of which they are composed. Chemical changes are also produced on the soil and atmosphere apart from those produced by vegetation, so that when the composition of plants is analyzed a number of substances are found which have not been named in treating of the constituents of soils.

THE CONSTITUENTS OF THE ORGANIC PART OF PLANTS.—The organic matter of which plants are composed consists of the following elements—*carbon, oxygen, hydrogen, nitrogen,*

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sulphur, and *phosphorus*. Chemical compounds produced from these elements are found in the organic parts of plants, and the compounds are divided into two classes viz., *nitrogenous* and *non-nitrogenous*. The *nitrogenous* substances are composed of carbon, oxygen, hydrogen, and nitrogen; while the *non-nitrogenous* bodies contain carbon, oxygen, and hydrogen, without nitrogen. The following are the principal constituents of the organic parts of plants, thus classified :—

Non-nitrogenous.	*Nitrogenous.*
Cellulose	Albumen
Starch	Fibrine
Sugar	Caseine
Gum	
Oil	

A large proportion of all vegetable matter consists of water, which is a compound of oxygen and hydrogen. When the water is evaporated by heating the vegetable matter in an oven, what remains consists of combustible and non-combustible substances. The combustible part, or that which can be consumed by fire, passing off in the form of gases, consists of organic matter; and that which remains in the form of ash, is inorganic or mineral matter. The following table (MacIvor's) shows the proportion of water, organic, and inorganic matter, contained in several farm plants :—

	Clover Hay.	Potatoes.	Peas.	Wheat. Grain.	Wheat. Straw.
Water	15.0	75.55	14.0	14.4	14.4
Albuminous bodies ...	14.2	2.06	23.5	13.0	2.0
Starch, sugar, and other non-nitrogenous bodies	37.2	18.54	50.0	67.0	30.1
Cellulose (fibre)... ...	24.8	2.11	9.0	3.0	47.5
Fat	3.1	0.75	1.0	0.6	0.5
Ash	5.7	0.99	2.5	2.0	5.5
	100.0	100.00	100.0	100.0	100.0

Taking vegetable produce after the watery constituents have been dispelled, or in a perfectly dry state, it is found to contain chiefly the following substances, in the proportion stated :—

	Clover Hay.	Potatoes.	Peas.	Wheat. Grain.	Wheat. Straw.
Carbon	47.4	44.0	46.5	46.1	48.9
Hydrogen...	5.0	5.8	6.2	5.8	5.3
Oxygen	37.8	44.7	40.0	43.4	38.4
Nitrogen	2.1	1.5	4.2	2.3	0.4
Ash	7.7	4.0	3.1	2.4	7.0
	100.0	100.0	100.0	100.0	100.0

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THE MINERAL CONSTITUENTS OF PLANTS.—Nearly all the mineral constituents of soil are found in the composition of plants. They generally exist in the form of compounds, to which distinctive names are given. The following elements and compounds are the principal constituents of the ash of plants :—

Potash	Phosphoric acid
Soda	Sulphuric acid
Lime	Carbonic acid
Magnesia	Silica
Oxide of iron	Chlorine

The proportion in which these mineral constituents exist in several different plants is shown in the following table by MacIvor :—

	Wheat.		Peas.		Mangels.		Sugar Cane.
	Grain.	Straw.	Grain.	Straw.	Roots.	Leaves.	
Potash	31.1	11.5	40.4	21.8	46.6	25.5	13.7
Soda	3.5	2.9	3.7	5.3	18.4	23.3	3.1
Lime	3.1	6.2	4.2	37.9	5.9	10.4	5.1
Magnesia ...	12.2	2.6	8.0	7.7	4.8	9.7	13.0
Oxide of iron ...	...	...	...	...	0.8	1.2	...
Phosphoric acid	46.2	5.4	36.3	7.8	8.3	5.4	6.6
Sulphuric ,,	2.4	2.9	3.5	5.6	3.7	7.2	6.4
Carbonic ,,	...	...	...	...	...	...	...
Silica	1.7	66.3	0.9	5.7	4.0	3.3	50.0
Chlorine	2.3	6.1	9.9	17.8	2.4		

From the foregoing statements in regard to the composition of plants it is evident that in the process of vegetation the plant derives the substances of which it is composed from the soil and the atmosphere. Water, the source of which is the atmosphere, is the largest component of most plants, while of dry vegetable produce the larger part consists of organic or non-mineral substances, the mineral constituents forming the smallest part of the plant. It is observable, too, that different plants are composed of the various constituents in different proportions, that different parts of a plant contain a different proportion of substances, and that a plant absorbs varying quantities of constituent elements at different periods of its growth. A knowledge of these facts guides the agriculturist in choosing the crops most suitable to his land, in manuring, and in arranging his rotation of crops, &c. The constituents of soils and plants have only been named in the foregoing brief chapters, but, as complete knowledge upon this branch of agriculture is of great value, the farmer is recommended to consult a text-book on chemistry in order to learn the properties of the various substances referred to.

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CHAPTER III.

SETTLING UPON LAND.

As the largest proportion of the land in the Australian colonies is unoccupied, except for grazing purposes, taking up new country and forming homestead settlements is likely to form an important branch of rural industry for a lengthened period. In addition to the land yet unoccupied there are extensive settlements still in the preliminary stage, so that the details of settling upon new holdings possess an interest for a large proportion of the rural population. For the terms upon which Crown lands can be occupied the reader is referred to the chapter at the end of this book, in which the leading features of the Land Acts of the different colonies are given. In America, and most other countries, the first consideration of the settler is a house to protect himself from the severity of the weather, but in Australia the genial climate, with its mild winter, enables the settler to place house-building in a secondary position. It is only in the south island of New Zealand that the average amount of attention must, of necessity, be paid to this department of pioneering work, and even there the winters are much less severe than in the United States or British America. The Australian settler can live in tents or quickly-built huts until the more urgent wants of his new position are supplied. His first care should be a supply of water for himself and his stock; he next must fence in his holding, and then attend in due course to house-building and cultivation. It will thereupon be the proper course to treat of these departments of pioneering work in their natural order.

Providing for Water.

The settler who is fortunate enough to be near a permanent stream or lake will be saved the necessity of making this question his first consideration, but in the majority of cases a permanent supply of water has to be provided upon newly occupied land. It is a mistake to hurry on with fencing and cultivation before taking steps to provide water for domestic purposes and stock in the summer months. The first work in the dry inland districts should be the making of the dam, the excavation of the tank, or the sinking of the well. Care should be taken that the well is not a shallow surface one, which will dry up when most required.

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The dam should be provided with a wide bye-wash to prevent its being taken away by the floods, and it should have a wall of puddled clay in the centre of the embankment extending through the surface to a solid subsoil. The greatest mistake in making tanks or dams is to provide such small reservoirs that the supply of water becomes exhausted when most required. Let the reservoir be large enough to hold at least two years' supply of water, and then the settler can safely begin to think of fencing and cultivation. For further remarks upon water supply see the chapter upon IRRIGATION.

FENCING.

Fencing and subdivision are important matters in the colonies, where, both upon purely grazing estates and farms, stock-keeping upon pastures is extensively carried on. In the mild climate of Australia, where stock can thrive upon pastures all the year round, and where housing and stall feeding have not to be resorted to, more than ordinary attention has to be paid to fencing. In many countries, such as Belgium, Holland, Italy, France, as well as China and other Asiatic countries, there are seldom fences between the different holdings, and in the Eastern States of America a similar absence of fences is observable. In some of the Eastern States of America "no fence laws" are enacted, only such fields as are kept in permanent pasture are fenced in, while the stock is herded on the remaining land during certain seasons of the year. No stock is allowed to go into the fields until autumn, and crops have to be removed by a certain date; while each farmer is allowed to run a certain number of animals, according to the size of his holding, upon the open land of the district. In Australia, however, permanent pasture is always the largest part of the land, and the rule is for every settler to fence in his holding, be it large or small. Even the pastoral tenants who occupy large stock runs upon lease from the Crown adopt some system of fencing the boundaries. In the Western and South-western States of America, where extensive sheep and cattle runs or "ranges" are occupied, the herding system is adopted, the stockowners having no legal right to their runs; but in Texas, New Mexico, Arizona, and California, where there are large freehold estates, fencing is rapidly taking the place of the old plan of shepherding and herding. In Australia, where all departments of the grazing industry are further advanced than in America, experience has shown good fencing and complete subdivision to be highly profitable.

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ADVANTAGES OF SUBDIVISION.—Whether for cultivation or grazing purposes land must be subdivided in order to be economically employed. Where grazing alone is carried on it is necessary, in order to carry on the various departments of breeding and to obtain the full benefit of the pastures. Skilful breeding cannot be carried on without several paddocks for the different sexes and ages of stock, while, as affording a change of pasture alone, subdivision is necessary. When stock are allowed to roam over an extensive range of country, they tread down and soil a certain extent of pasture, and lose the relish for the whole. The finer grasses are eaten out and the coarser kinds are untouched, while feeding time is lost in travelling to water. The same piece of country, divided into several paddocks, each paddock being supplied with water, will keep a much larger quantity of stock in better condition. When one paddock begins to get stale, the stock is removed to another which is fresh, the coarser grasses are kept down, the finer grasses preserved, and, while the pastures are kept in good order, the animals thrive on account of the frequent change of food and the nearness of the water. The grazing properties of the Western District of Victoria are known to carry fully twice the number of sheep and cattle that they did before fencing and subdivision were adopted. When agriculture is combined with grazing the importance of subdivision is even more apparent, for without numerous paddocks it is impossible to make full use of the pastures while the crops are growing.

BOUNDARY FENCES.—In erecting a boundary fence the landowner has to consider not only the keeping of his own stock in, but the keeping of other stock out. All kinds of travelling stock—horses, cattle, and sheep—have to be kept off his land; and, if he wishes to be a successful breeder of pure-bred animals, he must be fenced against stray mongrel bulls, stallions, and rams. The wild animal that can jump, and the loafing settler's starved brute, that will push and crawl for a mouthful of stolen grass, have alike to be taken into consideration. The boundary fence, therefore, that will give satisfaction must be high, close, and strong. Live hedges along the boundary fence will assist to make it close and high, and will not only provide shelter, but keep stock from being disturbed by the traffic upon the roads. For further remarks upon hedges, see the "Farm Calendar" in another part of this volume.

SUBDIVISION FENCES.—While all kinds of stock have to be

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considered in erecting boundary fences, it is only necessary to take a farmer's own stock into account in subdividing. The farm stock—whether sheep, cattle, horses, or swine—have to be kept from the cultivated fields, and prevented from mixing. The fences employed in subdivision may, therefore, be of a special kind, suitable for that purpose. Thus, the farmer who keeps sheep will not require a high fence; while one who breeds horses or cattle alone does not need a close fence. Considering the value of sheep, however, as stock for the farm, and the special suitableness of the Australian climate for producing valuable wool, sheep-proof fencing should be generally provided. One or two pig-proof paddocks can also be recommended as a profitable part of a system of subdivision. It is a mistake to keep pigs exclusively in styes. Turn the pig out to grass in properly fenced paddocks, and his popularity will increase, to the general advantage of Australian farming.

MATERIALS FOR FENCING.—Local circumstances form the best guide to the kind of fence which should be erected, and the most economical materials to be used. Where timber is plentiful log fences serve a useful purpose for a time, then a cheap supply of posts and rails recommends that material in some cases, while abundance of stone will suggest stone walls in other cases; and for the treeless regions, where other materials are scarce and expensive, wire fencing is the most economical. Such conditions, with the caution that the cheapest fence is not always the most profitable, must be left to suggest the best materials to employ.

LOG FENCES.—When land is so heavily timbered that clearing is necessary, the log fence possesses the advantage of using up a large quantity of wood. In such circumstances the settler builds his fence and, to some extent, clears his land at the same time. A post-and-rail fence, in such cases, would be in danger of frequent injury from falling trees. The log fence provides for the immediate closing-in of the land, and clears a space for safely erecting a better fence in the future. The best log fence is that made by building the logs one above the other, large logs being placed at the bottom, and smaller ones on the top. This fence has the advantages of taking up a large quantity of timber and being a good close fence while it lasts. The "dog-leg" and the "chock-and-log" fences are adopted to economize both timber and labour. These fences are neither durable nor close, while they do not so well serve the purpose of clearing the land. When logs are so scarce as

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to suggest such fences, posts and rails should be used in preference. The log fence, at best, should be looked upon as a pioneering expedient, and, before timber becomes too scarce in the locality concerned, posts and rails or wire should be substituted. With the erection of the post-and-rail fence on the boundary, a hedge should be planted. In the case of the subdivision lines, hedges planted along the log fences may be made to serve the purpose of dividing the fields after the logs have been removed.

POST-AND-RAIL FENCING.—Where local circumstances suggest posts and rails as the most economical material for fencing, the most important point is to have the fences properly erected. The kind of timber available depends upon the locality, and the characteristics of the different timbers are generally locally known. The harder timbers, such as red gum, are generally the best for posts, while other varieties, such as messmate, are equally suitable for rails. Charring the posts is a course justified by experience, and dressing the posts with coal tar is considered equally effective in preserving the part inserted in the ground from decay. As the part most liable to decay is that which is near the surface, the usual course is to char or dress with tar a belt of the post about a foot in width 2 ft. 6 in. from the end, so that when the post is put 3 feet in the ground the protected part is a little above and a little below the surface. Effective boring machines can now be used, which economize the work of mortising the posts. The strength of the rail should not be destroyed in adzing, but the rails should be put in so as to completely fill the mortise. It is generally found that wires can be advantageously used along with posts and rails. Good substantial sheep and cattle proof fences are made with a top rail, or two or three rails, with from two to six wires, according to circumstances. In making a sheep-proof fence the combination of rails and wires is preferable to rails alone, being lighter on the posts and less liable to be effected by winds.

WIRE FENCES.—In erecting wire fences a top rail should be provided wherever practicable, especially on the boundaries of a property, but there are extensive areas in the colonies where the price of timber renders this course too expensive. Where wire fencing is adopted, timber is generally scarce, and it is an important object to use as little as possible. When a top rail is used, posts have to be the width of the ordinary panels apart, and this also contributes to the difficulty of adopting the top rail system. Wire fences, which are fairly effective in

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keeping stock in their proper paddocks, are erected without the top rail, and with the posts much farther apart than in the ordinary post-and-rail fence. In some cases the wires are run through battens, which, occupying a position midway between the posts, serve to keep the wires in their places, and not as substitutes for more substantial supports. Good strong straining posts, well shored, are important, especially when the ordinary posts are placed very wide apart. Very handy and effective wire strainers are now made, which facilitate the tightening of the wires, and it is advantageous in every way to keep the wire fence well strained up, and in good order. The use of iron studs instead of posts, besides being of service in stony ground, where the sinking of post holes is difficult, is economical where timber is dear. The relative cost of timber and iron, taking durability into account, will be a guide as to which kind of supports to adopt.

STONE WALLS.—For durability and serviceableness no fence is superior to the well-built stone wall. When cultivation is to be carried on in stony districts, the stone wall, like the log fence, can be erected in conjunction with clearing the land. In such localities also it is difficult to sink post holes, while the material is abundant and handy for building stone walls. If the well-built stone wall is to be commended, the badly-built wall is to be emphatically condemned. The well-built wall lasts for generations, requiring but little repairs. That which is badly built is continually tumbling down, and requiring a constant expenditure of labour in keeping it in order. Constant supervision is needed in the erection of stone walls, as the slightest carelessness or want of skill on the part of the builder entails trouble and labour for all time in constant repairing. The cheap, badly built wall consists of two shell walls, with loose stones filled in between. Such an erection is a good barometer, for it will tumble down at every change of air, but it is wanting in all the necessary qualities of a good fence. The stones, and especially those on the lower tiers, should be carefully laid, so as to rest on a solid foundation, and be capable of bearing the weight above, while binding stones should be put in not more than 4 or 5 feet apart. The binding stone extends through the wall from one side to the other, and binds the whole together.

OTHER FENCES.—There are various combination and other special fences suitable to particular cases. A useful combination fence is that formed partly of stone and partly of posts with rails or wire. The stone part consists of a low

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wall 2 or 3 feet in height, and the other of posts rising above the wall, bearing either rails or wires. Turf or sod fences have been tried with indifferent success in the colonies, and they are seldom worth the labour expended upon them. Stake or stub fences, when timber is plentiful, are erected at comparatively little cost, and serve many useful purposes. They are made of posts or slabs placed on end in the ground close together, and are useful for keeping out rabbits or dogs, and even answer well for enclosing pig paddocks. Wire netting is an expensive fence, but it is employed advantageously in special cases.

GATES.—The swing gate is established as a decided improvement upon the slip panel, although too many farmers cling to the old system. It will be found advantageous to erect substantial gates with good iron hinges and proper latches. Let the road be formed through the gateway so as to keep dry and sound, and don't try to save money off the paint bill. Gates, whether of iron or wood, last much longer if regularly painted, and appearances should not altogether be disregarded in the country. Where nature is seen at the best, man's work should not be the most slovenly.

BUILDINGS.

The buildings required upon a homestead vary according to numerous circumstances. A residence for the occupier is generally required, but the outbuildings necessary depend upon local conditions and the nature of the industries carried on upon the holding. The building materials to be chosen must also be dependent upon local circumstances, that which is cheapest, when durability and suitableness are taken into account, claiming the preference. The mild character of the Australian climate enables agricultural and pastoral pursuits to be carried on without much attention being paid to providing buildings. The cold of winter does not force people to build substantial residences, and stock can be kept with comparatively little shelter. The result is that homestead buildings, especially in the early stages of settlement, are generally of a very inferior description. It is to be regretted that many settlers are led by the mildness of the climate to an injurious degree of carelessness in regard to buildings. The poor character of the homestead buildings not only gives an unattractive appearance to our settled districts, but also occasions considerable loss. The poor erections,

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which are put up to serve the turn of the new settler, are too often retained after the preliminary stages of taking up new country have been passed through. This tendency is all the more inexcusable when land is generally owned by its occupiers. It should be remembered that substantial, convenient, and neat-looking buildings pay for themselves, and add more than their cost to the value of the holding upon which they are placed.

DWELLING HOUSES.—The occupier of land in the country should live in a good house. No man has more need of a comfortable house than the farmer, and no man has a better right to possess one. Building blocks are cheap, materials are not dear, and it is a poor business that cannot afford a house for those engaged in it. The house, however, is too often neglected by the farmer. A poor makeshift is erected to serve until fencing, grubbing, and tank digging are completed, or until the first crop is taken off, and this inconvenient dwelling is too often allowed to become permanent. It should be remembered that the farmer's returns, as a rule, come only once a year, and that when house building is put off from one harvest to another, an important part of a lifetime soon passes. A number of years passed in a hut tells on the health, and otherwise robs a man of the comfort he ought to enjoy. Children are also growing up, and a few years of hut life has a serious effect upon them both physically, mentally, and morally. In whatever way the subject is looked at, it must be evident that building a good house should not be neglected by the occupier of land. It is not necessary to suggest what materials should be used; these will be recommended by circumstances. The house should be roomy, and calculated to protect the inmates from both cold and heat. It should also be neat and attractive in appearance. A tasteful house need cost very little more than one which is gloomy and ugly in appearance; and much can be done in beautifying the homestead by attending to the garden and orchard, and in planting trees and hedges.

OUT-HOUSES.—The stables, barns, and other out-houses can also be made to look pleasing, and neatness will be found far more profitable than unsightliness. Although the climate is mild, grain and other farm produce will be destroyed by the rains, and thus the cost of a barn is soon lost. Stock can live without shelter, but they will thrive much better with it. Valuable horses should not be kept in open sheds with straw roofs that will not keep out the rain, and the losses of horses will soon absorb the cost of a good stable. Implements and

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machinery are generally costly, and they are soon destroyed by the winter rain and the hot sun. He is a bad farmer and a mistaken economist who leaves his costly reaping machine in the field to be ready for the next crop. A machine shed will soon pay itself, and the damage done by the weather will rapidly come to more than the cost of a building. Stables and sheds made of rough timber and covered with straw roofs answer very well as a temporary makeshift, but if erected at all they should be as soon as possible replaced by permanent buildings. Wool sheds, dairies, wine cellars, fruit sheds, and other buildings will be required in special cases, and the industries concerned will be found capable of paying for the erection of suitable buildings.

Grubbing and Clearing.

A large proportion of the country occupied by settlers is more or less thickly timbered, and clearing and tree grubbing have generally to be attended to. When timbered land is intended for grazing purposes, the pastures are much improved by ring-barking the trees and burning off the dead wood, and where cultivation is contemplated trees and stumps have to be grubbed out. Occupiers of timbered land lose a great deal by neglecting to improve the pastures by ringing and clearing, and farmers often make the mistake of carrying on cultivation without grubbing out the stumps and trees. Experience has proved that these operations are remunerative, and they should be attended to by all who wish to make the best use of their land.

Tree Ringing.—All trees are more or less injurious to pasture on account of shading it too much from the sun, thus lessening the fattening properties of the grass, even where the quantity is not diminished. Australian trees, moreover, through possessing surface roots, rob the pastures of the plant food in the soil; while in the case of box, sheoak, and other species, the fallen leaves render the surface soil sour and unsuited to the growth of grass. Tree ringing, or the killing of trees, or cutting a ring around the stem to prevent the passage of the sap, is extensively practised all over the timbered portions of Australia, owing to the beneficial effects resulting to the pastures. In the moist coast districts the operation generally doubles the carrying capabilities of the land, and in the warmer inland districts the beneficial effects are still more striking.

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NOTCH RINGING.—In notch ringing a belt of bark is not only taken off, but a notch running round the tree is also cut in the sap-wood about 2 inches deep. This is an effectual means of killing the trees, being also quick in its effects, but it is more expensive than ring-barking or merely stripping off a belt of bark, and open to some serious objections. The sudden checking of the sap causes young shoots to sprout from the stump and roots, and the smaller branches of the trees decay so rapidly as to fall upon the grass in all directions. Considerable labour is required to kill the shoots, and the fallen branches also require to be gathered up. Much of this trouble is avoided by ring-barking—a system which is generally preferred.

RING-BARKING.—In ring-barking, a belt of bark about a foot in width is taken off the tree, and the sap-wood is not cut into. This system is much cheaper than notch-ringing, and possesses several advantages. The tree dies slowly but surely, and is not so liable to send up shoots from the stump and roots; while the limbs, and even the smaller branches, dying gradually, harden and preserve in such a way as to remain without falling for many years. Owing to the labour involved in destroying the shoots from ringed trees, the barking system is much in favour; and the other advantage, of rendering the limbs and branches less liable to fall, is also a strong point in its favour.

SEASON FOR RINGING.—The best season for ringing is a matter of some importance. As the object is to kill the tree, ringing should be carried out when the sap is up. To ring too early in the spring, when the tree is growing most rapidly, and the sap is ascending from the roots to the branches, obviously has the effect of producing shoots and suckers. When the trees are in bloom, which in northern districts is in September, is soon enough to begin. At that season the work is also most easily carried out, for then the bark strips most readily. Owing to the fact that the leaves of the trees wither immediately after ringing in the summer and autumn, many suppose that time to be the best; but the trees ring-barked earlier will as certainly cease to show growth in the following spring, while their decay will be more gradual. The principal thing to be avoided is ringing too early in the spring, when a growth of shoots and suckers is certain to be produced.

SAVING SHADE TREES.—There is some danger of too much ring-barking. Many settlers make the mistake of ringing too much. Finding that trees interfere with the growth of grass,

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and that the pasture is improved by destroying the timber, it frequently happens that settlers rush to the extreme of ringing all the trees upon their land. Hence the holding not only possesses a dismal appearance, but, after a time, the want of shelter for the stock is severely felt and a lifetime is not long enough to reproduce the shade and shelter required. It is an easy matter to pick out the best trees for timber and shade purposes, and leave them living. A few trees will do more good in furnishing shade from the sun and shelter from the cold winds than the extra grass which might be obtained by their destruction. Belts of timber should also be left so as to break the force of prevailing winds—a course which will not only be beneficial to the stock, but will also supply timber and firewood, and add to the beauty of the country; while the effect upon the climate of general attention to these particulars is likely to be beneficial.

CLEARING UP.—To go to the expense of tree-ringing, and leave logs and branches scattered over the land, is a mistake which is far too common. In addition to the fact that the grass which is shaded from the sun by logs and withered branches is at least as sour and non-fattening as that shaded by growing trees, there is a large extent of land actually covered by the *débris*, and prevented from producing grass at all. The folly of keeping land in such an unproductive state is self-evident, and many settlers greatly improve the character of their grass land by clearing off the rubbish. Gathering up the smaller wood and branches, and stacking them against the larger logs, preparatory to being burned, is a course which has been found highly remunerative. Except where it is necessary to burn off large logs, the heaps may be small and numerous, involving very little labour in gathering the wood together. It will be found advantageous to scatter the ashes over the adjacent pasture, and sow grass seed on the bare patches formed by the fires.

GRUBBING.—When land is intended for cultivation the trees have to be grubbed out and removed. In many cases throughout the wheat-producing districts the land is only partially grubbed prior to being cultivated. The smaller trees and saplings, up to about a foot in diameter, are grubbed out and burned off. The larger trees are ring-barked and left standing in the fields. As a preliminary process this system has something to recommend it. To grub and burn off green trees is a much more expensive process than dealing similarly with dry timber. By carrying on cultivation around the trees for

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a year or two nature does much to assist the farmer in clearing his land, and less outlay is demanded at the outset of his career. It is a common mistake, however, to carry on from year to year without completing the clearing of the land. Limbs are continually falling, more or less crop is destroyed every year, and agricultural operations are interfered with in many ways. The trees should be grubbed out after the first crop has been taken off. When trees have been ring-barked for the improvement of the pasture, and cultivation is about to be carried on, there is no excuse for adopting the partial system, which, in such a case, has nothing to recommend it.

HAND GRUBBING.—The system of grubbing trees and stumps without mechanical assistance has been much practised, but is likely to be in a large measure abandoned in favour of cheaper processes. According to this system the earth is dug away from the tree or stump, the roots are cut through with the axe, and then the tree is made to fall or the stump is taken out. Burning the roots is an important part of the work. Many of the larger roots extend horizontally for a considerable distance under the surface, and, if not taken out, will seriously interfere with ploughing. All roots should be removed which come within a foot of the surface, and this work must be carefully superintended, for, if imperfectly carried out, serious trouble will be involved in future agricultural operations.

GRUBBING BY MACHINERY.—Grubbing is an operation in which mechanical aid is of great service, and there are many kinds of grubbing appliances which work well. The general principle is to apply lever power to pulling down the trees or drawing up the stumps, breaking the roots instead of cutting them. The ordinary kind of tree-grubber consists of a 15-ft. lever and an iron fulcrum plate of 9 ft. in length. At the one end the machine is attached by a strong chain to an anchor stump or tree, and at the other by means of chains and rods to the tree to be operated upon. The chain around the anchorage is as near the ground as possible, and the rods are attached to the tree which is being grubbed 15 ft. or 20 ft. from the ground. When the gear has been attached, the lever is moved as far as possible in one direction, when a pin is put into a hole in the fulcrum plate. Then the lever is moved in the opposite direction, and when the half-circle has been completed another pin is put in to retain the advantage gained. Thus, at every movement of the lever the fulcrum is shifted a few inches along the plate, and the process is con-

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tinued until the tree is uprooted. In most of the grubbers made upon this principle the iron plate is in one piece, with two parallel rows of pin holes, but some makers have adopted a double plate. There are in such machines two narrow plates, each containing one row of holes, the advantage claimed being that either a longer or a shorter leverage can be employed. Before the strain on the rods becomes heavy the outer leverage can be employed, the plates spreading out as required, and as the strain increases the inner or shorter leverage can be resorted to, the plates coming close together for the purpose. With the outer leverage there is less power but more speed, and thus time is saved at the beginning of the process, when much power is not required. In some cases horses or bullocks are employed in working the lever, but in general two men can apply sufficient power for practical purposes.

BURNING OFF.—Trees have not only to be grubbed out, but the timber must also be got rid of, and burning is generally had recourse to. Box timber burns well, and can be got rid of without much difficulty, but red and white gum, and some other kinds of timber, are not so easily dealt with. In burning large logs it is advantageous to heap earth up about them, thus keeping in the heat of the fire, and a good plan is to adopt the pit system. A long narrow pit about 6 ft. deep is formed, sloping at the ends. This pit is filled with timber, and after a good fire has been created it will consume logs rapidly. The pit forms a kind of oven, keeping in the heat, which quickly affects the logs as they are put in. Such a pit placed at the foot of a slope can be conveniently fed by rolling logs towards it. By heaping logs up over the pit at night the fire will feed itself till morning, the logs from above coming down into the fire as those below become consumed.

HINTS TO SETTLERS.

PREPARING STUMPS FOR BURNING.—The saltpetre and kerosene system of treating stumps is thus described by a correspondent of *The Australasian*;—"After cutting off the live tree in the autumn, a hole 18 in. deep is bored with a 1¼-in. auger down the centre of the stump; into that two or more ounces of saltpetre are put, and a plug is driven in to prevent the entrance of rain. In fine weather in the spring the plug is removed, and about a quarter of a pint of kerosene

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is put in. This, being set on fire, will continue to burn away quietly until the stump and roots are consumed right into the soil."

WORKING A TREE-GRUBBER.—The system of grubbing by mechanical means will be understood by the following account of a trial which took place before a large number of farmers in the Avoca district, in 1884:—At the trial the machine was anchored to a stump by means of a chain, made of iron, nearly an inch in thickness, and by means of rods formed of $\frac{7}{8}$-in. iron connection was made with a green gum tree about 40 yards distant. A short chain, similar to that around the anchor stump, was put around the tree 16 ft. from the ground, and to this the rods were attached. The grubber is intended to be worked by two men at the lever, and a boy to put in the pins, but at the trial three boys worked the lever, and the inventor himself attended to the pins. The stem of the tree was 2 ft. 6 in. in diameter, and proved to be exceptionally well rooted, constituting a good test for the grubber. Before the tree came over the boys required help at the lever, but, on being assisted by a bystander, they succeeded in bringing the tree to the ground. The tree had a sound tap root, 18 in. in diameter where broken off, and a surface one a foot through. All the roots were so disturbed as to be easily taken out in completing the work of grubbing the land.

Owing to the strong surface root, which did not break, but twisted after the tree had been partly uprooted, the length of the fulcrum plate was exhausted before the tree was made to fall. Several men leaned on the rods, and by this means brought the tree to the ground. This shows the value of the light single chains attached to some machines for the purpose of taking up the slack. By the use of this chain the rods are tightened before the plate is brought into use, and then there is no danger of exhausting the plate before the work of uprooting the tree is completed. Owing to the delay caused by the tree failing to fall after the lever plate had been used up the time occupied in bringing the tree to the ground was 20 minutes; whereas, if the delay had not occurred, the time would have been less than 15 minutes. As already stated, the tree was a very difficult one to manage, and in actual work the average time required would probably be about 10 minutes. The machine was handily worked, and all present were convinced of its power to answer the purpose intended.

The simple work of taking out and putting in the pins might easily be done automatically, and thus save the time of

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the boy who has now to be employed in this department. The pins in the ratchet wine-presses adjust themselves automatically, and some grubbing machines are also similarly constructed—an improvement which might be easily introduced in all cases. The side chains for taking up the slack are also an important addition which should be attached to every tree-grubber, in order to prevent the delays which are otherwise apt to occur. It is seldom that the grubbers are required to uproot green trees. The more economical system of clearing land, which is generally adopted, is to kill the trees by ring-barking, and afterwards complete the process by grubbing. The partly-decayed roots are much more easily burned or taken out than the green ones, and the dry trees in falling break up in such a way as to facilitate their being burned up. There is no doubt that tree-grubbing machines save a great deal of labour, and should receive the attention of all those who are engaged in clearing the timber off their land.

CHAPTER IV.

CULTIVATION.

CULTIVATION is the work of bringing about and maintaining in the soil conditions favourable to vegetation. The cultivator, therefore, has to concern himself with the mechanical condition of the soil necessary to enable seeds to germinate and the roots of plants to absorb nutriment, as well as with the temperature of the soil, and the supplying of deficient constituents of plant food.

TILLAGE.—Tillage operations are necessary to destroy weeds, and reduce the soil to the mechanical condition favourable to the growth of cultivated crops. As plants absorb their constituent elements in a liquid form through the minute openings or mouths in their numerous thread-like rootlets, it is necessary for promoting vegetation that the soil should be reduced to fine particles, lying loosely together. In this condition the rootlets of plants can freely search for the nutriment required, and air and moisture can readily convert the mineral and organic substances into the form in which they can be taken up and assimilated by the plants.

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In the process of tillage weeds are destroyed, and the soil is separated into fine particles, forming a bed of loose earth, in which seeds can germinate and plants can grow. Spade tillage or digging is the system of working which produces the best results. The gardener digs deep, turns down the weeds, and thoroughly pulverizes each spadeful of earth. In ploughing, harrowing, or scarifying, we are only endeavouring to produce the effects of digging by less laborious means; and it should be remembered that our tillage is only complete in the proportion in which it approaches in depth, in the burying of weeds, and in completeness of disintegration, the spade-tilled beds of the gardener.

PLOUGHING.—The plough is a substitute for the spade. This fact is the best guide to its use, and should not be forgotten, as it is apt to be in a country where ploughing matches are frequent. Prize ploughing possesses many qualities which have no bearing upon practical tillage, and which should not be allowed to render the important essentials of ploughing to be overlooked. The proper rounding of the lands is important as a drainage expedient in wet districts, but is of no consequence over those extensive portions of Australia where there is only a light rainfall. It is important that the sod should be turned over in such a way as to cover or bury the grass or weeds, but the angle of the sod need not be considered further than it affects the action of the harrow in breaking up the soil. Flat ploughing answers very well for sandy soils; but in the case of stiff, clayey soils, which are intended to lie in bare fallow, setting the sods at an angle facilitates the pulverizing action of the rain, the air, and the sun. In this treatment of stiff soils we have the example of the spade husbandman, who digs "rough" in such circumstances. In all cases the object of the plough is the same as that of the spade, viz., to reduce the soil to a fine tilth.

DOUBLE AND SINGLE-FURROW PLOUGHS.—The double-furrow plough, with which one man and very little extra horse-power turn two furrows instead of one, is an example of an assured advance in labour-saving agricultural appliances. Three-furrow, four-furrow, and multi-furrow ploughs are in the experimental stage, but the double-furrow has established itself as a pronounced success. In the colonies, where wages are high, the saving of labour is a most important consideration, while economizing horse or bullock power is of much less moment. The double-furrow plough would be an advantage, therefore, if it saved manual labour at the expense of in-

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creasing the need of horse-power, but the implement economizes both labour and power. In the ordinary ploughing of broken-up land three horses and one man with the double-furrow turn over three acres of land in a day, which would be good work for four horses and two men with the single-furrow, while the quality of the work is completely satisfactory. A double-furrow plough costs less than two singles, and there is a saving of one horse and two men in working the implement. It is not surprising, therefore, that the wheatgrowers of Northern Victoria, South Australia, and the farmers in other parts of the colonies are extensively adopting the double-furrow plough.

LEVER AND HANDLE PLOUGHS.—The lever double-furrow is generally used in the coast districts of Victoria; but in South Australia and Western Victoria the double-furrow with handles is coming into general use. The lever double-furrow is familiar to all farmers, the plough-heads being fixed to short iron beams, and the implement being guided, raised, and lowered by means of levers. The implement is strong, well made, and capable of doing first-class work, but it is heavy, being in striking contrast to the light gang plough of America. The handle double-furrow of South Australia is a much lighter implement, and of simpler construction. It is like an ordinary single plough, but having two beams instead of one. The beams to which the plough heads are attached are strongly braced at the required distance apart, and they taper backwards, forming the long stilt handles of the plough. The implement is easily managed, requiring no more skill or strength on the part of the driver than the lever plough, and the style of construction enables a lighter implement to be produced. Experience is teaching farmers the advantage of using a lighter and less elaborate implement than the standard lever plough.

THREE-FURROW PLOUGHS.—Three-furrow ploughs are being used in increased numbers, but they are not so generally adopted as double-furrows. They are generally well spoken of, however, and are likely to increase in favour with the farmers. In making three-furrow ploughs the lever principle is generally adopted. The implement becomes too unwieldy to be managed by handles, and hence the adoption of the general design of the standard double-furrow, with the necessary levers and steering rod. In ground that has been broken up four horses are used, and four acres is considered a fair day's work. There is evidently a substantial saving by

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this process as compared with double-furrow ploughing, and the system will no doubt become increasingly popular as its advantages are better known. In breaking up new land the double-furrow is generally employed with a team of four horses, and the three and four-furrow implements are in most cases used only in ploughing cultivated land. When the three-furrow plough is used for breaking up, six horses, or a bullock team of equivalent strength, are required. It is generally considered best to do the stiff work of breaking up with the double-furrow, and employ the three or four-furrow in the lighter operation of turning over the land which has been previously ploughed.

FOUR-FURROW PLOUGHS. — Four-furrows are sometimes employed in the inland districts, and, although not many of them are used, they are generally appreciated by those who have put them to the test. There is no doubt that light four-furrow ploughs, made especially for old land, could be employed with great advantage. After the land has been ploughed deep once or twice an occasional shallow ploughing can be profitably resorted to, and this work could be economically carried out by means of a light implement, turning four or more furrows. Such a process would be much preferable to the system of scarifying for a crop which is too frequently resorted to.

DEEP PLOUGHING.—Science and experience alike condemn shallow ploughing, and point to deep culture as producing the best results. The growing crops can only obtain nutriment from the portion of soil prepared by the plough, and when this consists of a shallow layer the roots of the plants are confined within narrow limits. When there is only a shallow soil upon a gravelly or unfertile subsoil, deep culture cannot be carried out, and the soil will soon become impoverished. There is no reason, however, why a deep soil, or one having a good subsoil, should be deprived of these natural advantages by shallow ploughing. By cultivating deep the roots of plants are given facilities for extending in search of nutriment, a greater quantity of plant food is provided, and by the absorption of more water by the soil a larger quantity of the constituents are rendered soluble and ready to be taken up by the roots of the plants.

DEEP CULTURE IN DRY DISTRICTS.—There are many who fail to recognize that the advantages of deep ploughing are available in localities where there is a deficient rainfall, and it is a common mistake in the dry sections of Victoria and South

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Australia for farmers to plough shallow. Now, it is in dry localities that the benefits of deep culture will be most decidedly experienced. In such districts moisture is the chief requirement of the crops, and it is only by pulverizing a sufficient depth of soil that the rain which falls can be retained. A hard pan is formed below the surface soil by the sole of the plough. Through this the rain cannot penetrate, and the whole store of moisture must be held by the surface soil. The more of this pulverized surface soil, the greater will be the quantity of moisture absorbed, and the deeper the soil the longer will the moisture be retained. Deep ploughing is best in all deep soils, but it is specially necessary where the climate is dry.

SUBSOIL PLOUGHING.—The facts which render deep ploughing advantageous are those which account for the benefits derived from subsoiling. In the case of a sandy or gravelly subsoil nothing is to be gained by disturbing it, for it is already too loose in texture; but clayey subsoils are always improved by being pulverized. A sandy soil is improved by mixing portions of the subsoil with it when the subsoil consists of clay, and, in the case of land which has been under cultivation for a long time, a fertilizing effect is produced by bringing up virgin soil from below the original surface soil. Apart, however, from the benefits arising from mixing portions of the subsoil with the surface soil, there are other and more important advantages resulting from stirring the land to as great a depth as practicable.

It frequently happens that the subsoil is not of a fertile character, and, consequently, that raising it to the surface injures for a time the productiveness of the surface soil. In the great wheat-growing plains of Northern Victoria and of South Australia the clay loam of the surface extends down without apparent change for two or three feet, or becomes slightly more clayey from the surface downward. Although there is but little difference apparent in the soil, that nearest the surface is found to be the most fertile, having evidently been rendered productive by the action of the sun and the atmosphere. Even the virgin surface soil is found to be improved by lying for a time in naked fallow before bearing a crop. This inferior fertility of the subsoil accounts for the unsatisfactory results sometimes obtained from deep ploughing in such localities. When the subsoil is of this character the practical course is to plough somewhat shallow at first, and work down deeper and deeper from year to year, thus gradually fertilizing the soil by cultivation until a sufficient depth is obtained.

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SUBSOILING.—This operation differs from deep ploughing, in that it does not bring the under soil to the surface, and its advantages are therefore available when the subsoil is not suitable for mixing with the upper soil. It consists in stirring and loosening the portion of the soil which lies beneath that turned over by the plough. The work may be done with a subsoil plough made for the purpose, or by means of an ordinary plough with the mouldboard taken off, the subsoiler working in the furrow after the ordinary plough. The plough and subsoiler combined is an implement which is employed in this work with good results. A subsoiling attachment like the coulter of a grubber or scarifier is fixed to the plough, so as to follow in the furrow behind the sole of the plough, thus stirring the earth below the ordinary ploughing. The loosened subsoil adds to the depth of earth in which the roots of crops can penetrate in search of plant food, and also increases the body of soil capable of absorbing and retaining moisture. In a dry climate the importance of increasing the power of the soil to absorb moisture cannot be overestimated. The air, too, is able to affect the soil to a greater depth, thus fertilizing the subsoil and deepening the body of friable mould which supports vegetation.

HARROWING.—The first object of harrowing is to complete the work of pulverizing the soil begun by the plough. It is therefore necessary to avoid harrowing when the soil is too wet to separate or crumble under the operation. In the case of clayey soils, especially, it is important to harrow when the soil is comparatively dry. A heavy stiff harrow, with the tines not too close together, is required in reducing a heavy stubborn soil, and the team should travel quickly to facilitate the pulverizing action of the implement. For lighter soils, or after the first breaking down of stiff land, and for the covering of seed, light flexible harrows with close-set teeth are the best. In all the applications of the harrow, whether for pulverizing, covering seed, or weeding, it is important to avoid carrying on the operation when the soil is wet.

SCARIFYING AND GRUBBING.—This operation is carried on for two purposes, viz.:—(1). To prepare the soil for seed as a substitute for ploughing; and (2) to cultivate fallow land, as well as between the rows of growing crops, such as roots or vines. For the first purpose it should be sparingly adopted, for it is less effective than ploughing, just as ploughing is less thorough than digging with the spade. The chief defect of the system is that it fails

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to cover in all the weeds which it disturbs; while it also pulverizes the soil less effectively than ploughing. In dry localities, where weeds do not grow luxuriantly, grubbing, or scarifying with an implement which is designed by the arrangement of its coulters to shift the soil more than once in passing through, will occasionally serve to prepare old land fairly well; but the practice of substituting the grubber or scarifier for the plough two seasons in succession can only produce poor results. It is a common mistake to suppose that there is any gain in relaxing thoroughness in working the soil. The proper use of the scarifier is not to take the place of the plough, but to help that implement. Thus it is useful to destroy weeds on fallow land, between one ploughing and another, and to cultivate the soil between growing crops, killing weeds, and keeping the surface in a friable condition.

ROLLING.—The roller serves the purposes of pulverizing the soil, breaking down the clods which have escaped the harrow, pressing the earth close about the roots of plants, and consolidating sandy or gravelly soils which are too open in texture. It is in the case of loose, sandy, or gravelly soils that the beneficial effects of rolling are most strikingly manifested. By pressing such soil together the roller is found to greatly increase its productive power. In rolling stronger soil the clods are broken down, and the land is rendered smooth for the working of harvesting implements or machines. The surface soil is also pressed together in such a way as to enable it to more effectively retain moisture, a point of great importance in nearly all parts of Australia, owing to the rainfall being light and the evaporation great. In addition to these advantages a further benefit is derived from rolling several crops after they have begun to cover the ground. The slight disturbance of the plant causes it to root more vigorously, and it is also benefited by having the earth pressed about its stalk and roots by the action of the roller. When the soil is stiff, and inclined to form hard clods, a spiked roller or one of the various "clod-crushers" is most effective. The clod-crusher, formed of movable plain or angular-toothed rings, produces excellent results, pulverizing the clods and leaving the surface smooth without the glazing effect of the plain roller. The spiked roller is also a serviceable implement, consisting of an ordinary wooden roller with numerous iron spikes driven into it, the spikes projecting about two inches. As in the case of harrowing, it is necessary to avoid rolling when the ground is wet. It is better not to roll the land at

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all than do so when the soil sticks to the roller. There are so many advantages, however, derived from rolling when the soil is dry enough that no farmer should neglect such an important part of tillage work.

Drainage.

Water, which forms such a large part of all vegetable produce, is an essential agent in the process of vegetation. Apart from the constituent elements of plants which it contains itself, water is necessary to render soluble and available as plant food the mineral and organic substances of which the soil is composed. In order to render the various services required of it a certain quantity of water is necessary, but an over-supply is as injurious as a deficiency. Irrigation is resorted to when the supply of water furnished by the rainfall is deficient, and drainage when there is more water than the soil requires. In addition to the difficulty of working wet soils, the crops obtained are unsatisfactory when the soil becomes overcharged with water; its temperature is reduced, and chemical changes are brought about which are unfavourable to vegetation. The soil is found to be cold and sour, and consequently unproductive. By draining off the surplus water from the soil the temperature is raised, and the air is allowed to circulate, thus assisting the moisture to dissolve the elements of fertility.

Drainage in a Dry Climate.—It is well known, also, that land which is over-saturated with water through want of drainage is more injuriously affected by drought in summer than land which is not over-supplied with moisture during the rainy season. From this it follows that drainage is as necessary to conserve moisture in dry seasons as to carry off surplus water in winter. Drainage increases the power of the soil to absorb and retain moisture, so that it benefits the soil by assisting to prevent injury resulting from too much or too little water. The subject of draining, therefore, is one which should not be altogether overlooked by farmers in the dry parts of Australia, while it is specially important where there is an average or copious rainfall.

Surface Draining.—In many of the wheat-producing areas of Australia, where the annual rainfall is not more than from 9 to 15 inches, the soil is capable of quickly absorbing all the rain which falls upon it. In such circumstances it is not necessary to make any provision for carrying off surplus water. The land is generally ploughed flat, the lands are wide, and the

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furrows, which are filled in by the harrows, are not opened up for drainage purposes. Where deep ploughing and subsoiling are carried out in these dry localities the moisture is quickly absorbed by the soil, and draining is unnecessary. In all but the driest localities, however, the winter rains cannot be absorbed by the soil, and it is necessary to provide for carrying off the surplus water; where the rainfall is medium, and the land possesses a sufficient fall, surface drains will prevent the soil from becoming overcharged with water. Land with a sandy or porous gravelly subsoil will require very little attention in the way of draining; but heavy soils, with more or less impervious subsoils, are apt to become unproductive through overmuch water. By ploughing a wet field in small lands, well thrown up, and cleaning out the finishing furrows after sowing and harrowing have been completed, the rapid passing off of surplus water is facilitated. From the water-furrows between the lands the water runs into cross furrows along the headlands, or through low-lying portions of the field. These cross furrows will connect with the drains at the sides of the fields. The size of the lands, and the height to which the crown is elevated, must be regulated according to the dampness of the soil. Small high-crowned lands are a serious obstacle to the successful employment of harvesting machinery, so that when land is sufficiently wet to necessitate such treatment, underground drainage should be resorted to. The drains into which the water-furrows empty must be sufficiently deep, with fall enough to facilitate the rapid carrying off of the water. The width of the drain, too, must be regulated according to its depth and the quantity of water to be carried. The bottom of a drain must be wide enough to prevent its being choked up by stones or *debris*, and the width at the top should equal twice the depth with the bottom width added; thus, a drain 4 ft. deep and 2 ft. wide at the bottom should be (4 ft. × 2 = 8 ft. + 2 ft. = 10 ft.) 10 ft. wide at the top. The earth taken from the drains should not be placed near the edge, but at a sufficient distance to avoid falling in, or removed altogether, and employed for the purpose of filling up depressions in the field.

DRAINING PASTURE LAND.—Pasture land is very much injured by insufficient drainage. In the same way as soil is rendered unproductive of cultivated crops by too much water, pastures are injuriously affected. Upon wet land grasses grow slowly, and the quality of the pasture is inferior. The nutritious and fattening grasses give place to rank, sour pasture, and

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even when good varieties of grass remain they lose their nutritive qualities. Not only are such pastures poor in feeding qualities, but they are fruitful causes of diseases in stock. The surface water should be quickly run off from pasture lands, while, by means of deep drains, facilities should be afforded for the escape of surplus water from the subsoil. In forming deep drains the slope of the sides should be in accordance with the rule given above, under the head of "Surface Draining." Where there is a good fall, and the chief object is to relieve the surface of surplus water, the drains may be wide, shallow, and crescent shaped. In such drains the gass will grow both on the sides and in the bottom; they do not tend to fill up, and, as they are clothed with grass, they can be as numerous as required without taking from the area of the pastures.

UNDERGROUND DRAINAGE.—A complete system of drainage can only be obtained by means of conduits beneath the subsoil. Such a system is naturally provided in some cases by the character of the subsoil when sand, gravel, or porous rock underlie the surface. The porous rock beneath the rich volcanic soil at Tower Hill, near Warrnambool, forms one of the best instances of natural underground drainage. In the case of wet soil, surface drains are only a partial remedy, and thorough effectiveness can only be attained by underground drainage. Upon the advantages of subdrainage, Lacoppidan, the Danish Professor of Agriculture, says:—"Whilst the open ditches may be of service as an incomplete system, proper drainage has many and varied beneficial influences. The more complete drainage carries off completely, and at the proper time, all the stillicidious water the land contains, prevents washing out, and causes rain water, by filtering through a thick layer of soil, to give off the greater part of its plant-nourishing matter; and, lastly, produces a renewal of air in the whole mass of soil that is situate above the level of the drainage pipes."

DEPTH OF UNDERGROUND DRAINS.—In all cases the underground drains should be deep enough to be out of the reach of the subsoil plough. This, however, is not the only consideration, for, in addition to keeping the conduits below the subsoil, it has to be decided whether a shallow system, with the drains from 18 in. to 2 ft. deep, or a deep system of drains 4 ft. deep is the more effective. Authorities differ upon the subject, but deep draining seems to be most generally approved of, and to give the best results. In deep drainage the channels do not require to be so close together, so that the

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system is less expensive than shallow draining, and it is held to be more effective. The land is not only more thoroughly drained, but the water from deep drains is clear, while that from shallow drains is muddy, showing that the latter system carries off valuable constituents of the soil.

TILE PIPE DRAINS.—The most approved system of underground drainage is that in which tile pipes are used. The distance apart of the drains depends upon the nature of the subsoil, a stiff clay soil requiring a greater number of conduits than land of more open texture. If a shallow system be adopted, the distance apart of the drains will vary from 16 ft. to 25 ft., and if a deep system be followed the distance will range between 25 ft. and 40 ft., according to the character of the soil. Professional assistance, or, at least, ability to take levels, is necessary in laying out a field for draining. The main drain will be execavated along the lowest level of the field, and the various branch drains will connect with it, the whole system having a sufficient fall to carry off the water from the pipes. The drains are excavated with the spade, but the bottom is formed by means of a draining spade, which, being only 3 in. wide, makes a narrow channel, into which the pipes fit, and are held in position. The pipes are laid one after another, and close together, fine soil being then filled in to a depth of a few inches, and the trench closed with the excavated earth.

SUBSTITUTES FOR TILE PIPES.—While tile pipes are the most suitable materials for underground drains, good practical results are frequently obtained by using substitutes which circumstances render more easily available. The best substitutes are stones, and when this material is plentiful the cost is much less than that of pipes. Stones, 2½ in. or 3 in. in size, may be put into a drain to a depth of 12 in., covered with a thin layer of smaller stones, and then covered with earth, thus forming an effective sub-channel. Another method is to press sods into narrow sloping channels, with the grass downwards, leaving a few inches space below for the pasasge of the water. Brushwood and straw are also used to fill the bottoms of drains, but it is false economy to employ such perishable materials.

HINTS ON CULTIVATION.

SHALLOW PLOUGHING.—Shallow ploughing is supported by farmers who state that they have in dry years obtained the

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best crops from land which had only been stirred on the surface, while the fact that good yields have been obtained from simply harrowing in the seed on the surface is also quoted in favour of the theory. The explanation of this theory is interesting as showing the dryness of the climate, and the small quantity of rain expected by the farmers. It is argued by the supporters of shallow ploughing that deep ploughing makes the soil dry. They say that the land at ploughing time is dry on the surface. There is a layer of dry soil on the top, say 3 in. in thickness, with a moist layer of soil beneath. If you plough to the depth of 6 in. you turn down the dry soil and bring the moist soil to the top. The moist soil on the top becomes dry, and you have 6 in. of dry earth. If you only plough 3 in. deep you have 3 in. of moist subsoil in which the roots of the crop can be supplied, while the light showers will probably be sufficient to moisten the surface. It is evident that the supporters of this theory do not fully recognize the increased powers of absorption given to soil by pulverization. If the 3 in. of subsoil, which they mention as being moist, has not been ploughed it will contain but little moisture, whereas if thoroughly pulverized it will contain enough to moisten the whole seed bed when turned down. The theory begins to consider the situation at ploughing time, but the whole year has to be taken into account. When there is a good depth of pulverized soil it will absorb and retain a supply of moisture from the rain which falls during the year to provide for the crop in the growing season. Theory would have to give way to experience, but when experience is divided accepted theories must stand.

PLOUGH DEEP.—Mr. J. C. T. Heard, of Natimuk, a retired champion ploughman and a successful Wimmera farmer, has, during the course of his experience, put the two systems of ploughing to the test, and the results were such as to confirm him in his support of deep culture. He has ploughed portions of the same field shallow and deep, and observed the difference in yield. The difference has always been in favour of deep ploughing, both the straw and the grain being superior. He has cultivated about 200 acres for 10 or 11 years, and has always obtained such yields as to encourage him to continue the system of ploughing deep. Mr. Heard would recommend ploughing deep in breaking up the land, and ploughing, if possible, for every crop in preference to scarifying. It is not so important to plough deep every year, but the first ploughing should be to a depth of 6 in. or 8 in.

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In some cases the subsoil is of a cold, sourish nature, and when turned up to the surface does not yield good crops for a season or two. In such cases Mr. Heard would not dispense with deep culture, but would avoid bringing the subsoil to the surface. The combined subsoil and double-furrow plough, by which the surface can be turned over and the subsoil stirred to a good depth, is recommended in such cases. It is considered specially necessary in such a dry climate as that of the Wimmera that there should be a deep bed of pulverized soil to absorb and retain a supply of moisture for the support of the crop.

Rotation of Crops.

While all plants are made up of the constituents contained in the soil, different plants do not contain these constituents in the same proportion. Thus, one crop takes from the soil a large quantity of a substance which another assimilates in a very small degree. When continuous crops of the same kind are grown upon land, the available supply of one or more constituents required by that crop becomes deficient, and the yields cease to be satisfactory. In such cases the land is sometimes said to be exhausted, or worked out; but the expression is erroneous, for other crops of a different kind can be successfully grown upon the same soil. There is only a deficiency of certain substances, and it may be that even these are not really abstracted, but only in an unavailable condition. Plants can only assimilate their nourishment in a certain form, and a soil may be lacking in fertility, not from an absence of the elements of plant food, but owing to these substances being in a condition unfavourable to the process of vegetation. Thus, when land becomes incapable of producing a certain kind of crop, a period of rest in bare fallow will have the effect of restoring fertility sufficiently to enable a crop of the same kind to be grown. From this fact it is evident that the forces of nature, having time to operate, set free and reduce to an available condition the mineral substances of the soil. It is not necessary, however, to resort to bare fallowing in order to allow the forces of nature sufficient time to operate upon the soil; for, when land becomes incapable of producing one kind of crop, it is able to support another. When the principal constituents of one kind of crop have become deficient in the soil, there may be a plentiful supply of plant food suitable for another. By changing, therefore, from the

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one crop to the other, the land can be kept profitably employed; while natural causes, operating in the soil, are supplying, in an available form, the conditions specially required by the original product. Bare fallow, or allowing the land to rest, had to be resorted to before the changing or rotation of crops was understood; but a system of rotation is now a recognized part of intelligent farming. Not only are different crops unlike in the proportion which their constituent parts bear to one another, but in their habits of growth. Elements which are in an unavailable condition for assimilation by one plant may be available for another, and deep-rooting crops can search for nutriment in soil which cannot be reached by those whose roots grow near the surface. By possessing a knowledge of these facts, and studying the composition and habits of the various crops, the farmer can adopt such a system of rotation as will greatly assist to maintain the fertility of the soil.

There are three classes of cultivated crops which differ widely in the proportion in which they contain the constituents of plant food, viz., cereals, leguminous plants, and root crops; and the members of these classes also differ from one another in the quantities of the principal elements of which they are composed. Thus the cereals, such as wheat, oats, and barley, contain more silica than leguminous plants, like beans, peas, clover, and lucerne, in which lime preponderates; while root crops, such as potato tubers, mangolds, sugar-beets, turnips, and onions, which contain but little silica, possess a large proportion of potash. It is evident that, owing to the different composition of the various classes of plants, a system of cultivating the different kinds of crops in rotation is less exhaustive to the soil than adhering exclusively to a single class. Thus, while one class of crops tends to render the soil deficient in silica, a change to leguminous plants allows time for the accumulation, in available form, of that constituent; and a further change to root crops, in the same manner, allows potash to accumulate, so that a system of rotation not only renders the process of exhaustion slow, but gives the natural agencies in the soil a lengthened period in which to convert the mineral constituents into an available, soluble condition. In arranging a system of rotation, crops of one class should be followed by those of a different kind, and the less frequently the classes are repeated the better, while in the same way there should be a sufficient number of members in each class to avoid the necessity of frequent repetition.

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In practically applying the above principles to the requirements of the different parts of the colonies, the farmer will be guided by a variety of circumstances, such as the value of produce and the suitableness of the soil and climate to the cultivation of the various crops. In the dry districts of the colonies, where wheat is the only crop capable of being grown, rotation is, of course, impossible, except in so far as bare fallow and allowing the land to lie in pasture are connected with the system. Grasses in such dry localities cannot be cultivated, but the natural grasses and weeds form a pasture upon which stock are grazed, while the soil is being prepared for future crop growing by the operation of natural agencies.

In the more moist portions of Australia the character of the climate admits of a wide range of products being cultivated, and renders an extended system of rotation practicable. The various common cereals, such as wheat, oats, and barley, are alternated with potatoes, mangolds, and peas by the most advanced farmers in the oldest established districts, and the cultivation of crops is frequently relieved by the sowing of rye-grass, clover, or other pasture plants. The sowing of two or more wheat or other crops in succession is seldom practised by good farmers, and should be avoided wherever practicable. Allowing the land to rest in pasture for longer or shorter periods is a frequent and commendable practice, but the cultivation of root and green crops should be more generally attended to.

In addition to the value of growing crops so different in composition from cereals, there are other advantages derived from the cultivation of root and green crops. The opportunities afforded by green and root crops, of cultivating the land and destroying weeds, should be valued by all farmers who wish to maintain the fertility of the soil. In addition to the ordinary advantages of rotation, some leguminous plants, such as peas, beans, and clover, produce a beneficial effect upon succeeding crops by the nitrogenous roots and leaves which they leave in the soil. Thus, the cultivation of the pea crop has had a striking effect upon the exhaustively cultivated soil in such potash-growing districts as Warrnambool, Lancefield, and Ballarat. A system of rotation is necessary, not only to maintain as long as possible the fertiility of the soil without manuring, but also in connection with the application of manures.

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MANURING.

The foregoing branches of agriculture—viz., "Tillage," "Drainage," and "Rotation of Crops"—are means of cultivating various vegetable products, and, however skilfully these operations are carried on, their ultimate effect is to exhaust the fertility of the soil. As the object of cultivation is to obtain heavy yields of farm crops, the more successful it is the more quickly will the soil be deprived of its elements of fertility. Thus, thorough tillage and good drainage, by securing large quantities of produce, facilitate the system of land exhaustion; while rotation of crops, although prolonging the period of fertility, by allowing time for recuperative agencies to work, must ultimately impoverish the soil. A system of rotation adds nothing to the soil to compensate for the mineral constituents removed by the crops, but only gives time for the accumulation in soluble form of substances already present in some other condition. Unless, therefore, the process of accumulation is as rapid as that of extraction by growing crops, exhaustion, although slow, is none the less certain. The power of natural agencies to act upon the soil and subsoil in the way of providing a supply of available plant food is probably greater than many authorities have supposed; but experience teaches that it is not sufficient to permanently maintain fertility. A wise system of rotation, providing for the infrequent repetition of similar crops, will sustain the fertility of the soil for a long time; but to recuperate thoroughly exhausted land, or to secure permanent productiveness, the application of manures is necessary.

THE APPLICATION of MANURES.—Manuring consists in adding to unfertile soils elements absent or existing in insufficient quantities for the growth of crops, or in maintaining in fertile soils a sufficient supply of those constituents necessary to the full development of cultivated plants. As the quantities of the various constituents of plants existing in fertile soil are generally large in proportion to the requirements of crops, the addition of small quantities of manure are sufficient to maintain fertility, while large quantities are necessary to recuperate land after exhaustion has taken place. Manuring, therefore, should not be deferred until the soil has become impoverished; but the more economical course is to add fertilizers to maintain the soil in a productive condition. As also a soil may be unproductive, not through some of its

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constituent parts being deficient, but through their being in an unsuitable condition for assimilation, the practice of manuring has to be directed to more than merely adding a supply of deficient substances to the land. The substances added must be capable of taking a suitable form; and some manures will be valuable, not so much on account of what they add to the soil as owing to their effect in rendering other substances soluble and available as nutriment to plants.

GENERAL AND SPECIFIC MANURES.—Some manures contain all the constituents of plant nutriment, and others consist of a limited number of fertilizing elements. The first class, of which animal or farm-yard manure is the best example, are called "general manures;" and the second class, such as salt, bone-dust, and guano, are called "special manures." In ordinary circumstances the general manures are the best, as they supply all the substances removed by all crops, but the special manures are useful in supplying any particular deficiency in the soil, or maintaining productiveness where a limited class of crops has to be cultivated.

THEORIES OF MANURING.—In the chapter upon the "Composition of Plants" it is pointed out that vegetable products derive their mineral or ash constituents from the soil, and their combustible or organic constituents partly from the soil and partly from the atmosphere. It is important to consider what portion of their non-mineral constituents is obtained from the soil. Baron Liebig at one time asserted that plants obtained the whole of their nitrogen from the atmosphere, and that, therefore, nitrogenous substances in the soil were unnecessary to the growth of crops. The supporters of this theory held nitrogenous manures to be unessential, and maintained that fertility could be maintained entirely by the application of special mineral manures. A series of field experiments, however, carried out by Lawes and Gilbert, at Rothamstead, proved the mineral theory of Liebig to be erroneous. The great German chemist afterwards practically endorsed the conclusions of Lawes and Gilbert, so that it may be taken as established that many farm crops obtain the largest part of the nitrogen which they contain from the soil. This fact gives to nitrogenous manures the value which former experience had assigned to them, but which the mineral theory would have dissipated. That cereals and root crops depend upon the soil for their supply of nitrogenous substances is proved by the Rothamstead experiments, but in regard to leguminous plants the case is not so clear. Upon this point the following opinion is expressed

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by MacIvor:—"In the present state of our knowledge it would be premature to say definitely whether leguminous crops, like beans, peas, and clover, draw their nitrogen from the soil or from the air, or partly from the one and partly from the other. The Rothamstead experiments, and also the results of Mr. George Ville, have shown that ammonia-salts do no good to these crops, indeed that they are positively injurious. Neither does nitrate of soda act beneficially. If, therefore, these crops obtain their nitrogen from the soil, they must assimilate other forms of nitrogenous food than those taken up by graminaceous plants."

FARM-YARD MANURE.—Farm-yard manure is the most important owing to its many valuable qualities, and the presence of it in larger or smaller quantities upon every farm. It is a general manure, containing all the substances which are found in the composition of plants. Farm-yard manure consists of the dung and urine of animals, mixed with the straw or other litter upon which the animals have been bedded. The quality of the manure depends upon the animals from which it is derived, the litter with which it is mixed, and the manner in which the mass is treated.

The dung of animals is rich in various substances, especially phosphoric acid, while the urine contains a preponderance of nitrogenous and ash constituents of plants. As the liquid and solid excrements of animals contain different kinds of constituents, it is important that they should be united in manure, so as to secure for the soil all the fertilizing substances which they contain. There is also a difference in the character of the manure obtained from different animals. Thus horse and sheep dung are open in texture, comparatively dry, and disposed to become heated in the heap; while cow and pig manure are more moist, and colder in character. It is, therefore, important that the different kinds of manure should be well mixed together in the manure heap, so that the tendency of one kind may be checked by the opposite tendency of another. The character of manure also alters with the varying condition of the animals from which it is obtained; but the most important difference in the qualities of animal manure is produced by the food consumed. Thus Lawes and Gilbert demonstrated that the more abundant the food given to animals, and the more nitrogenous matter it contains, the higher will be the value of the manure obtained. These authorities estimate that while the manure of animals fed upon oil cake would be worth £4 18s. 6d.; upon linseed cake, £4

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12s. 6d.; beans, linseed, and peas, £3 14s. to £3 2s. 6d.; oats, wheat, and barley, £1 15s. to £1 10s.; clover hay, meadow hay, and bean straw, from £2 5s. 6d. to £1 0s. 6d.; those fed upon other straw and roots would produce a manure worth only from 18s. 9d. to 4s.; that from pea, oat, wheat, and barley straw, ranging from 18s. 9d. to 10s. 9d.; and that from potatoes, mangolds, turnips, and carrots from 7s. to 4s.

THE MANURE HEAP.—From the foregoing it will be evident that mixing the different kinds of manure together in the heap is an important matter. It is necessary to add sufficient straw or litter to absorb the liquid manure, and to guard against losing the most valuable constituents of the heap through drainage or evaporation. The best way to add the straw is to allow it to be trodden in by the stock, cattle and swine accomplishing this object most effectually. By leaving the manure to lie too long in the yards its best constituents are apt to be lost, and to avoid this the yards or sheds should be frequently cleaned out and the manure removed to the heap. The heap should be placed in such a position that the liquid will not be inclined to drain off. A pit about 2 ft. deep should be excavated in a retentive soil, and, if such soil is not available, means should be adopted to render the pit capable of retaining water. Spread straw or other vegetable refuse over the bottom of the pit and commence building the manure heap, taking care to mix by spreading the drier and more moist matter in alternate layers. As the nitrogenous and other valuable constituents of the manure are in danger of being lost by evaporation, especially in a dry climate, covering the heap is a matter of special importance. The more completely the heap is protected from the sun, the better will be the quality of the manure; covering the heap entirely with a layer of earth is one of the most practicable and effective means of retaining the valuable constituents of the manure. As the climate of the Australian colonies is a dry one, and the evaporation great, there is special need for covering the manure heap, and it is also more than ordinarily important that the manure be well rotted. When there is a heavy rainfall, fresh or unrotted long manure may be profitably used, but only well made farmyard manure is of service in the dry climate of most parts of Australia.

THE COMPOST HEAP.—Compost is a mixture of various refuse animal and vegetable substances in a condition suitable for manuring land. Such substances as nightsoil, fowls' droppings, ashes, soot, sawdust, seaweed, blood offal, &c., which are

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unsuitable for mixing in the manure heap, should be gathered together and formed into compost, which is a highly valuable manure. Owing to the fact that thorough unproductiveness of soil generally results from a deficiency of nitrogen, and that the refuse matter of the farm is in nearly all cases rich in this constituent, the compost heap should receive careful attention. Place a few loads of earth where the compost heap is to be formed, spreading the earth so as to cover the ground to a depth of about 10 in. Have a supply of earth at hand to mix with the contents of the heap, and also a quantity of lime for the same purpose. In building up the heap, cover each layer of refuse matter with a layer of earth or lime; upon decaying nitrogenous substances place a layer of earth; and upon animal remains, such as bones, offal, horns, skin, &c., use lime or wood ashes. The mass should be moistened with liquid manure or water, so as to facilitate the heating and decomposition of the various substances. In addition to utilizing various waste substances as manure, the compost heap serves to destroy the seeds and roots of weeds placed in it, rendering them not only harmless but useful. As showing the value of the compost heap, the following table by Lacoppidan may be referred to, giving the nitrogen contained in some of its constituent substances :—

100 lbs.	ordinary farm-yard manure contains					6½	ozs.	nitrogen.
100	,,	human excrement (solid and fluid) contains				21½	ozs.	nitrogen.
100	,,	fowls' dung	...	...	...	41½	,,	,,
100	,,	fresh blood	...	...	...	47	,,	,,
100	,,	air-dried flesh	...	...	...	208½	,,	,,
100	,,	dry seaweed	...	...	...	22	,,	,,

LIQUID MANURE.—While the solid manure obtained from animals contains a large quantity of phosphoric acid and other substances, it is poor in nitrogenous matter as compared with urine. The liquid excrement is rich in nitrogenous matter and mineral or ash constituents; and liquid manure, which consists of urine drained off from the solid excrements, is also enriched by valuable matter which it has dissolved. As the urine, in passing through the manure and litter upon which it falls, dissolves and carries off important constituents of the solid matter, liquid manure is of the highest value. Stables, piggeries, and cattle-sheds, therefore, should be planned so that the liquid manure will drain off to be properly preserved. An excavated tank or catch-pit, covered over and provided with a pump, should be made near the manure heap for the

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reception of the drainage from the stables, sheds, and piggeries. The liquid collected in the tank should frequently be used to spread over the manure heap, as this is the best means of utilizing the liquid manure. The manure heap and compost heap should be made to absorb as much as possible of the liquid manure, and the remainder should be quickly spread upon the land. Should it not be practicable to employ the catch-pit frequently or once a fortnight, a small quantity of diluted sulphuric acid should be put in to fix the ammonia, which would otherwise be thrown off in the process of decomposition.

APPLICATION OF FARM-YARD MANURE.—Manure should, when practicable, be carted to the field as soon as rotted, and spread upon the field at once, instead of being left to lie in heaps. When left in heaps the manure is impoverished by having a larger quantity of its fertilizing matter washed into the soil, causing unevenness in the succeeding crops, and producing blight where the heaps have stood. The manure should also be ploughed into the soil quickly after being spread, to prevent the loss of nitrogenous constituents through evaporation. The quantity of manure required depends upon a variety of circumstances; but the general principle is, that root and fodder crops can scarcely receive too much manure, while cereals are apt to be blighted by over-manuring the land. Well-informed custom, therefore, follows the course of manuring the fallow crops or the pasture for the benefit of succeeding cereal crops, instead of manuring directly for cereals. As a top-dressing for pastures the manure gives good results both immediately and in the succeeding cultivated crop.

BONE-DUST.—The bones of animals contain about 50 per cent. of phosphate of lime and 30 per cent. of gelatinous matter, rich in nitrogen. Bones constitute a valuable manure, owing to containing a large quantity of such valuable constituents as phosphoric acid and nitrogen. The importance of nitrogen has been already referred to, and it will be remembered that phosphoric acid, an important constituent of most crops, is frequently represented in soils in a small proportion. 1,000 lbs. of fresh horse or cow dung contains about 4 lbs. of nitrogen and 3 lbs. of phosphoric acid, while 1,000 lbs. of bone-dust contains 50 lbs. of nitrogen and 240 lbs. of phosphoric acid. Bones will remain in the ground for years without being dissolved, but if ground to a fine powder their valuable organic and ash constituents become quickly available as plant food. It is this fact that leads to the use of bone-dust instead of broken bones

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as a manure, and the finer the powder to which the bones are reduced, the quicker will be the action of the manure.

SUPERPHOSPHATE OF LIME.—This manure is made by treating moistened bones with sulphuric acid in such a way as to render their constituents easily soluble. In treating the moistened bones with the acid, heat is produced by chemical action, the bones are dissolved, and a thick liquid is produced, which, on drying up, leaves a moist, greyish powder, called superphosphate of lime. The same process is carried out upon other phosphatic substances as well as bones, and thus superphosphates are made from minerals which, in their natural state, are so insoluble as to be unavailable as manures. Superphosphates are of varying quality, according to the substances used in their formation, and the nature of the treatment carried out. A good superphosphate, made from bones, should be rich in soluble phosphates and nitrogenous matter. The superiority of this kind of manure over bone-dust consists in its fertilizing constituents being in a more soluble and available condition. The dry climate of Australia makes this property of the manure especially valuable.

THE BONE HEAP.—The bones of the farm can easily be rendered suitable for manure by breaking them into half-inch lengths, heaping them up, moistening them with water or liquid manure, and covering them with earth. After a few days the mass will become heated, and in the course of a few weeks the bones will be so soft as to be easily dissolved in the soil. When the process is properly carried out the manure is better than bone-dust, as the loss sustained in boiling for the crushing process is avoided. Owing to the dryness of our climate rendering bone-dust frequently incapable of dissolving in the soil, it is advantageous also to mix this phosphate in a heap with farm-yard manure, and thus render it more soluble.

APPLICATION OF BONE MANURE.—Bone-dust is slow in its action, and requires moisture to render it effective. In our dry climate its benefits are frequently obtained more effectually in the second and third than the first year. It is valuable for land of open texture, from which more soluble manures are apt to be lost through the subsoil. For pasture land it is an excellent manure, encouraging the growth of clover and fine grasses, and it can be advantageously used in sowing down, or as a top-dressing. In applying bone-dust to cereal and root crops, it should be harrowed into the soil as early as possible, so as to get the advantage of the winter rains. When put early into the ground, bone-dust is a good manure,

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both for root and cereal crops, and is profitably employed where hay is frequently grown upon the same land. For retentive soils, and when quick results are required, superphosphate of lime should be used in preference to bone-dust. This manure gives good results when applied to both roots and cereals, and, like bone-dust, should be worked into the soil in preference to being used as a top-dressing.

GUANO.—This manure consists of the droppings and other remains of sea fowls. Its quality depends upon the climate in which it has been accumulated, that from a dry region being rich in nitrogenous matter, while that from a moist climate is poor in such substances, and largely made up of phosphate of lime. The best Peruvian guano contains from 12 to 14 per cent. of nitrogen, 12 per cent. of phosphoric acid, and 1½ to 2 per cent. of potash; while some guanos contain little else than phosphate of lime.

LACEPEDE ISLAND GUANO.—This guano is rich in lime and phosphoric acid, and contains a fair percentage of nitrogenous matter. It is slow in its action, giving the best results in the second year, and it has been successfully used for root crops, peas, and cereals.

MALDON ISLAND GUANO.—The guano obtained from Maldon Island is mainly composed of phosphate of lime, and is better suited for yielding a superphosphate than for use as a manure in its natural state. *Huon Island Guano*, *Flat Island Guano*, and *Bat Guano* are also chiefly of a phosphatic character.

APPLICATION OF GUANO.—As Peruvian or other nitrogenous guano contains its valuable fertilizing constituents in an available form, it is a powerful and quick-acting manure. It is a good manure for clayey soils, and can be used with advantage for either cereal, root, or fodder crops. When used upon pastures it has a forcing effect, and it is serviceable in producing a rapid growth when it is desirable to force a crop through a critical point of its growth. Owing to its richness in nitrogen, Peruvian guano can be profitably used along with phosphates, but when used by itself it should be mixed with twice its own bulk of earth to ensure its even distribution. Although guano does not readily part with its ammonia, it should be worked into the soil soon after being taken to the field.

COMMON SALT.—Common salt, which is composed of sodium and chlorine, is an important mineral constituent of all plants. It is useful for destroying weeds and grubs in the field, and is a very valuable special manure. Its power of attracting and

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retaining moisture gives it special value in a dry climate, making it one of those manures which act beneficially upon others, and upon the insoluble substances in the soil. Near the seashore there is generally sufficient salt in the soil, but in other cases its application as a manure increases the yield of both root and cereal crops. Mangolds, onions, beans, turnips, and cabbages are specially benefited by an application of salt to the soil. It is suitable for using along with other manures, and when employed by itself it produces good effects. When applied to the wheat crop upon rich soil it strengthens the straw and checks a too abundant growth. In the dry portions of Australia it is particularly valuable owing to its affinity for moisture, and in such circumstances will give better results than a richer manure. Salt may be either sown upon the land and worked in, or mixed with other manures.

SULPHATE OF AMMONIA.—This nitrogenous manure, when pure, contains about 25 per cent. of ammonia, and is consequently highly valuable as an application to soil deficient in nitrogen. It is used with good effect in cultivating either root or cereal crops. As a spring dressing for backward cereal crops it is very effective, and it is good for potatoes, mangolds, and beets. Sulphate of ammonia is economically used along with special phosphatic manures.

NITRATE OF SODA.—Pure nitrate of soda contains 36½ per cent. of soda and 63½ per cent. of nitric acid. It is a highly valuable special manure, enriching the soil mainly with nitrogen. Nearly all farm crops are benefited by its application, but the best effects are produced upon cereals and grasses. Its effects upon wheat, oats, and barley are strikingly beneficial, and it is well suited for application to root crops. MacIvor states that "there is no source of nitrogen better suited for application to cereals cultivated in a dry climate than nitrate of soda." It is a quick-acting manure, and as its soluble constituents are apt to be washed away by rains, spring is the best time for its application.

POTASH MANURE.—Many farm crops, and especially roots, take a large quantity of potash out of the ground, and although this mineral is largely represented in most soils it is liable to become deficient by constant cropping. In the case of strong clay soils, rich in potash, exhaustion does not rapidly take place, but poor, sandy soil soon becomes impoverished of its limited supply of potash. The potash salts available as manures contain from 10 to 50 per cent. of potassium,

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combined with sulphuric acid or chlorine magnesia and common salt. These salts are beneficial manures for grass and hay crops, for beans and other leguminous plants, and for root crops. It is better to apply them along with phosphatic or nitrogenous manures than by themselves. The potato crop is greatly benefited by the potash manure, and it also improves the land for the succeeding cereal crop.

WOOD ASHES.—The ashes from wood constitute a highly valuable manure, being rich in potash as well as containing phosphate, sulphate, and carbonate of lime. Soil deficient in potash is greatly improved by the application of wood ashes for the cultivation of all kinds of crops. Roots and leguminous plants are specially benefited by this manure, and it is also used with advantage for grasses and grain crops. It may be used either by mixing with the soil or as a top-dressing. Care should be taken to collect and preserve all the ashes made on the farm, and they should be protected from the rain, which would wash out their most valuable constituents. In dry parts of the colonies, where straw cannot be readily converted into farm-yard manure, the practice of burning the straw left standing by the stripping machine has the merit of returning the ash of the straw to the soil, and is preferable to the system of selling the straw off the farm. Ashes can be conveniently and well preserved in the compost heap.

NIGHTSOIL.—This manure, which is rich in nitrogen, phosphoric acid, potash, and other constituents of plant food, is a highly valuable fertilizer. Chiefly by its means the Chinese have maintained the fertility of the soil for thousands of years, and its value is now becoming appreciated by western nations. The supply of nightsoil upon the farm should be utilized to the greatest possible extent, and the sewage of our cities and towns should be returned in some form to enrich the soil of the country. The compost heap is a suitable means of preserving the nightsoil of the farm. This manure, both the solid and liquid parts of which are valuable, should not be exposed to the air, but covered with earth, which will absorb and preserve its fertilizing constituents.

POUDRETTE.—The nightsoil of large towns and cities is dried and put into a form suitable for being conveniently transported under the name of *poudrette*. The contents of closets and cesspools are emptied into shallow reservoirs, and when the excreta is nearly dry it is mixed with earth, ashes, sawdust, or other absorbent material, disinfected, and placed in sacks or barrels to be sold as manure. The value of *poudrette* depends

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to a great extent upon the process employed in drying and absorbing the nightsoil. The different kinds produced contain from 29 to 79 per cent. of nitrogenous organic matter, and from 6 to 7 per cent. of phosphates.

BLOOD.—As blood contains nearly all the constituents found in the composition of plants, it forms a very valuable manure. It contains, besides phosphates, salt, and potash, a large percentage of nitrogen. Blood and the flesh and bones of dead animals, which are also rich in the elements of plant food, should all be treated in the compost heap, and the "blood manures" made from the drainage of the abattoirs should be highly appreciated by farmers.

FISH.—In Europe and America fish are successfully used as a manure, and it is stated by an American writer on agriculture (Mr. R. L. Allen) that the Indians followed the practice long before the discovery of the new world. The bodies of fish, and the offal obtained from fish markets, are composed of organic nitrogenous matter, phosphoric acid, lime, and other minerals. The fish are sometimes simply ploughed into the soil, but it is better to form them into a compost with earth, when the manure, at the rate of from 25 to 35 cwt. per acre, can be advantageously applied to nearly all kinds of soil and crops.

REFUSE ANIMAL MATTER.—Horns, hoofs, hides, hair, and wool are all rich in nitrogen, and therefore valuable as manure. They are difficult to dissolve in the compost heap, and are acted upon very slowly by the soil. Even when steeped in sulphuric acid, horns and hoofs take several months to dissolve, and a longer time is required in the compost heap. As they contain about 16 per cent. of nitrogen, however, and only require time to dissolve, they should be frequently gathered and put into the compost heap. Rotted woollen rags is an important manure in the hop gardens of Kent, and nearly all such animal substances contain valuable fertilizing qualities.

SEAWEED.—Seaweed is a well-known manure of light quality, extensively used along the shores of all old agricultural countries. It contains a large proportion of potash and soda salts, and quickly dissolves in the soil. It is esteemed as being more valuable than farm-yard manure for the potato crop; while its value for turnips and other roots, as well as for the succeeding grass or grain crops, has been thoroughly established by experience. The seaweed is generally spread over the field, and ploughed into the soil.

SOOT.—Soot is a valuable manure, especially that from coal, which is superior to soot produced from firewood. It consists

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principally of carbon, but contains about 25 per cent. of mineral matter. As a quick-acting manure for young cereal crops it is very effective, and it is highly valuable for root crops.

REFUSE VEGETABLE MATTER.—As all vegetable matter contains the elements necessary to the growth of other plants, it is evidently important to utilize as manure all the waste vegetable products of the farm. The waste leaves of root crops, stubble, weeds, and such vegetable matter as can be effectively utilized by being ploughed into the soil, produce a fertilizing effect; but the roots and seeds of weeds likely to sprout in the soil, as well as other vegetable refuse, should be collected and rotted in the compost heap.

LIME.—The value of lime as a manure is owing both to the constituents which it adds to the soil and the beneficial effect which it produces upon the existing organic and mineral substances. Some soils are naturally deficient in lime, and others become impoverished of lime through continual cropping. In both of these cases the application of lime is necessary, while it is also beneficial in changing the physical condition of some soils, and setting free their insoluble constituents. Heavy, cold, clay soil and damp, sour soil are improved by being opened in texture and sweetened by the action of lime. Upon light, dry soils lime has little beneficial effect, but nearly all heavy soils are improved by the application of this manure. As it only adds one important mineral constituent to the soil, it cannot be expected to supply deficiencies of other elements of plant nutriment, but it improves land by acting upon substances which are present in the soil in an unavailable form. Lime performs an important service in thus liberating the insoluble or unavailable organic and mineral constituents which support vegetation. It is, therefore, in a sense, a means of exhausting the soil, and cannot be used to an unlimited extent without the application of other manures. Used judiciously, lime, in addition to applying an important mineral element of plant food, improves all, excepting light, sandy soil, rendering them the better able to produce leguminous root and cereal crops and grasses.

APPLICATION OF LIME.—The quantity of lime required by land depends upon a variety of circumstances, but as a general rule the more clayey and damp the soil the heavier will be the dressing needed, the average being from 50 to 200 bushels per acre. After being burnt the lime may be carried to the field and placed in heaps ready for spreading when slaked, or it may be slaked previously in the compost heap, or

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in a heap by itself. The heaps, whether on the field or elsewhere, should be covered with earth, and, if there is no rain, water may be poured on to facilitate the slaking process. The slaking will reduce the lime to powder, and then it may be spread over the land. A common practice is to plough the lime in, but as its tendency is to work into the subsoil, harrowing in is a preferable method. A good dressing of lime should last 10 or 12 years. Turnips and other root crops, and peas, beans, and clovers are specially benefited by the application of lime, and after being exposed to the air long enough to become effete or form a carbonate, it serves as a good top-dressing for pastures.

MARL.—Deposits of marl which have been formed for the most part by accumulations of shells at the bottoms of lakes supply a useful kind of manure. Marl is a mixture of lime, clay, and sand, in varying proportions, and its value as a manure is mainly regulated by the quantity of lime which it contains. The proportion of lime in different marls varies from 20 to 90 per cent., the average being about 30 per cent.; and sulphuric and phosphoric acid are generally present in small quantities. In marl deposits the proportion of lime generally increases from the surface downwards, so that mixing the marl from different parts of the face of the pit is advantageous. As lime is its principal constituent, what has been said as to the uses and applications of that manure will also apply to marl. It should be pulverized as much as possible before being ploughed in, and is benefited by lying some time after being spread upon the field. Burning marl before applying it to the soil facilitates its pulverization and increases its activity as a manure.

SHELL SAND.—This manure consists of broken shells, mixed with more or less sand, and as lime enters largely into its composition, it produces beneficial effects upon heavy clay and peaty soils. An application of about 12 tons per acre to stiff clay soil has the effect of opening the texture, and generally acting in the same way as lime. Its value has been well tested in old agricultural countries, as well as in some of the coast districts of Australia.

GAS-LIME.—This substance consists of lime which has been used in the manufacture of gas. When exposed to the action of the air for some months it loses the objectionable substances derived from the manufacturing process, and becomes available as a manure. It is not nearly so strong as lime, but in a slighter degree it acts in a similar way upon the soil.

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GREEN CROP MANURE.—Manuring land by means of ploughing-in a green crop sown for the purpose is recommended by the experience of farmers in both ancient and modern times. We have already seen that the fertility of soil depends both upon the constituents of plant nutriment which it contains and its physical condition, and in each of these particulars green crop manuring produces beneficial effects. By rendering the soil moist and mellow the green manure tends to set free the unavailable mineral constituents of the soil, and it also adds to the soil some of the substances contained in the green crop which is cultivated. The carbon, oxygen, and hydrogen, of which the green crop is composed, is derived from the atmosphere, and added to the soil by the ploughing-in of the crop, and in the case of deep-rooting plants mineral constituents derived from the subsoil are also added to the surface soil. The decay of the vegetable matter in the soil produces *humus*, or vegetable mould, the presence of which is necessary to the growth of plants, for without it the important constituents of plant food assume conditions in which they cannot be assimilated by the roots. By the improved texture of the soil, resulting from the presence of mould, and owing to the chemical action which results, the constituents of the soil are set free and made available to the growing plants, and when the green crop consists of deep-rooting plants, mineral constituents brought up from the subsoil are added to the store already within reach. Such a system of manuring is especially valuable in a country where labour is dear and conditions are unfavourable to the making of large quantities of farm-yard manure. In Australia, also, where the dryness of the climate tends to produce an absence of *humus*, or mould, in the soil, green-crop manuring should receive special attention.

PRACTICE OF GREEN MANURING.—Crops for supplying green manure should be rapid in growth, and produce a large quantity of vegetable matter, while deep-rooting plants also possess an additional element of value. The pea crop has been most frequently tried, and with the most satisfactory results, as a green manure in Victoria. In the Warrnambool and Lancefield districts especially, ploughing-in a crop of green peas is found to be an excellent manure for potatoes, and the productiveness of the exhaustively cultivated land has greatly increased since the custom was introduced. The crops used as a green manure in different countries are clovers, lucerne, peas, beans, vetches, maize, buckwheat, spurry, white lupine, turnips, rape, and white mustard. All these crops are suitable for green manur-

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ing purposes, and may be selected according to local circumstances. The deep-rooting crops are clovers, lucerne, and the white lupine. As the most frequent defect of the soil in such a dry climate as that of most parts of Australia is a deficiency of *humus*, the deep-rooting character of a green manure crop is seldom the most important consideration. The crop which, under local circumstances, will produce an abundance of green vegetable matter to mix with and mellow the soil should be cultivated. In the dry wheat-growing areas the growth of green weeds and wheat which springs after the autumn rains should be ploughed into the soil, as this course is calculated to yield more profitable results than feeding off with stock. For green-manuring root crops in moist climates many of the plants named can be used, but in the dry wheat-producing districts the choice of the farmer is limited, owing to the difficulty of getting green crops to grow in time for ploughing-in before the sowing season. Some such quick-growing plant as the white mustard and rape can only be resorted to in these circumstances. It would be a profitable practice in the wheat-producing districts to adopt green-manuring along with bare fallowing. During the autumn, winter, and spring a growth of green crop manure from spurry, rape, or mustard could be obtained, which, being turned down before summer, would keep the soil in good condition for the sowing of the early wheat crop. Green manure crops should be ploughed into the soil when the plants are coming into bloom.

Hints on Manuring.

Ashes as a Fertilizer.—Unleached wood ashes contain all the constituents of plant food that the ordinary or worn-out soil needs, except nitrogen. By their chemical action they render much of the inert nitrogen in soils available, and in that way may be said to furnish nitrogen. This is true of lime, and on this power of making nitrogen available the greatest value of lime, when applied as a fertilizer, depends. Ashes also have a good mechanical effect upon the soil, especially heavy clay soils, which are made lighter and more porous, so that air and water circulate more freely. Ashes do not suffer waste by being washed out to the extent that is true of the more soluble and concentrated fertilizers sold in the markets—their effects are therefore more lasting.

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GREEN MANURING.—The practice of ploughing down green crops with the object of "manuring" the land is a recognized method of effecting that end. If plants obtained the whole of their nourishment from the soil, it is obvious that the soil would not be enriched by ploughing down a green crop. But as they obtain part of their nourishment from the atmosphere, through their leaves, the beneficial action of the practice of green manuring can be understood. Thus, after a green crop has been ploughed in, the soil necessarily contains more of the organic elements essential to vegetable nutrition than it did before that crop was grown. In like manner the succeeding crop has the advantage of a ready supply of mineral elements which have been worked up by the roots of the fertilizing crop from the soil and subsoil, and which, in many instances, owing to their sparing solubility, are with difficulty obtained under ordinary circumstances.

PROFESSOR LAWS ON NITROGEN.—In a letter reprinted in the *Australasian* Professor Laws says:—"Boussingault, the most thorough investigator of modern times, has conducted numerous experiments on this subject, and has arrived at the conclusion that plants could not assimilate free nitrogen. At Rothamstead we carried out similar experiments for three years with the same result; and quite recently Boussingault, in a letter to Dr. Gilbert (which he gave him permission to publish), says:—'If there is one fact perfectly demonstrated in physiology, it is this of the non-assimilation (of nitrogen) by plants.' This opinion from one who conducted scientific experiments on his farm in Alsace long before the time when the Rothamstead experiments were commenced, and who lately received one of our Royal Society's medals for his services rendered to agricultural chemistry, will, I hope, show that I have some ground for ignoring the scientific fact to which he alludes. I will pass on to another point. Mr. Barclay compares the action of nitrogen on vegetables to that of alcohol on man; 'that it is stimulative and useful within narrow limits, but an application in excess is positively injurious.' If being told incessantly that nitrogen acts as a stimulant to vegetation could make me believe it, I should have nodoubt of the fact; it is, I may say, the almost universal agricultural belief. Now, when we say that alcohol is a stimulant, we mean that it produces a certain action on the brain, nerves, and muscles, but it forms no part of these organs. There are millions of people who never tasted alcohol, and its presence in the body is not necessary for the performance of any of the

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vital functions. Compare this with nitrogen in vegetation. Wherever you find the most activity, there you find the most nitrogen. I may also say that chlorophyl, the green colouring matter of leaves (where alone carbonic acid is decomposed and starch and sugar formed), is a nitrogenous body. The whole structure of plants consists of cells. Sach, the eminent German botanist, says—'If a cell contains a nitrogenous body, it can develop new chemical combinations and form new cells; if it contains none, it is not capable of further development.' Now, a substance which is thus closely connected with all the most important functions of vegetable life is surely entitled to occupy a higher position as regards plants than alcohol does as regards man. That the use of nitrogen in manure may be abused there is no doubt; associated with nitrogen in plants we find certain mineral substances, but if these be absent the nitrogen accumulates in the plant, and the decomposition of carbonic acid ceases. In the annual report of the Aberdeen experiments Mr. Jamieson says that our attention at Rothamstead is chiefly directed to nitrogen. This is so far true, inasmuch as it is the most complicated and important substance with which we have to deal, and also because we feel sure that, until correct ideas are formed as to the position of nitrogen, there will be no progress in scientific agriculture. My own opinion is that at the present moment nothing would contribute so much to the well-being of the farming interest, or enable us to compete against the cheaper agriculture of the United States, as a large and inexpensive supply of nitrogen in manures."

CHAPTER V.

IRRIGATION.

IRRIGATION, or the artificial watering of land, is specially valuable in a dry climate. Water, as already shown, enters largely into the composition of all plants; and it has also been pointed out that the constituent substances of soils must assume a liquid form before they can be assimilated in the process of vegetation. Soil may, therefore, be barren while containing large supplies of plant food, owing to the absence of moisture to reduce the substances to an available soluble

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condition. Mr. T. K. Dow, who visited America as representative of the *Australasian*, reported that the barren desert land of Utah becomes fertile when irrigated by the Mormon settlers, the sandy-looking, sterile soil changing, under the effects of water, to dark, productive loam. In Texas, New Mexico, Arizona, and parts of California, similar effects have been observed, proving the correctness of Professor Johnson's opinion. The last-named authority referred to says—"The great deserts of the world are not sterile because they cannot yield the soil-food required by vegetation, but because they are destitute of water. . . . Poor soils give good crops in seasons of plentiful and well-distributed rain, or when skilfully irrigated; but insufficient moisture in the soil is an evil that no supplies of plant food can neutralize." This truth is further borne out by the fact that the soil is known to be exceedingly fertile in those extensive tracts of northern Victoria and South Australia, where, through the dryness of the climate, poor yields are nearly always obtained. There are but few sections of the globe where the rainfall is so copious and regular as to render irrigation entirely non-effective; while the benefits derivable from the system in any case are likely to be in proportion to the dryness of the climate. As, therefore, insufficiency of moisture is a characteristic of the Australian climate, irrigation is a subject of special importance in these colonies.

OBJECTS OF IRRIGATION.—The chief object of irrigation is to supply a deficiency of moisture in the soil. Upon this branch of the subject Professor Church gives the following reasons for resorting to irrigation:—

> "1. To make up the absence of irregular seasonal distribution of rain, or for a local deficiency of rainfall.
> "2. Sometimes a particular crop is irrigated because the crop is of an aquatic or semi-aquatic nature.
> "3. To encourage early and rapid growth by warmth of the water, or by the dissolved plant food which it contains.
> "4. That the land may be enriched, and its level raised by means of the deposit from the water."

It is only in the first of these objects that the Australian farmer is generally interested, for in our warm, dry climate the most important consideration is to make up for the absence or deficiency of rainfall.

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EFFECT ON SOIL.—The artificial application of water affects both the texture and the composition of soils. "The immediate effect," says Professor Church, "upon the *consistence* of the soil is to soften it and render it more easily penetrable by the plough and by the roots of the plants. Hence, in dry climates, water is frequently applied before ploughing, at the rate of about 400 to 500 cubic yards per acre, or barely enough to loosen the earth to the depth of a foot without drenching it. But it is most important to observe that the ultimate effect of long-continued irrigation is to condense and harden the surface to a very inconvenient degree. Irrigation affects the *quality* of the soil by introducing into it common air and other gases, and vegetable and mineral matter held in suspension or solution by the water. In most cases the substances so introduced are beneficial to vegetation; but in some they are highly obnoxious. Even the water of large rivers sometimes, as has been observed in India, deposits on the surface, or introduces into the texture of the soil, salts, which in the course of time render it wholly sterile." It is obvious, therefore, that only water of suitable quality should be used for irrigation. When water free from noxious ingredients is used, it sets free the constituents of plant food in the soil, and renders all the beneficial services of a sufficient rainfall. Too much irrigation is injurious in the same way as too much rain, and the damage is in proportion to the quantity of the over-supply.

EFFECTS UPON CROPS.—Irrigation properly applied affects vegetation in the same way as a sufficient fall of rain. Crops of all kinds can be grown to perfection by a judicious application of water, but over-irrigation may result not only in checking vegetation, but also in giving quantity of produce at the expense of quality. Owing to the heavy yields obtainable by means of irrigation, it is too frequently forgotten that the quality of the product suffers when too much water is applied. Excessive watering also renders the land sodden and sour. The aim of the farmer should be not to drench the land, but to supplement the deficiency of the natural supply of moisture.

SUPPLY OF WATER.—A supply of water for irrigation may be obtained from running streams, wells, or reservoirs. Permanent running streams give the best supply, as the water is generally of a suitable kind, and is available whenever required. The alluvial soil usually found adjacent to rivers and streams is well suited for irrigation, and the permanent supply of water enables a variety of crops to be cultivated in different seasons of the year.

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RUNNING STREAMS.—The water in running streams is generally fresh, and free from injurious salts or other ingredients deleterious to vegetation. On the other hand, it usually holds in suspension valuable mineral and organic matter, which is deposited on the land in the process of irrigation, increasing the fertility of the soil. None of the Australian rivers are known to contain water unsuitable for irrigation, while most of them are more or less muddy streams, carrying large quantities of matter calculated to improve the quality of the soil upon which their waters may be used for irrigation. Of this character are the Murray and its numerous tributaries, which traverse a large portion of the continent.

WELLS.—The brackish water obtained from wells is in many cases injurious to vegetation, and consequently unsuitable for irrigation. All water which is not fresh does not contain noxious ingredients, or they are not always present in sufficient quantities to be injurious to crops. Analysis, or experimental results, must decide in each case the suitableness of the well water for irrigation; and the water can be improved both in quality and temperature by standing some time exposed to the sun and air before being applied to the land. Water may be "brackish" or "hard" through containing ingredients which are not only harmless, but positively beneficial, and hence the necessity of testing it by analysis or experiment. First experiments are apt to be misleading, for, in the event of the water being unsuitable, its injurious effects may not appear until through repeated applications the land becomes impregnated with the noxious minerals. Land reclaimed from the sea, or containing injurious or surplus salts owing to other circumstances, can be rendered fertile by the application of fresh water, which washes out the objectionable ingredients.

WELL-HEAD RESERVOIRS.—It is seldom advisable to irrigate with water drawn directly from a well. The water is improved both in quality and temperature by standing for some hours exposed to the sun and air. Well water is frequently cold, and, if applied to crops in warm weather, produces injurious effects. It is customary in California, where well irrigation is extensively practised, to form a large surface reservoir around the pump or pipe-head, and in this the water is aired before being applied to the land. Such a reservoir not only enables the water to be exposed to the air and sun, but it stores a supply for the purposes of irrigation. The supply of water from wells is necessarily limited. In the case of deep wells the quantity available is limited according

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to the capacity of the pump, and artesian wells according to the pressure and the measurement of the pipe. In all cases the supply is sufficiently limited to render the reservoir important. The pumps are kept working at all times, night or day, and at seasons when irrigation is not being carried on; while in the case of artesian wells the flow is also continuous, so that a large reservoir can be filled, giving a valuable supply available for irrigation. The reservoir is conveniently formed by excavating with the plough and scoop, and using the earth taken out to erect surrounding banks. From the reservoir the water can be led by gravitation over the land at a lower level in the same way as from a canal.

ARTESIAN WELLS.—The supply of water from artesian wells is specially valuable, owing to its being available without the necessity of pumping or being raised by other mechanical means. The volume also being constant furnishes another advantage as a means of irrigation. In California, orchards and vineyards are frequently irrigated from artesian wells; and, in some cases, fields of wheat, forty acres in extent, are also supplied. Artesian wells of equal volume, with water flowing several feet above the surface, have been found at Sale, Portland, and other points near the coast; while, in the central districts of New South Wales and South Australia, similar discoveries have been made, so that there is good grounds for expecting large quantities of water to become available from artesian wells all over the Australian continent. A considerable area of land could be irrigated from such wells as have been discovered without the assistance of storage reservoirs, while, by means of well-head supply reservoirs, the area could be largely increased.

DAMS OR TANKS.—Limited supplies of water for irrigation can be obtained by means of dams and tanks. By erecting dams across watercourses, or at the outlet of natural reservoirs, large quantities of water can be stored at comparatively little cost, and such favourable conditions can be profitably taken advantage of. In the case of open plains in dry districts, it is also practicable to store considerable quantities of water. Even where the rainfall is light a large quantity of water runs off the land; and, although the quantity that can be stored is comparatively small, the circumstances make it proportionately valuable. There are few localities, however, where nature has not provided basins and depressions that can be easily converted into reservoirs to conserve water, which

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would otherwise be lost Even when tanks have to be formed, economy can be effected by building banks of the excavated earth. A reservoir a quarter of an acre in extent, and 10 ft. deep, would contain 108,900 cubic feet, or about 680,625 gallons, sufficient to give a watering one inch in depth to 30 acres of land. A cubic foot of water contains 6·232 gallons, or nearly 6¼ gallons.

CANALS.—Canals to convey water from the source of supply to the land which is to be irrigated are formed by excavating a channel of the required dimensions, and using the earth taken out for erecting banks on each side. A system of forming canals entirely on the surface, by making banks with earth taken from the excavations on the outside, has been advocated; but it has not been supported by competent authorities, or adopted in any part of the world. To utilize the earth excavated from the channel in forming banks is a manifest advantage, and the practice is universally followed in the irrigating states of America. The carrying capacity of a canal depends upon its dimensions and its gradient. A fall of one foot in the mile is a safe and convenient gradient; but at the rate of two feet per mile there is more or less danger of the banks and sides of the canal being cut away by the force of the water.

WEIRS AND FLOOD-GATES.—In ordinary circumstances a supply of water, available by means of gravitation, is the most desirable for irrigation, but much depends upon the circumstances of each case. Sometimes the banks of a river or creek are low enough to admit of a canal being filled without the aid of a weir, and in such circumstances the water is applied for irrigation in the most economical manner. The head of the canal is lower than the level of the stream, and all that is required is a flood-gate to shut off the water or regulate the supply. Substantial stone or wood work is needed in erecting the flood-gates on the banks of the stream, but this is much less expensive than constructing a weir. In Colorado and California several canals are supplied in this way, and it is seldom in those states that high weirs are necessary. Next to requiring no weir at all, the most favourable conditions exist when the water of the stream has to be raised only 1 ft. or 2 ft., and when the object can be accomplished by forming a ford of loose stones. Difficulties increase as it becomes necessary to raise the water higher above its natural level. Timber is extensively used in forming weirs in America, but it is seldom that the water has to be raised more than 8 ft. or 10 ft. The

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weirs are usually constructed by driving piles into the ground to support transverse beams, a rear apron of stones or wood being provided, over which the water flows from the crest of the dam. Upon a similar plan a large number of weirs have been erected over small creeks in the northern parts of Victoria; but the result has been somewhat disappointing. In the case of large streams no other system is practicable; but the smaller creeks were more successfully dammed by the earth banks erected by the original pastoral settlers. The squatters' dams in the interior districts are solid earth banks, entirely turning the stream in flood time into a wide by-wash, and these have stood for many years, while the more expensive wooden weirs of a recent date have, in many cases, been washed away. The banks of Australian rivers are higher, and the streams have a wider range of rise and fall than in America, so that there is greater difficulty in constructing weirs. Fewer weirs, however, are necessary, for a much larger area of land can be commanded by a single canal owing to the more level character of the country.

PUMPING.—When water has to be raised by mechanical means for irrigation the cost is generally greater than when the supply is obtainable by means of gravitation. Experience in the Murray Valley, however, has demonstrated that large supplies can be raised by centrifugal pumps at a reasonable cost. Pumps, with pipes 15 in. in diameter, and raising 5,000 gallons per minute, and others 18 in. in diameter, raising 7,000 or 8,000 gallons per minute, are used on the Murray, near Echuca, and the whole cost of pumping and distributing the water is estimated at less than 5s. per acre of land irrigated. When large quantities of water have to be raised a height of under 25 ft. or 30 ft. the centrifugal pump is most economical, but for higher lifts and smaller quantities of water pumps upon the plunger principle are generally preferred. Water wheels, California pumps, and pipe and chain water lifts are also successfully employed in raising a supply for irrigation, in special cases, and local circumstances must decide as to the best means to employ.

DISTRIBUTION OF WATER.—In applying water to root crops, vines, or fruit trees, the most approved method is to run furrows from the supply channel between the rows of trees, vines, or roots. In the case of trees or vines, flooding the surface soil tends to make the roots grow upwards, encourages suckers, and otherwise injures the plantation. By running the water along the furrows, the subsoil becomes

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moistened, and the roots are encouraged to grow downwards to the supply. When flooding the surface is resorted to, a small embankment of earth is formed around each tree to keep the water off the land near the stem, and thus cause the moisture to reach the roots through the subsoil. When practicable, irrigation should be practised in the evening or at night, rather than during the heat of the day.

FLOODING.—In watering cereal crops flooding is the method generally adopted in America and Australia. The water is made to cover the surface of the fields, finding its way among the growing crops. In the case of the American farmer there is a continuous though limited flow from his "lateral" or supply ditch, and the farmers along the Murray fill the supply channel by means of pumping. When the channel is full, the water is a foot above the surface of the field, and small openings are made in the lip of the aqueduct about 10 yards apart. The water flows from these openings over the land. At first it might be thought that furrows would be necessary to convey the water to a distance from the main channel, but it has been found from experience that no assistance of this kind is required in the case of the clayey soil of northern Victoria. If it were desired to use a limited supply of water in giving a slight wetting to a field, some more detailed means of distribution would be needed, but not when level land is to be thoroughly soaked. Remembering that a continuous supply of water is coming from an elevated channel, it will be easily understood how the distribution takes place. The soil nearest the supply takes in water until it is completely soaked and will take no more. Then an overflow takes place to land further out, which in turn gets saturated, leaving the water to be forced on to a further distance, and so on until the limit of the field is reached. With a plentiful supply of water the channels need not be closer than 10 chains apart, but, in order to economize the supply, more frequent channels are desirable.

DISTRIBUTING FURROWS.—Where there is a limited supply of water, or where it is desirable to economize what is available, distributing furrows may be profitably introduced. Mr. Leitch, of Gunbower station, has prepared for an experiment this season, which will probably show good results. A field sown with wheat is provided with a system of distributing furrows designed to assist the rapid watering of the soil. The furrows are shallow, being more correctly described as "plough marks," and, after being formed, the land was rolled, so as to level

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down the earth thrown out by the mouldboard. By running the roller one way only the earth was pressed away from the plough mark and levelled down, so that while nothing was left that would interfere with harvesting machinery, there remained a shallow, smooth channel to carry water. The plough marks are 15 ft. apart, and crossed with similar marks 21 ft. apart. It is considered that the water will run quickly along this network of shallow channels, and soak in from one to the other, thus more rapidly and thoroughly moistening the soil. This system is a modified form of that followed in America, where the farmer has a limited head of water to deal with, but as long a time as he wishes to attend to its distribution.

HOSE DISTRIBUTION.—Where the soil is a loose alluvium, or of a sandy character, flooding according to the above methods cannot be carried out, for the water will sink into the subsoil and fail to spread itself over the surface. In such circumstances the use of the canvas hose is a convenient and practical method of distribution. Mr. Pearse, of Bacchus Marsh, who has been engaged for some years in growing chicory, as well as other root crops, employs this means. The water is raised from the Lerderderg by means of a Californian pump, driven by an engine to supply some of the fields, and by a water-wheel to supply others. An aqueduct runs along the banks of the river, with a slight elevation above the cultivated land. It would be a waste of pumping power to attempt to force the water along furrows to the bottom of the paddock, owing to the great loss by absorption, and it was to overcome this difficulty that Mr. Pearse invented his system of irrigating by means of calico hosing. A thick calico or canvas hose, made in 20 ft. lengths, is attached to the aqueduct, and when the first length is filled with water its end is inserted 10 in. or 12 in. into an empty length. This forms a complete join by the pressure of the water, and length after length is added until the bottom of the field is reached. The water is now allowed to run until as large an area as possible is irrigated, when one of the lengths of hose is taken off, which brings another space of 20 ft. in width within reach of the water; and so the process is continued until the top of the land near the aqueduct is arrived at. The hose is again attached to the aqueduct at a point two chains further along, and another strip of land is irrigated from the bottom to the top of the field, and so on until the whole of the crop has been watered. The same system is adopted by some of the hop-growers on the Mitchell and Ovens rivers with marked success.

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SUB-IRRIGATION.—Applying moisture to the subsoil would, no doubt, be as beneficial to grain crops as in the case of trees and vines, but there are difficulties in the way of carrying out the system. In some countries, and in one notable instance in California, pipes have been laid underground for the purpose of irrigating the subsoil. Results have been highly satisfactory, but the cost is excessive. Fair success, however, has been attained by watering grain crops by means of furrows, as in the case of root crops or trees, without flooding the surface. Mr. Patchell, of Kerang, has followed this plan for years, and finds the result to be much better than when flooding is resorted to. Mr. Patchell's plan is to get the land as level as possible. Having been perfectly levelled, the land is cultivated deep, and ploughed into medium-sized lands. The lands are made as flat as possible, and the water-furrows are deep and well defined, so that when tillage is completed, the appearance of the field is, as far as practicable, like a level plain traversed by drains. The furrows are connected with the water-channels, and they are filled, but not to overflowing. The furrows are full of water, but the surface of the field is dry. By keeping the furrows full for a time the water soaks to the right and left, wetting all the subsoil, and even the soil near the surface, but not producing the effect of forming a hard crust under the subsequent influence of the sun. In irrigating the garden this method is found to be especially necessary; and for the purpose of carrying it out the land is divided into small plots, separated by water-channels.

DRAINAGE.—It is as necessary to drain off the surplus water as to supply a deficiency of moisture. The most frequent mistake of irrigators is to put too much water on the land, and an equally common error is a failure to provide for drainage. Where the subsoil is porous less care is needed; but in the case of such a retentive subsoil as exists in most of the dry regions of Australia, drainage cannot be neglected without injurious results. The channels which convey the water to the land can be made to serve as drains for taking off the surplus. Provision should be made for employing the channels as soon as the fields have been irrigated, so that they may act as drains to take off the surplus supply. A quick application of water, giving the land no more than it can absorb in a few hours, and then a quick draining off of the surplus, constitutes the treatment most approved by practical experience.

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RUST DISEASE.—In cultivating the wheat crop by means of irrigation, the rust disease must be guarded against. Although Australian farmers have not had much experience of irrigation, enough has been learned to show that this disease can be encouraged by an unskilful use of water. Rust is apt to be produced by too much water, or deficiency of drainage, and by irrigating at the wrong season. The wheat producer will, therefore, have to avoid putting too much water on the land, and will find it necessary to provide for draining off the surplus supply, while he will irrigate his wheat crop not too late in the season. It will be found advantageous to irrigate soon after sowing, and again early in the spring, avoiding late irrigation as a source of danger.

IRRIGATING PASTURES.—Flooding is the principal method employed in watering pastures in the Gunbower district; a large area of grass land has been irrigated in an imperfect manner, but the following is an improved method in older countries. A system of small channels or furrows from 20 ft. to 30 ft. apart is formed across the paddock, the furrows running at right angles to the fall of the land. The furrow on the highest side of the paddock is filled first and made to overflow, the end being dammed up. The water flows over the land to the next furrow below, which, being similarly dammed up, overflows, sending the water to the next, and so on until the whole field or meadow is covered. Night is the best time for irrigating pastures, and care must be taken to drain off the water. Too much water will destroy pastures, and it is necessary to provide for the rapid draining of the surface. As a rule six hours will be long enough to leave the water upon the pastures.

QUANTITY OF WATER.—The best method of measuring water is to allow it to run over a weir without pressure. A notch or opening in a weir in which water is standing without pressure is measured, and these dimensions, with the depth of water flowing over the weir through the notch, give the number of inches being delivered per second. In California one cubic foot per second is allowed for each water-right, and in Colorado the allowance is 1 44-100 cubic feet, or nearly 1½ cubic feet per second, a water-right serving 80 acres of land. A flow of water equal to one cubic foot per second would cover 4 acres of land to a depth of about 6 in. in 24 hours. By noting the effect of 3 in. of rain upon a crop, we may infer that a large quantity of water is not required at one time, and the aim

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in irrigation should be only to make up the deficiency of the natural supply of moisture.

CHAPTER VI.

GRAIN CROPS.

WHEAT.

WHEAT, which has been cultivated since the most ancient times, increases in importance as a farm crop with the advance of the human race in civilization. Flour, the manufactured product of wheat, becomes more and more the staple food of nations as they rise in the scale of modern advancement; and hence the cultivation of this cereal receives an increasing share of attention. Although growing to the greatest perfection in the temperate zone of the earth, wheat can be successfully cultivated in a great variety of climates, from the equator to beyond the arctic circle, being, like man, whose food it seems designed to supply, capable of thriving under widely varying circumstances.

CHOICE OF SOIL.—Soils containing a large proportion of clay are best suited to the requirements of the wheat crop. A good firm soil, consisting of clay or clayey loam, yields the best results, and the presence of lime is essential. Carbon and oxygen are important organic constituents of both straw and grain, and the ash constituents of the grain are mainly phosphoric acid, potash, magnesia, and lime, while silica is an important element in the composition of the straw. Wheat can be successfully grown upon light calcareous or marly soils, but the suitableness of land for this crop is generally in proportion to the degree in which it possesses a clayey nature. Rich alluvial or vegetable soils are apt to produce too luxuriant a growth of straw, with a liability to rust and blight.

PREPARATION OF SOIL.—Wheat is a deep-rooting plant, and a good depth of well-prepared soil is, therefore, advantageous to its growth. In addition to its tap roots, which penetrate the subsoil, the plant possesses lateral roots, which search for food near the surface, so that a deep, well-worked seed bed is essential. Upon suitable soil, in a high state of fertility, good crops are sometimes obtained by shallow and imperfect culti-

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vation, but this fact should not mislead the agriculturist into supposing that such treatment is advisable. As a rule, the success of a crop will be in proportion to the depth of pulverized fertile soil in which the roots are able to search for nutriment; and in a dry climate, where moisture is always insufficient, such will be more especially the case. A loose tilth is not required, but a firm soil, well pulverized, and a deeply stirred subsoil, should be provided for the wheat crop.

MANURE FOR WHEAT.—Farm-yard manure has to be very carefully applied to the wheat crop, as it is apt to produce over-abundant growth, an undue proportion of straw, and a tendency to "lay" or lodge, and to rust. It is better to apply the farm-yard manure to the previous root crops, or, when applied directly to the wheat crops, salt, ashes, or effete lime may be used to check the evil effects. Peruvian guano sown broadcast and harrowed-in with the seed at the rate of 2 or 3 cwts. per acre, or an equal quantity of bone-dust or superphosphate, may with advantage be applied to the wheat crop in moist localities; but in the dry districts of the colonies immediate results need not be expected from any manure, owing to a deficiency of moisture to render the constituents soluble. The following year, however, after the winter rains have moistened the soil, advantage will accrue. Nitrate of soda is one of the best manures for wheat in dry districts, and in such localities it may be either applied in winter, or used as a top-dressing in spring for late crops. The burning of stubble or the straw after the stripper in dry districts supplies the soil with ash constituents, and destroys the seeds of weeds. While inferior as a system to the making of farm-yard manure, it is the only one available over a large area of Australia. Green manuring could be followed with advantage in such localities, as a deficiency of moisture and *humus* is one of the principal defects in the condition of the soil.

VARIETY OF SEED.—The distinction between winter and spring wheat is of little importance in Australia. In countries where there are cold frozen winters, quick-growing spring wheats are valuable as maturing after the winter in time for harvest; but as there is an absence of such winters in Australia, the best winter varieties can always be cultivated successfully. In choosing the variety of seed, local circumstances form the best guide. A wheat which is the best for one country is not successful in another, and the same rule applies to different districts. The most profitable wheats cultivated in Australia are Tuscan, Purple Straw, Port M'Donnell, and English

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Velvet, and it is well known in each district which variety thrives best under local circumstances.

SELECTION OF SEED.—Opinions are divided upon the question of plump or thin seed, but Mr. Hallett's theory is backed up by admirable results. His method is to apply the principles of selection, and to study the laws of descent in the vegetable as well as the animal kingdom. "Like begets like," he contends, in the case of plants equally as in the case of animals. Every plant of wheat, for instance, possesses one ear that is better than the rest, and every ear one grain that is superior to the others. By selecting these superior ears and their best grains, and sowing them, seed is obtained which produces a wheat possessing superior qualities. This system of selecting seed and regarding its pedigree is held to maintain and improve the quality of the cereal, and those who have acted upon the theory have succeeded in producing a fine sample. Objectors assert that plumpness of condition is no test of pedigree, as a well-bred animal may be thin and poor; and that good grain is produced from thin seed in the same way that good stock is raised from well-bred parents low in condition. It is also a matter of fact that when rust has been destructive in South Australia good crops of excellent grain have been raised in the following seasons from the sowing of shrivelled seed. Extremes in this controversy, as in all others, should be avoided. A single season is not likely to produce striking effects. Shrivelled grain from a plant having a good pedigree would not show inferior progeny in a single season; but it does not follow that the continuous use of thin seed would maintain a high standard of quality. Careful selection year after year of well-developed seed will be found to act in the direction of maintaining the quality of the grain, and the pedigree of the plant will not fail to tell upon the character of its progeny. Thus, a well-filled sample, produced under exceptionally favourable circumstances from a poor variety, should not be relied upon to reproduce good grain, as it would not be so likely to yield satisfactory results as a less plump seed from a stock of better pedigree. In changing seed, therefore, pedigree, as well as the appearance of the grain, should be taken into account.

PREPARATION OF SEED.—The most important preparation for seed is to make it clean. Passing through the screen dresser will not only remove all light and imperfectly developed grain, but also remove foreign seeds. Keeping the seed clean is better than attempting to destroy weeds after they have been sown, and this is especially the case in those dry

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districts where wheat is the staple crop. In those localities, owing to the infrequency of rains, weeds are destroyed with difficulty. There is generally no rain until that falls which is needed for the wheat crop, and then it is too late to destroy weeds. Wild oats, drake, and other weeds grow with the crop, spoiling the sample, and propagating themselves in the ground until further cultivation becomes impossible. "Keep the land clean by sowing clean seed" is the best advice to farmers in the wheat-growing areas, and the most successful wheat-growers have always acted upon the injunction. Thoroughly cleaning the seed by passing it through the screen will save much afterwork in the way of destroying weeds, and prolong the period during which wheat can be grown on the same land in dry districts.

PICKLING SEED.—Pickling seed is generally carried out by farmers, and chiefly as a prevention of smut. The system is sometimes called "steeping," but this term is misleading, for steeping seed wheat should be carefully avoided. The seed should not be left in the pickling liquid long enough to become steeped, but should only be covered by the pickle, and then allowed to dry before being sown. When seed is thoroughly moistened in the pickling-tub, and then sown, it will germinate; and, should the season be dry, the absence of moisture in the soil to carry on vegetation will cause the seed to perish. If not allowed to remain too long in the pickle, the seed will lie in the dry ground until the soil becomes moistened by the rain, and thus receive no injury. The most common, and the most effective pickle, is a solution of sulphate of copper (blue vitriol), generally known as blue-stone. The bluestone is dissolved in hot water at the rate of about a quarter of a pound to a gallon of water, and this quantity is sufficient for half a bag, or two bushels of wheat. Half a pound per bag is a sufficient quantity of bluestone. A handy method is to partly fill a large tub with the liquid, and, putting about two bushels of wheat in a bag, submerge the bag in the liquid. In about two minutes the liquid will have reached all of the grain in the bag, and then the bag can be raised upon a cross-bar on the tub and allowed to drain. The salt or brine pickle, extensively used in America, is a brine made of salt water sufficiently strong to float an egg. The wheat is steeped for five minutes, then taken out and mixed with one-twelfth its own quantity of dry lime. Another plan is to dip the wheat in a strong solution of lime, the lime forming a thin coating upon the grain. In all

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cases care must be taken to avoid soaking the wheat. While the method of dipping the wheat sacks saves labour, putting the grain loose into the liquid has the advantage of assisting to clean the seed, for light grain and foreign seeds rise to the top, and can be skimmed off.

BROADCAST SOWING.—Sowing the seed broadcast is the system most generally followed, as it involves the least labour. Regularity is the principal object to be aimed at, as loss results from having the seed too thick in one place and not thick enough in another. Where a large area is to be sown broadcast sowing machines are used with advantage. There are several machines in the market which save considerable labour, and do the work more regularly than it can generally be done by hand.

DRILLING.—The drilling system possesses many advantages over broadcast sowing. Not only can greater regularity be obtained, but the horse hoe can be afterwards used to destroy weeds and stir the soil while the crop is growing. When the soil is rich, and inclined to produce weeds, drilling is specially advantageous. The only drawback to the system is that it involves more labour than broadcast sowing, but the extra labour is claimed to be more than paid for by the increased yield obtained. In the dry wheat-growing areas of the colony there is not much to recommend drilling in preference to broadcast sowing, but in the more moist localities, and especially on rich volcanic soil, where weeds grow luxuriantly, the system can be adopted with advantage. In such localities, both in the colonies and in America, drilling has been adopted as the more profitable, even when a high rate of wages has to be paid for the kind of skilled labour required.

QUANTITY OF SEED.—The quantity of seed to sow is a debatable question, but thin sowing is recommended by the experience of large numbers of practical farmers. Some varieties of wheat require to be sown thicker than others, and plump seed has to be sown in greater quantity than more shrunken grain, as there is a greater number of seeds to the bushel in the latter case. It is natural for the plant to tiller or produce numerous shoots, and as many as 100 stalks have been known to sprout from a single seed. Thick sowing retards tillering, and produces a weakly straw, bearing an inferior head of grain; while thin sowing induces tillering and the production of strong, well-bearded straw with plump grain. In the dry wheat-growing areas, where early sowing is the rule, and the crop has a long time for tillering,

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from three-quarters of a bushel to a bushel and a quarter are generally sown; while in more moist localities, with a later period of sowing, the quantity varies from one and a quarter to two bushels per acre.

TIME OF SOWING.—Early sowing has been proved to be essential in the dry districts of the colonies. Not only do the early crops yield the best results, but a late period of sowing cannot be depended upon to secure an average crop. The annual rainfall is so light that the wheat crop requires the benefit of all that is available during the season. If the autumn rains have fallen before the crop is sown, the plant remains backward during the dry winter, and is not so fully benefited by the spring rains as the crops which have been well established through being sown early. Many farmers begin to sow in March, and the sowing season is well on in the month of April. A considerable breadth is sown in May, but those farmers who sow in June or July only do so in hope of meeting with an exceptional season. In the more moist coast districts, May, June, and July are generally favourable sowing months for wheat, but May sowing is in most cases more successful than that sown in July. Wheat should be sown in a comparatively dry seed bed early in the winter.

WATER FURROWS AND DRAINAGE.—Wheat is liable to be injured when there is deficient drainage by an over-supply of moisture during winter. In the dry areas of the colonies there is very little danger from this cause, except where irrigation is practised. Underground drainage will be found advantageous in the moist coast districts, and, where there are no underground drains provided, care should be taken immediately after harrowing to mark out well-defined water furrows, as it is undesirable to allow surplus water to lie upon the wheat land. Where irrigation is practised the work of providing water furrows is especially important, for, in addition to killing the seed, a surplus of moisture is apt to produce the rust disease.

ROLLING.—As the wheat crop flourishes in a firm seed bed, rolling is an operation of special importance. It may be carried out immediately after harrowing, or when the crop is beginning to cover the ground. When carried on after the braird has appeared, rolling not only makes the surface soil firm and levels down the clods, but acts beneficially by pressing the earth about the root of the plant. Fine weather should be chosen for rolling, when the soil is not moist enough to be sticky. It is better to roll when the dust rises after the implement than when the soil is too moist. Although of great

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importance, the operation had better be left undone than carried out in wet weather when the soil adheres to the roller.

AFTER HARROWING.—Upon the clayey land usually sown with wheat the crop is greatly benefited by harrowing in the spring. The surface becomes crusted and set during winter, and the harrow breaks the crust, giving the roots of the plant a better opportunity of spreading. It also, by breaking some of the roots and shifting their position, revives the vitality of the plant, causing it to grow more vigorously and send out fresh shoots. Upon late or thin crops the effect is most beneficial. The few plants destroyed are more than compensated for by the increased vigour of those which remain. A light harrow should be used, the soil should be comparatively dry—in fine weather following showers—and the operation should be carried out before the braird is quite covering the whole of the surface. Harrowing and rolling are both carried out with advantage to the wheat crop early in spring.

FEEDING-OFF.—When the approved system is adopted of sowing early to get advantage of all the rains, it is frequently found that the wheat crops are very forward early in the spring. In such cases there is danger of rust, and the crop will possess a weakly straw, liable to lodge or "lay." Feeding-off the crop at the end of winter in such cases is generally attended with advantage. If not delayed too long, the feeding-off may be complete, baring the crop to the ground. Sheep are the best kind of stock for this purpose, but light cattle may also be used. A large flock of sheep which will quickly eat off the crop should be preferred. The crop will tiller vigorously after the grazing, receiving benefit both from being nipped off and from the treading of the ground. The principal danger is in delaying the operation until too late in the season. It is advisable to put on the sheep in dry weather, and soon enough to allow the crop to recover under the influence of the spring rains.

TIME OF HARVESTING.—It has been well established that the wheat crops yield the largest quantity of the best quality of grain by being harvested before it is dead ripe. Where the stripper is used this matter cannot be considered, for the grain has to be ripe and dry for the successful working of the machine. When wheat is reaped, however, it should be remembered that there is an advantage in harvesting early. When the grain has become glazed, but before it has become hard, it is in the best condition for reaping. It is kept from shrivelling by drawing nutriment from the straw after being cut,

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and both weight and quality are benefited by being reaped before the grain becomes hard and dry. Grain stripped "on the green side" shrivels as it is cut off from connection with the straw, but the case is different when the wheat is reaped. Wheat that is stripped or reaped after it is dead ripe possesses dryness, flouriness, and other excellent qualities, but is inferior in strength to that which has been reaped slightly on the green side.

REAPING.—Over a large portion of the earth's surface, reaping in one form or other has to be adopted in harvesting grain crops, the Australian system of stripping or threshing the grain on the uncut straw being possible only upon a limited area under a special climate. The reaping-machine, which took the place of the sickle and cradle, is now being superseded by the reaper and binder—a machine which reaps and binds the grain at one operation. The reaper and binder is the most economical harvester yet invented which is capable of general application. Upon the coast districts of Australia, in New Zealand, in Europe, and in all parts of America except on the Pacific coast, the reaper and binder is the most labour-saving harvester available. Farmers in the colonies have a choice of several American and English reaping and binding machines, which work in a thoroughly satisfactory manner. It is only in a dry climate like that of northern Victoria, or the inland districts of the continent, that the reaper and binder meets with a formidable rival.

STRIPPING.—In South Australia, northern Victoria, and western New South Wales, or what may be called the interior sections of the Australian continent, climatic conditions admit of the use of the Adelaide stripper. In the interior districts, therefore, farmers can either use the reaper and binder or the stripper, and they thus possess an advantage enjoyed, perhaps, nowhere else, except on the Pacific coast of America, where a somewhat similar though inferior machine, "The Californian Header," is used. As to whether the stripper or the reaper and binder is the better machine to use in the inland districts there are differences of opinion. There can be no question that stripping is much the cheapest system of harvesting wheat; the only question is as to whether the cheapness is not counterbalanced by other considerations.

COST OF STRIPPING.—Cheapness is the principal recommendation of the stripping system. Amongst the first settlers in the Wimmera district were a considerable number of Germans from South Australia, who came to the colony

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with their stripping machines, and an intimate knowledge of the South Australian system of making wheat-growing pay. The other selectors, who came from the southern parts of Victoria, soon learned to appreciate the stripper, and the result was that cheap production and an almost complete independence of the labour market were established from the first in the Wimmera district. Thus, having been able from the outset to harvest the crops at a very low cost, and having been saved from the extortionate wages which had to be paid in other districts, the Wimmera farmers had an advantage which has contributed in no small degree to what measure of success they have attained. Some idea of the cheapness of stripping may be formed from the fact that the work is done by contract for from 4s. to 6s. per acre. Taking 6s. per acre as the contract price for stripping an average crop, and remembering that a farmer will be able to harvest his own crop at something below the contract rate, it is not difficult to see that no other machine has any chance of competing in price with the stripper. The farmer engages to supply food to the men and horses working the stripper, and this, with the charge per acre, brings his crop, in the shape of wheat and chaff, to the winnower. By supplying a winnowing machine and finding food for the men he gets his wheat cleaned and put into bags at 6d. per sack, so that the whole harvesting process up to carting the bags to the railway station is done cheaply and quickly. When it is considered that, even with the reaper and binder, after supplying string and going through the processes of reaping, stooking, and stacking, the item of threshing has still to be paid, it will be admitted that for cheapness the stripper is unrivalled.

OBJECTIONS TO THE STRIPPER.—The principal objections to stripping are that it wastes the straw and tends to foul the land. As to wasting the straw, the objection is most potent in those districts where there is a good growth of straw, and where the commodity is most valuable. Over a large area of the inland districts, however, the straw is thin and short, so that if saved it would be of little value. When there is a good growth of straw, the importance of saving it will increase in proportion as the advantages of keeping stock are appreciated. As to fouling the land, there is no doubt that more wild oats and other foreign seeds fall on the ground by letting the crop get dead ripe for the stripper than when the grain is reaped earlier in the season, but this evil is to a large extent modified

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by keeping the land clean and sowing clean seed. "There are no wild oats or weeds in a stripper, and we sow clean seed," say those farmers who use the stripping machine with success. The stripping system is not consistent with the principles of good farming, but good farming cannot be carried out in those inland portions of the continent where continuous wheat-growing alone has to be resorted to. The growing of wheat, however, in combination with the keeping of stock, can be profitably carried on, and the Australian stripper is a valuable aid to the system.

STRIPPING AND CLEANING.—"The Combined Harvester," inspected by the gentleman who visited America in 1883 on behalf of the *Australasian*, was described as the latest invention in harvesting machinery. The machine is a Californian header, with cleaning appliances attached. It reaped or headed, threshed and cleaned the grain at one operation, the bags being filled and turned off ready for market. In the following season two Australian inventors patented combined machines, consisting of strippers with cleaning appliances, and at a trial held that year at Dookie in competition for a premium offered by the Government of Victoria, work was done which gave promise of the new machines being ultimately successful. As the Australian stripper is a more economical machine than the Californian header, the combined stripper and cleaner, if perfected, will be superior to the combined harvester of California. There is therefore a good prospect of the dry districts of the colonies continuing to possess the cheapest system of harvesting in the world.

REAPING AND STRIPPING.—The same objections which are urged against the stripper affect the combined harvesters, while, if the chaff is blown out on to the field, there will be an additional tendency to render the land foul. There will, however, be increased cheapness of harvesting to act in the way of compensating for losses of this kind. The contest between strippers and reapers and binders is confined to the interior districts, and in such localities both the machines have their share of patronage. In the coast districts the reaper and binder has no successful rival. A number of successful farmers in the northern district use both machines. The reapers and binders are set to work fully a fortnight before the grain is fit to strip, and thus a large area is cut before the rush of the harvest commences. The stripped grain can be sent to market should prices be favourable, and that which has been reaped is stored in the straw until

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threshing time. By this means the period of harvest is advantageously extended, and a portion of straw is also saved for the use of stock.

STOOKING.—The treatment of the cut grain upon the field is of less importance in Australia than in more rainy climates. Where the stripper is used as a harvester there are, of course, no sheaves to stook; and, even where reaping is resorted to in the dry inland districts, stooking is of so little importance that it is roughly carried out or dispensed with altogether. One of the latest improvements in the reaping and binding machine is a sheaf carrier, by means of which the sheaves, instead of being dropped singly in rows over the field, are deposited in groups of four or six. This facilitates the work of stooking, but it is a common practice in the inland districts to allow the sheaf carrier to supply the place of stooking entirely, the grain being carted directly from the heaps or groups of sheaves. The weather is so warm as to render the drying process rapid, and as rain seldom falls during harvest stooks can be neglected with comparative safety. In the coast districts, however, stooking is generally necessary, and the importance of the work increases with the moistness of the climate of the locality. Both stacking and stooking are very important departments of farm work in New Zealand, for there the grain has to complete the process of ripening both in the field and in the stack. The best system of stooking in moist climates is that of forming the stook of two rows of sheaves placed upon their ends, about 18 in. apart, and leaning towards each other so as to meet at the top. The stook is formed by taking a sheaf in each hand, placing the butts on the ground the required distance apart, and pressing the tops together. A second couple of sheaves is similarly placed alongside, and then another and another, until all the grain has been gathered from a convenient distance, and thus a long stook is formed with a space between the sheaves through which the air can pass. The stook is strengthened by the finishing operation of placing a sheaf at each end, leaning inwards. Where the climate is moist the end sheaves should be so placed as not to stop up the space intended for the passage of air. There are few parts of Australia, however, where much care is needed to facilitate the drying of the grain, and a common method is to simply form round stacks. This method consists in placing one sheaf on end, and building circles of others around it with their heads leaning inwards until the stook is the size desired.

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CARTING-IN.—In carting in the grain the Australian farmer is saved much anxiety owing to the general prevalence of dry weather during harvest. His chief care must be to avoid bringing the grain to the stack too soon after any rain which may have fallen. The grain dries quickly in the stook, but slowly in the stack. Small or medium-sized drays or waggons, with light, quick-moving teams, will be found more profitable than attempting to save time by extra large loads. The principal labour involved is the pitching of the sheaves, and but little can be done to economize in this department. The sheaves have to be hand-pitched on to the framed drays or waggons, and in most cases they also have to be pitched off upon the stack. On the Pacific coast of America the loose "headed" grain is transferred from the waggon to the stack by means of derrick forks like hay, or by placing a rope net in the waggon, by which means the load is lifted on to the stack through the operation of the derrick. Derrick forks cannot be worked upon sheaves, but the net rope can be used—a system by which a portion of the work of hand-pitching can be economized. The derrick or spar elevator used in stacking hay can easily be used to raise the net ropes employed in carting in the grain crop.

STACKING.—Although the climate of Australia renders the treatment of the grain upon the field a matter of comparatively little importance, stack building cannot be neglected with impunity. Much loss is sustained through insufficient attention being given to this department of farm work. It is seldom the intention of the farmer to leave the grain long in the stack, and hence the building of stacks receives too little attention. There is so little extra labour involved in building good stacks that as much care should be taken in carrying out the work as if they were intended to stand throughout the winter. It should not be assumed that the grain will be threshed before the autumn and winter rains come on, and as these rains are very penetrating the stacks should be built with care.

STACK STANDS.—The practice of building stacks upon the bare ground, so generally adopted, should be avoided. Even in a dry season the sheaves next the ground are damaged, and frequently several tiers of sheaves are more or less injuriously affected. The loss of grain is generally more than would pay for a stack stand, and the sample of a much larger quantity is frequently damaged by mixing with the musty wheat from the bottom of the stack. It is shortsighted

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policy to lose any grain after all the expense of cultivating it and carting it to the stack has been incurred, while if grain is worth growing it is certainly worth saving. A thick foundation of straw is better than nothing, and a better plan is to place logs or stones in position, and cover with straw; but the best stack stand is made by putting a timber frame upon supports about 1 ft. or 18 in. above ground. A stand of this kind is not expensive, will last for years, keeps the grain dry by admitting a current of air, and is a protector from mice, weevil, and other vermin.

STACK BUILDING.—The most important principle in building a stack is to keep the centre higher than the outside, from the beginning to the completion of the work. It is only by attending to this from start to finish that the grain will, after the stack has settled, lie in such a way as to keep the rain from penetrating. The extent of damage likely to result from the stack getting wet is the measure by which to gauge the importance of attending to this essential. A sheaf is first placed on end in the centre of the stack stand, and others are placed around it, in the same manner as in forming a round stook in the field. This process is continued until the edge of the stack is reached, when a beginning is again made in the centre, and so on. It will be necessary occasionally to lay extra sheaves in the centre, to keep it higher than the sides, and in placing the outer tier in position care will have to be taken to keep the butts far enough out, so that the eaves will overhang the foundation. In the case of a square stack, particular attention is required at the corners to make the corner sheaves overlap and bind each other. Place the tier at the eaves further out than the lower one, and then begin to draw in, continuing with each succeeding tier until the top is formed, in the case of a round stack, by a single sheaf placed on end.

THATCHING AND COVERING.—Covering the grain stacks is a course too often neglected, and the loss resulting is considerable. All that has been said in regard to the mistake of producing grain and failing to save it, through careless stacking, applies with equal force to neglecting to provide suitable covering from the weather. The mildness of the climate, which encourages a careless system of stacking, results also in insufficient attention being paid to covering the grain ricks. When stacks are intended to stand only for a short time they should be well covered with rick cloths of tarpaulin, or other waterproof material, as providing covers will be found cheaper than thatching; but in the case of stacks intended to stand throughout the

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winter thatching is the more profitable course. Rushes and tussock grass are sometimes available for thatching, and can be used with advantage; but straw, of which there should always be a sufficient supply, answers the purpose well. The straw should be carefully sorted out into bundles, and then put on by an experienced thatcher. Begin at the eaves, and add tier after tier upon a section 4 ft. or 5 ft. wide, until the top of the stack is reached. A quick method is to lay on bundles, spread them out until the layer is about 9 in. thick, rake and pat down firmly, secure with straw rope or hemp lashing to pegs, and proceed with the next tier, continuing until the top is reached; but in the more complete system the thatcher takes small bundles, amounting to a good handful, and places each in position singly. The top of the bundle is gathered in to a point and inserted under the straw or hay of the roof, the bottom spread out, raked, and beaten down, and each section secured by ties as completed. In putting in the pegs which secure the ties they should be driven slightly upwards into the roof, so as not to lead water into the stack.

THRESHING.—The farmer who keeps a threshing machine of his own can have this important operation carried out to his mind, but as threshing for the most part is done by travelling machines worked by contract, it is often difficult to prevent waste and loss. It is frequently the contractor's main object to get through the work, and it should be the farmer's aim to see that the threshing is properly carried out. Frequent inspection of the straw will be necessary to see that all the grain is being taken out, and the sprouts will also have to be watched to see that the grain is not being cracked. Equal supervision will be advantageous to ensure that the grain is properly cleaned, and that it is not being blown away over the riddles. The farmer will earn more money in attending to these things than in trying to fill a man's place in pitching sheaves or hauling away chaff. The system of threshing by contract adopted in the colonies might be improved upon. At present a certain sum per bag is paid for the threshing, the thresher being relieved from all trouble as to finding men and supplying food. The farmer has to collect a large staff of men for a few days, and make arrangements for supplying them with food. The American system, as described by Mr. T. K. Dow in the *Australasian*, seems much more convenient. A certain charge is made for threshing, and the owner of the machine carries out the whole work, paying men's wages, catering for his workmen, and relieving the farmer of a great deal of anxiety. A gang of

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men travel with the machine, carrying a cook, a portable kitchen, and all requisites with them. The worry of gathering up men and providing them with food is one of the farmer's greatest troubles in the colonies, and the American system might be adopted with advantage.

DRESSING GRAIN FOR MARKET.—Too much attention cannot be paid to properly cleaning the grain before it leaves the farm. It is a mistake to grow good grain and sell it as inferior, because of imperfect cleaning. Freights are generally too high to be paid upon drake or wild oats, which also lower the price of the good grain. Buyers of Australian wheat have been much to blame for giving as high a price for foul as for clean samples, but frequent complaints from London are now changing this policy, and in future farmers who send foul wheat to market will obtain a low price. A continuance of carelessness in the matter of proper winnowing and screening will have the effect of bringing into existence extensive cleaning establishments at the ports of shipment, the cost of which will have to be borne by the farmers. If the threshing machine does not turn out a perfectly clean sample, the grain should be passed through the dressing machine before leaving the farm.

WINNOWING IN THE FIELD.—A large proportion of the wheat grown in Australia is winnowed in the field as it comes from the stripping machine. Most of the winnowing machines in use are capable of turning out a good sample if sufficient time be devoted to the work, the chief mistake being in hurrying through in order to keep up with the stripper. Wide winnowers, with plenty of riddle space, should be used, and large machines are generally to be recommended. There is much saving of labour in using large portable winnowers capable of cleaning after several strippers. A small horse-power to work such winnowing machines is advantageous; hand labour is generally expensive, and upon a farm the work of a horse should cost little. Horse power is, therefore, economically applied to such heavy work as turning the grain-dresser.

STORING GRAIN.—Grain is stored on the farm either loose or in sacks. Where a suitable barn is available it is a safe and easy way to shoot the grain on the floor, and fill the building, or a section of it, up to near the wall plate. The walls must be close and strong enough to resist the pressure of the weight of grain; while the roof must also keep out rain. So stored, grain is protected fairly well from the ravages of mice.

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STACKING SACKS.—In stacking sacks the most important consideration is to protect the grain from mice. There are two ways of securing this end. The first one is to leave space for the cats to run all through the stack, and the other is to leave no spaces through which the mice can penetrate. According to the first plan the first tier of bags is laid about a foot apart, and the next tier, which is laid transversely on top, is also made up of bags about a foot apart. By thus leaving a space between all the bags the cats can creep about through the stack in every direction, keeping the mice from the grain. The other system is quite as effective, and equally practicable. A layer of sacks is placed in position close together, and chaff from the thresher or winnower is spread over, being tightly pressed into all the spaces. After laying the next tier more chaff is put on, being rammed into every space, and the process is continued until the stack is built. The whole is then covered with chaff and straw, and the mice are unable to make their way into the sacks. In the dry districts sacks can be stacked in this way in the field with safety for a considerable time. When stored in the field, sacks should be kept well off the ground and covered with a thick layer of chaff or straw.

RUST IN WHEAT.—Hardly a season has passed during the last twenty years without announcements being made of the discovery of some new "rust-proof" varieties of that cereal. Australian farmers have been told to look to India for wheats possessing the desired immunity, and we are bound to admit that in that direction there should be, theoretically, the best chance of obtaining what we all must so ardently desire. No sooner has wheat-growing become well established in a newly occupied country than symptoms of rust begin to appear; in fact, after five or six splendid yields the dreadful parasite often makes a clean sweep of the most promising crops, and this ultimately leads to the abandonment of wheat-growing in the locality affected and to the return of the land into pasturage. Such was the early history of wheat-growing in New South Wales; such is the history of the results of wheat culture in many localities in every Australian colony in which that industry has been extensively carried on at any time. Nor does the history of wheat-growing differ in other parts of the world. The country whence the Romans drew their chief supplies of wheat became afflicted with the scourge, and that to such an extent as to induce the establishing of the feast called "rubigalia," at which prayers and sacrifices were offered

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up to induce the gods to spare the wheat crops and avert the attacks of rust. Coming down to modern times, we have all seen how wheat-growing has rolled westward over that greatest of agricultural countries, the United States of America, and how the eastern states having been rendered, by constant cropping, temporarily unfit to produce the staple breadstuff, are now chiefly utilized in dairying and grazing. History, however, both ancient and modern, records no discovery of a method of evading visitations of rust, of which practical use can be made. Modern science has nearly laid bare the mutations of the microscopical fungus which is familiarly known as rust, but our increased stock of knowledge of its natural history has not even faintly suggested a method of preventing its attacks. The black-bearded Russian wheats introduced by Signor Marteli, some twenty years ago, were free from rust for a considerable time, but when grown experimentally in gardens whose soils were too rich in nitrogenous matters the straw became rank, and the dreaded red stripes appeared. The experience of cultivators in all ages has gone to show that soil containing an excess of stercoraceous matter, combined with moisture in such quantity as to induce rank and watery growth, will assuredly lead up to a development of rust. The spores of the parasite are, during the whole of the summer months, floating in the air, and, as Tyndall has said, are ever ready to fix on a host which presents conditions which will enable them to thrive and increase on it. Science has hardly yet determined whether the cracking of the cuticle of the straw arises before the spores have taken possession of it, or whether the cracking is occasioned by the inability of the watery stem to withstand the heat of the sun, and the spores, which are floating about, are then lodged in the openings, and are there developed. The point is not essentially important, for rust invariably takes possession of the straw under certain well-ascertained conditions; these, plainly stated, are an unhealthy state of the plant caused by the assimilation of an excessive proportion of certain elements, and of too small a proportion of others (notably of silex). Experience, especially in Australia, has also shown that the constitution of the wheat plant undergoes a considerable modification. Thus, after several years' culture, the red wheats of America and Great Britain lose their distinctive characteristics, and gradually become light in colour. Red wheats are, in fact, rarely grown in these colonies, not because they are not in favour, but on account of their undergoing a

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gradual change of character, the natural effect of the climate. Even in the very first season the red varieties of Mold's and other imported wheats have yielded grain decidedly different from the seed sown, although of unquestionably superior quality. In starting, then, on a quest after rust-proof varieties of wheat, the would-be discoverer should allow due weight to each of the foregoing conditions. That certain varieties are less liable than others to the attacks of rust needs no further proof than that already within the ken of the multitude; but that any existing variety will withstand rust after culture for a series of years in unfavourable soil and climate has yet to be proved. Whilst Defiance and Champlain have not been rusted on certain farms, they have on others not enjoyed immunity from the scourge. The most severe test to which any wheat could be put would be to sow it on the site of an old dunghill, one of those sometimes seen in the corner of a paddock. Wheat that will grow healthily on such a spot would be fairly entitled to be regarded as rust-proof until its constitution has been changed by a long continuation of adverse conditions. A knowledge of the conditions of soil and climate which have to be encountered, and of those in the plant which will help it to withstand the rust, is of the first importance to the grower. Given a variety having hard, smooth straw, soil of the most suitable quality and in the most favourable condition, as much will have been done as at present can be to ensure immunity from rust. The conditions of weather and soils which usually conduce to the development of rust are—(1) a rank early growth caused by a loose condition of soil, and the frequent occurrence of genial showers; (2) the occurrence of dry hot weather as the spring advances, checking and almost stopping growth. In seasons of the foregoing character crops stunted by growing on hard soil often turn out healthy, although the yield may not be large.

Hints to Wheat-growers.

Sow Clean Seed.—Sowing clean seed is a matter of special importance in the northern districts. It is of importance anywhere, but the cleaning of land is so difficult in the dry areas of the colonies that the best system of weeding is to keep the weeds from getting a hold. Prevention is better than cure. By sowing nothing but clean seed the land can be kept free from wild oats, barley, and drake for a long

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time; but if these foreign seeds once get into the wheat-fields it is almost impossible to get them out. Bare fallow and feeding-off with sheep is the best remedy, but, owing to the infrequency of the rains, it is difficult to get the weeds to sprout. The soil is not easily exhausted, but when care is not taken in the choice of seed it becomes so foul that cropping it is rendered unprofitable. In these circumstances, "sow clean seed" is advice which should receive special attention. By means of an adjustable screen all the seed can be carefully prepared, so that, beginning with new land, the mistake which so many commit is avoided, and not only are the paddocks kept in good order for a long time, but a clean sample is always sent to market.

FEEDING PLOUGH HORSES.—Do not cut a dirty crop for hay, or the crops will soon all be dirty. This is a mistake which is commonly made, and the result is only too frequently to be seen. As a part of the system of keeping the land clean, a portion of the wheat crop which is free from wild oats, barley, or drake should be made into hay, and then the land will not be made foul by the plough horses. Wheaten hay and chaff with bran are the only food given by many wheat-growers to the farm horses, and this is, no doubt, a very safe means of preventing weeds from getting into the soil. Upon some wheat-growing farms crushed oats are used as horse feed, but if there is any fear of the crushing machine not doing its work completely, the system of using bran and clean wheaten hay cut into chaff can be relied upon as effectual. After using all these precautions to keep the land clean bare fallow can be had recourse to as a means of giving the land a rest and dealing with any weeds which may make their appearance.

TRY GREEN-MANURING.—Manuring does not yet receive any attention in the dry wheat-growing areas, and is not likely to do for some years to come. If the land can be kept clean it will produce average crops for a long period, and when manuring becomes necessary some kind of fertilizer will be needed which will better suit the requirements of a dry climate than those in use in more moist localities. Green-manuring is a subject which farmers should study, and in regard to which experiments should be tried. With such a rich subsoil the ploughing-in of some deep-rooting green crop like lucerne would no doubt be found to be an excellent means of re-fertilizing the surface soil.

SOW EARLY.—In regard to the time for sowing, the only difference of opinion now existing in the inland wheat-growing

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districts is as to whether early or very early is the best, late sowing being out of the question. Some farmers believe in getting the seed in as soon as possible, even as early as March, and, in the event of a luxuriant growth, feeding-off with sheep, while others consider from the middle of April to the end of May the most suitable season. As it happened once or twice that the very early sown crops have perished and had to be resown, April and May are regarded as the safest months for putting in the seed.

Oats.

The oat crop is cultivated over a wide range of climate, but it requires more moisture than wheat. In New Zealand the climate is more favourable to the growth of oats than in any of the Australian colonies, and, as a rule, it is only in the coast districts of Australia that the crop can be profitably cultivated. In the colonies, besides being cultivated as a grain crop, oats are extensively grown for hay.

Varieties of Seed.—There are numerous species of oats, but for practical purposes they may be divided into two classes, viz., the common oat and the Tartarian oat. In the common oat the seeds grow on all sides of the central stem, and in the Tartarian oat the seeds grow on one side of the stem. Of the common oat, some of the principal varieties are—the Potato oat, the Sandy oat, the Hopetown oat, the Dun oat, and the Poland oat. The potato oat has a somewhat compact ear, with round short grains and thin husks. It has rather a short straw, and, owing to being liable to shake out, should be cut on the green side. The sandy oat possesses a somewhat smaller, but hard, bright, heavy grain of good quality. Its straw is tall and stiff, and does not shed its grain freely. The Hopetown is a short, thick, bright grain, yields well, and grows straw of medium length. The Tartarian oat has a long, strong straw, and a long bright grain, yielding well in favourable conditions, but requiring more moisture than some other varieties. The Calcutta brown oat is an inferior grain, but can be successfully cultivated where the climate is too dry for white oats. As in the case of wheat, varieties should be chosen according to local conditions.

Soil and Climate.—The oat crop flourishes in a less clayey soil than wheat. Fair yields can be obtained from loamy soils and medium soils of different variety, but the best results are

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obtained from fertile alluvial soil. The habit of the roots is much the same as in wheat, so that the same system of cultivation is required; deep and thorough working of the soil giving the best results. The crop can only be successfully cultivated in a moist climate, as the plant requires more moisture than wheat.

SOWING.—Pure seed should be sown, and at the date found best suited to the circumstances of the locality. June is a good month for sowing. Oats do not require to be sown so early as wheat, but the end of June is generally late enough. Oats require sowing thicker than wheat, as the plants do not tiller so much. Two bushels per acre is little enough seed on good land, and from three to four bushels may be sown with advantage on medium soils.

AFTER-TREATMENT.—Rolling after the crop is up is advantageous, but the crop does not benefit by harrowing in the same way as wheat. Feeding-off should as a rule be avoided, as the crop will not suffer so much as wheat from overgrowth, and does not recover well after being eaten down. Top-dressing with salt, at the rate of 2 cwts. to the acre, has been found advantageous, and, except in very rich soil, the land should be well manured with guano, bone-dust, or well-rotted stable manure before sowing.

HARVESTING.—The reaper and binder is the best machine for harvesting the oat crop in all parts of the colonies. In the inland districts the stripper is used, but, except when the straw is too short for reaping, the process is a wasteful one.

THE CATERPILLAR.—Oats are singularly free from disease, rust and smut generally giving very little trouble. The caterpillar pest, however, is sometimes very destructive. No practical means of saving the crop from this pest has been discovered, the best course being to sow early varieties that ripen before the advent of the caterpillars, and cutting the crop before it is over-ripe. For notes on stacking, threshing, &c., see remarks under the heading of "Wheat."

BARLEY.

Barley is a highly valuable grain, which is cultivated successfully in the moist coast districts of Australia, and in Tasmania and New Zealand. Requiring a more moist climate than wheat, the crop is not extensively cultivated in the inland portions of Australia, although near the mountain ranges fair yields are obtained in average seasons.

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VARIETIES.—In the colonies the varieties of barley are generally divided into two classes, viz., malting barley and feeding barley. Cape barley, used chiefly for feeding purposes, is a hardy variety, easily cultivated, and yielding heavily, but commanding a lower price on account of not being suitable for malting. Of the malting kinds the common English barley, the Chevalier, and the Battledore are the principal varieties cultivated. The Chevalier possesses a strong straw, less liable to lodge than the common English, and the grain is much esteemed. It ripens a fortnight later than the common variety, but this can be overcome by sowing earlier. The Battledore is a good variety for malting, and is a heavy yielder.

SOWING.—Barley should be sown about the same time as oats, June being a suitable month in the coast districts and May in the inland districts. Pure seed should be chosen, and sown at the rate of about two bushels per acre, and early varieties are preferable where the crop is in danger of being attacked by caterpillars. Like oats, the barley crop is liable to be destroyed by this pest, and the best preventive is to get the crop harvested before the visit of the caterpillars.

CHOICE AND PREPARATION OF SOIL.—Barley flourishes in a well-worked soil. The soil should be put into a loose, fine tilth, and the crop is generally admirably suited after one of the well-hoed root crops. The soil should be of medium richness, and manure should not be applied directly to the crop. After potatoes or other root crop, to which manure has been applied, barley can be sown with advantage. Rolling after the grain is up is advantageous, but harrowing or feeding-off are not advisable.

HARVESTING.—In the coast districts of Australia the reaper and binder is the best machine for harvesting barley, and even in the inland portions of the continent the same machine will be found most profitable. The stripper harvests barley fairly well in the inland districts, but, although the waste is less than with oats, reaping is preferable. The stripper is essentially a wheat harvester. General directions for harvesting will be found under the heading of "Wheat."

RYE.

Rye is not extensively cultivated in Australia, nor is it grown so largely, in proportion to other grains, in New Zealand as in

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America and Europe. It grows well upon poor soil, and is resorted to in America after the land has become impoverished by continuously producing other cereals.

PREPARATION OF THE SOIL.—Rye flourishes in a generous sandy loam, and grows well on light sandy and gravelly loams. It requires more moisture than wheat, but grows in a poorer soil. Upon a rich loam, where wheat would lodge, rye will do well, owing to its stronger character of straw. The preparation of the soil is much the same as for the wheat crop.

SOWING AND AFTER-TREATMENT.—Rye intended for grain should be sown at the same time as the earliest wheat, at the rate of from one to two bushels per acre, according to the soil. Rolling and harrowing are beneficial as with wheat, and feeding-off when early growth is luxurious is also advantageous.

HARVESTING.—As rye straw is not valuable, stripping would be a good means of harvesting but for the fact that the crop is not frequently grown in the dry districts where the stripper is used. The reaper and binder can be efficiently used for harvesting rye, and the remarks upon that machine as a harvester for wheat will generally apply to the crop.

RYE AS A GREEN CROP.—As a green crop rye is much esteemed in different parts of the world and in the colonies. It produces an abundant growth of green fodder, possessing valuable feeding properties, particularly suitable for animals giving milk. When intended as a green crop, about four bushels per acre of seed can be sown, and it can be mixed with rape or tares. The rye should be cut or fed-off before the straw gets too stiff, as it becomes less suitable for stock as it matures.

MAIZE OR INDIAN CORN.

Maize is not cultivated to any great extent in the Australian colonies, although some of the moist coast regions have been found well suited for the crop. It is the staple crop of the United States, being much more important than wheat, as it forms the chief food for farm animals. The climate of North America not admitting of cattle being fattened upon the natural pastures, stock have to be fattened by food raised by cultivation, and maize is the chief crop cultivated for this purpose.

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SOIL AND CLIMATE.—Maize is in its natural home in the rich alluvial soil on the vast flats along the rivers of America. It thrives best, therefore, upon loose alluvial soil, and river flats are more suitable for its growth than any other soil. It is a gross feeder, requiring abundance of plant food to support its stalks, leaves, and grain. The crop can be manured freely without danger of injuring it, and a good yield can only be obtained from soil in a fertile condition. A warm summer is required to ripen the grain, and a good supply of moisture is necessary for the growth of the plant. It will ripen in any part of Australia, but it is only in the moist coast districts of the continent that there is a sufficiently heavy rainfall to produce a good crop. There is a large area of land—especially along the rivers draining the eastern slopes of the continent—well suited for maize. In such districts yields as heavy as in any part of America are obtained, and the crop might be more extensively cultivated with advantage.

CHOICE OF SEED.—The varieties of seed are numerous, and the best kinds are easily obtained in the colonies. The yellow varieties are the best for general purposes, and the white for table use or human food. The kind of seed which has been found most suitable for a given district should be chosen. The varieties differ widely in regard to yield, quality of grain, and date of ripening; early varieties are generally the best, as least likely to be injured by frosts.

PREPARATION OF SOIL.—The plant requiring a large supply of nutriment from the soil, and having both deep and wide-spreading roots, depth and thoroughness in cultivation are necessary. Plough deep, and reduce the soil to a fine tilth; manure well if the land is not in good heart, the crop paying well in increased yield for liberal treatment.

SOWING OR PLANTING.—A common practice in this country is to sow the seed in continuous drills, but the best results are obtained in America from sowing in separate hills, 3 ft. or 4 ft. apart. The land is marked off into squares, and the hills set equal distances apart each way. Eight or ten seeds are sown at each point, and, after the plants have come up, the surplus stalks are weeded out, leaving four or five healthy plants in each hill. Sowing machines are used in America, which deposit and cover-in the seed in the manner required. A boy and a horse working one of these machines can plant about ten acres per day. Thin sowing is preferred, as giving the best yield of grain. Seed is frequently steeped for one or two days in a solution of saltpetre, a course

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which is found to accelerate the growth of the plant and protect the seed from birds, mice, and worms. Dressing with tar is also carried out when mice or birds are specially troublesome; it is found to be an effectual remedy. The seed should be covered about 2 in. deep, and the sowing season must be chosen so as to escape as far as possible the late frosts. In Victoria the crop for grain is sown from the beginning of October up to the middle of November.

AFTER-TREATMENT.—The ground should be stirred with the scarifier, and the weeds destroyed, soon after the plants are well above the surface. Surplus shoots must be weeded out and the soil kept loose and clean until harvest. Hilling-up, or turning the soil up towards the stalks, is a common practice in the colonies, but it is disapproved of in America. A main point is to conserve the moisture for the benefit of the crop, and leaving the surface flat and keeping it loose is the best means to this end. Potato-growers have found hilling-up to be a mistake, and maize-growers would also do well to avoid the practice.

HARVESTING.—When the stalks are intended for fodder they should be cut whenever the grain in the cob is glazed, and before it hardens. The grain then hardens without shrinking, and the valuable feeding qualities of the stalks are preserved. The effects of frosts can also be guarded against by early harvesting, the crop not suffering any injury in the stook. In the Western States of America, where labour is dear, the cobs are pulled from the standing stalks, hogs and cattle afterwards being turned into the fields to eat the best part of the stalks. As the cobs are pulled off, they are "husked" or stripped of their covering, and carted to a crib or shed to dry; when dry they are threshed or "shelled." In husking, the cob is taken in the left hand, and, with a short husking pin fixed to a strap in the right hand, the husk is torn off. A man can gather and husk about an acre a day, representing about 70 bushels of shelled corn.

SHELLING OR THRESHING.—Shelling machines of all sizes are used when maize is intended for market. Mr. T. K. Dow, writing of the maize-growing industry of America in the *Australasian*, says:—"Only a small proportion of the crops, however, is shelled at all. It is a general custom to give the unshelled cobs to cattle, pigs, and nearly all kinds of stock. There are farmers here and there who both shell and grind the corn for the stock, but the rule is to feed upon the unshelled cobs, the cattle and hogs between them utilizing the bulk of

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the nutritive constituents. Such corn as is sent to market for the purpose of going to other states, or being exported, is shelled by large machines driven by horse or steam-power. Hand shellers are used upon very small farms, but when any considerable quantity of shelling is done horse-power is employed. One of the smallest horse-power machines in use—'the Duplex'—is worked by one horse, or, if required, by two men. The cobs are carried into the shellers by a revolving apparatus; the cobs and corn are separated after being shelled, and the corn is carried up an elevator to a bagging spout. When worked by one horse the machine shells and cleans about 600 bushels per day. Such a machine would cost to the American farmer from £9 to £10 without the horse-works. The Keystone Manufacturing Company, of Sterling, Illinois, do a large business in turning out corn-shellers of all kinds. Some of the machines are four or six horse power, and are capable of shelling as much as 2,000 bushels a day, the only labour required being to shovel the cobs into the elevator which carries them into the stripping gear, and to bag up the shelled corn from the spout. There is seldom any bagging, however, for the spout generally runs the corn into a waggon or a railway truck—corn, like wheat, being handled in bulk and stored in 'elevators.'"

MAIZE AS A GREEN CROP.—As a green crop maize possesses many valuable qualities. It produces a large quantity of fodder possessing highly valuable feeding properties. For this purpose the crop should be sown upon well-worked, rich, or liberally manured soil. Seed should be sown at the rate of three or four bushels per acre. Good results are obtained from broadcast sowing, but when weeds are troublesome, continuous drills are preferable. The fodder can be used for stock at all stages, but it is better to cut it and house it than expose it to severe frosts.

CHAPTER VII.

THE HAY CROP.

IN the Australasian colonies very little grass is cut for hay, the system of having hay meadows adopted in Great Britain and the eastern and central states of America being almost

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entirely unknown. Oats or wheat are sown for hay in the colonies as in the Pacific coast states of America. Owing, also, to the warm dry climate, the work of haymaking differs considerably from that carried out in colder and more moist countries. Instead of leaving the hay to dry for days, and spreading or "tedding" it out of the swath, it is gathered without much delay into windrows and cocks, the warm dry atmosphere rapidly maturing the hay. Oats are the most common cereal sown for the hay crop, but wheat also makes good hay, being sweet and much relished by stock.

CULTIVATING FOR HAY.—It is too frequently the case that farmers who are careful about other crops give very little attention to the field which is intended for hay. While grain crops are kept clean and well cultivated, the hay is often allowed to be foul with weeds and stunted in growth, so that the yield is light. It should be remembered that wild oats and other weeds in the hay will soon spread to other parts of the farm, and that it is a loss to expend labour upon harvesting a light crop. Cultivate the land well for hay, and sow clean seed, manuring liberally with bone-dust or farm-yard manure, if necessary. The seed should be sown thicker than for grain, and the land should be harrowed fine and rolled so as to present a smooth surface to the mowing machine.

MOWING.—The mowing machine has taken the place of the scythe. A machine should be chosen which will cut close to the ground, as the heaviest hay is near the roots, and "an inch at the bottom is worth two at the top." As to the time for cutting, a good deal will depend upon the purpose for which the hay is intended. The most nutriment is in the hay which is cut after the grain has filled, for there is then substance in the straw, while there is also the grain. Hay for market is best to have a bright green appearance, which can only be attained by cutting early. The most advisable course, in general, is to cut whenever the grain has pretty well filled, and before the straw begins to lose its green appearance. This is generally when the straw, below the first or second joint, and the flag leaf turn white.

SHEAFING HAY.—The custom of binding the hay crop into sheaves is becoming more and more general every season, a system which has gained ground rapidly since the introduction of the reaping and string binding machine. Hay for manger feeding is better to be made in the ordinary way, but the process is expensive, and the sheaf hay is better for cutting into chaff. The reaper and binder now cuts low

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enough, and binds the sheaves well without missing, while the sheaves, being dropped in groups of from four to six, are conveniently stooked, and the work of haymaking is complete. There is thus a great saving of labour, and the hay is in the best condition for cutting into chaff, a form in which the greatest quantity is now used. In the climate of Australia the hay cures with sufficient rapidity in the stook. Make the sheaves small, and the stooks to contain not more than twelve or fourteen sheaves, and the hay will not be in danger of heating in the field.

WINDROWING AND COCKING.—The hay wilts sufficiently in a few hours after being cut to be raked into windrows, and a day or two afterwards, according to the weather, the cocks may be formed. The hay should not be put up into large cocks before well dried. In the case of rain falling, and the weather remaining damp, of course longer time has to be allowed than in fine dry weather. In fine weather there is generally more danger of delay in making the cocks than in gathering the hay too quickly; but the medium must be aimed at. The hay will cure well enough in the small cocks, where it will not become so dry or lose its green colour so much as in the swath or windrow. The larger cocks should be broad at the base to resist the wind, and built high in the centre from the beginning so as to keep out rain. In windy localities it will be better to tie down the cocks with hay ropes than rebuild them after a rain and wind storm.

STACKING.—First of all a rick-stand should be made to keep the bottom of the stack off the ground, as it is unprofitable to grow hay and allow it to be spoiled after being carted. A thick bedding of straw is better than nothing; but a timber rick-stand, through which the air can circulate, and the cats can hunt for mice, will pay for itself in a single season. A tarpaulin is always handy on a farm, and it will be of service in case of rain while the stack is being built. The most important point in building the stack is to keep the centre high from start to finish. Thatch, sheets of corrugated iron, or some form of covering, should be put on when the stack is made, as there is much waste on the top of the stack when left exposed, however well it has been built. It is important to save labour in carting and stacking, as well as in making the hay, and the farmer will do well to adopt such cock-lifters and stacking-elevators as may be within his reach.

CALIFORNIAN HAYMAKING.—As the rate of wages is even higher in California than in Australia, the employment of

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labour-saving appliances is a feature of the hay harvesting in that country. Mr. T. K. Dow, in the *Australasian*, thus describes the Californian system :—"The leading principle is not to use manual labour where horse-power can be applied ; but in carrying out this end there is a great variety of contrivances. In dealing with the hay harvest it will be borne in mind that the hay is not put up into stacks permanently, but only as a preliminary step to being pressed into bundles and packed into barns. The stack is narrow, so as to save pitching, and it is not high, for the same reason, the length being extended as required. In some cases the hay is pitched into waggons by hand, and in the same way pitched on to the stack, these stacks being made only a little higher than the frame of the waggon. In the vicinity of large towns, where hay is grown for market, hundreds of low, long stacks without tops are to be seen in the fields. These will later on be sent to market before the rainy season, or pressed and put into barns. It never rains during the summer months, but it is thought necessary to have hay under cover before the end of autumn. In conveying hay from the field to the stack, a common method is to employ a large wooden rake, with very long teeth, or a large 'bunching rake.' This rake, which is drawn by one or two mules, according to the size of the hay-cocks, is driven under the bundle of hay, forming a sledge for it, and by this means it is drawn to the stack. In other cases a rope is passed around the hay-cock near the bottom, and thus the whole is drawn over the field to its destination. Raising the hay on to the stack, or directly into the barn, is generally managed by some arrangement of block and tackle. In one case it will be a projecting beam from the ridge-pole of the barn, to which a block is attached, a mule drawing the load to the hay-loft ; while, again, it is a derrick erected for the purpose and set on wheels, so as to be easily conveyed to any part of the field. A very common plan is to pitch the hay into waggons in which a rope netting is laid. The loaded waggon is drawn under the derrick, a hook attached to both sides of the net, and a span of mules raises the whole load above the stack, a man guiding the swinging mass to any part of the stack required, and setting loose the tackling by means of a check-line. There is nothing difficult or mysterious in any of these contrivances, and many of them are already partly adopted on some Australian farms. A clear idea of the end to be attained, and the application of well-known mechanical principles, alone are necessary. The

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saving of labour is the end in view, and that is an end which we also wish to attain in the colonies."

GRASS HAY.—In making grass hay in Australia, particular care has to be taken to prevent too rapid drying. Lucerne is not unfrequently cut for hay, and, if properly treated, is very valuable in this form. The lucerne should be raked up into windrows almost immediately after being cut, and taken to the stack before the leaves begin to fall from the plant. If not harvested quickly in warm weather the leaves will fall off and the hay will be dry and brittle. In making prairie or other grasses or clovers into hay the same rule must be observed. There is little danger in gathering quickly, but the hay becomes injured by being allowed to dry too much. As a rule, grasses should be cut for hay when in flower.

CHAPTER VIII.

CULTIVATED PASTURES.

THE practice of laying down land to what is known in Great Britain as permanent grass can hardly be said to have attained much importance upon farms in the colonies; real permanence is not greatly in favour, the intention being simply to give the land a few years' rest in grass to prepare it for another course of spoliation. But on many of the larger grazing estates extensive areas have from time to time been laid down with the express object of forming permanent pasturage. The course of practice commonly pursued is to take a series of crops of cereals from the new ground and then lay it down with a mixture of grasses, in which rye-grass is the principal ingredient. The results of this system of management have been widely different, real permanence having, apparently, been secured in some localities, and quite the contrary in others. It is noteworthy, in connection with these differences, that good permanent pastures, in which rye-grass largely predominated, were not few in the colonies several years ago. Of late years success has not so commonly followed attempts to form permanent grazing grounds; after a term

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of, say, five years and upwards the sown grasses have usually become thin, and the native species they were intended to have supplanted have reappeared, although weakly, and have been left to do duty as pasturage as best they could. At this stage the owner has usually arrived at the conclusion that the grasses are worn out, and that another course of grain-cropping is indicated as the proper thing. To graziers who desire to grow only sufficient hay and oats for the use of the establishment, the necessity for periodically resorting to arable farming on a considerable scale is annoying.

The continued improvement of grass lands in England, under certain conditions as regards stocking, is so well established a fact as to justify inquiry why results of an opposite character are held to obtain in this country. The climate of Victoria and the adjacent colonies is not a fixed quantity, but it may be said generally that—excepting in the cooler districts—it is less favourable for the grasses known as English than the climate of Great Britain. As a rule, English grasses succeed fairly for a time in the more elevated and least arid portions of these colonies—together a very considerable area of first-class country; but it cannot be said that in any large number of instances their longevity is even fairly satisfactory. There is little room for doubting that the very general use of rye-grass is a fertile source of their early decadence. That grass belongs to the same natural order as wheat, and removes from the soil nearly the same constituents. If, therefore, rye-grass is sown after cereals, the land, so far from obtaining the designed spell or rest, is still subject to a continued exhaustion, mitigated by the substitution of feeding-off by stock for the total removal which occurs in the case of cereals, whether the object be hay or grain. Full allowance must be made, in estimating the causes of the early wearing-out of our pastures, for the persistent overstocking to which most of them are subjected. The paucity of vegetable matter in the soil must also be allowed due weight in considering the question before us, but that is only in part due to the climate, for in its virgin state the soil is found to contain more *humus* than after it has passed through the customary routine of colonial cropping. Beyond all the considerations already suggested comes the question whether greater permanence might not be assured for our pastures—especially for those in the cooler farming districts—by sowing grasses

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in mixtures which would not be open to the same objection justly urged against rye-grass. On examining any old English pasture, or any native Australian one, the careful observer will be enabled to count quite a large number of genera and species in a single square yard. It will be found that leguminous plants are present, and that besides these (which include clovers) there are many feed plants other than grasses proper. And yet in England, also, it must be said, complaints have become frequent of late years of the early decadence of new pastures which were intended to be permanent. The result is attributed by a recent writer—Mr. Launce de Laune, who has been permitted to contribute a paper to the *Journal of the Royal Agricultural Society of England*—(1) to the presence of rye-grass and other annual grasses, which die after seeding once or more, according to the opportunity afforded them; and (2) to the absence of those grasses which are by nature perennial. It must not be forgotten that rye-grass is by nature an annual, and that the permanence of the so-called perennial characteristic of certain varieties of that grass depends wholly on the maintenance of those conditions of culture under which it was first evoked.

A third cause of the early failure of new pastures in England is said to be the use of an insufficient quantity of seed, and also of biennial clovers which die out. The writer above alluded to challenges the soundness of certain seedsmen's advice to sow largely of rye-grass and only some 4 lbs. per acre of cocksfoot, and condemns *in toto* the introduction of annual grasses into mixtures for permanent pastures. His experience has led him to suggest that the four coarse grasses, valuable beyond all others for permanent pasture, are cocksfoot *(Dactylis glomerata)*, meadow fescue *(Festuca pratensis)*, catstail or Timothy *(Phleum pratense)*, and to these he adds meadow foxtail *(Alopecurus pratensis)*. These five grasses, he says, should form the bulk of all pastures on good soil, either for sheep or cattle. The finer or minor grasses are crested dogstail *(Cynosurus cristatus)*, hard fescue *(Festuca duriuscula)*, rough meadow grass *(Poatrivialis)*, fiorin *(Agrostis stolonifera)*, sheep's fescue *(Festuca ovina)*, and golden oat-grass *(Avena flavescens)*. He observes that a meadow composed of the above would be perfect as regards grasses, assuming that the proper proportions are used; it would produce food for stock nearly all the year round. The clovers, which should be used in much smaller quantities than the grasses, are perennial red clover (cow grass), alsike, and white or Dutch

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clover. Seeds of milfoil or yarrow *(achillea millefolium)* ought never to be omitted. The above he considers to be all that are needed to constitute a first-class pasture on the best and medium soils. For poor soils the mixture would have to be modified. Thus, on dry lands, foxtail, rough meadow grass, and fiorin would have to be omitted, and a smaller quantity of meadow fescue used, whilst the proportion of cocksfoot, crested dogstail, and yarrow should be increased. He condemns rye-grass in all its varieties, and Yorkshire fog *(Holcus lanatus)* as "the grasses most pernicious to newly-formed pastures." The value of cocksfoot and its superiority over rye-grass has been well established by experience in the colonies.

A MIXTURE OF SEED.—Although rye-grass should not be sown alone, it fills a valuable place in a mixture. In addition to the grasses mentioned above, prairie-grass should be included as one of the most valuable elements in a mixture of seed for pasture. The advantages of sowing a mixture are not confined to securing permanency of pasture, but a more healthy food is provided for stock. The change of food provided by the different grasses is good for the stock, and as in the mixture there will be early and late winter and summer grasses, the pasture is likely to be kept in good order all the year round.

VARIETIES OF GRASS.

The characteristics of various grasses are thus given by Mr. F. Willis, of Rothamstead :—

LOLIUM PERENNE *(Common Rye-grass)* is a very valuable grass to the grazier, not only on account of its nutritive qualities, but because it produces abundance of root-leaves throughout the season, until checked by frosts. It is moderately early, and succeeds best in wet and warm seasons, and is a very prevalent grass in the fine old ox pastures of Leicestershire.

LOLIUM ITALICUM *(Italian Rye-grass)*.—This is generally considered a bearded variety of the common rye-grass ; but it arrives sooner at maturity, has a greater abundance of foliage, which is broader, considerably taller, and less inclined to spread out. Its comparatively limited duration fits it well for sowing in mixture with other grasses intended for permanent pasture, or for renovating bare places, as it dies out and gives

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place to the more slowly maturing perennial sorts, which are destined to fill the ground.

PHLEUM PRATENSE *(Timothy or Catstail Grass).*—This species thrives best on moist loamy soils. It is unsuitable for chalk, or stiff clay lands, but can withstand extremes of temperature. It yields an early and productive growth on first laying down, but appears to die out after a few years. Some authorities state that this variety is more agreeable to cattle than any other grass, and in America it is cultivated almost exclusively where the soil is favourable.

ALOPECURUS PRATENSIS *(Meadow Foxtail Grass).*—One of the earliest and best of grasses for continuous cropping, because it yields a very large proportion of leaf to the stems, which are broad, long, and soft, and grow rapidly when cut or eaten down. It succeeds best on rather superior soils of medium texture, and requires about two years after sowing to arrive at full maturity.

DACTYLIS GLOMERATA *(Rough Cocksfoot).*—A perennial grass with stiff fibrous roots, descending often to a considerable depth into the soil. Its habit of growth is tufty and rather unsightly when on very rich soil, but it is a very valuable grass in most pastures on account of the great quantity of produce which it yields, and the rapidity with which its leaves grow after being cut or grazed down. It prefers good moist soils, and is one of the first to start in the spring, but if allowed to stand too long its leaves get hard and coarse.

FESTUCA OVINA *(Sheep's Fescue.)*—A densely tufted perennial grass, growing plentifully on dry elevated pastures where there is but little struggle or competition. It will thrive on a variety of soils, and will resist the effects of severe drought in summer better than some of the larger growing and deeper rooted species. Its leaves are narrow and fine, and produce a soft towy herbage. It is moderately early, and yields a fair share of later growth, especially if the autumn rainfall is not deficient.

FESTUCA DURIUSCULA *(Hard Fescue).*—Apparently a variety of Sheep's Fescue, and upon some soils the two kinds blend one into the other in such a manner that it becomes almost impossible to mark the distinction. Like *F. ovina* its leaves are rounded and wiry, but longer, more luxuriant, and earlier. It thrives on a great variety of soils, but prefers those which are light and dry; it is, therefore, recommended for most pasture lands, particularly as it yields a greater amount of fodder than

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might be expected from its comparatively dwarf habit of growth, and retains its verdure during the winter in a remarkable degree.

FESTUCA PRATENSIS and F. ELATIOR (*Meadow Fescue and Tall Fescue*).—These plants have a slightly tufted habit of growth, with broad, lively, green coloured foliage. They are moderately early, and are very partial to moist soils. They form excellent pasture grasses, well liked by all kinds of domestic herbivorous animals. Although their root fibres descend to a greater depth into the soil than those of *F. ovina* or *F. duriuscula*, yet they can with difficulty withstand the effects of a very dry season, requiring shade and abundance of moisture ; whereas the former species are generally the most conspicuous grasses under defective soil and climate conditions.

POA ANNUA (*Annual Meadow-grass*).—This species is one of the most common grasses in all temperate climates, and is considered as a very troublesome weed. In some parts of Suffolk it forms whole fields, to the exclusion of all other grasses, being a very early and rapid grower. It is greedily eaten by cattle, consequently is recommended as a meadow grass, and especially for making good thin or blank places.

POA TRIVIALIS (*Rough-stalked Meadow-grass*).—A very valuable grass in a mixture for pasture lands, particularly on damp soils. Its stoloniferous shoots begin to grow tolerably early in spring ; as the season advances these shoots are dried up by the effects of the sun, but they start again towards the end of the summer, when the weather becomes moist, and continue green during the greater of winter.

POA PRATENSIS (*Smooth-stalked Meadow-grass*).—A perennial grass with a powerful root-growth. It is generally recommended for sowing in pastures from its yielding a large quantity of herbage at a very early period of the season ; but it is not a great favourite with agriculturists, owing to its thickly matted creeping roots, which are considered to impoverish the soil, and its foliage ceases in a great measure to grow after the month of June ; it is also very liable to be injured by the disease called "rust." It flourishes naturally in dry situations, producing rather long, narrow leaves, which are of a coarse and hardish nature.

AGROSTIS VULGARIS (*Common or Creeping-rooted Bent-grass*).—A most variable perennial grass, having a kind of subterraneous creeping stem. Owing to the extensive root-possession, especially in the upper or richer layers of soil, which this plant acquires, and the consequent difficulty of

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extirpation, it is usually considered as a troublesome pest in any light arable soils, being one of the grasses known as "twitch" or "couch." It is naturally distributed in pastures and waste places, wet or dry, and will grow on gravelly soils where more valuable grasses fail. It is a very late grass, but continues to yield its foliage far into the winter.

AGROSTIS SPICA-VENTI (*Silky Bent-grass*).—A useful grass for sowing in blanks of grass fields, or on first laying down pasture, as it quickly produces a supply of luxuriant foliage, much relished by cattle. It, however, entirely disappears after about two years.

AVENA PUBESCENS (*Downy Oat-grass*).—A very early and hardy grass, natural to dry pastures, especially in chalky or limestone districts; foliage rather narrow, not attaining to any considerable length. It succeeds in meadows best where the herbage is thinnest.

AVENA FLAVESCENS (*Yellow Oat-grass*).—A late variety, yielding a considerable bulk of fine herbage. It deserves a place in all mixtures for light, dry soils.

ANTHOXANTHUM ODORATUM (*Sweet-scented Vernal-grass*).—This grass is very early, but produces a scanty portion of herbage. It is remarkable for giving out a pleasant smell during the process of drying, and it is principally to the presence of this species that hay from natural meadows owes it peculiar fragrance. It is said that pastures where this grass abounds produce the finest quality of mutton.

CYNOSURUS CRISTATUS (*Crested Dogstail*).—A late grass that will grow on the poorest soils, and in seasons when many other species can with difficulty exist—due most probably to its penetrating roots, which draw up moisture from the lower depths of the subsoil and ensure the herbage against suffering from drought. It has fine light green foliage, and forms a close, dense turf, being therefore well suited for lawns and grazing pastures to fill up the places between the larger-growing species.

TRIFOLIUM PRATENSE (*Red Clover*).—A perennial plant of many varieties, and of longer or shorter duration, that which is usually found in permanent pasture being sometimes termed by agriculturists *Pratense perenne*. It is very valuable for feeding, and should find a place in all good pastures.

TRIFOLIUM REPENS (*White or Dutch Clover*).—A low-creeping and much more dense and leafy species than the red clover. Grows naturally in meadows and on a great variety of soils and situations, being in great repute in all the better

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class of grazing lands. In fact, it is to the prevalence of this species that the goodness of the herbage is often attributed. It is a late variety, but continues to produce a continuous supply of fresh foliage far into the autumn.

TRIFOLIUM FILIFORME (*Yellow Clover or Trefoil*).—This is a small clover, recommended for growing on very gravelly or rocky places, which are incapable of supporting the more valuable grasses and clover.

LOTUS CORNICULATUS *(Birdsfoot Trefoil)*.—A plant well suited for growing on dry elevated pastures and healthy soils. It gives a bulk of short herbage, and from the depth to which its roots penetrate it is not liable to be injured by drought, and is thereby enabled to retain its verdure when other plants are dried up.

ACHILLEA MILLEFOLIUM (*Milfoil, or Yarrow*).—A perennial plant that will grow in the poorest, driest, and most sandy soil, being capable of bearing extreme drought without injury. It gives abundance of leafy herbage throughout the season, which is well liked by cattle.

LUCERNE.—Although more properly a fodder plant for cutting, lucerne forms the best and most serviceable pastures in the warm, dry portions of Australia. The best results are obtained by cutting the lucerne and feeding it to stock, but if not eaten too close it will stand grazing for some time. Its chief recommendation is that it grows rapidly in the summer and autumn, showing quick growth after every shower. When water is available for irrigation very large quantities of fodder can be obtained from lucerne, and, even when it cannot be irrigated, it constitutes a highly valuable kind of pasture. Its roots strike very deep, rendering it able to resist the effects of drought, and in its cultivation the soil requires to be well worked to a good depth.

THE CULTIVATION OF GRASSES.—The soil requires to be well worked in preparation for grasses. Weeds will choke the young grass, and the early stages of the plants determine the future condition of the pasture. Let the soil be worked deep, and harrowed to a fine tilth. The system of sowing grass seed along with a cereal crop has been found by experience to be objectionable. One of the crops must suffer, and it is important that the grass should get a good start. In moist districts spring sowing is sometimes successful, but April and May are the best months. Cover in the seed with a seed harrow or light brush harrow. In moist climates grass seed may be sown upon the unbroken surface, and worked in

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with harrows or the treading of sheep, but this can only be done successfully in special localities. The young crop may be lightly grazed with sheep during the first summer. The grass crop is a good one to top dress with farm-yard manure. It is greatly benefited by the treatment, and the soil is manured for the succeeding grain crop. Cultivated pastures should be subdivided into four or five fields. This course will not only benefit the stock, but keep the pastures from being destroyed. Such pastures as lucerne and prairie-grass especially require the aid of subdivision, and all grasses are benefited by being allowed time to recover and to seed.

CHAPTER IX.

GREEN CROPS.

GREEN crops, which consist of a different order of plants from cereals, and assimilate the elements of the soil in different proportions, are valuable to the agriculturist as affording him a means of giving the land a change and introducing a system of rotation which is less exhaustive than continuously growing one class of produce.

PEAS.

The pea crop, which is referred to at some length in the chapter on "Green-Manuring," is one of the most profitable in itself, as well as affording a beneficial change to the soil. It requires a somewhat moist climate, and, therefore, can rarely be successfully cultivated in the dry inland parts of the Australian continent. In the coast districts, however, and in Tasmania and New Zealand, peas are successfully cultivated.

SEED.—There are numerous varieties of both garden and field peas, with varying characteristics, rendering them suitable for different localities. As in the case of all other seeds, the kind which does best in some localities will be found less suitable for others, and it is consequently fruitless to recommend varieties. The variety which is found to do best in the district should be chosen, and the general direction to secure pure

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seed should be attended to. With mixed seed there are unequal ripening, a poor sample, and other drawbacks, which are avoided by sowing pure seed.

PREPARATION OF THE SOIL.—Strong clay land is suitable for peas, but a free, volcanic loam or limy wheat soil gives the best results, and a good rainfall is necessary to ensure a heavy yield. Manure should not be directly applied to the crop, as such a course is likely to produce too strong a growth of haulm, but after a well-manured potato crop good results are likely to be obtained. The land should be well and deeply cultivated, and reduced to a pretty fine tilth.

SOWING.—Except where weeds are likely to prove troublesome, peas may be sown broadcast at the rate of two or three bushels per acre; but in rich soil, where weeds are liable to spring drilling is preferable, as the land can be worked between the rows with the scarifier, and kept clean. July is a good month for sowing in the coast districts of Victoria, but when there is danger of frosts sowing may be more advantageously delayed till August.

HARVESTING.—The most expeditious method of harvesting is by using the wooden pea rake. Instead of cutting the haulm with the sickle, the turnover horse rake is put in, which gathers the crop in the same way as in haymaking. The rake pulls up and breaks off the plants, and the system is found to be economical and effective. Peas are frequently threshed with the flail on cloths spread in the field, but by carting and threshing in the barn or stack-yard there is less waste, and the haulm can be saved for feeding stock, it being valuable for this purpose.

BEANS.

The common bean and the English horse bean are both extensively cultivated as a field crop in Europe and America, but are not generally grown even in those moist portions of Australia and in Tasmania and New Zealand where the climate is suitable. The valuable feeding qualities of both the bean and the haulm should cause the crop to receive more attention in those parts of the colonies where climatic conditions are favourable to its cultivation.

SOIL AND CULTIVATION.—The bean flourishes in a loose, generous soil of medium fertility. The soil should be well worked, but not heavily dressed with fresh manure. As the bean is a tender plant in its younger stages, the seed should

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not be sown until all danger of frost is past. Upon clean land the seed may be sown broadcast, but the best system is to sow in drills about 2 ft. apart, covering to the depth of about 2 in., and sowing from 1½ to 2 bushels per acre.

HARVESTING.—When the pods assume a yellow colour the crop is fit for gathering; when ripe the stalks are easily pulled up, or they are sometimes cut with a scythe. In the drying climate of Australia a day or two in the field after cutting is generally sufficient to render the beans fit for carting and threshing. Thresh with the flail, and preserve the haulm for stock. Sheep especially do well upon the bean haulm.

TARES OR VETCHES.

Tares or vetches are a valuable green crop cultivated extensively in Europe and America, but not receiving a sufficient share of attention in the colonies. It is chiefly used as a green fodder crop, for, although the seed is nutritious, the best results are obtained from using the crop in a green state.

CULTIVATION.—The crop grows best upon well-worked clayey soil, but does satisfactorily upon any fairly fertile or well-manured land. Work the soil well and deep, and dress liberally with farm-yard manure. Sow either in winter or spring, at the rate of from 2 to 2½ bushels per acre, broadcast. The crop may be grazed or fed-off by folding sheep, but it is better to cut the fodder as required. The fodder is good for horses and cattle, and specially valuable for feeding milking cows.

CHAPTER X.

ROOT CROPS.

ROOTS being a different order of plants from cereals and leguminous plants, and consequently differing in the proportion in which they take the various elements of fertility from the soil, play an important part in the system of cultivation by rotation while producing valuable crops, and enabling the farmer to carry on operations for the destruction of weeds. When roots are cultivated in rotation with green and cereal

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crops, the farmer has not only a variety of products to reward his toil, but possesses the additional advantage of following a system which is most favourable to maintaining the fertility of the soil.

POTATOES.

The potato, which is a native of the American continent, is extensively cultivated in nearly all parts of the world. It can be successfully cultivated both in warm and cold climates, but a certain quantity of moisture is necessary to produce a good yield. In the inland dry districts of Australia the rainfall is generally insufficient for the potato crop, but in the coast districts, and near the mountain ranges, the climate is favourable, as well as in Tasmania and New Zealand.

SOIL.—The most suitable soil for potatoes in the colonies is a reddish or chocolate clayey loam of volcanic origin, but the crop grows well in any free, fertile loam. In the valleys of rivers, or upon rich forest lands, where there is a fairly copious rainfall, the potato crop can be successfully cultivated.

SEED.—The varieties of potatoes are numerous, and the kinds best suited to different localities are well known. New varieties can be tried upon experimental plots, but the main crop should be planted with the sort best suited to the locality. In preparing the seed, it is false economy to cut the potato into numerous small sets; it is better to select medium size potatoes and plant whole. Cutting the potato into two parts, and thus making two sets from each, is adopted with good results, but making numerous small sets is generally found to be less satisfactory.

PREPARING THE LAND.—The land should be thoroughly worked for the potato crop. Work the soil deep and well, reducing to a good tilth, and enriching with manure. Farm-yard manure spread liberally upon the surface and ploughed in generally gives satisfaction, and salt, ashes, and bone-dust can also be advantageously employed. When the soil has been well pulverized and manured, the potatoes can be planted with every expectation of a good crop.

PLANTING.—Ploughing-in is the system of planting generally adopted in the colonies, and the results are entirely satisfactory. The sets are placed in the furrow from 10 in. to 12 in. apart, being set at one side so as to be protected by the

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soil from the horses' feet. The next furrow turned covers the seed, and two more sods are turned over before the next row of sets is planted, so that the rows are about 18 in. apart. In some cases the three-furrow plough is used, and the sets are planted in the open furrow every round. Deep planting is adopted in some countries, but in the best potato-growing parts of the colonies the seed is seldom put in more than 4 in. or 5 in. in depth.

AFTER-TREATMENT.—After planting, the ground should be harrowed down fine, and the principal attention required until harvest is to keep down the weeds. In very moist localities the earth may be hilled up on each side of the plants, but there are few parts of Australia where this course is not injurious. It is generally important to conserve the moisture during summer, and leaving the surface flat is the best course. Keeping the surface stirred tends both to attract and retain moisture, and this is the principal treatment required by the potato crop.

DIGGING AND STORING.—When the tops are withered near the roots the potatoes are ripe and fit for digging. They should then be dug up before the rain comes, which otherwise will cause second-growth. Digging machines have been invented, but they all require special conditions which seldom exist, and they are not generally adopted. Ploughing-out the potatoes is sometimes adopted, but if the work is done well there is not much saving of labour, so that hand-digging with the fork is the system most generally followed. The potatoes should be bagged-up as soon as taken out of the ground, as exposure to the heat of the sun soon injures them. In storing potatoes they must be kept cool and dry. This is best done in a covered building, but when such is not available they may be pitted in the open field. A shallow excavation, about 1 ft. or 2 ft. deep, is made in a dry situation, and protected by drains from moisture. The potatoes are put in and heaped up in the form of a pitched roof. The heap is then well covered with straw or thatch sufficiently to keep the potatoes from the wet or from injurious effects by the heat.

THE SWEET POTATO.—This root, which is extensively grown in the United States, is highly esteemed both for the table and as food for stock. It flourishes in a free, generous, and rather sandy loam. The soil should be well manured and thoroughly worked. A moist, warm climate is required for the crop, and, under favourable conditions, the system of cultivation differs little from that followed with the ordinary potato.

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Mangels and Beets.

Beet and mangel-wurzel are root crops extensively cultivated as food for stock. In France and Germany a variety of beet is much used for making sugar, and in California the industry is also profitably carried on. It is as a food for stock, however, that the beet crop is most generally used, and the large productive variety known as mangel-wurzel is most commonly cultivated for this purpose. A somewhat moist climate is required, and consequently, as far as the colonies are concerned, it is only in New Zealand, Tasmania, and the coast regions of Australia that the crop is cultivated successfully.

Soil.—The beet or mangel crop requires a somewhat friable or well-worked soil. The soil may be inclining to a sandy loam, but it must be fertile. Work the soil thoroughly to a good depth, and dress liberally with farm-yard manure. Artificial manures may also be used, such as bone-dust, which can be drilled in with the seed. Liberal treatment is necessary except upon the richest soil, but the crop will generally pay well for the labour and manure.

Cultivation.—Soak the seed in water from twelve to twenty-four hours before sowing, and sow in drills about 2 ft. apart, at the rate of from 4 lbs. to 6 lbs. of seed to the acre. The land should be prepared in the autumn, and kept in order until sowing time, which is the early spring. When frosts are not likely to be injurious the seed may be sown early in August; but in other cases September will be a more favourable month, and upon shallow soils the globe varieties will be the most suitable; while the long sorts will do best where the soil is deep and fertile. After the plants have come up, thin-out to about a foot apart, and keep the surface well stirred and free from weeds during the spring and summer. The roots may be used during the autumn, but must be taken up and stored on the approach of winter. They are stored in the same way as potatoes, and can with little care be preserved throughout the winter.

Turnips.

The turnip crop is a valuable one in moist climates, which alone are favourable to its cultivation. It is extensively grown

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as food for sheep and other stock in Europe and America, while in New Zealand it is one of the most profitable resources of the farmers. There are only limited districts in Australia where the climate is sufficiently moist for the successful cultivation of the crop.

SOIL.—A fertile sandy loam is best suited to the turnip crop. In New Zealand fair crops are obtained from new land without manure, but, as a rule, the soil should be worked into a fine tilth and well manured.

SOWING.—The chief varieties are the white turnip and the *Ruta Baga* or Swede, the latter growing upon a stronger soil and keeping better than the former. The soil having been well prepared as for all root crops, the seed should be sown in drills 2 ft. apart, at the rate of about 2 lbs. per acre. Broadcast sowing is generally adopted upon the virgin soil in New Zealand, but drilling is preferable in most cases. Use a turnip drill, which will furrow, cover, and roll at the one operation. Turnips are sown in England and America in the month of June, or about midsummer; and a favourable time for sowing the main crop in the southern hemisphere should be chosen between September and January, according to locality, Swedes being sown a fortnight earlier than white turnips. Bone-dust drilled in with the seed is advantageous.

AFTER-TREATMENT.—When the plants show themselves above the ground, the scarifier should be set to work to keep down weeds and stir the surface soil. Thin-out the drills when the plants are well up, leaving a space of about 6 in. between them.

DISEASES.—The turnip is subject to many diseases, the most common in the colonies being an aphis blight, known as "the fly." The best remedy is to facilitate the healthy and rapid growth of the plant. Manuring the soil and drilling-in manure with the seed are generally relied upon to enable the crop to survive the disease. The seed is also soaked before sowing, to facilitate rapid germination, and some New Zealand growers find it advantageous to plant turnips in alternate rows with mangels, as a means of mitigating the effects of the disease.

STORING.—When turnips are not all eaten off in the field they are stored for winter use. Special care must be taken in storing turnips to prevent them from heating. Heaps may be formed in the same way as with potatoes or mangels, but it is necessary to provide, at frequent intervals, holes, extending from the bottom to the top of the heap, for ventilation. These can be kept open by inserting a bundle of straw, or rather

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building the turnips around a bundle of straw in forming the heaps.

Carrots.

The carrot is one of the most valuable farm products. It possesses rich nutritive qualities, and will grow in a great variety of soils, but, like other roots, requires a considerable supply of moisture to bring it to perfection.

Soil.—The soil best suited to the carrot crop is a generous sandy loam, but it will grow well upon stronger and more clayey soils, provided there be depth enough for its roots to search in for plant food. The soil should be deeply and well worked, and liberally dressed with farm-yard or other manures.

Cultivation.—Carrots are sometimes successfully cultivated by sowing broadcast, but drilling is preferable. The drills should be about 20 in. apart, and it is a good practice to assist the germination of the seed before sowing, so as to ensure that the crop should get ahead of the weeds. An approved method is to mix the seed with fine mould, damp the mixture with water, and keep for about 10 days before drilling. Sow about 2 lbs. of seed to the acre, and, after the plants are up, thin-out to about 1 ft. or 8 in. apart. A top-dressing of liquid manure can be profitably applied, while the scarifier will have to be kept at work stirring the soil and destroying the weeds. When it is required to keep the carrots till winter, the tops are cut off, and the roots stored in the same way as potatoes or turnips.

CHAPTER XI.

MISCELLANEOUS CROPS.

In addition to the various farm crops treated of in the foregoing chapters, there are several others of a more special character, the cultivation of which is limited to certain localities possessing peculiarities of soil and climate favourable to their growth. In the present chapter it will be sufficient to deal with such as can be successfully cultivated in different parts of the Australian colonies.

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