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F. R. Arndt.

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The
CULTURE
of
CITRUS FRUITS

Under the Climatic and Geographical
Conditions pertaining to the
Murray Valley.

BY
F. R. ARNDT

Author of
"Fruitgrowing under Irrigation," "Possibilities of Irrigation,"
etc., etc.

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ADJ. ALICE

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PREFACE

During the expansion of the citrus industry that has within recent years taken place along the Murray Valley the absence of any book of a general nature dealing with the culture of citrus fruits under local conditions has often been a considerable handicap to new growers in the laying out and management of their plantations. It is with the object of attempting to remedy this disability that this work is published, and it is the author's hope that new and prospective citrus growers may find the information herein contained of some use to them.

A considerable portion of the subject matter contained in the following pages has been taken from the author's previous works—from a pamphlet entitled *Orange Culture*, published in 1914, and from *Fruitgrowing under Irrigation*, published in 1918. The whole of such extracts from these works as are herein incorporated have been revised, two new chapters have been added, and an endeavor made to present the subject to the reader in a plain and concise form.

F. R. ARNDT.

Berri, River Murray,
South Australia.

4th November, 1919.

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CHAPTER I.

THE MURRAY VALLEY.

The portion of Australia supplied with the largest volume of running water is the Murray Valley. The Murray has its source in the Snowy Mountains, and fed by its tributaries, the Darling, Murrumbidgee, Goulburn, Mitta, Ovens, Compaspe, and Lodden, in normal years brings down large volumes of water, which, with the exception of the comparatively small quantity utilised for irrigation purposes, is discharged into the sea.

The greater portion of the country through which the Murray, Darling, and Murrumbidgee flow has an average annual rainfall of about 10 inches, which renders the growing of crops without irrigation a somewhat hazardous operation.

Owing to the fact of large volumes of water flowing through dry, but, on the whole, fertile country, the Murray Valley is, in the natural course of events destined to become—to a far greater extent than it already is—the seat of the chief irrigation districts of the Commonwealth.

For their suitability to fruit culture the irrigation settlements of Mildura, Merebein, Renmark, Berri, and Waikerie, all of which are situated along the banks of the Murray, have long been noted.

The kinds of fruit chiefly grown consist of various varieties of the grape vine, such as the sultana, zante currant, and Gordo Blanco, different sorts of deciduous trees, like the apricot, peach, and pear, and Washington Navel and mandarin oranges.

The Washington Navel thrives better here than elsewhere in Australia, the conditions favorable to its growth appearing to be practically ideal. Mandarins also thrive well and bear heavy crops, while the Valencia Late is also proving a profitable variety.

WATER SUPPLY.

With the exception of the Yanco irrigation area (Murrumbidgee), which is watered by gravitation, the various Murray irrigation settlements are supplied with water by means of pumping plants, lifting the water into the irrigation mains to heights varying from about 40 feet to 130 feet.

Water is applied on most of the irrigation settlements in four or five irrigations, ranging from August to March for deciduous trees and vines, but for citrus an additional irrigation is usually given during April or early May.

CLIMATE.

The climate of the Murray Valley is hot and dry. The rainfall, as before stated, averages about 10 inches per annum, and is insufficient for fruit culture without the aid of irrigation. The months of November, December, January, February, and March are usually hot, the temperature often exceeding 100 degrees Fahr., and sometimes reaching 110 degrees during severe heat waves. Hot, northerly winds often accompany these heat waves. The nights during the summer months are usually cool.

The climate during the autumn, winter, and early spring is mild. The days are usually fine and sunny. The night temperature sometimes sinks a few degrees below freezing point, but any considerable damage to plant life from frost is rare.

During September and October the equinoctial gales often blow with considerable force and per

sistence, making it necessary to take precautions against the drifting of the surface soil of the looser sandy slopes.

NATURE OF MURRAY LANDS.

The land suitable for fruit growing along the Murray consists of two distinct sections: the river flats and the high lands.

The river flats consist of alluvial soil deposited by the river in the course of ages. These flats are, on the whole, fairly level, but usually contain numerous small local irregularities, which have to be graded off before the land can be planted. The soil usually consists of a variety of clays and loams of a fairly heavy nature, which are often overlaid with a layer of sand.

The high lands generally consist of loose, sandy rises, which in their native state are often thickly timbered with pine, mallee, and other bushes. The soil is generally a red, sandy loam. The depth of soil varies from about 2 feet to 5 feet, and is usually underlaid with a loose, light-brownish marl. Land of this nature exists by the thousands of acres along the Murray Valley.

CHAPTER II.

LOCATING THE CITRUS GROVE.

SUITABLE SOIL.

Owing to the fact that citrus, as other varieties of fruits, do not do equally well in every kind of soil or situation, it is first of all necessary to select a piece of land having characteristics best suited to their requirements.

Regarding the class of soil best suited for citrus trees, experience has shown that loose, rich soils which have perfect drainage have given the best results. This does not mean that citrus trees will not grow on rather heavy land. On the Adelaide plains, as well as on the river flats at Renmark and Berri, oranges and lemons do remarkably well on rather heavy clay soil; but young trees are somewhat difficult to start in such soil, and their growth for the first three or four years is slow.

The deeper class of soils of the Murray uplands may be said to be practically ideal citrus land. Land of this nature is, in its native state, usually covered with pine, needlebush, or big mallee, and consists of a red sandy loam, from 3 to 5 feet in depth, underlaid by a loose, greyish-brown calcareous marl.

Local experience has shown that citrus trees do not thrive on land having limestone, either in the form of rock or rubble, within a few feet of the surface, as such land is often full of salt, or on land underlaid with a whitish, putty-like clay.

The alkali problem is probably the most serious danger that the citrus grower has to face upon the Murray uplands, as such salts as sodium chloride

(common salt), sodium sulphate (Glauber's salt), and magnesium sulphate (Epsom salts) are highly detrimental to all varieties of citrus trees. Therefore, land likely to develop alkali trouble, such as shallow soils under 3 feet in depth resting upon limestone, or upon a hard or tenacious subsoil, should be avoided by the planter. However, as the presence of alkalies in a soil is due to defective under drainage by choosing deep land, with a loose subsoil, no damage from alkali trouble should be experienced.

SITUATION NOT SUBJECT TO HEAVY FROSTS.

Although, on the whole, severe damage to citrus trees due to frosts is but a rare occurrence on the Murray Valley irrigation settlements, there are yet certain situations subject to comparatively heavy frosts which should be avoided by the planter.

It is a matter of common observation that frosts are the most severe in valleys, hollows, and low areas, while the adjacent hillsides or elevated lands remain comparatively untouched. This is because the cold air from the hillsides, being heavier, drains off into the lower levels and settles there, while the warm air rises to replace it. This interchange of air continues until frost occurs in the lower levels, while the higher lands escape.

A citrus grove should, therefore, never be located in a hollow, basin-shaped depression, or in a narrow gully.

THE IDEAL POSITION.

The ideal position of a citrus grove is on a slope facing the east, as experience has shown that the rays of the rising sun are less injurious to frosted plants than they are if the sun is some distance above the horizon before it strikes them; while the slope of the ground will allow the cold air to drain off into lower levels. Of course, a situation facing the east, although desirable, is not essential for the location of the grove, the one thing necessary being

that the plantation has perfect air drainage, so that the cold air can drain away ; and therefore a position on sloping ground is the best.

One thing the planter should be careful of, and that is to plant no belt of evergreen shelter trees along the boundary at the lowest portion of the grove. Such trees, being in full leaf in winter when the frosts occur, prevent the cold air from passing freely away and force it back upon the plantation, thus causing frost on the lower portion of the grove. Should a breakwind be required along the lower boundary, it should consist of deciduous trees.

GOOD DRAINAGE ESSENTIAL.

As all varieties of citrus trees are impatient of stagnant water about their roots, they should only be planted on land having perfect drainage, and, therefore, shallow soils, or very heavy soils whereon the water stagnates, must be avoided by the planter.

As one of the greatest drawbacks on an irrigation area is the menace of seepage, land that is full of hollows, or that has a heavy sub-soil, should not be chosen. Seepage is brought about by the irrigation water running along the sub-soil and coming to the surface where this sub-soil is shallow or where it meets the surface of the ground. Blocks situated on sandy rises which peter out on to clay flats are liable to develop seepage, which will show itself along the line just above where the clay and sand meet. Land that contains hollow, basin-shaped, depressions should also be avoided, for unless the sub-soil of such depressions consists of deep sand, the water from the surrounding higher lands will soak into the hollows and kill the plants it contains. A block of land having deep soil of a uniform nature, with a not too tenacious sub-soil, and having an even slope, is about as good a proposition as can be obtained.

CHAPTER III.

GETTING THE LAND READY FOR PLANTING.

CLEARING, FENCING, PLOUGHING.

The expenses of clearing will, of course, vary according to the nature and density of the natural vegetation. Box lands, as well as pine and mallee country, vary from about £2 to £6 per acre, according to the size and density of the natural growth. For the grubbing of the more heavily timbered lands grubbing machines and tree-pullers are usually used, and on some of the Government irrigation areas steam traction engines are employed in pulling out the trees and stumps.

To protect the orchard from the ravages of rabbits and stock it is necessary to enclose the plantation with a good substantial wire fence, with 3 ft. wire netting. At normal prices for material, a 4 ft. high fence, posts 12 ft. apart, four wires, and wire-netted, will cost about £60 per mile. After the land has been cleared it should be deeply ploughed to loosen the soil and to get rid of the roots of the native tree which occupied the land. The cost of a first deep ploughing will be about £1 per acre.

GRADING.

As it is essential for the success of an irrigated orchard that there should be an uninterrupted flow of the irrigation water, all irregularities of the surface of the ground which would interfere with the water flow should be graded off.

Lands having any considerable fall, such as the greater portion of the high lands, require but little

grading, which will be mostly restricted to the removing of small bumps or rises. On no consideration should more soil be removed than is absolutely necessary, as experience has shown that where from six inches to one foot of the surface soil has been graded off and trees planted on the exposed sub-soil, that their growth has been slow and unsatisfactory for years. On the box flats and on other lands where there is but little fall, the grading has to be more thorough, as the slightest rise will stop the flow of the irrigation water.

The cost of preparing the land for planting will, of course, vary with the nature of the land. On the State irrigation areas of South Australia, the Government makes advances to settlers for grubbing, fencing, grading, and channelling up to £15 per acre. Not every block, however, will cost as much as this to prepare for planting, and £12 per acre may be taken as a rough average.

CHAPTER IV.

LAYING OUT THE LAND FOR WATERING.

IRRIGATION CHANNELS.

After the land has been grubbed, graded, and ploughed, the next thing is to have the irrigation channels put in from which the land is to be watered. The channels are usually made from lime or cement concrete, but irrigation by means of reinforced cement piping has within late years been introduced and given satisfactory results.

The greatest care should be exercised as to where the channels are put down. Upon the position of the channels depends the length of the rows of trees to be watered. Experience has shown that in loose, sandy loam rows 5 chains in length are long enough, and that on no consideration should rows over six chains long be watered in one section on this class of land.

As on the loose, sandy rises, of which the irrigation settlements chiefly consist, the furrow system of irrigation is practically the only one that is used it follows that the water is flowing for a considerable time past the first trees of a row before it reaches the last one, therefore, the longer the rows are, the longer will the water take to reach the end. On very long rows the first tree will have had too much water before the last tree will have had enough, and the top of the land will in time become water-logged, to the injury of the trees. In any case, the surplus water will soak down the slopes along the sub-soil, and should this in any case come close to the surface of the ground,

the water will come up there in the form of seepage, bringing the alkalies contained in the soil with it, and killing the plants in the vicinity. Having short rows means, of course, much channelling, which greatly adds to the first cost of the place, but it will pay in the long run in the ease with which the land can be watered, and in the satisfactory growth of the trees.

Another matter in which care has to be exercised is to see that the channels are so situated that the grade of watering is not too steep or too level. On sandy rises a fall of one foot to the chain is sufficient, while anything under 4 inches to the chain is too little. It is a mistake to water straight down steep slopes, as the force of the water washes deep gutters in the land at the top. The washed-out soil carried down by the water silts up the furrows further down the slope, causing the water to spread over the land at that place, so that very little water reaches the end of the rows.

Where the land is hard, as on most of the flats, the grade along which to irrigate may be considerably less than upon sandy rises, as the soil absorbs the water far more slowly than is the case with the looser land. The danger of watering along an almost level grade on loose, sandy land is that, through the porous nature of the soil, the water sinks in so rapidly that the top ends of the rows get too much water before the bottom ends have had sufficient. Unless the drainage of the land is excellent, such a system of watering will, sooner or later, cause seepage to appear lower down the slopes. Thus it is not safe to water with a fall of less than 4 inches to the chain on sandy rises—from 6 to 9 inches being the most convenient grades.

CHAPTER V.

VARIETIES TO PLANT.

The Washington Navel is the most extensively planted of all varieties of citrus grown in the Murray Valley. As previously stated, this variety thrives exceedingly well under the conditions existing along the banks of the Murray, and with the exception of occasional unfavorable seasons, is a consistent bearer of heavy crops of well-flavored and highly-colored fruit. Being so well suited to the district, this variety is likely to remain the chief kind grown for many years to come.

The Thompson's Improved Navel has also been planted to a limited extent, but whether it will be as profitable a variety to grow as the Washington Navel experience has yet to prove.

The Valencia Late is another variety that has been planted to some extent within recent years, and is proving itself suited to Murray Valley conditions. This variety does not ripen until the navel crop has been practically disposed of, and although hardly of the best quality, comes on to the market when this is bare of citrus fruits, and so realises satisfactory prices.

The varieties of mandarins that have given good results are:—Oonshui (early, but does not keep well), Dancy's (highly colored, good bearer), Beauty of Glen Retreat (little later than Dancy's, good bearer).

The lemons usually grown are Lisbon (heavy winter cropper) and Villa Franca (good bearer, ripens some fruit during summer if autumn flowering is not destroyed by frosts).

For the purpose of marmalade making the Poor-man orange is grown to a limited extent.

CITRUS STOCK.

Another thing the planter will have to consider, and that is upon what stock the young trees are budded. In Australia citrus trees are usually budded upon Seville, sweet orange, and lemon stock. Of the three the Seville stock makes the hardiest tree, and American and Australian experience seems to be at one in this matter. The Seville is not so liable to collar rot as the lemon and sweet orange, and can, therefore, be grown on wetter land than either of the other two, and has proved itself able to withstand floodings and to grow in fairly moist situations. The Seville as a stock causes slow growth to the variety budded upon it, makes for a rather bushy tree, and the fruit, although of good quality, is somewhat smaller than that grown either upon sweet orange or lemon stock.

SWEET ORANGE STOCK.

The sweet orange as a stock makes for a quick growing, vigorous tree. On a good, loose, loamy soil, where water does not stagnate around the butts of the trees, and where the drainage is good, the sweet orange stock gives good results. It gives a large and vigorous tree, and induces a good crop of good-sized fruit. Owing to a widely spread belief that the sweet orange is more resistant to the effects of moisture and to the baneful influences of many of the alkalies dissolved by irrigation water, many growers prefer it as a stock to the rough lemon.

ROUGH LEMON STOCK.

As a stock, the lemon has the reputation of being the least hardy of the three varieties under consideration, and is usually held to be more liable to collar

rot, impatient of much moisture around the roots, and more likely to suffer from the attacks of alkalies than the other two.

Therefore, trees on this stock should not be planted on soil likely to be flooded by rain or irrigation water ; but will succeed on dry situations having good drainage.

Rough lemon stock is the favorite stock for citrus trees at present used in Sydney, having practically superseded the Seville and sweet orange for that purpose, and is there known as the "Citronella" stock. This variety has also been extensively used as a citrus stock along the Murray Valley, and so far has given good results.

The rough lemon stock gives rise to a tall, vigorous tree, with large sized fruit, and trees budded upon it grow very quickly and come early into bearing.

In the writer's plantation Washington Navel trees, budded upon sweet orange and lemon stock, were planted side by side at the same time, and in the same class of soil, and at the present time (eight years after planting) not only have the trees on the lemon stock beaten the others in fruitfulness, but in quality of fruit—size, thinness of rind, and sweetness—as well. However, this position may not be maintained in the future, as the trees on the orange stock steady down in growth and yield heavier crops, but it bears out what appears to be the general experience—that the lemon stock is conducive to early fruiting.

Briefly stated, sweet orange and rough lemon stock may be safely used on dry situations having loose soil and good drainage, while sour stock is best suited to wet land, or land likely to be flooded.

CHAPTER VI.

PLANTING.

After the land has been grubbed, ploughed, graded, harrowed, channelled, and it has been decided what to plant, the ground is next set out for planting.

The length and grade of the rows of trees and vines necessary for their satisfactory irrigation has already been dealt with in Chapter IV. Where the land is hilly or undulating it is often impossible to water all the land of a holding with the same grade, therefore the orchard has often to be laid out in two or more sections, each section having a different grade along which to water. This somewhat spoils the appearance of uniformity of the plantation, but with our furrow system of watering this is often unavoidable, as the success of the orchard depends upon its efficient irrigation, so all other considerations must give place to this.

Citrus trees are usually set out in orchard form varying from 20 feet to 24 feet apart. As many varieties of citrus—and especially the Washington Navel—are of spreading habits, they should on no consideration be planted closer than 20 feet. The standard distance for planting deciduous trees has for many years been 20 feet apart on the square, and many citrus plantations have been laid out according to this standard. However, in very rich, loamy soil, wherein the trees make heavy growth, their branches are apt to get too close to each other when the trees reach maturity, thus interfering with the cultivation of the plantation, and, therefore, in this class of soil it is better to plant the trees from 22 feet to 24 feet apart.

PEGGING OUT.

After the grade and length of the rows, as well as the distance at which it is intended to plant, has been decided upon, the ground has next to be pegged out for planting. This is usually done by means of a wire-planting line that has either metal or cloth tags inserted at regular intervals at the distance at which the trees are to be planted. In using, the line is drawn tight, and a peg is driven into the ground at every tag.

Where the land is fairly level, or has but a gentle fall, the channel may be used as a base line and the rows go off at right angles from it; but where the rows, in order to have the correct grade, branch off from the channel at other than right angles, then the line drawn from the channel at the angle it is intended to water should serve as the base line, and all other measurements should be taken from this.

Owing to mistakes made in the laying out of a plantation remaining for the orchard's existence, those without previous experience should obtain the aid of an experienced man to help them with this work.

PLANTING OUT.

Citrus trees are generally planted along the Murray Valley during the first two weeks of September. Planting during the month of May has something to recommend it, as it gives the trees ample time to make new roots before the hot weather sets in. Trees planted in May have to receive a planting irrigation, should be protected by hessian or other means from the winter frosts, and if the winter is dry, as is often the case, will have to receive a winter watering. As the pumping plants of most of the irrigation areas are not at work during the winter months, the difficulty of obtaining a late autumn or winter irrigation has militated against the autumn planting of citrus, and makes September planting the easiest and safest proposition.

Citrus trees are received from the nursery in boxes packed in earth or damp sawdust, with the tops covered with hessian. If it is intended to plant within a few days of their arrival, the trees, if they are in good condition, may be left in the boxes until planting time, care being taken to place the boxes in a cool and shady place, the tops kept covered up, and ample supplies of water given to the roots and tops. If it is not intended to plant for some time, or if the leaves of the trees are limp, the trees should be taken out of the cases and heeled in in a shady place. Plenty of water should be given to both the roots and foliage, and the tops left covered with hessian.

Before planting the roots should be shortened back and all broken roots removed. In cutting back the tops it is not advisable to head the trees too low. Clean stems of about 18 inches are more desirable than shorter stems, on account of the limbs of low-headed trees, being nearer the ground, getting in the way of the cultivator. Besides this, the fruit of low-headed trees is apt to come in contact with the earth, and is therefore liable to be spoiled. Trees having long, clean stems should have their stems protected by straw or hessian loosely tied around them for the first summer to prevent injury from sun scald, which covering may be removed in early autumn. Trees that have been headed low in the nursery should have all drooping growth removed, and pruned to *upward* growing branches, and under all circumstances all unripe shoots should be cut off.

Citrus are best planted with an irrigation, the water running along the furrows and being led into the holes while the trees are being planted. Care must be taken that the trees are not planted deeper than they stood in the nursery—if anything a little higher to allow for settling—as citrus do not do well if deeply planted.

When taking the trees out to be planted, the roots should be kept covered with a damp bag or piece

of hessian, or carried with the roots in a tub of puddle until they are planted. Nothing is so injurious to young citrus trees than to have their roots exposed, even for a few minutes, to the influences of sun or wind.

If the trees are planted before an irrigation, they must be each given a bucket of water immediately after planting, and the irrigation should follow in a couple of days. A good cultivation should follow, especially close to the trees, which should be done with a forked hoe or rake to avoid cutting the roots.

CHAPTER VII.

COVER CROPS.

Crops of annual plants, such as cereals and legumes, are often grown in the plantation, and are usually designated as cover crops. Cover crops are generally grown for shelter or for green manure, or for both. If situated on sandy land the soil of a newly planted or young orchard is liable to be blown about by the wind, especially after it has been freshly ploughed or cultivated, as the young plants have insufficient foliage to protect the ground from the full force of the wind. During a gale the sand is often blown with considerable force against the stems and foliage of the trees to their great injury.

Along the Murray Valley the weather is usually fairly calm during the summer and autumn months, but during September and October the equinoctial gales often blow with great force and persistence. During these storms, on newly-ploughed and freshly-planted orchards situated on sandy land, the damage done is sometimes severe—the drifting sand barking the trees, destroying their foliage, and even covering the irrigation channels with sand. To avoid losses from sand-drift in newly-planted orchards it is necessary that the soil should be held together by a mass of plant growth. This can be accomplished by sowing strips of cereals or legumes in the rows the way it is intended to water. If the trees are planted 20 feet apart a 9 feet strip will be sufficient for the first season, and a 6 feet strip for the second and third years. In every case the cover crops should be sown during the autumn or early winter months, so that the crop is of some considerable height by September, when the windy weather begins.

On newly-planted lands containing a fair supply of humus, such as on deep mallee soils, where it is not necessary to plough in green crops for manure for some years, the cover crops may consist of cereals, such as wheat, oats, or barley. Wheat has proved to be a very satisfactory cover crop for the first three years among young trees, if drilled in with manure in strips from 6 feet to 9 feet wide. Enough hay can in this way be grown to keep the grower's horses for some years, and provided the crop is manured on a liberal scale, no injury to the land or the trees should result. After the trees are three or four years old they should have developed sufficient growth to shelter the ground from the worst effects of the wind, and cover crops for shelter will no longer be required.

Trees planted in land having a deficiency of humus will not make satisfactory growth, and that compound must be added to the soil if the orchard is to be a success. The cheapest way to get humus into the soil is by ploughing in green crops. The crops grown for this purpose are generally legumes, such as peas, clovers, vetches, which acquire, through the agency of the root-inhabiting bacteria, the necessary nitrogen for their growth out of the air, so that when they are ploughed in both humus and nitrogen are added to the soil. Like cereals, legumes are best sown or drilled in with a good dressing of phosphates, say, 2 cwts. to the acre in the autumn, so as to be well established before the cold weather sets in.

The best time to plough in is when the crop is in flower, and it should first be rolled down by short intervals abreast of the plough, so that the plough is able to turn the crop under.

As the clean system of summer cultivation that is necessary to practice under irrigation burns up the humus in the soil, it is advisable to plough in green crops in established orchards at regular intervals.

CHAPTER VIII.

IRRIGATION.

As previously stated trees are usually irrigated on the furrow system, that is, one or more furrows are ploughed on each side of the rows, and the water is allowed to run along them until the orchard has had sufficient. The check system—flooding the land with an even sheet of water—is sometimes practised on level land of a rather stiff nature; but owing to the heavy cost of grading where the land is at all hilly or undulating, this method is not practised to any considerable extent.

As it is necessary for the success of the orchard that every tree should have as nearly as possible the same amount of water, the watering should be so managed that the water does not take too long to reach the last trees of the row, nor should it be so rapid as to cause a washing away of the soil at the beginning of the row. As far as circumstances will permit, this end may be attained by the application of the following principles to the varying conditions of soil and grade.

Firstly: Fairly level land of a stiff nature. This class of land, whether watered by flooding or by furrow, may be irrigated with a large stream of water running into the checks or along the furrows, as the grade (if any) is insufficient to cause a washing away of soil, and the soil too tenacious to absorb the water quickly. On the river flat land it is, on the whole, not quite so essential to economise in the use of water as it is on the highlands, as the under-

drainage is usually good ; but heavy watering may result in water-logging the land for a time to the injury of the trees.

Secondly: Short steep rows on sandy land.

These should be watered with a small stream running along the furrows for a comparatively long time. Watering with a large stream down steep slopes soon washes the top soil away, causing deep gutters to form, while the washed-out soil silts up the furrows further down the slope, so that the water spreads there, and very little reaches the end of the rows. A small stream will not cause this trouble, but as by this means the quantity of water going into the soil is not very great at any time ; the time of watering must be extended to allow for this.

Thirdly: Rows of moderate length and grade on sandy slopes. Rows of 5 chains in length, with a grade of about 9 inches to the chain, give very satisfactory results in irrigating. These are best watered with a moderate to large stream along the furrows, and will give little or no trouble through silting. The size of the stream to use depends not only on the grade but also on the nature of the land. The sandier the land is, the more will it be absorbent of moisture, and the longer will the water take to get to the end of the rows. Therefore to get as nearly as possible an even distribution of water over the whole orchard it is necessary, other things being equal, to make it a rule in irrigating to follow the principle of the sandier the land the larger the stream.

Fourthly: Rows of moderate length with but little grade on sandy land. These should be watered with a large stream running along the furrows for a comparatively short time, for to water such rows with a moderate to small stream would cause the top trees of the row to receive too much water before the last ones have had sufficient.

As stated in previous chapters, nothing is so detrimental to the welfare of the orchard as to water along an almost level grade on sandy land ; for the great quantity of water it is necessary to use before the end of the rows are watered may cause seepage to appear on the lower portion of the holding should the under-drainage of the land not be perfect. But seepage may also be brought about, even on land that has been well laid out, both as regards channelling and planting, if the watering is careless or excessive. One of the quickest ways to ruin a piece of land is to water along a gentle grade with a small stream, or along a fairly steep grade with a large stream. In both instances the upper portion of the rows gets too much water and the lower portion too little, with the likelihood of seepage appearing on the lower part of the holding at some time.

The chief work in connection with the irrigation of the orchard is to see that the furrows are kept running. Weeds and leaves will occasionally block the outlet pipes, and these must be removed. Furrows that are silting up must be cleared, and those that have burst must be repaired. Where the land has been well laid out for watering not much work is experienced in its irrigation ; still it is necessary for a man to be in attendance for the greater portion of the time to see that all goes well.

AMOUNT OF WATER TO USE.

The art of irrigation may be said to consist of securing the maximum of crop from the minimum of water. The advantages of not using more water than is absolutely necessary is apparent for three reasons : *firstly*, that irrigation, which is at best a mussy occupation, should not be unduly prolonged, as this results in a waste of time and labor ; *secondly*, that the economical use of water lessens the danger from seepage ; and *thirdly*, that excessive watering leaches out the most expensive plant foods, such as nitrates, contained in the soil, and carries them deep

down into the sub-soil out of the reach of the roots of the plants.

Provided that the land is kept well cultivated, newly-planted trees do not require more than from 15 inches to 20 inches of irrigation water the first season. When once established and before they come into bearing, trees planted on sandy land can be kept in vigorous health on 15 inches and under of irrigation water per annum. One of the greatest mistakes often made by newcomers on irrigation areas is in watering too heavily. On most of the irrigation settlements the regulations formulated by the governing authorities permit the individual irrigationist to use up to 24 inches of water per acre ; but these regulations are not always enforced, with the result that inexperienced irrigationists often put far more water on to their land than is good for it. Seepage, the greatest foe the irrigationist has to fear, is more often brought about by excessive or careless watering than by any other means. Experience has shown that 24 acre inches per annum is amply sufficient for vines and trees in full bearing, and that with good cultivation it is possible to obtain the heaviest crops with considerably less water than this.

SOME EXPERIMENTS IN IRRIGATION.

To give practical illustrations of the results that may be obtained by an economical use of water combined with thorough cultivation, the writer hopes that he may be pardoned by here introducing the results of a few experiments made at his plantation, which is situated on the uplands of Berri.

For irrigation purposes, the citrus plantation was divided into three different sections, each section receiving different amounts of water. . Meter readings were not kept until the trees were in their third year. Naming the sections A, B, and C, the irrigation records are as follows :—

SECTION A (Five Acres).

Seven Years Old, 1919.

Season.	Acre inches of Irrigation water used.	Rainfall 1st July to 30th June.	Total Water received, in acre inches.
1914-15 ...	17	5.3	22.3
1915-16 ...	18	7.73	25.73
1916-17 ...	10	16.64	26.64
1917-18 ...	13	13.93	26.93
1918-19 ...	18.5	8.11	26.61

SECTION B (Five Acres).

Seven Years Old, 1919.

Season.	Acre inches of Irrigation water used.	Rainfall 1st July to 30th June.	Total Water received, in acre inches.
1914-15 ...	20	5.3	25.3
1915-16 ...	24	7.73	31.73
1916-17 ...	15	16.64	31.64
1917-18 ...	21	13.93	34.93
1918-19 ...	18	8.11	26.11

SECTION C (Five Acres).

Eight Years Old 1919.

Season.	Acre inches of Irrigation water used.	Rainfall 1st July to 30th June.	Total Water received, in acre inches
1914-15 ...	15	5.3	20.3
1915-16 ...	18	7.73	25.73
1916-17 ...	11	16.64	27.64
1917-18 ...	14	13.93	27.93
1918-19 ...	15.5	8.11	23.61

Although during these five years Section B received 98 acre inches of irrigation water as against 76.5 acre inches received by Section A, yet the growth and general health of the trees on both sections, which are situated on similar soil, was, as far as all appearances went, identical. However, during the 1917-18 season, as shown by the occasional wilting of some of the trees, it was evident that Section A, with 13 inches of irrigation water, had received the minimum amount, lower than which it was not safe to go if the crop was not to be lost. Nevertheless, on Section C, during the 1917-18 season, the application of 14 inches of irrigation water proved sufficient to mature an average crop of four cases of fruit per tree from a section of mandarins situated on land of a similar nature to Sections A and B.

PERIODS OF WATERING.

In normal seasons citrus trees are watered at intervals from August or September to the following April, in five or six irrigations, on an average of about six weeks apart from each other. If the Spring is wet or cool, the first two irrigations need not be heavy, but good waterings should be given during the late Spring and Summer months, i.e., from November to March. On no account should the trees be allowed to get dry at the roots during this period, or the crop will be lost. For the filling out of the fruit, unless there have been heavy Autumn rains, an April irrigation is necessary.

CHAPTER IX.

CULTIVATION.

So closely connected with irrigation as to be practically a part of it is the subject of cultivation. The irrigation of a piece of land is of little use unless it is followed by cultivation, as the water poured into the soil soon evaporates unless the surface of the ground is kept well stirred. Cultivation destroys the small capillary tubes along which the moisture passes through the soil into the atmosphere, and by thus forming a blanket of loose earth on top, through which evaporation can only imperfectly take place, the lower layers of the soil are kept moist.

Another result of cultivation is that by checking evaporation the formation of alkalies on the surface of the ground is prevented.

In arid regions, such as the greater portion of the Murray Valley consists of, the rainfall has never been sufficient to leach much of the natural salts out of the land and to carry them away in the river water. When this land is irrigated some of the salts are dissolved by the water. Capillary action draws the salt-impregnated water to the surface of the ground, where the water is evaporated and the salts left as a residue. As some of these salts are highly detrimental to plant life, being especially injurious when concentrated on or near the surface of the ground to the crown and surface roots of fruit trees, it is necessary, were it only for this reason alone, that the work of cultivation in the orchard should be of a thorough nature.

During the early part of the season, while the weather is still cool, the cultivation of the whole of the orchard is not quite so essential as it is during the summer months. If cover crops intended for hay, such as wheat or oats, are grown in between the rows of young trees, these should occupy strips of not more than 6 feet wide, so that a two-horse cultivator can be driven along each side of the rows of trees. After such cover crops are mown, which will be either in October or November, the whole orchard should be cultivated or disc-harrowed, and kept well-worked and free from weeds for the rest of the season.

Where the land cannot be stirred by horse-cultivation, such as near the stems of the trees, the land must be kept loose and the weeds destroyed with the hoe. Young trees should receive special cultivation close to the tree, as the roots are not far from the stem, and the forked hoe, which does not cut the roots, if by accident it is inserted too deeply into the soil, is a very useful implement for this work. To ensure satisfactory growth in a young orchard too much care cannot be exercised in this work of close cultivation, as every weed is a pump drawing the moisture into the air that the young tree requires for its needs.

One of the greatest mistakes often made by newcomers on irrigation settlements is in the lack of sufficient cultivation. How often are not newly-planted orchards met with with but a 2 feet to 3 feet strip of cultivated land along each side of the rows of trees, while the rest of the land is given over to the production of a crop of luxuriant weeds, which rapidly pump the moisture out of the land, and by creating a dry belt alongside the cultivated one, rob the latter of most of its moisture. Under such circumstances it is impossible for the trees to make satisfactory growth, and the development of the orchard is retarded.

The cultivation of a piece of land, by checking evaporation from out of the ground, causes most of

the moisture to remain in the soil for the use of the plants occupying the land. Therefore the more thorough and more often the cultivation of the orchard takes place the less will be the evaporation, and consequently the smaller will be the quantity of water required to maintain the plants in good condition. The golden rule for the irrigationist to adopt is to apply *the minimum of irrigation with the maximum of cultivation* consistent with the satisfactory growth of his plants. To follow the opposite principle—to make up for lack of cultivation with excessive irrigation—is to court disaster, for such a policy, if persisted in, causes either the formation of surface alkalis or the water-logging of the sub-soil, or both, and ultimately results in the death of the plants and in the ruin of the land.

A cultivation of the orchard should follow every irrigation after the ground has been allowed to dry a little, so as not to puddle the soil, and also after every rain of any consequence. Where the ground is naturally hard or turns up in lumps, an additional cultivation in between each irrigation is desirable. During the late autumn and winter months, if no cover crops have been planted, weeds may be permitted to come up, but should be ploughed in green in the early spring. Cover crops intended for green manure should be rolled down and ploughed in when in flower, and the whole plantation should be ploughed up every season during the late winter or early spring months, after which no more weeds should be permitted to grow for the rest of the season.

CHAPTER X.

PRUNING.

As a whole no class of fruit trees require less pruning than citrus trees. At the time of planting the young trees should be cut down to about 18 inches to 2 feet. When growth commences young shoots will spring out all along the stem. All shoots below a foot from the ground should be rubbed off, thus allowing a clean stem of at least a foot where the trees have been cut back to 18 inches. Where the trees have been left 2 feet high a clean stem of 18 inches should be left. Some years ago it was the custom to grow high-headed trees having a bare trunk of 4 feet or over.

Experience having proved that high-headed trees are more liable to suffer from strong winds, more liable to have their stems injured from sun burn, and that the fruit was not so cheaply to gather as from low-headed trees, some citrus growers went to the other extreme, and headed their trees but a few inches above the bud. This made for a low, bushy tree, with branches very close to the ground, which brought a portion of the fruit into contact with the earth, and with the limbs so low as to be in the way of horse cultivation. It was therefore found that a clean stem of about 18 inches in height gave the best results.

Citrus trees usually make from two to four growths during the season. The growth of young trees is often so rapid that it cannot support itself, and bends down until it touches the ground. It is not advisable to have the branches as low as this, as on frosty nights

the cold is greatest nearest the ground, and the fruit is liable to be frost bitten. Therefore, whenever the branches bend down too low they should be cut back to an upward bud at the place where the downward arc commences. The main branches of a citrus tree should have an upward tendency. The natural drooping habit of a citrus tree so trained will soon assert itself again through the formation of side branches, and through the weight of the fruit.

Citrus trees that have become too dense in the head should be thinned out somewhat, so as to let in a little light and air, as darkness is conducive to the growth of insect pests. All dead wood should also be removed.

All water-shoots growing out of the old wood are best removed, as these often grow with excessive vigor, and by taking up a great portion of the sap of the tree rob the other branches of nourishment, thus making for a lopsided development.

The best time to prune citrus trees is during spring and early summer, as if left too late in the season growth will often have taken place on shoots or branches that would have been pruned away at the spring pruning, thus resulting in waste of energy.

CHAPTER XI.

MANURING.

Of all the operations connected with the growing of citrus fruits the subject of manuring is one of the most important. However rich the soils may naturally be, through continual cropping they will, sooner or later, become impoverished, unless sufficient fertiliser is applied to the ground to replace the plant food removed. The elements which enter into the composition of plants are carbon, oxygen, nitrogen, hydrogen, potassium, calcium, magnesium, phosphorous, sulphur, and iron. Of these, all except nitrogen, potash, phosphorous, and sometimes lime, are usually present in sufficient quantities for the needs of the trees.

Young citrus trees require a liberal supply of nitrogen if they are to make vigorous wood growth. When the trees come into bearing very large amounts of nitrogen are no longer necessary, as they impair the fruitfulness of the trees, wood formation taking place at the expense of fruit. Citrus trees of all ages should always be supplied with a liberal supply of phosphoric acid (phosphates) or the health of the tree will suffer, and the fruit will not develop normally. For the formation of citrus fruits a plentiful supply of potash is essential. Harold Hume, of the University of Florida, the American citrus expert, says of potash manuring in respect to citrus trees:—"If large amounts of potash are taken up by the trees it will be found that the rind of the fruit will be much thinner than otherwise and the amount of rag will be greatly lessened. A plentiful supply of potash in the fruit has an excellent influence on its keeping

quality. If too little be present the fruit will be soft and is likely to break down shortly after removal from the trees. To increase the keeping and carrying quality of citrus fruits a large amount of potash and a small amount of nitrogen should be used."

STABLE MANURE.

Stable Manure is one of the best of fertilizers to apply to the soil, having a fairly high nitrate content as well as being valuable for adding humus to the land. Four one-horse drays will hold about one ton of this matter in a dry state, which, if spread over an acre of land, will enrich the soil with humus to about the same extent as an average cover crop, although its nitrogen-enriching properties are considerably less. A ton of stable manure to the acre would be a very light dressing to give, so light, in fact, that it would be a somewhat difficult matter to spread it over the land thinly enough to go round. A dressing of four or five tons to the acre applied every third year would give satisfactory results, and keep up the humus content of the soil.

The fertilising elements in a ton of rotted stable manure have been variously computed to consist of from 6 to 7 lbs. phosphoric acid, 6 to 12 lbs. of potash, and from 8 to 15 lbs. of nitrogen. This would be equal to about 21 lbs. of superphosphates, 12 to 24 lbs. of sulphate of potash, and from 75 lbs. to 120 lbs. of blood manure. This is from manures in a partly rotted state, hence containing considerable quantities of water, but the quantities of these ingredients from a perfectly dry sample would probably exceed this amount to some extent.

CHEMICAL FERTILIZERS.

As in many instances it is not possible to obtain sufficient quantities of organic matter to bring on to the land to make up for all the nourishment removed from the soil by continuous cropping,

chemical fertilizers have to be used to make up the deficiency. As Australian soils generally appear to be somewhat weak in phosphoric acid, phosphates are usually the first kind of manures used to maintain the crop returns from the land. Commercial varieties of phosphates are of two kinds, the organic classes, such as bone dust and bone superphosphate, and the inorganic forms, made from various kinds of phosphatic rock. Of these bone dust is the slowest in its action, lasting about two seasons in the soil before being entirely dissolved. By not being so water soluble as other kinds of phosphates, the manurial properties of bone dust are not so readily leached out of the soil by heavy rains or irrigation, and, therefore, although slower, last longer in the soil for the roots of plants to feed on. The mineral superphosphates are usually water soluble to a great extent, hence their action on plant growth is rapid, and for this reason their effect is not lasting, therefore must be applied annually to keep up growth and crop returns.

Potash as a fertilizer is also needed on most soils that are being continuously cropped. As has been previously mentioned, potash is usually contained in considerable quantities on many classes of clay lands, but it often needs applications of gypsum to make it available for plant growth.

Lime may also be applied on many soils with great benefit, especially on heavy clay lands, which are rendered looser and generally more productive by the action of the lime in making more available many of the plant foods contained in the soil.

DEPLETION OF SOIL BY CROPPING.

The depletion of a soil by cropping depends, of course, upon the nature and extent of the crop. According to Hume, in his work on *Citrus Fruits*, 800 lbs. of oranges will remove from the soil $\frac{1}{2}$ lb. phosphoric acid, 2 lbs. potash, and 1 lb. nitrogen. A crop of 400 Australian cases, weighing about

20,000 lbs., would at this rate deplete the soil to the extent of $12\frac{1}{2}$ lbs. phosphoric acid, 50 lbs. potash, and 25 lbs. nitrogen. In addition to this, allowance must be made for a quantity of plant food necessary to make good leaf, branch, and root growth, and for the amount of these ingredients leached out of the soil by rain or irrigation. Assuming the total amount of plant food removed from the soil by these agencies to be three times that taken out by the fruit alone (Hume's estimate) then the quantity of these substances lost to the land would be:— $37\frac{1}{2}$ lbs. phosphoric acid, 150 lbs. potash, and 75 lbs. nitrogen. Allowing for an 18 percentage of phosphoric acid, a 50 percentage of potash, and a 20 percentage of nitrogen, this is equivalent to 2 cwt. of superphosphate, almost 3 cwt. of sulphate of potash, and 4 cwt. of sulphate of ammonia, or to a total of about 9 cwt. of chemical fertilizers.

Supposing such a crop of 400 cases of fruit were removed from one acre of ground, 9 cwt. of chemical manures would, therefore, be required to make good the deficiency in the soil caused by the production of this quantity of fruit.

METHODS OF APPLICATION.

Different classes of fertilizers may be applied at various times of the year. Such slow-acting manures as vegetable mould or bone dust, which contain ingredients not easily leached out of the soil by rain or irrigation, may be applied during winter or early spring, as but little plant food would be lost before the root activity commences. On the other hand, fertilizers containing highly soluble ingredients, such as most mineral superphosphates and the various classes of nitrates, are best applied during early spring or summer, when the roots of plants are active. Generally speaking, phosphates should not be put into the ground later than October if the current crop is to receive their full benefit, but nitrates may often be advantageously applied, as in

the case of citrus, during summer as well as spring-time.

Manures may be put into the ground either by being drilled in, broadcasted and ploughed in, or by being scattered along the bottom of plough furrows and ploughed in. Drilling in manures with the wheat seed drill cannot be recommended, unless the land is ploughed deeply afterwards, as the drill only penetrates the soil for a few inches, and the manure is placed thereby too near the surface of the soil for the roots to obtain, especially where the furrow system of irrigation is practised and the water does not leach the manure down to the roots.

Broadcasting and Ploughing in the fertilizer is theoretically the best way to apply manures, as every portion of the orchard is then evenly supplied. In practice, however, unless the land is cleanly and deeply ploughed, all the fertilizer will not be turned into the bottom of the furrow, and, moreover, where the furrow system of watering is used, a great portion of the manure will not receive sufficient moisture to carry it down to the roots of the plants because it is not evenly distributed.

Manuring in Furrows, despite its disadvantages, is the best way to apply fertilizer where the furrow system of irrigation is used. One or more deep furrows should be ploughed along the rows of trees or vines, not closer than four feet to the stems of bearing trees, and the manure scattered in the bottom of the furrows—the furrows then ploughed in and the new furrow thus formed used to water the plantation at the next irrigation. By this method the fertilizer is put deeply into the soil, thereby tending to keep the roots down in their search for plant food. By being in close proximity to the irrigation water the fertilizer is easily dissolved for the use of the roots of the plants ; but for this reason an extra heavy irrigation should not follow the application of manures, as some of the properties may be washed too deeply into the sub-soil for the plants to reach.

CHAPTER XII.

HARVESTING AND PACKING.

Along the Murray Valley, in normal years, mandarins ripen in June and July, the Washington Navel during June, July, and August, and the Valencia Late during October and November, but the last-mentioned variety will often hang on the trees until the end of the year.

Oranges should not be picked until they are well colored, as if gathered and placed upon the market while the skin is still partly green the acidity of the fruit has a detrimental effect on both the demand and selling value.

In picking oranges secateurs are generally used. The fruit is first severed from the tree with a stem of twig about an inch in length adhering to it. This stem is then carefully removed by cutting it off as closely to the skin as possible without injuring the rind, and the orange is then placed in the picking bag or receptacle used for holding the fruit.

The use of the double cut has been found to result in speedier and neater harvesting operations than if it is attempted to sever the fruit from the tree by cutting quite close to the rind by means of a single cut in among the branches and leaves of the tree. The object of cutting the stem away quite close to the fruit is because if it is left projecting it is apt to injure the other oranges while standing in the picking tins or boxes by piercing or otherwise injuring the rind.

Oranges are either firstly picked into picking bags, or placed into picking tins or picking boxes direct.

In handling, the greatest care should be exercised that the rind is not bruised or cut, as fruit so damaged quickly develops decay. After being harvested, oranges should be allowed to sweat for a few days in the picking boxes before they are sent to the packing house, as the skin in shrinking becomes somewhat tougher and is in consequence not so easily injured whilst the fruit is being packed.

In packing, oranges are first graded, either by mechanical graders or by hand, and are then packed according to the diagonal system of packing into standard bushel cases.

The number of Washington Navel oranges that are packed to the case varies from about 53 for very large fruit to about 200 for small fruit—the sizes at present most favored by sellers at Melbourne (the chief market for navel oranges in Australia) being those of medium size, i.e., fruit going from about 83 to 154 per case. Mandarins are usually packed on the diagonal system, and vary from about 200 to 300 per case. After having been stencilled, packed, and nailed down, the number of fruits each case contains is branded on the outside of the case.

At present, the packing and marketing of citrus fruits is carried on by both individual growers and by associations of growers in the form of co-operative societies.

Although it may pay individual growers harvesting large quantities of fruit—such as 1,000 cases or over—to erect private packing houses with all up-to-date appliances, such is not the case with smaller growers who have but a comparatively small quantity of fruit to handle. In such instances growers have either to hand-grade, pack, find markets, and consign their fruit themselves, or to send it to a packing association to do this work for them.

As the quantity of citrus fruits produced yearly increases, due to the large plantings made in recent years, thereby making increased marketing facilities

essential, both in the Commonwealth and overseas, it seems highly probable that individual growers, acting independently of each other, will not be able to cope satisfactorily with the situation in the future, and that the handling of the fruit through large co-operative organisations will become necessary.

CHAPTER XIII.

DISEASES AND INSECT PESTS.

MAL-DI-GOMA.

One of the worst diseases of citrus trees in America is mal-di-goma, or foot rot. It is also prevalent in Australia, although not to so great an extent. Foot rot attacks citrus trees at the crown roots, extending a foot or so above the ground and downward among the roots. The presence of the disease is first noticed by the discharge of gum at the diseased spot. Later on the bark rots away, and the tree eventually dies. The disease seems to be caused either by water standing around the roots, the crown roots becoming injured through careless cultivation or otherwise, or too deep planting. As these matters rest greatly in the hands of the grower, the careful orchardist will see that his trees do not needlessly suffer from these causes. Where the land has to be flooded to water the trees the trees should be budded on the Seville stock, as experience has amply proved that both sweet orange and lemon stock are liable to suffer from foot rot if planted in wet situations.

Affected trees should have the earth removed from around the main roots, the decayed portions of the bark cut clean away, and after the ground has been well aerated, fresh soil obtained from outside of the citrus plantation should again be placed around the roots.

MOTTLED LEAF.

A disease that has been doing considerable damage to some of the citrus plantations of the Murray Valley during recent years is that known as "mottled leaf."

This disease is due to the partial absence of the green coloring matter, or chlorophyll, in the leaves of the tree, and gives the leaves the appearance of being variegated yellow and green.

As the disease progresses, the yellowing of the leaves increases, until these turn practically all yellow, the branches die back, and little, if any, fruit is set.

In his valuable book on "Citrus Fruits," Professor J. E. Coit, of the California University, mentions that this disease was probably the most serious problem that Californian citrus growers had to face. At the present time the cause of this disease is but imperfectly known, but as many Californian experimenters are now investigating this citrus malady it is to be hoped that a satisfactory solution of this problem will soon be found.

The writer has seen trees badly affected on land showing signs of over-irrigation, on land showing traces of alkali trouble, and to a lesser extent in situations where the conditions for citrus culture were apparently ideal.

That mottled leaf may in some instances be overcome by the application of somewhat heavy dressings of organic nitrogenous manures, the writer has proved from his own experience. The trees on a portion of his citrus plantation growing in a deep, red soil, which was but poorly supplied with humus, developed mottled leaf to a considerable extent, so that their growth became very slow, and no fruit was set. A dressing of stable manure equal to about 5 cwt. per tree was spread over the land and ploughed in early in the Spring. Within a few months the trees were showing signs of recovery, and after a year the mottled leaf had practically disappeared; the trees were making vigorous, healthy growth, and have remained in good condition ever since.

Growing among the other perfectly healthy trees of the writer's plantation, odd trees here and there developed mottled leaf, although the conditions

favorable to their growth were to all appearances perfect. These trees were treated with organic nitrogenous manures applied in liquid form, from one to three applications being given, and within a year from the first application the mottled leaf had disappeared and the trees were making strong, healthy growth.

ORANGE SCALE.

Red Scale is a small circular insect of a reddish brown color, which increases very rapidly under circumstances favoring its growth, which are moist and muggy atmospheric conditions. The only effective way of getting rid of it is by fumigating the trees with hydrocyanic acid gas, which is generated by treating potassium cyanide with a diluted solution of sulphuric acid. Fumigation is done in the night time, the gas being liberated under a tent, which covers the tree. For 100 to 150 cubic feet of tent space the amount of ingredients generally used are 1 oz. potassium cyanide, 1 oz. sulphuric acid, and 3 ozs. of water.

The red scale, which is the most harmful of all insect pests to the orange tree, has up to the present time not made its appearance among the orange groves of the South Australian portion of the Upper Murray Valley.

Brown Scale. This variety of the genus of Lecanium, or unarmored scales, is fairly well known to the citrus growers of the Murray Valley. The full-grown insect is about one-eighth of an inch long, broadly oval, convex upon the disc, surrounded by a thin flat margin, and of a brownish color. The scale thrives upon the bark and leaves of the branches of the tree by sucking out the sap, and is generally found in the greatest numbers in situations not directly exposed to the sun.

SPRAYING.

The usual methods used for combating this scale are by means of sprays made of oils of various kinds and of resin compounds.

Red Oil. Various brands of "red oil" mixture are upon the market. The usual methods of mixing are to take equal quantities of rainwater and red oil, place the oil in a bucket or spray pump, add the water slowly, stirring or churning vigorously the while. When the oil and water have thoroughly emulsified, add twenty times as much water as there is emulsion—that is, forty times the amount of oil used—and mix up well in the barrel of the spraying outfit. This mixture may be considered as full strength, and a stronger solution than this is not advisable. The chief thing to see to at mixing is that the oil and water emulsify thoroughly, which will not be the case if the water is at all hard, and should it be in this condition it should first be softened by dissolving a handful of washing soda in it before mixing it with the oil.

The usual time for using red oil spray is in the summer months, generally during the months of January and February, and to guard against sun-scald of the leaves and fruit is best applied during a cool spell during these months. Should the weather be warm to hot when the spraying is being done, a solution of one gallon of oil to 50 gallons of water will be found strong enough to kill the scale.

Kerosene Emulsion is preferred by some growers for spraying purposes. This is made up in the proportion of 2 gallons of kerosene, $\frac{1}{2}$ lb. soap, 1 gallon water. The soap is dissolved by boiling in the gallon of water. The water is taken off the fire, and the kerosene added slowly, the mixture being churned with a spray pump for ten minutes or so, until a stable emulsion is formed. Another gallon of warm water is then added, bringing the solution up to 4 gallons.

Spraying is usually done in the summer months in between the growths, that is, when one growth has finished and before the next starts. For spraying at such times each gallon of the emulsion is diluted with not less than ten gallons of water ; but for trees that are in active growth fifteen gallons of water to one of the emulsion will be strong enough for the young foliage to withstand. For badly affected trees two sprayings about a fortnight apart may be necessary to eradicate the scale.

Resin Wash. Owing to the scalding effect upon the leaves and fruit that sometimes follow the use of the various oil sprays, some growers prefer spraying their citrus trees with a resin wash made up in the proportion of 1 lb. resin, 1 lb. washing soda, $\frac{1}{2}$ lb. soap, to 5 gallons of water. This is applied in a similar manner as the oil sprays, and usually but little damage to the foliage of the trees is done.

Note.—No spraying of citrus trees should be attempted if the trees are in want of moisture, as when in this condition the leaves of the trees have often not sufficient vitality to withstand the suffocating effects of the spray, and so fall off ; whereas if the spraying takes place when the leaves are full of moisture, such as after an irrigation, and other conditions are favorable, ill-effects seldom follow.

CHAPTER XIV.

COST OF BRINGING A CITRUS PLANTATION
INTO BEARING ON STATE IRRIGATION
AREAS OF SOUTH AUSTRALIA.

To estimate the amount of capital required to bring a citrus plantation into bearing is a somewhat difficult subject, as the price of material and of labor is a fluctuating quantity, and, further, owing to the fact that the expenses per acre will vary with every holding, as no two pieces of land will cost the same to clear, grub, grade, and to maintain in good condition. However, a rough average, both on the capital outlay and upon the income per acre, can be struck, and the estimates here drawn up have been chiefly compiled from Berri data.

As the price of labor, material, water rates, etc., have greatly risen since the beginning of the war, and as this increase in prices shows no immediate likelihood of falling, the estimates here drawn up show an advance on those quoted in my book, *Fruit-growing under Irrigation*, which were compiled according to normal pre-war costs.

As this chapter is chiefly written for new settlers on the State irrigation areas along the Murray Valley in South Australia, it has been taken for granted that the assistance of the Irrigation Department in fencing, grading, grubbing, and channelling has been availed of. Where this has not been done, the initial outlay will probably be increased by £10 per acre.

ORANGES (WASHINGTON NAVELS).

CAPITAL OUTLAY ON ONE ACRE.

Initial Outlay.

	£	s.	d.
15 per cent. deposit Irrigation Department for channelling, grubbing, at £12 per acre	1	16	0
Ploughing	1	0	0
100 orange trees	10	0	0
Pegging out and planting	1	10	0
Total initial outlay	£14	6	0

UPKEEP.

Cultivation for five years	25	0	0
Water rates and rent, five years	7	17	6
Pruning and spraying, five years	5	0	0
Net expenses for sixth year, after deducting net income	3	0	0
Total upkeep	£40	17	6

HARVESTING PLANT.

	£	s.	d.
Picking or sweat boxes	2	0	0
Proportionate expenditure on storing or curing shed	8	0	0
Total	£10	0	0

	£	s.	d.
Interest on initial outlay and upkeep for six years	10	10	0
Owing Irrigation Department after five years	10	0	0
Total capital outlay	£85	13	6

The initial outlay for planting an acre of oranges is greater than that of any other class of fruit, owing chiefly to the greater cost of the trees themselves. In planting, also, greater care than is necessary with other trees has to be taken, and if the season is dry a special irrigation will be needed at planting time.

On calculating the annual expenses of cultivation and irrigation at £5 per acre a low estimate has been taken. A glance at the young orange plantations at Berri at once reveals the blocks that have received the best cultivation. So readily do orange trees respond to good cultivation that a first class looked after orange grove will come into profitable bearing at least a year before a block that has received but average attention.

Orange trees ought to produce some fruit in their fifth and sixth years. Allowing for half a case per tree at six years, at the price of 5/ per case net. This would still mean a net expense of £3 per acre, after deducting all working expenses for the year.

As well as other fruit, oranges require a harvesting plant. In addition to picking cases or sweat boxes, a storeroom or curing shed will have to be erected, as oranges, after being picked, are generally stored or "cured" on shelves or shallow boxes for a few days to a week to allow the skin to shrink and become leathery before being sent on a long journey.

Through orange trees taking so long to come into bearing, the loss of interest on the capital invested is considerable, and after six years amounts to £10 10/, thereby adding that sum to the cost per acre.

A total capital outlay of £85 per acre for six years appears, no doubt, a large sum; but on careful consideration I cannot see how it can be reduced. In the above estimate no loss is allowed for trees dying in their first year before they are established, neither for special irrigations at planting or other times, or for carting water to young trees during dry spells in between irrigations. So, if anything, the total expenditure could easily be increased.

PROBABLE INCOME FROM AN ACRE OF ORANGES.

Oranges planted in good, deep soil usually commence to bear in their fourth year. The crop, however, will be inconsiderable; and the fifth year's crop will also be small. At six years half a case to the tree may be expected, while at seven years the trees should be bearing a case or more to the tree.

Regarding prices, it is obvious that, owing to the decreased purchasing power of money, due to the increased cost of living that has taken place in recent years, the minimum price at which oranges will pay to grow is considerably higher now than it was a few years ago. If the minimum payable net price was 4/ per case two or three years ago, then it is at least 5/ per case to-day (1919), and should the purchasing power of money continue to fall, then the payable minimum price must show a corresponding rise. Therefore, under the economic conditions existing in these changing times, the following calculations can only represent some general approach to accuracy for probably the next few seasons.

Allowing for net prices to the grower of 5/ and 6/ per case, and calculating 100 trees to the acre, this makes an income of £25 and £30 per acre respectively at one case per tree. In my estimates for full bearing trees the annual expenses have been estimated at £28 5/ on a crop of two cases per tree. But on a crop of one case per tree the expenses of manuring (£4) and of harvesting (£8) will only be one half of that of full grown trees, so a reduction of £6 per acre must be allowed for this, thus reducing the annual expenses to £22 5/. A crop of one case per tree, at 5/ net per case, would, therefore, just pay a little over working expenses if no allowance for depreciation were made.

Coming to the subject of depreciation, no deductions have been allowed for the first 10 years of the plantation's existence, as the irrigation channels

or pipes should still be in good repair, and if the site of the plantation has been well chosen, as regards soil and position, seepage troubles should not have made an appearance in so short a time.

I have estimated the total life of the trees at 30 years. The first six years as a period of infancy, the time from the seventh to tenth years as the age of coming into bearing and paying working expenses and somewhat over, and the period from the tenth to thirtieth years as the age when in full bearing. During these last 20 years an annual allowance of £2 per acre has been debited for depreciation on harvesting plant, channels, and for provision for drainage, as well as an additional depreciation of 5 per cent. per annum on the capital outlay of £85.

In the estimate I have calculated the average crop at 200 cases per acre, commencing in the tenth year of the orchard's existence, and continuing at that rate for the following 20 years:—

PROBABLE INCOME FROM AN ACRE OF WASHINGTON NAVELS

			£	s.	d.
200 cases at 6/ per case net	..	..	60	0	0
200 cases at 5/ per case net	..	..	50	0	0

ANNUAL EXPENSES.

			£	s.	d.
Cultivation, ploughing, irrigation..	..	..	7	0	0
Pruning and spraying	..	..	5	0	0
Water rates and rent	..	..	2	5	0
Manures	..	..	4	0	0
Harvesting and curing expenses ..	..	..	8	0	0
Expenses of management and superintendence	..	..	2	0	0
Total	..	..	£28	5	0

DEPRECIATION.

	£	s.	d.
On harvesting plant, channels, provision for drainage	2	0	0
On orangery on 5 per cent. of capital outlay	4	5	0
	<hr/>		
Total depreciation	£6	5	0
	<hr/>		
Total annual expenses	£34	10	0

	£	s.	d.
Net profit per acre, at 6/ net per case ..	25	10	0
Net profit per acre, at 5/ net per case ..	15	10	0

According to the above figures oranges will pay to grow if 200 cases of saleable fruit, averaging 5/ per case net, or over, to the grower, are harvested per acre. At less than this price, however, oranges cease to be profitable as an investment, as the same amount of capital would probably show a higher rate of interest if invested in other industries.

PRESS COMMENTS

"From the author (Mr. F. R. Arndt) a copy of *Fruitgrowing under Irrigation* has been received. The work is devoted especially to the conditions in the Murray Valley, and is an exhaustive treatise on a subject of great importance at the time the use of Australian rivers is being considered. . . . The man who intends to enter the fruitgrowing industry will find valuable information in the chapter devoted to the cost of starting an orchard and the time that must elapse before any return can be obtained."—*Daily Herald*, Adelaide, 24th December, 1918.

* * *

"From Mr. F. R. Arndt, of Berri, has come to hand copies of his exceedingly interesting and informative book on *Fruitgrowing under Irrigation*. The publication contains about 120 pages of facts and comments, which every irrigation fruitgrower should be acquainted with."—*South Australian Register*, Adelaide, 24th December, 1918.

* * *

"For the large and growing number of settlers in our irrigation areas who, in becoming irrigationists, are adopting a mode of life new to them this book will be found of great value, and there are few among the ranks of experienced irrigationists who may not derive some benefit from its perusal."—*Murray Pioneer*, Renmark, 3rd January, 1919.

"I have carefully read Mr. Arndt's book on *Fruitgrowing under Irrigation*. . . . It is, to my way of thinking, the best connected study on the subject published in Australia, on an Australian basis. The explanations in relation to all field operations are simple and to the point, and most practical in character. . . . My personal opinion is that a copy of this book should be in the hands of every new settler or intending settler who proposes entering upon fruitgrowing on the irrigation areas of the Murray Valley."—GEO. QUINN, Horticultural Instructor to the S.A. Government, in the *Journal of the Department of Agriculture of South Australia*, April, 1919.

University of California,
College of Agriculture,
Berkeley,

18th February, 1919.

Dear Mr. Arndt,—I have read with deep interest your book, *Fruitgrowing under Irrigation*. Your statements are very clear and straightforward, and the information conveyed must be very helpful to anyone undertaking fruitgrowing under your conditions. I congratulate you on a good piece of work.

(PROFESSOR) E. J. WICKSON.

University of California,
Agricultural Experiment Station,
Berkeley,

24th July, 1919.

Dear Mr. Arndt,—I have just returned to my office from an 18 months' war emergency job . . . (and) find on my desk the book entitled *Fruitgrowing under Irrigation*. . . . I find it intensely interesting.

J. ELIOT COIT,
Professor of Citriculture.

THESE COMPTES

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