THE EXPERIMENTAL RESULTS IN THEIR RELATION TO BITTER PIT AND A GENERAL SUMMARY OF THE INVESTIGATION.

BY D. McALPINE.

FOURTH REPORT.

1914-15.

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to the Can. Comm.

With D. McAlpine's
Compliments

D. H. Ross,
TRADE COMMISSIONER,
OF THE
GOVERNMENT OF CANADA
STOCK EXCHANGE BUILDINGS,
MELBOURNE.

DUNN'S FAVOURITE
(MUNROE'S FAVOURITE)

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BITTER PIT INVESTIGATION.

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AND

A GENERAL SUMMARY OF THE INVESTIGATION.

(WITH 70 FIGURES AND COLOURED FRONTISPIECE.)

BY D. McALPINE,

APPOINTED BY THE COMMONWEALTH AND STATE GOVERNMENTS OF AUSTRALIA.

FOURTH REPORT.

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BITTER PIT INVESTIGATION.

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INTRODUCTION.

In order to appreciate what has so far been done in the way of throwing light upon this widespread disease of the apple and other pip-fruits, it is necessary to remember that at the outset of the investigation it could still be referred to as a "mysterious disease," and there was no known method of coping with it. I was appointed by the Commonwealth and State Governments of Australia for the definite period of four years, for the purpose of investigating the causes of and remedy for Bitter Pit—a line of research very wide in its scope.

The limited time at my disposal affected the mode of investigation to a certain extent, and the breeding of new varieties of apples, for instance, combining immunity from the disease with other desirable qualities, was out of the question. Besides, several of the experiments, as in the testing of different stocks, were not continued sufficiently long to give definite results. However, the investigation of the cause was the principal object, and this has been done, and at the same time a number of experiments have been undertaken in the orchard, with a view to the control of the disease.

At first the disease was supposed to be of parasitic origin, but extended investigation failed in this and other countries, to substantiate any such cause. There is now no suspicion of a Bitter Pit parasite to explain or to account for the symptoms, so that we are thrown back upon the working of the living organism itself, to see how the disturbance of the normal functions is brought about.

In connection with this investigation there are three outstanding features which materially aided me in bringing it to a successful issue.

First of all, the abundance of specimens in the shape of numerous orchard trees bearing pitted fruit, enabled me to carry out a series of experiments in each State of the Commonwealth. In some varieties of apple, not only were the majority of the trees liable, but the individual fruits on the trees were affected, sometimes to the extent of 60 or 80 per cent. Plenty of material was thus available for chemical analysis, and biologic study of the disease at different stages.

To any one engaged in special research, it is well-known that an abundant supply of suitable material is a great aid to experimental investigation. In the Studies on "Cancer and Allied Subjects," conducted under the Special Research Fund, at Columbia University, the programme could not in some instances be carried through owing to the want of material. The bio-chemist had to acknowledge that "Without tumourous animals, without cancer patients and without carcinomatous supplies, all our plans for direct chemical attack on the cancer problem had to be suspended." I was particularly fortunate in having abundance of material from six States, and often specially instructive specimens from the intelligent and observant Orchard Supervisors.

Again, it is hardly sufficiently realised even by orchardists themselves, the amount of intelligent control which they can exercise over the habits and the fertility of the tree. "As the twig is bent, the tree's inclined." By starting from a healthy stock and a suitable scion, the orchardist can build up a tree with the height of stem, the spread of branches and the amount of wood he desires for bearing the future crop. He can supply deficiencies in the soil by manuring, retain the moisture in the soil by cultivation, aerate the soil by drainage, determine the number of branches and develop wood-buds or fruit-buds by pruning, help pollination where necessary by growing suitable varieties beside each other, and can regulate the distribution of fruit on the tree, so that each one receives its necessary supplies. The action of the pruning knife in its effects upon the future of the tree, has been compared to that of Natural Selection. Natural selection, in the words of Darwin, "preserves favoured races in the struggle for life," and pruning, controlled by the intelligence of the orchardist, can direct the growth into new channels and lead to the betterment of the fruit.

It is mainly owing to this controlling influence which the orchardist can exercise over his individual trees, that the success of measures for the prevention or mitigation of Bitter Pit is rendered possible.

Finally, the possibility of placing the apple, after removal from the tree, in cold storage, where the development of Bitter Pit is retarded, and the ripening process arrested, is a factor of prime importance. The fluctuating conditions of temperature and humidity can be regulated, so that the apples practically remain, and can be taken out, in the same healthy condition as when put in. The early losses which attended the over-sea shipment of fruit can now be prevented, and there is no longer any excuse for fruit arriving at its destination in an over-ripe or pitted condition.

It will thus be evident that our means of controlling Bitter Pit have been largely increased owing to a knowledge of the contributing factors. These factors include every phase in the life of the tree, from the nursery where it is reared to the orchard where it is planted, so that the general bearing of this investigation must be kept in view as well as the particular issue to which it is finally directed.

The experimental results will now be considered, in so far as they affect the practical measures to be adopted for preventing or lessening the disease. And since it was laid down in my first report "that the final test of the results obtained must be their actual value to the practical man," the investigation will appropriately be brought to a conclusion by showing some of its practical applications.

I.—DEVELOPMENT OF BITTER PIT AFTER APPLES ARE GATHERED—X-RAY TREATMENT.

It will be remembered that in explaining the cause of Bitter Pit in Report II., a distinction was drawn between the disease developing while the apples were still growing on the tree, and its development in fruit which showed no signs of it on the tree, but afterwards appeared on keeping. The importance of this distinction lay in the fact that if the disease originated anew in store, then some further explanation was required to account for it.

There is a general impression that it may exist in an incipient stage, although not discernible on the exterior, and this view was supported by the well-known fact that sometimes apples were found to be pitted although there was no external sign of it. In order to settle the matter on a scientific basis, X-ray treatment was adopted, but hitherto no definite result was obtained, because the particular apples experimented on showed no sign of Pit under the X-rays, and no Bitter Pit afterwards developed. This was only negative evidence, but now positive evidence has been obtained that those apples which show some flaw in the flesh afterwards develop the Pit on keeping.

For the purpose of this experiment I picked on 18th January, 12 Cleopatra apples from a tree which had already borne pitted fruit, when they were rather more than half-grown. They were all carefully scrutinized, and found to be perfectly sound, as far as naked-eye appearances went. Six of them were submitted to the X-rays by Dr. Ferguson Lemon, of Melbourne, on 20th January, each with their respective number, and the remaining six were retained as a check. Only one of the six that were submitted to the X-rays showed a flaw in the flesh. This flaw was immediately beneath the skin, as shown in Fig. 1. All were kept under the same conditions in my laboratory.

Early in April they were finally examined, and No. 3 was the only one showing signs of Bitter Pit. Both X-ray photographs and ordinary photographs were taken of this particular specimen, and the original flaw beneath the skin can still be seen, with the addition of the development of a number of brown flecks throughout the tissue. (Fig. 2.)

It would appear that the X-rays can discriminate between the honeycombed tissue characteristic of Bitter Pit and the solid flesh of the healthy apple. The check also showed one apple pitted when examined at the same time. Although only a limited number of specimens were dealt with, the evidence points to the conclusion that the initiatory stage of the disease begins on the tree and afterwards develops further in store. (Figs. 3 and 4.)

The results were so promising from the use of the X-rays that it seemed desirable to test a larger number, and instead of being taken directly from the tree, fruit was used which had been kept in cold storage for a considerable time. An Annie Elizabeth tree was selected, of which fully 50 per cent. of the fruit was pitted, and on 27th January I picked a case of clean apples, about three-fourths grown. It was placed in the Government Cool Store on 10th February, where it was kept at a temperature of 30-32 degrees Fahr. At the end of three months 36 of these apples, without any visible sign of Bitter Pit, were submitted to the X-rays by Dr. Herman Lawrence, of Melbourne. Three of these apples (Nos. 13, 14 and 15) showed distinct signs of Bitter Pit internally, and the whole were kept in my office for future examination. At the beginning of June, when kept for about three weeks, they were carefully examined, and all were found perfectly free from Pit, with the exception of the three above-mentioned, which were badly pitted as shown in Fig. 5. These were again submitted to a similar degree of X-rays, and a comparison instituted between the visibly clean specimens and the same after Bitter Pit had developed in an unmistakable manner (Figs. 5, 6, 7.).

The apples were finally examined towards the end of July. They were still fresh-looking and sound, but slightly shrivelled, and only one had rotted, which was covered with "blue mould."

The presence of Bitter Pit can thus be revealed by means of the X-rays, even although there is no visible external sign of it, and in the case of experiments where it is necessary for decisive results that apparently clean apples should afterwards develop Bitter Pit, this will enable us to select the fruit suitable for the purpose in view.

II.—BIO-CHEMICAL RESEARCHES ON BITTER PIT.

A. C. H. ROTHERA, D.Sc., M.A., M.R.C.S., WITH THE CO-OPERATION OF L. C. JACKSON, M.Sc., AND H. KINCAID, D.Sc.

The investigation was undertaken with certain definite points in view. These were to determine, if possible, whether the condition of Bitter Pit could arise *de novo* in apples removed from the tree in an apparent state of cleanness, or whether it was present, though latent, in all those apples, which though apparently clean when gathered, subsequently pitted.

At the same time, and as a part of the above problem, attention was directed to the conditions which might influence the appearance of Pit in gathered apples, and also to tests which might permit of the detection of the disease before any actual brown areas were detectable.

Incidentally, interest in the theory advanced by Drs. A. J. Ewart and Jean White, that Pit is due to metallic poisoning of certain groups of cells in the highly-susceptible apple pulp, compelled some work of a subsidiary character to be undertaken.

It is well-known that apples may be gathered from an orchard in an apparently clean condition, and subsequently develop the characteristic lesions of Bitter Pit.

McAlpine has shown that apparently clean apples may be maintained in that condition by holding at a steady temperature of 32° F. This is probably the usual phenomenon of arrest due to the great slowing up of all vital activity. There is nothing to indicate that there is any permanent influence on the incidence of the disease. When the low temperatures are discontinued, and the apples again exposed to ordinary conditions, the apples which then develop Pit may be those predestined to the condition when they left the tree.

The evidence which I have to bring forward is mainly statistical. It has been my experience, that in spite of the varying conditions, under which apples have been kept in the laboratory, that either the apples as received were good, and remained good, or were from the outset marked as a bad lot.

In all some 600 apples were kept under observation under various conditions, often more than a month, in the hopes that some suggestion might be obtained of the conditions influencing the subsequent appearance, or non-appearance of Pit. It is very strongly felt, that if the conditions responsible for the appearance of Pit are in action, subsequently to the gathering of the apple, the different laboratory histories of the many apples received, and kept under controlled conditions, should show some variety of influence upon the incidence of Pit. Clean apples, all from the same tree, were kept in separate groups under such varying conditions as :—

(*a*) Laboratory room fluctuations.
(*b*) Saturated moist air at 27° C.
(*c*) Dry air at 30° C.
(*d*) An atmosphere of carbon dioxide.

It is necessary, however, to point out, that in spite of the almost untiring assistance given by Mr. McAlpine in procuring material, it seemed almost impossible to hit upon just that class of material really desired—the apparently clean apple, which was to Pit on being kept.

The plan mapped out for the various investigations was to procure some five dozen apples all from the same tree.

The tree was to have a bad reputation as regards Pit, and might even have pitted apples upon it. The five dozen selected apples were, however, to be clean.

They were then divided into three or four batches (usually 20 apples in each batch, if possible), and each batch was then placed under the different conditions previously referred to. Frequent examinations were made for the appearance of Bitter Pit, and any pitting was carefully noted. Often too, the presence or absence of starch in the apples was determined in the hopes that material might be found, showing definite survival of starch patches, sufficient to indicate the probability of an early Pit area not yet dead and browned. This point will, however, be treated under a separate paragraph.

To return, however, to the experiments under the above conditions, it may be said, that though the varieties of apples employed were selected for their susceptibility to Pit, and though they had been gathered in nearly all cases from trees actually having many pitted apples this particular season (1915), yet they remained particularly clean, only one or two apples developing a single or sometimes two Pits out of a batch of 20 under experiment. Such a low and insignificant disease incidence prevents any dogmatic statistical comparison as to the respective merits, or disadvantages of the laboratory treatment, but indicates that the apples were inherently clean, and not to be encouraged to Pit even by such unorthodox methods of keeping as water saturated air at 27° C., for a month or more at a time.

In the only definite experiment which showed any distinction between groups of apples held under different conditions, the results were as follows :—

ANNIE ELIZABETH APPLES—DIAMOND CREEK.

APPLES FROM ONE TREE.

	Group I.—16 Apples.	Group II.—20 Apples.	Group III.—24 Apples.
	On laboratory table. Day temp. fluctuated 64°-88° F.	Dry air at 26°-30° C. Equals 79°-87° F.	Moist air (saturated). 26°-28° C equals 79°-83° F.
Jan. 7th	Commenced experiment.		
,, 12th	3 well pitted, 1 with 3 Pits, 1 with 1 Pit.	All clean.	1 Pit, 1 markedly pitted.
,, 27th	6 well pitted, 5 slightly.	1 with Pit-like groove.	2 with 1 Pit, and 1 marked.
Feb. 5th	No further change.	Ditto.	Ditto.

NOTE.—The night minima ranged from 50°-60° F.—*Argus*.

The experiment indicates that the steady high temperatures led to a less percentage of pitting (5 per cent. for dry oven, 12 per cent. for moist oven, as against 69 per cent. for room with its fluctuating temperature).

This experiment, however, stands alone, and unconfirmed. No further batch of apples could be procured clean, which pitted to any extent during subsequent keeping and observation. Generally, as mentioned, they remained uniformly clean, except for one apple, or at most two, showing perhaps a single Pit or possibly two Pits.

Should it be possible in a future year to confirm such a finding, then it would appear that either the later stages in the development of Pit (*i.e.*, those leading to its being distinctly recognisable to the eye), are controllable, not only by low uniform temperatures, but also by high uniform temperatures, or that Pit is particularly encouraged by high fluctuating temperatures.

The experiment was never contradicted by any later experiment.

The next lot of apples (Annie Elizabeth, Diamond Creek) kept from February 8th to March 8th in three groups of 18 each :—

(*a*) At room fluctuation (68°-80° F. for daily maxima) (51°-66° F. for daily minima.—(*Argus Reports*).

(*b*) In moist air, 27°-28½° C.—80° to 83° F.

(*c*) In dry air, 28°-29° C.—83°-85° F.

Gave :—

(*a*) 22% (*b*) 5·5% (*c*) 11% pitted.

Some Cleopatras from Mr. Lang, Harcourt, gave for March 8th to April 12th under similar conditions :—

Room.	Moist Oven.	Dry Oven.
(*a*) 20%	(*b*) 20%	(*c*) 10% (?).

The batches consisted of only ten apples each, and therefore one apple pitted (plus or minus) is all that is meant by the difference between 10 per cent. and 20 per cent. Also the apples are classed as pitted on a single lesion, which is extremely rigid.

More Annie Elizabeth apples in four groups of ten each under the same conditions as above, but with one group kept in an atmosphere of Carbon dioxide at room temperatures (*d*) gave :—

(*a*) 20% (*b*) 10% (*c*) 0% (*d*) 0%

Generally speaking, the apples on the laboratory table seem to have shown a little more Pit than those from the other group.

It is not intended, however, to do more than point this out. It would be most incautious to make any dogmatic deduction until clear confirmation—on a larger scale—be obtained.

Should the point be subsequently fully established that fluctuating temperatures increase the amount of Pit in apples, apparently plucked clean, then it will be necessary to establish a relationship between the appearance of Pit and irregular metabolism in the apples.

The ripening process is evidently going on the whole time, but with unevenness, and certain cell groups may not adapt themselves sufficiently to the checks and accelerations constantly occurring to retain their vitality in competition with their neighbours.

Again, should there be ample confirmation of the effect of irregular ripening in producing Pit in gathered apples, then irregular growth and ripening conditions, whilst the apple is still on the tree, are all the more likely to be the causes of the trouble as the vital activity is then all the greater.

It would, however, be premature from the relatively limited work of one season to make a definite statement. All that can be said is, that with the material which passed through my hands there was a distinct suggestion, either that regular ripening conditions protect the gathered apple from the development of Pit, or that irregular ripening conditions produce Pit in the gathered apple.

It appears to me that the former alternative should be considered the more likely, until at all events fuller evidence can be obtained.

Certain observations are called for with regard to the apples received for experimental purposes.

Out of 400 clean apples, for the most part of unripe appearance, those developing Pit under observation numbered at most 30. Of these 30 the great majority were classed as unclean on a single Pit or two pits.

The notes of experiments show only eight as developing marked Pit.

This means, that in order to detect the earliest evidence of Pit at that initial stage, before there is any depression of the skin, or browning of the affected cells, 50 apples must be gone over section by section with some test capable of unmasking the Pit—and as yet that test is not discovered.

The explanation of the low incidence of the disease in the laboratory-kept apples is :—

(*a*) That many of the clean apples came out of cool storage late in the 1914 season, when all fruit, which was to Pit had already done so, and only the **really** clean fruit remained with a clean appearance.

(*b*) That even with the fruit received in the height of the 1915 gathering season, the fruit was showing some signs of the disease, if about to pit, or else was actually clean.

In short, the period of Pit incidence had occurred before the fruit reached the laboratory in all but a very small minority of the apples received.

The material required was clean fruit from a single tree, with a bad reputation for Pit. The appearance of Pit on the tree marked the clean fruit, as that which was most likely to be of interest. Yet, in only the brief week or two of the harvesting season was clean fruit obtained which pitted under observation. Other supplies, which had been especially put aside in cold storage, emerged either permanently clean or pitted.*

One fine supply of Rome Beauties arrived in a condition in which to the casual observation they appeared clean. But there was a just perceptible mottling in darker green, and on peeling it was obvious that this mottling was due to Pit. Out of 84 apples 50 were at once grouped as pitted, and of the other 30 only 6 were actually clean.

Consequently one feels that the determination of Pit or no Pit occurred prior to the apples reaching the laboratory.

THE EARLY DETECTION OF PIT.

Considerable attention was directed to this point, but it must be admitted that no actual results were obtained, and from what is now known this was almost inevitable.

(*a*) From the work having been for the most part carried out on unsuitable material ;
(*b*) From the insufficient mass of material examined ;
(*c*) From the considerable experimental difficulties.

The methods by which the problem may be attacked can, however, be discussed, and the difficulties met with may be stated, in order to clear the ground for future work.

MICROCHEMICAL METHODS.

One of the most striking pictures of Bitter Pit is afforded when an affected apple has the peel removed. In a badly diseased apple the whole peeled surface appears studded with small brown areas of dry and shrivelled cells. As the affected tissue is more abundant towards the periphery of the apple, it is just under the skin that the bulk of it is seen.

It is also just under the skin that one would naturally look for Pit by special microchemical methods in apples apparently clean, but possibly doomed to Pit on being kept.

(*a*) STAINING METHODS DEPENDING ON ENZYMES.

Reagents which colour under the influence of oxidase enzymes were applied uniformly to the surface of apples which had been peeled. *Pārā-phenylene-diamine* (without hydrogen peroxide), and tincture of Guiacum (with or without hydrogen peroxide) were used. In all cases uniform and good staining was obtained with no indication of localised areas with excess, or defective oxidase enzymes. Results were therefore negative. As later experiments showed the material used was unsuitable. By this is meant that subsequent evidence indicated that the fruit was in reality clean, and not in all probability with any latent Pit present. Methylene blue was also tried for the presence of reductase. No evidence of such a ferment was obtained.

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*Mr. McAlpine informs me that no separation of clean and unclean apples was made prior to the cold storage. Cases of apples (the apples all from a single Annie Elizabeth tree) were placed in the Cool Store in the condition as gathered.

(*b*) STAINING METHODS DEPENDING ON ACIDITY.

It was thought that it might be possible to detect different groups of cells possessing different acidity to the general pulp cells around them. At first phenolphthalein was employed, made just alkaline with 1, 2, 3, – – 5, etc., drops of $\frac{N}{10}$ alkali (soda) to 5 c.c. of the reagent (1 per cent. phenolphthalein, 5 drops added to 5 c.c. water), until just no longer decolourized by the apple juice. The reagent, however, proved unsatisfactory.

Later a note in a scientific periodical called attention to a special reagent, Dinitro-hydroquinone (Henderson's Reagent), with a wide colour range. This material not being procurable on the market was made in the laboratory and also used.

The apples were sufficiently acid to give the acid colour. The cells in sections examined under the microscope were yellow, and only the vascular bundles showed a difference in tint, namely, an orange-red (less acid).

Again, however, it is impossible to say that the apples used were suitable, *i.e.*, with Pit present though not yet showing the brown staining.

A third indicator stain, Methyl violet, has been tried, but is only suitable for very acid apples.

As to applying these reagents to apples having Pit visibly present, to see if they are suitable reagents for examining apples in which Pit is not present, there is this difficulty, that the pitted areas have apparently a sponge action. The reagent is mopped up and stains deeply the tissues around and beneath. Thus the pitted area appears more deeply stained to the eye. The pitted area not only sponges up the reagent, but also exuded apple juice. And this brings up the greatest difficulty of all in applying these methods.

In peeling the apple the whole surface is swept by the juice escaping from the cut cells, and juice from the healthy cells is carried over other cells, which for the sake of argument may be considered unhealthy.

The first essential then is to carefully blot with filter paper the whole surface of the apple. When the reagent is next applied it requires only a very short time for the same difficulty to arise again. The surface of the apple becomes bathed in reagent containing those contents of the cells, which readily diffuse out, *e.g.*, acids, sugars, etc.

Partly, then, from inherent practical difficulties, and possibly also from the right material not being available at the time, no results of any value were obtained.

It has been previously shown that with the Pit incidence in apples received clean, at least 50 apples would have needed to be carefully mapped before it could be claimed with any certainty that an apple destined to subsequently Pit had been handled. It is regretted that more apples were not examined in this way, but a peeled apple is an apple lost, and the material was required for other experiments.

To press this class of experiments would require that in another season a large number, say 200 apples, should be completely mapped over with a suitable reagent. Should then some six or eight apples show local patches, the size of Pit, staining in an anomalous fashion, then this should be approximately the number of apples pitting in a control batch of 200 apples kept under observation. Only then could it be legitimately assumed that the anomalous staining had shown an early condition of Pit.

(*c*) STAINING METHODS, SHOWING STARCH.

In my experience Pit has practically always been associated with starch. No desire arises to contradict the statement that pitted tissue may not show starch, *i.e.*, if the disease develops before or after the starch stage. But perhaps it may be said, without fear of contradiction, that in 99 cases out of 100 starch is present. In other words, it would appear that the critical time for the apple is when the pulp cells are loaded with starch, and before the starch has been converted into sugar.

I agree most emphatically with Mr. McAlpine, that an apple which is ripe (no starch) is past the danger of pitting. I feel that I am on the point of declaring that an apple which has already lost its starch (though it may not look or taste ripe) is also past the danger.

At any rate a great majority of the clean apples received at the laboratory were already passed the starch stage, though still green and unripe, and as they proved themselves practically free from subsequent pitting, they bear out the point raised.

Starch metabolism and Pit are evidently closely associated.

Consequently, it was with a good deal of confidence, that peeled apples were stained with iodine for persistent patches of starch-bearing cells. It would be most interesting to know whether certain cells could maintain undissolved starch grains for any length of time before showing the visible lesions characteristic of Pit. An apple might be gathered clean whilst still in the starch stage. If on keeping, the starch was transformed into sugar in the general mass of pulp cells, leaving actual groups of cells of the dimensions of Bitter Pit areas still with unconverted starch, then that would be an early indication that Pit was present. In Rome Beauties, such masses of starch-bearing cells were found, though, unfortunately, the apples were actually just under suspicion of pitting from their naked eye appearance (there was a suspicious dark mottling under the skin, and on peeling the areas were light brown).

No earlier cases were found, and it still remains to determine whether starch persistence can be separated from the browning and sponging of Pit by any marked interval of time.

Most of the apples I received had already lost their starch, and were already either pitted or permanently clean. As previously mentioned, the decisive point in their history had passed.

This brings one to an interesting practical point. There seems to be no doubt that apples are harvested at very different times in their ripening history. The starch may or may not already have been converted. The question arises whether after storage, and its effect upon the incidence of Pit, can be adequately investigated without being correlated to the condition of the apple (in respect of its inner metabolism) at the time of gathering.

If the apple is gathered subsequently to the conversion of its starch and is clean, one would expect any reasonable storage to be adequate.

If on the other hand, it is gathered with starch still present, can special methods of subsequently guarding it, help it to pass the critical period of starch conversion without leaving groups of cells to die ?

BITTER PIT AND POISONS.

At one stage in the investigation it was proposed to use an experimental method based upon the sensitivity of the pulp cells of the apple to minute traces of metallic poisons as described by Ewart.

It was argued that if an apple had latent Pit—not yet fully developed—certain groups of cells, namely those which would later die and form the Pits, would perhaps, on account of a lowered vitality, be more readily poisoned than their healthy neighbours.

It was proposed to treat the surface of peeled apples with solutions of metallic poisons just too dilute to kill the healthy cells, and then watch for the death of cells in certain small defined areas within the following 24 to 48 hours.

It was found, however, that the peeled apple immediately commenced to disintegrate in any of these extremely dilute metallic salt solutions, which are virtually distilled water. A peeled apple at once commences to fluff and shed its cells within 5-10 minutes in pure distilled water.

This observation caused us to make a communication to the Royal Society of Victoria, based on further work, questioning Ewart's experimental evidence of the susceptibilities of apples to dilute poisons.

It was argued that the removal of minute areas of cuticle practised by Ewart made the apple skin permeable, and the pulp cells were then poisoned, not only by the dilute metallic salt, but also by the distilled water.

Ewart subsequently convinced us, and a small committee (Dr. Osborne and Dr. Hall), that if only the very outermost layer of the skin is removed, *i.e.*, only the cuticle, then the entry of distilled water is apparently controlled, and not sufficiently rapid to injure the pulp cells beneath the denuded area. The question, however, merits further work, for the metallic poison probably commences by killing the epidermal cells, and the subsequent injury to the pulp cells may then all the same be due to a combined action of poison and distilled water. Ewart admits the injury which distilled water may produce, and does produce, should anything more than just the cuticle of the apple skin be removed by the razor.

Again, in the experiments as carried out with the careful technique suggested by Ewart, we would suggest that the metallic salt acts as catalyst to the cell oxidase thus facilitating the browning of the cells, which is really the chief thing to be seen.

The natural questions the onlooker asks are :—

(1) Is the condition produced identical with Bitter Pit ?
(2) If so, what evidence is there to connect the death of cells as found in Bitter Pit with the death of cells produced by metallic poisoning ?

To make the poisoning theory applicable to the widely distributed disease of Bitter Pit, it is necessary to postulate absorption by the roots.

It becomes necessary to show that poison absorbed in this way does produce the localised lesions characteristic of Pit.

EXPERIMENTS WITH HALF-GROWN APPLES.

These apples were gathered with about one foot of the branch upon which they were growing. They were Esopus Spitzenburg, from a Box Hill orchard.

There were two apples to each branch.

On 27th November they were placed with the stalk in the following solutions, and left in front of a window with north aspect.

(1) Water containing a little Eosine.
(2) Distilled water.
(3) Distilled water + 1 in 150,000 Copper Sulphate.
(4) Distilled water + 1 in 600,000 Copper Sulphate.
(5) Nutrient Solution.
(6) Nutrient Solution + 1 in 200,000 Copper Sulphate.
(7) Nutrient Solution + 1 in 600,000 Copper Sulphate.
(8) Nutrient Solution + 1 in 100,000 Mercuric Chloride.
(9) Nutrient Solution + 1 in 500,000 Mercuric Chloride.

(1) WAS A CONTROL.—By 30th November Eosine was visible under the skin of one of the apples on the branch, and on 6th December it was found in the flesh (in the veins), chiefly around the core of the other. Therefore there is every reason to assume that in the other experiments the poisonous solutions were also absorbed.

On 6th December all apples were examined. None of them showed any signs of Pit. In some cases they were commencing to shrivel, notably in (5), due to the nutrient solution having fallen to a level which no longer covered the stalk. This was not at once detected, so that the apple branch was for a time deprived of fluid.

In (8) and (9) the apples were remarkably firm, with no signs of shrivelling.

On 14th December the apples were again examined. The shrivelling was more marked than on the 6th. No signs of any localised lesions were seen, several of the apples were cut, but showed no indication of pitting.

The rest were kept under examination for a time, but ultimately rotted or became too shrivelled to be of any further interest. The experiment remained negative.

WATERING APPLE TREES WITH COPPER SULPHATE SOLUTION.

The experiments were carried out at Burnley with Mr. McAlpine's co-operation.

Four varieties of apple trees were selected by Mr. McAlpine, all being susceptible to Pit, and with bad reputations from previous years. They were "Gravenstein," "Williams' Favourite," "Charles Ross," and "Jonathan"—one tree of each variety. The strength of copper sulphate solution used throughout was one in 100,000.

This strength was based upon a publication by Ewart in the Proceedings of the Royal Society of Victoria, Vol. XXVI. (1913), page 12, on the toxic limit for the growth of apple seedlings.*

Each tree received the following waterings :—

27th November—20 gallons between the four trees.
11th December—40 gallons between the four trees.
24th December—40 gallons between the four trees.
8th January—40 gallons between the four trees.
22nd January—20 gallons between the four trees.

The results are :—

	Picked	Yield	Pitted		Picked	Yield	Pitted
"Gravenstein" ..	18th Jan.	100	8	"Charles Ross"	25th Jan.	48	10
"Williams' Favourite"	8th Jan.	10	—	"Jonathan"	13th Feb.	164	16

Mr. McAlpine kindly supplied these figures. The "Charles Ross" were sent to me and kept under observation for several weeks. No further pitting occurred.

SUMMARY.

It appears that the question as to whether apples are to Pit or remain clean is for the most part decided before their starch is converted to sugar, that is, when for the most part they are still on the tree.

Laboratory experiments indicate some possible influence of the after treatment of picked apples on the incidence of Pit, but the work requires to be greatly extended, with material which can now be better recognised as suitable.

Microchemical methods of detecting early Pit (before the browning stage) have not yet given any special results, but the methods which may be suitably employed are discussed.

No further evidence has been obtained to support the posioning theory of Pit.

Experiments conducted with a view to producing Pit in apples by the absorption of poisons in solution by the natural channels were negative in the laboratory, and inconclusive in the orchard.

The orchard experiments require repeating on trees of Pit-susceptible variety, but with previously clean history.

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*Ewart places the toxic limit between 1 in 100,000 and 1 in 500,000. The strongest solution, 1 in 100,000, was selected as it would be diluted by the water present in the soil.

III.—LIABLE AND NON-LIABLE VARIETIES COMPARED AND CONTRASTED.

In studying the contrasts between liable and non-liable varieties of apples, we have chosen the Cleopatra as one of the most susceptible commercial varieties grown in Australia, and Yates as one of the least susceptible. But if our investigation had been more extensive, we might have included Annie Elizabeth and Northern Spy among the former, and Stone Pippin and Dunn's Favourite among the latter.

Cleopatra or Ortley, Northern Spy and Yates are of American origin, and Annie Elizabeth and Stone Pippin are both English apples, while Dunn's Favourite or Munroe's Favourite is an Australian seedling, supposed to be a chance seedling from Stone Pippin, which it resembles.

The chemical composition of the fruit of Cleopatra and Yates at different periods of growth has been again determined, but irrigated samples of Yates were not obtainable this season, owing to the failure of the crop where irrigation was practised. The wood of both these varieties has also been submitted to analysis, and the composition of the ash determined in one and two year old wood taken from trees in the same orchard. The rate of growth of the fruit was also carefully measured under the same climatic conditions, and while this was primarily undertaken to settle the exact stage of growth at which Bitter Pit first appeared, it may conveniently be considered in connection with a comparison between the two varieties.

The nature of the leaf has also been investigated in a large number of varieties, especially with reference to the hairy covering on the under surface.

Since only unirrigated apples of the Yates variety were procurable this season, a comparison will be made between them and unirrigated Cleopatra apples.

In the green and ripe apples of Cleopatra, the percentage of juice was 96, while in the Yates it was only 92. Therefore the Cleopatra is the juicier apple. The amount of ash is the same in the green and ripe Cleopatra apples, but in Yates it is slightly less in the green apple. The acidity is practically the same in both Cleopatra and Yates, being slightly higher in the green as compared with the ripe apple. In correspondence with this, the cane-sugar content is less in the green than in the ripe apple, and considerably so (less than half) in the case of Yates.

The tannin differs but little in the green and ripe Cleopatra apples, whereas in Yates it is much less in the green apple. When ripe both apples have about the same amount of tannin. In the irrigated and unirrigated Cleopatra apples, the analysis shows that there is very little relative difference in the amount of moisture, and Mr. Scott has pointed out that there is no appreciable difference even when the investigation is carried out on an extensive scale.

"To the ordinary man in the street it would be natural to assume that if he grew apples on a tree that was left to grow under natural conditions as regards soils, climate and cultivation, and another that was grown under artificial conditions, say with the aid of irrigation, that the fruit of the latter would contain more moisture than that grown under ordinary conditions. That this does not always follow is one of the results of the analysis of apples grown under both conditions. The fact that no appreciable difference is to be noted is further borne out by a more extended series of analyses conducted by Jones and Colver, of Idaho, U.S.A. It will be sufficient here to note only the average of all the analyses of irrigated and non-irrigated apples :—

Apples.	No. of Analyses.	Moisture.	Total Sugar.	Acids.	Crude Protein.	Solids Insoluble.
		%	%	%	%	%
Irrigated	116	83·14	10·84	·322	·200	2·66
Unirrigated	168	82·61	10·84	·336	·283	3·19"

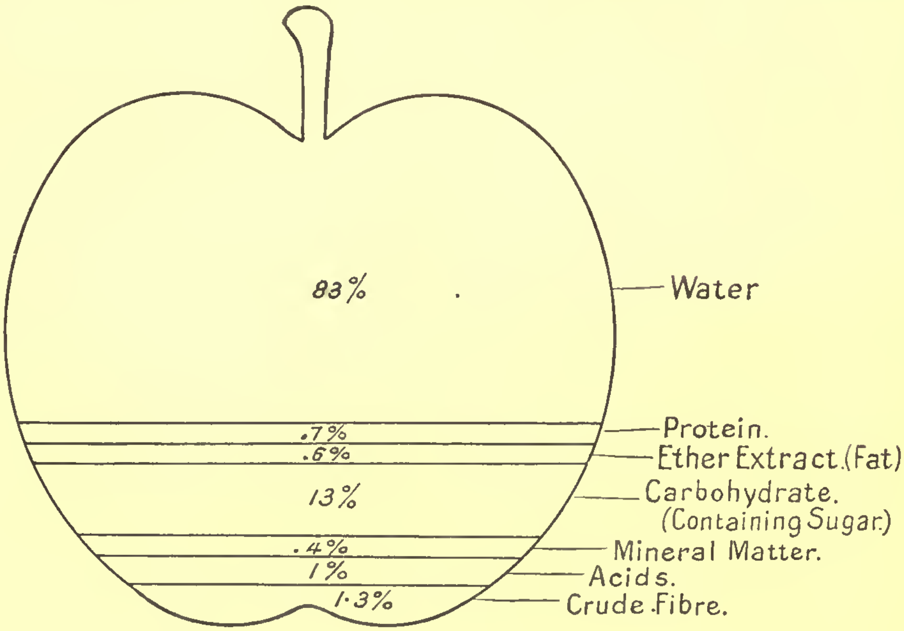
TABLE I.—RESULT OF ANALYSIS OF APPLES OF THE CLEOPATRA AND YATES VARIETIES (GREEN AND RIPE), GROWN AT HARCOURT, VICTORIA.

Description of Sample.	Cleopatra, unirrigated.		Cleopatra, irrigated.		Yates, unirrigated.	
	Green, 5/2/15. 8 Apples.	Ripe, 14/4/15. 8½ Apples.	Green, 5/2/15. 10 Apples.	Ripe, 14/4/15. 7 Apples.	Green, 5/2/15. 17½ Apples.	Ripe, 14/4/15. 15½ Apples.
Quantity taken	1,000 grams	1,000 grams	1,000 grams	1,000 grams	1,000 grams	1,000 grams
Juice expressed	750 ccs.	680 ccs.	775 ccs.	720 ccs.	735 ccs.	7·5 ccs.
Gallons per ton	167	152·1	173·2	161·1	164·3	159·9
Weight of pulp	146·62 grams	191·65 grams	116·1 grams	147·4 grams	166·12 grams	174·7 grams
Moisture in pulp	69·56%	78·65%	62·73%	78·11%	49·81%	52·81%
% of Juice in pulp	73·59%	84·11%	66·05%	81·92%	52·25%	56·65%
% of dry matter in apples ..	3·87%	3·04%	3·94%	2·66%	7·93%	7·57%
% of Juice in apples ..	96·13%	96·96%	96·06%	97·34%	92·07%	92·43%
ANALYSIS OF JUICE.						
Sp. Gr. at 15° C. ..	1·058	1·0695	1·053	1·0488	1·049	1·0728
Freezing point	—1·78°C. (28·80°F.)	—2·04° C. (28·33°F.)	—1·68° C. (28·98°F.)	—1·33° C. (29·61°F.)	—1·47° C. (29·36°F.)	—2·115° C. (28·2°F.)
Total solids, by weight ..	14·42%	16·98 %	12·98 %	16·05%	11·84 %	17·14 %
Ash, by weight	0·33%	0·323%	0·31 %	0·244%	0·36 %	0·438%
Total acids as malic, by weight	0·64%	0·43 %	0·67 %	0·402%	0·64 %	0·57 %
Cane sugar, by weight ..	3·36%	4·08 %	2·58 %	4·09 %	2·20 %	4·99 %
Reducing sugar, by weight ..	9·33%	10·27 %	8·73 %	10·30 %	7·39 %	8·71 %
Tannin, by weight	0·07%	0·04 %	0·02 %	0·014%	0·003%	0·031%

TABLE II.—ORDINARY ANALYSIS OF CLEOPATRA AND YATES APPLES (GREEN AND RIPE), GROWN AT HARCOURT, VICTORIA.

	Cleopatra, unirrigated		Cleopatra, irrigated		Yates, unirrigated.	
	Green.	Ripe.	Green.	Ripe.	Green.	Ripe.
Date of Sampling ..	5/2/15	14/4/15	5/2/15	14/4/15	5/2/15	14/4/15
	%	%	%	%	%	%
Moisture	83·66	83·53	85·21	86·79	81·78	79·26
Ash	0·33	0·32	0·32	0·24	0·38	0·44
Protein	0·44	0·34	0·55	0·38	0·63	0·72
Crude fibre	1·33	0·80	1·22	0·76	1·95	1·35
Nitrogen free extract	13·54	14·46	12·11	14·50	14·62	17·63
Ether extract	0·70	0·55	0·59	0·33	0·64	0·60
Containing sugar ..	12·69	14·35	11·31	14·39	9·59	13·74

The ordinary analysis of an apple enables us to give a general view of its percentage composition. It is graphically represented in the accompanying diagram, where the water is seen to be in the greatest proportion and the mineral matter in the least.



The carbohydrates constitute the principal nutritive element in the fruit, and the mineral matter, although relatively small in amount, plays an important part in the process of digestion. In keeping with the analysis of the juice, shown in Table I., the moisture in Cleopatra is practically the same both in the ripe and green fruit, viz., 83 per cent., and in Yates it is less, viz., 79-81 per cent., the green fruit containing the most.

A distinction must be drawn between the amount of juice found in an apple and its juiciness. The term "juiciness" refers to the succulence of the apple to the taste, and is the opposite of the "dryness" or "mealiness" so frequently found in over-ripe apples. Dr. J. K. Shaw, Research Pomologist, Massachusetts Agricultural College, oxplains that these "mealy" over-ripe apples contain as much, and sometimes more, water than do apples in good condition, and which would be described as juicy. The impression of mealiness arises through the fact that in over-ripe apples the middle lamellae are softened presumably by some enzyme, and the cells separate in the mouth yielding the taste, or rather tastelessness, of the cell walls instead of that of the juicy cell contents.

P. R. Scott, Agricultural Chemist, thus compares the Cleopatra and Yates apples in their green and ripe state :—

" Comparing the Yates and Cleopatra at both stages of growth, it may be noted that the Yates contains a higher percentage of crude fibre and carbohydrate content than the Cleopatra, less juice and consequently a higher percentage of insoluble solids. This to my mind appears the distinguishing difference between these two varieties and probably accounts for the more solid structure of the ripe fruit of Yates. The lengthened period of growth of this variety may have some effect in producing this variation, which appears to be more or less an inherent property making for a stronger constitution.

"Taking a survey of the ash content, the latter surmise is given added weight, as although the ash content in each case is under ·5 per cent., still the Yates apples appear to contain more than the Cleopatra, and in conjunction with the insoluble solids adds to the difference between these two varieties."

Table III.—Analyses of Ash of Juice and Solids in Cleopatra and Yates Apples (Green and Ripe), Grown at Harcourt, Victoria.

	Cleopatra, unirrigated.				Cleopatra, irrigated.				Yates, unirrigated.			
Date ..	Green— 5/2/15.		Ripe— 14/4/15.		Green— 5/2/15.		Ripe— 14/4/15.		Green— 5/2/15.		Ripe— 14/4/15.	
	Juice.	Solid.	Juice.	Solid.	Juice.	Solid.	Juice.	Solid.	Juice.	Solid.	Juice.	Solid.
Fe_2O_3 & Al_2O_3	·004	·002	·003	·002	·003	·002	·003	·002	·007	·004	.006	·004
CaO	·008	·004	·010	·003	·009	·006	·009	·008	·009	·016	·011	·005
MgO	·012	·008	·010	·006	·014	·007	·009	·004	·014	·012	·019	·005
K_2O	·144	·010	·130	·022	·137	·010	·104	·006	·125	·046	·197	·023
P_2O_5	·026	·019	·024	·018	·021	·011	·015	·008	·018	·017	·030	·011
SO_3	·010	·004	·008	·004	·009	·004	·008	·003	·014	·008	·013	·006

The constituent in greatest proportion in the ash of the juices is potash. In the green Cleopatra it is in greater proportion than in the ripe, whereas in the green Yates it is less than in the ripe. In the ripe condition the juice of the Yates contains more potash than that of Cleopatra.

In the amount of lime there is a remarkable agreement in both varieties.

It was considered desirable to have analyses made in different States of well-known varieties of apples susceptible to and comparatively free from Bitter Pit, so as to compare differences in the chemical composition which might result from being grown under different conditions of soil and climate, heat and moisture. In New South Wales the Experiment Farms of Bathurst and Glen Innes were laid under contribution, and in Queensland the Experiment Orchard at Stanthorpe. Six varieties were selected for analysis—three liable and three non-liable. The liable varieties were Cleopatra, Northern Spy and Annie Elizabeth, with Five Crown substituted for the latter in Queensland. The non-liable varieties were Yates, Dunn's Favourite and Stone Pippin.

The fruit was analyzed in the half-grown and in the ripe condition, and one can see by glancing at the tables the chemical differences between these two stages.

TABLE IV.—ANALYSES OF HALF-GROWN APPLES FROM BATHURST EXPERIMENT FARM.

	Cleopatra.	Dunn's Favourite.	Annie Elizabeth.	Northern Spy.	Stone Pippin.	Yates.
Gallons juice per ton, apples ..	94·39	83·81	91·67	92·69	88·74	76·58
Sp. gravity of juice	1·0544	1·0543	1·0565	1·0593	1·0522	1·0645
	%	%	%	%	%	%
Acidity as malic acid	·938	1·213	1·315	1·045	1·205	·755
Cane sugar	1·50	2·370	1·590	2·220	·965	1·284
Reducing sugars as dextrose	7·380	7·260	8·290	8·360	8·554	9·988
Tannin	·017	·024	·015	·034	·045	·044
Ash	·281	·342	·358	·294	·282	·422
Oxides of iron and aluminium	·014	·012	·036	·028	·028	·034
Potash	·185	·157	·208	·163	·154	·245
Lime	·019	·024	·030	·017	·037	·026
Magnesia	·016	·031	·012	·008	·015	·025
Sulphuric acid	·012	·012	·017	·013	·021	·021
Phosphoric acid	·018	·018	·017	·011	·015	·027

TABLE V.—ANALYSES OF HALF-GROWN APPLES FROM GLEN INNES EXPERIMENT FARM.

	Cleopatra.	Stone Pippin.	Annie Elizabeth.	Dunn's Favourite.	Yates.
Gallons juice per ton, apples	85·46	93·68	103·54	73·95	101·07
Sp. gravity	1·0450	1·0451	1·0520	1·0610	1·0590
	%	%	%	%	%
Acidity as malic acid, per 100 grams ..	·469	·891	·630	·476	·396
Sucrose	1·455	·848	4·627	5·394	1·932
Reducing sugars as dextrose	7·116	7·435	5·910	6·898	9·094
Tannin	·167	·240	·128	·230	·210
Ash	·228	·307	·175	·230	·244
Oxides of iron and aluminium	·016	·018	·015	·020	·022
Potash	·120	·171	·083	·121	·106
Lime	·006	·009	·026	·028	·020
Magnesia	·006	·010	·013	·018	·014
Sulphuric acid	·009	·012	·014	·010	·029
Phosphoric acid	·007	·012	·016	·022	·023

TABLE VI.—ANALYSES OF RIPE APPLES FROM GLEN INNES EXPERIMENT FARM.

	Dunn's Favourite.	Annie Elizabeth.	Yates.	Stone Pippin.
Gallons juice per ton, apples ..	64·71	98·60	86·280	98·605
Specific gravity	1·0720	1·0560	1·0660	1·0567
	%	%	%	%
Acidity as malic acid	·664	·630	·469	·950
Sucrose	4·570	2·040	4·820	1·550
Reducing sugars as dextrose ..	6·133	7·076	6·035	9·066
Tannin	·067	·046	·057	·138
Ash	·369	·262	·271	·270
Oxides of iron and aluminium .	·016	·017	·011	·010
Potash	·186	·133	·146	·156
Lime	·011	·007	·010	·014
Magnesia	·015	·009	·012	·010
Sulphuric acid	·008	·004	·010	·010
Phosphoric acid	·020	·022	·023	·027

TABLE VII.—ANALYSES OF HALF-GROWN AND

Laboratory No.	Date of the Analysis of Juice.	Variety.	Condition of Fruit.	Per 100 of the Fruit.				Juice Expressed per 100 Edible Portion.	Gallons of Juice per ton of Fruit.	Analysis			
				Edible Portion.	Core.	Skins.	Juice Expressed.			Specific Gravity at 15° C.	Sucrose.	Reducing Sugars as Dextrose.	Acidity as Malic Acid.
				%	%	%	% By weight	% By weight			%	%	%
843	18/1/15	Stone Pippin ..	Half Ripe	66·7	13·3	20·0	32·2	48·3	68·4	1·0516	2·64	7·18	1·67
1232	12/3/15	,, ..	Ripe	74·3	10·5	15·2	43·2	58·2	91·2	1·0600	1·51	10·50	·77
844	19/1/15	Northern Spy ..	Half Ripe	72·5	11·5	16·0	37·0	51·0	78·4	1·0566	3·28	7·92	1·15
1229	10/3/15	,, ..	Ripe	78·9	5·9	15·2	36·0	45·6	76·0	1·0610	4·67	8·38	·57
845	20/1/15	Cleopatra	Half Ripe	70·8	11·5	17·7	41·5	58·6	88·2	1·0517	3·20	7·19	·93
1230	11/3/15	,, ..	Ripe	76·2	9·0	14·8	39·2	51·4	82·5	1·0637	3·84	9·56	·73
846	21/1/15	Five Crown ..	Half Ripe	68·3	13·4	18·3	35·6	52·1	76·2	1·0509	3·02	6·71	1·18
1231	11/3/15	,, ..	Ripe	74·3	9·7	16·0	29·2	39·3	61·6	1·0600	5·14	7·12	·69
847	22/1/15	Yates	Half Ripe	64·9	13·7	21·4	38·4	59·1	81·2	1·0508	3·25	7·21	·81
1233	12/3/15	,, ...	Ripe	70·0	12·4	17·6	41·6	59·5	87·5	1·0640	4·52	8·71	·70
848	22/1/15	Munroe's Favourite	Half Ripe	70·1	12·9	17·0	35·4	50·2	74·5	1·0605	4·91	7·43	1·20
1228	10/3/15	,, ,,	Ripe	76·9	7·0	16·1	12·4*	16·1	26·1	1·0666	6·05	7·58	·61

* This sample of Munroe's Favourite was dry and mealy, therefore yielded so little juice.

RIPE APPLES FROM STANTHORPE, QUEENSLAND.

of Juice.								Analysis of Skins.							
Tannin.	Ash.	Analysis of Ash calculated to per cent. weight of Juice.						Moisture.	Ash Analysis calculated to per cent. Water-free Material.						
		Fe_2O_3 Al_2O_3	CaO.	MgO.	K_2O.	SO_3.	P_2O_5		Ash.	Fe_2O_3. Al_2O_3.	CaO.	MgO.	K_2O	SO_3.	P_2O_5.
%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
·039	·341	·012	·016	·013	·196	·008	·008	81·8	2·68	·02	·14	·10	1·38	·06	·18
·162	·252	·004	·008	·010	·121	·005	·006	79·2	1·83	·03	·11	·15	·98	·07	·08
·135	·419	·006	·008	·004	·175	·008	·006	79·2	2·03	·03	·04	·08	1·03	·07	·10
·285	·252	·007	·005	·008	·116	·006	·011	79·2	1·88	·13	·05	·11	·97	·06	·11
·160	·273	·005	·011	·009	·126	·009	·006	80·4	2·12	·05	·08	·12	1·10	·06	·11
·170	·257	·004	·007	·009	·133	·007	·007	78·0	1·61	·06	·07	·12	·93	·05	·10
·228	.298	·006	·018	·008	·141	·011	·006	78·0	1·98	·03	·09	·11	1·01	·04	·09
·352	·288	·007	·008	·009	·144	·004	·008	77·6	1·49	·05	·07	·11	·89	·04	·10
·061	·341	·006	·027	·016	·168	·010	·007	76·8	1·95	·02	·19	·14	·81	·04	·12
·069	·264	·003	·011	·013	·151	·003	·005	76·0	1·47	·05	·15	·12	·73	·04	·08
·088	·374	·006	·018	·012	·180	·007	·012	76·8	2·16	·03	·06	·10	1·01	·05	·11
·235	·379	·017	·013	·016	·175	·013	·017	77·2	1·92	·07	·04	·10	1·02	·07	·10

Amount of Juice.—If an attempt is made to arrange the varieties in the order of their amount of juice, it is found that in eaeh district there is a different arrangement. In the Bathurst district the Cleopatra has the most, and the Yates the least, while in the other two districts the Yates sometimes contains more juiee than the Cleopatra.

So definite analysis does not support the view that the amount of juiee in the apple and Bitter Pit are neeessarily assoeiated.

Ash.—If the same method is followed with the amount of ash in the juice, there is no eonstancy in the arrangement.

Acidity.—The greater amount of aeidity does not seem to have any bearing on the liability to Pit, as in each of the districts Cleopatra and Yates have the smallest amount.

Cane-Sugar Content.—Sucrose or eane-sugar is found to be greatest in all the districts in Dunn's Favourite, and least in Stone Pippin, so that a wide difference in sugar-content does not seem to have any relation to pitting. Besides, Cleopatra and Yates eome together when the varieties are arranged in the order of their sugar-content.

Lime in Ash of Juice.—There is sometimes very little difference in the amount of lime present in liable and non-liable varieties, but in all the districts the half-grown Yates contains a slightly greater amount than Cleopatra.

TABLE VIII.—RESULT OF ANALYSES OF TWO AND THREE-YEAR-OLD WOOD OF CLEOPATRA AND YATES, GROWN IN BURNLEY HORTICULTURAL GARDENS.

Samples submitted were as follows, 1 and 2 being 4 years old from the bird-proof enelosure and the remainder being old trees from the orchard :—

1. Cleopatra, on Yarra Bank.
2. Yates, on London Pippin Seedling.
3. Cleopatra, from Orchard.
4. Cleopatra, from Orchard.
5. Yates ,,
6. ,, ,,

	1	2	3	4	5	6
	%	%	%	%	%	%
Moisture	37·46	33·10	39·25	47.24	32·82	40·58
Ash	1·94	1·33	1·32	1.40	1·28	1·18
Per cent. of ash—						
Phosphorie acid	6·22	8·20	5·87	5·92	12·80	9·83
Potash	13·90	14·06	18·89	14·96	12·16	14·94
Lime	38·20	34·94	31·97	33·18	35·37	32·42
Magnesia	7·84	9·05	—	7·19	13·38	11·72

CLEOPATRA AND YATES COMPARED.

	Cleopatra.			Yates.		
	%	%	%	%	%	%
Moisture	37·46	39·25	47·24	33·10	32·82	40·58
Ash	1·94	1·32	1·40	1·40	1·28	1·18
Per cent. of ash—						
Phosphorie aeid	6·22	5·87	5·92	8·20	12·80	9·83
Potash	13·90	18·89	14·96	14·06	.12·16	14·94
Lime	38·20	31·97	33·18	34·94	35·37	32·42
Magnesia	7·84	—	7·19	9·05	13·38	11·72

Average—		
Phosphoric acid	6·00	10·28
Potash	15·92	13·71
Lime	34·45	34·24
Magnesia	7·52	11·38

Samples of wood were taken for analysis from young and old trees of Cleopatra and Yates in June, in order to determine if there was any striking difference in their composition.

It was found that there was less moisture in the wood of Yates, and a little less ash than in Cleopatra, when grown in the same orchard.

There is a striking difference in the amount of phosphoric acid and magnesia in the young wood of Yates as compared with that of Cleopatra. Phosphoric acid is a very necessary and important nutritive substance to the tree, and magnesia influences the formation of chlorophyll, since it is an essential constituent of it. The much larger proportion of these two substances in Yates will probably aid in the formation of a better nourished and healthier fruit.

MINERAL CONSTITUENTS OF DRIED APPLE SKINS.

The analyses of the dried skins of several varieties of apples grown in New South Wales and Queensland generally agree with the results previously obtained from Yates and Cleopatra apples grown in Victoria.

The percentage of ash was usually greater in the half-grown than in the full-grown and ripe apples.

In a susceptible variety such as Cleopatra, the amount of ash is greater than in a non-liable variety, such as Yates, but while this is relatively true, there are other non-liable varieties, such as Dunn's Favourite, in which the percentage of ash is greater than in Cleopatra.

The ingredient present in greatest proportion is potash, and it was invariably greater in the half-grown than in the full-grown fruit, with the exception of Dunn's Favourite, grown in Queensland, in which it was equal in both stages.

The amount of lime is greater in Yates than in any of the others when half-grown, but in Dunn's Favourite, grown at Glen Innes, New South Wales, it was very slightly in excess of that of Yates.

If a general comparison is made between the percentage of ash in the juice of the apple and in the skin, there is seen to be a large increase in the latter.

TABLE IX.—MINERAL CONSTITUENTS OF DRIED APPLE SKINS FROM HALF-GROWN APPLES, BATHURST EXPERIMENT FARM.

	Cleopatra.	Dunn's Favourite.	Annie Elizabeth.	Northern Spy.	Stone Pippin.	Yates.
	%	%	%	%	%	%
Total ash	2·871	2·692	2·683	2·494	2·289	2·664
Potash	1·704	1·410	1·510	1·229	1·133	1·434
Lime	·103	·162	·114	·057	·190	·270
Magnesia	·160	·137	·122	·106	·113	·120
Oxides of iron and aluminium	·150	·144	·112	·128	·154	·168
Phosphoric acid	·267	·216	·182	·145	·158	·168
Sulphuric acid	·152	·151	·142·	·118	·118	·124

TABLE X.—MINERAL CONSTITUENTS OF DRIED APPLE SKINS FROM HALF-GROWN APPLES, GLEN INNES EXPERIMENT FARM.

	Cleopatra.	Stone Pippin.	Annie Elizabeth.	Dunn's Favourite.	Yates.
	%	%	%	%	%
Total ash	3·043	3·149	2·869	3·213	1·923
Potash	1·564	1·605	1·397	1·569	0·804
Lime	·068	·117	·169	·181	·178
Magnesia	·138	·146	·146	·157	·142
Oxides of iron and aluminium	·112	·102	·146	·154	·156
Phosphoric acid	·204	·170	·266	·207	·169
Sulphuric acid	·119	·149	·172	·122	·098

TABLE XI.—MINERAL CONSTITUENTS OF DRIED APPLE SKINS FROM RIPE APPLES, GLEN INNES EXPERIMENT FARM.

	Dunn's Favourite.	Annie Elizabeth.	Yates.	Stone Pippin.
	%	%	%	%
Ash	2·291	2·629	1·517	2·404
Potash	·993	1·121	·688	1·257
Lime	·094	·120	·100	·132
Magnesia	·094	·109	·093	·111
Oxides of iron and aluminium	·134	·151	·094	·095
Phosphoric acid	·190	·188	·175	·201
Sulphuric acid	·090	·143	·070	·097

TABLE XII.—COMPARISON BETWEEN PERCENTAGE OF ASH OF JUICE AND ASH OF SKIN OF APPLE.

		Ash of Juice.			Ash of Skin.		
Variety.	Condition of Fruit.	Bathurst.	Glen Innes.	Stanthorpe.	Bathurst.	Glen Innes.	Stanthorpe.
Cleopatra ..	Half-Grown	·281	.228	·273	2·871	3·043	2·12
,, ..	Ripe	—	—	·257	—	—	1·61
Yates ..	Half-Grown	·422	·244	·341	2·664	1·923	1·95
,, ..	Ripe	—	·271	·264	—	1·517	1·47
Stone Pippin	Half-Grown	·282	·307	·341	2·289	3·149	2·68
,,	Ripe	—	·270	·252	—	2·404	1·83
Northern Spy	Half-grown	·294	—	·419	2·494	—	2·03
,, ..	Ripe	—	—	·252	—	—	1·88
Five Crown ..	Half-Grown	—	—	·298	—	—	1·98
,, ..	Ripe	—	—	·288	—	—	1·49
Dunn's	Half-Grown	·342	·230	·374	2·692	3·213	2·16
Favourite	Ripe	—	·369	·379	—	2·291	1·92
Annie	Half-Grown	·358	·175	—	2·683	2·869	—
Elizabeth ..	Ripe	—	·262	—	—	2·629	—

COMPARISON OF THE RATE AND AMOUNT OF GROWTH BETWEEN YATES AND CLEOPATRA APPLES.

The rate of growth of an apple has an influence upon the development of Bitter Pit, for when one is slow and steady, and the other rapid and irregular, under similar conditions, the slow-growing is less liable to Pit than the quick-growing.

The size of an apple, as represented by the amount of growth, has also a bearing on the result, for when the crop is light and the individual apples rather overgrown, there is usually a larger proportion of Pit. The fruit of the Yates is naturally small, relatively to that of the Cleopatra, which is large to medium.

For purposes of comparison the rate and amount of growth in Yates and Cleopatra apples was determined. Two apples of each of the varieties growing near each other were selected for observation, and measurements were made at stated intervals, generally once a week. A pair of calipers was used for this purpose, in which the measurement was automatically recorded (Fig. 56). Growth in length as well as in diameter was measured. The fruit set in October, but it was 9th November when the first observations were made. Yates was the only one which adhered to the tree until it was ripe, and fell naturally on 26th April. By this time the starch was all converted into sugar, as the flesh of the apple gave no blue reaction with iodine. Cleopatra dropped prematurely in January, so that a complete record for that variety is not available.

As might be anticipated, the greatest amount of growth occurred in November and December. The Yates attained its full growth about three weeks before it fell, and remained stationary afterwards, so that the energy of growth ceased before the fruit was ready to be detached from the tree.

If we take the total amount of growth in length made by the Yates apple during the season, and examine the proportions for the different periods of spring, summer and autumn, it is found that in the spring months the growth was $\frac{32}{58}$, in the summer months $\frac{20}{58}$, and in the autumn months $\frac{6}{58}$. Over one-half of the total growth in length was made in the spring months.

If the growth in diameter is considered similarly, it is found that in the spring months it was $\frac{42}{76}$, in summer $\frac{30}{76}$, and in autumn $\frac{4}{76}$. So that the growth in breadth in the spring was also over one-half the total.

In the accompanying table the rate and amount of growth is shown at weekly intervals.

TABLE XIII.—AMOUNT OF GROWTH AT STATED INTERVALS IN YATES AND CLEOPATRA APPLES—EXPRESSED IN THIRTY-TWO PARTS OF AN INCH.

Date.	Yates. Length.	Yates. Diam.	Cleopatra. Length.	Cleopatra. Diam.	Rainfall between Dates. inches.	Date.	Yates. Length.	Yates. Diam.	Cleopatra. Length.	Cleopatra. Diam.	Rainfall between Dates. inches.
November 9	24	28	31	26	—	February 2	50	66	—	—	·09
16	28	34	38	32	—	8	51	68	—	—	—
23	29	37	41	38	—	15	52	70	—	—	·06
30	32	42	48	44	1·63	22	52	70	—	—	·36
December 7	36	46	48	52	·12	March 1	52	72	—	—	—
14	38	48	56	52	·51	8	54	73	—	—	·02
21	40	54	58	62	1·35	15	54	74	—	—	·04
29	44	56	60	64	·64	22	54	74	—	—	·02
January 4	44	58	66	70	·20	27	54	74	—	—	—
11	46	60	68	72	·92	April 5	54	74	—	—	·31
18	48	64	(Dropped)		—	9	58	76	—	—	·46
25	48	66	—	—	·49	12	58	76	—	—	·97
						19	58	76	—	—	·13
						26	58	76	—	—	—
								(Dropped)			

RELATION BETWEEN THE NATURE OF THE LEAF AND BITTER PIT.

The leaves of apple trees are very varied in their character, and yet they are so characteristic in different varieties, that they often serve to identify the particular sort. They are apt to vary in different portions of the individual tree and typical examples are to be looked for on the upright shoots freely exposed to sun and air. Their size and shape, colour and texture, upper and under surface are all points worthy of note, but we will confine our attention to those characters which have a direct effect upon the transpiration.

Since the leaves are the chief organs of transpiration, they have received special attention, and any points in their structure which favour or retard it, will have an influence upon the amount of water given off, relatively to the water supply. The exit of water in the form of vapour is regulated by means of openings in the skin, known as *stomata*. In the case of the apple leaf, as in most leaves, they are entirely absent from the upper surface, and are distributed over the lower surface to the number of about 246 per square millimetre. Associated with these on the lower surface, there is usually a pubescence or downiness, which may be short or long, fine or coarse, and may be often rubbed off as a woolly or downy covering.

This downy covering consists of densely-packed dry hairs, and brings about a reduction in the transpiration, because the air entangled in the meshes of the hairs is stationary, and transpiration is therefore less active than it would be if the air were continually renewed.

This pubescence is more prominent, as a rule, in the young leaves, and it was observed that while the leaf of Yates is smooth on the under surface, that of Cleopatra is very decidedly downy. It is evident that if transpiration is retarded in the leaves, there will be a greater amount of moisture conveyed to the fruits.

It has already been remarked that the Yates apple, from its size and shape and general characters, is more nearly allied to the Crab than Cleopatra is, and the smooth under surface of the leaf will allow of transpiration to take place more freely and thus tend to prevent excessive transpiration by the fruit.

In the original Wild or Crab apple in Britain, the leaves are either smooth underneath or downy when young, and De Candolle notes in his " Origin of Cultivated Plants," that there are two varieties wild in Germany, the one with smooth leaves and ovaries, and the other with leaves downy underneath.

This division into smooth and downy leaves suggested that a more extended examination of varieties might be made, and since there are between six and seven hundred apple varieties in the Burnley Horticultural Gardens a census was taken of the nature of the leaves in each case.

It was only among the Crabs that the leaves were decidedly smooth on the under surface, and of these only the following eight :—

American Cherry.	Large Red Siberian Crab.
Barry.	Transcendent.
Darling.	Virginian Crab.
Dean (Double Flowering).	Yellow Siberian Crab.

This hairy covering is practically absent in the Yates, in common with many of the Crab apples, and in correlation with this, the Yates is much less drought-resistant than the Cleopatra. The Yates is usually planted in the valley for moisture, owing to its susceptibility to drought, and since this variety is apt to bear a large crop of undersized fruit, the necessity for a good supply of water is apparent.

IV.—THE NATURE OF THE VARIETY—PREDISPOSITION AND IMMUNITY.

It is a matter of common experience that particular varieties of apple are more subject to Bitter Pit than others grown in the same orchard, also that a variety may be badly affected in one locality and comparatively free in another. This predisposition to or immunity from the disease evidently depends on some factors in the plant itself, or is due to the action of the environment.

An attempt was made to determine some of these factors by comparing a non-liable variety such as Yates with a liable variety such as Cleopatra. From its size and shape and general characters, the Yates was considered to be more nearly allied to the Crab apple than Cleopatra, and the Crab itself is immune. In fact the tendency to Bitter Pit is inherent more or less in the very constitution of the cultivated apple, whether grown in Australia, or at the antipodes of Australia, in Britain. Bitter Pit is a functional disorder, in which the vascular system or conducting tissue is largely concerned, and the cultivated apple has in a great measure lost the hardy nature of its ancestors.

The Crab apple is small and sour, and only on an average one inch in diameter. It is so called on account of its sour biting taste like the nip of a crab. As soon as our ancestors began to improve it, and enlarge it, and make it more succulent and sweet, the vascular system or stringy material was interfered with; it was reduced relatively to the size of the fruit, and a softening of the fibre occurred. As a consequence, there is a delicacy of constitution introduced and a feebleness in the power of the rapid transport of food materials, so that we have to counteract this tendency to a weak conducting system by appropriate methods of treatment.

In seeking to determine important points of difference between Cleopatra and Yates, which might possibly explain their different behaviour towards Bitter Pit, it is necessary to extend the observations or experiments over several seasons, and obtain results in different districts.

In the matter of the amount of juice in the fruit, for instance, ripe specimens from different orchards showed sometimes a greater amount of juice in Cleopatra and sometimes in Yates during the past season. In the previous season specimens taken from the same orchard showed a greater amount of juice in Yates than in Cleopatra, so that this factor varies in different seasons and even in the same season.

In the young wood of Yates, analysis showed a much higher percentage of phosphoric acid and magnesia, as compared with that of Cleopatra, but these are only the results for a single season. From the practical point of view these chemical differences cannot be controlled by the orchardist, but they may throw light upon the hidden causes which influence the development of Bitter Pit.

In order to determine the differences, if any, in the minute structure of the wood, as regards the vessels of Cleopatra and Yates, I selected one, two, and three-year-old wood of each, bearing fruit-buds, from the Burnley Horticultural Gardens. Numerous transverse sections were made, and as the medullary rays radiating from the pith to the cortex are very regularly distributed I was thereby enabled to count the number of the vessels, bounded on each side by the medullary rays.

At the same time their diameter was carefully measured in micro-millimeters or microns, which are approximately $\frac{1}{25000}$ of an inch, and as the shape is somewhat oval, the longer and shorter diameter was determined. The average number and diameter of the tubes is shown in the following table, but the length of the tubes is not taken into account.

Table XIV.—Average Number of Tubes between the Medullary Rays and their Diameter in Cleopatra and Yates respectively.

	Number of Tubes.		Diameter of Tubes.	
	Cleopatra.	Yates.	Cleopatra.	Yates.
One-year-old wood ..	18	18	26 × 21	33 × 25
Two-year-old wood ..	27	27	32 × 23	31 × 29
Three-year-old wood ..	45	61	34 × 25	34 × 28

An increase in the number of tubes is only shown in the three-year-old wood of Yates, and the difference in diameter is not great, but on the whole it is in favour of Yates. Taking the results of a single season, the larger number of tubes and their greater diameter in Yates will allow a freer flow of sap, and if this ensures a more regular supply of nourishment to the growing fruit it will tend to reduce the liability of Pit.

In a constitutional disease such as this, there is an evident possibility of starting from an immune stock, and this may either be obtained by crossing or from a chance seedling. I have already crossed immune Yates with susceptible Cleopatra, the object being to get the size and quality of Cleopatra combined with the immunity from Pit of the Yates. This is necessarily slow work, but once the proper strain has been secured, it can be multiplied indefinitely.

A seedling apple tree, supposed to be from the Irish Mother, has been raised and grown by Mr. W. McKeown, at his Glenone Orchard, Dromana. It has been named "Glenone" by Mr. E. E. Pescott, and bears large and beautifully-marked fruit with a delightful aroma, and is so far free from Bitter Pit (Frontispiece). It was grafted on to a Ben Davis stock, and came into bearing in 1911. This season it produced between 4 and 5 bushels of fruit, which ripened early in March, and is suitable for both culinary and dessert purposes.

A cross between Cleopatra and Rome Beauty has already been referred to, raised by Mr. Robin, of Nuriootpa, and named "Clerome." It is considered to resist Pit as well as its seed-parent, Rome Beauty, in that district. By the above means a disease-resisting variety may be reared of commercial value, and since there is no question of a parasite being concerned in this disease, there is no danger of a complication arising from breeding adapted races of the pest at the same time.

V.—LATERALS IN THEIR RELATION TO BITTER PIT.

What promised to be a very instructive experiment with regard to the fruit borne by laterals was initiated during season 1913-14, but owing to the failure of the crop during the past exceptional season, only one of the varieties bore fruit on the lateral selected.

Boston Russet was the solitary variety which bore two fruits on the lateral as compared with nine the preceding year, which were all clean when picked. Of the two fruits one was clean when picked and the other (a windfall) was pitted.

The tree itself only bore eight fruits, of which five windfalls were clean, and of the remaining three which were picked two were clean and one pitted.

There were twelve fruit spurs on this lateral in July, 1914, but the severe frost of 16th October destroyed most of the blossoms.

Fourteen trees were selected for this experiment, but the results of a single season cannot be accepted as conclusive.

VI.—EFFECT OF RINGING AND FRACTURING THE BRANCHES.

The respective branches were ring-barked in six different months in 1912, and the operation was rather severe as about one inch of bark was removed right round. On account of the earliness of the season, the fruit was picked in February instead of March, as in the previous year.

In no case was the wound completely healed, but the callus from the upper and lower margins had almost met here and there on the branches rung in August and September. On the latter the strongest callus of all had developed, and this had been maintained from the start.

It is interesting to follow the order in which the ringed branches shed their leaves entirely, as shown in the following table. The last to lose their leaves were those branches which had been the earliest and the latest rung. The remainder of the tree had completely shed its leaves on 8th July, or two months later than the earliest of the rung branches (Fig. 8.):—

TABLE XV.—RESULTS OF RINGING THE BRANCHES OF ANNIE ELIZABETH APPLE TREE AT BURNLEY HORTICULTURAL GARDENS.

Date of Ringing.	Clean No.	Pitted. No.	Total Yield No.	% Pitted.		Shedding of Leaves.
28th June, 1912	17	5	22	23		15th May
30th July, 1912	39	49	88	56	49	7th ,,
29th August, 1912 ..	8	8	16	50		7th ,,
30th September, 1912 ..	16	0	16	—		10th ,,
30th October, 1912 ..	16	5	21	24	14	10th ,,
6th November, 1912 ..	22	4	26	15		15th ,,
Total for ringed branches ..	118	71	189	37		
Remainder of tree ..	84	40	124	32		8th July
Windfalls	132	15	147	10		
	216	55	271	20		
Entire tree ..	334	126	460	27		
Check tree ..	48	25	73	34		
Windfalls ..	48	10	58	17		
	96	35	131	26		

SUMMARY.

This experiment was continued for three seasons on a vigorous-growing Annie Elizabeth apple tree about fourteen years old, at the start. As regards the effect on the development of Pit, there was invariably less when the cinctures were made in the spring than in the winter months, and when done in the month of September there was least of all. When the results obtained from the check tree are compared with those from the partially cinctured tree, there is practically little difference in the amount of Pit, but as regards yield, the latter had two to three times more fruit than the former.

The checking of the sap-flow in the month of September, when it normally moves more freely with the advent of spring, resulted in a diminution of the Pit, and for the past two seasons there was none at all.

Constricting the branches by means of wire was also tried, but the wire used was too thick, and in no instance has it been overgrown. The fall of the leaves was not affected in any way, and the results are of no value.

Constricting the trunk by girdling with a zinc band has been in operation for two seasons, but the results given in connection with the Pruning Experiments do not indicate any influence upon the development of Pit.

In 1913 several Cleopatra trees had a limb purposely fractured as shown in Report III., Fig. 24, in order to determine the effect on the development of Pit. When the fruit was gathered in 1914, there were very few pitted apples on any of the trees, and a comparison with the fruit from the fractured limbs did not show any striking differences. During the past dry season only one of the broken branches bore fruit. Of the five miserable-looking specimens one was clean, two were pitted and two were "crinkled," which is rather an unusual occurrence in Cleopatra. The clean apple was two inches in diameter, and the others were smaller, one of which only reached $1\frac{5}{8}$ inches in diameter. There was only one apple on the rest of the tree, and it subsequently rotted.

"RINGED" PEAR TREES.

In the Second Progress Report reference was made at p. 31 to old pear trees which had been completely rung and yet continued to bear fruit for several years.

The Williams pear tree at Box Hill, Victoria, about 40 years old when rung in July, 1910, bore more and better fruit for three consecutive years than formerly. A photograph taken in February, 1913 (Fig. 30), shows the pears still attached to the tree, and they were of fine flavour and juicy. Next season the tree produced an abundance of blossom, and fruit was formed, but it never ripened. In February, 1914, the shrivelled fruit was still hanging on the tree, which was apparently dead.

A Josephine pear tree near Bathurst, between 50 and 60 years old, was rung in April, 1912. In the two succeeding years it produced better crops than the owner ever remembered. It was visited in May, 1915, by the Manager of the Bathurst Experiment Farm, and he reports :—"The old pear tree is moribund, and one large limb nearest the house has been removed. Many of the remaining branches are dead. There are green leaves almost about to fall on one portion. The owner informed me that the crop was light this season, but the pears matured satisfactorily. It would appear it cannot live through another season."

These examples show that pear trees can mature their fruit for at least three seasons after being rung. The pears produced were sound, but since neither Pit nor "Crinkle" was found in the fruit of the adjoining normal trees, no conclusions can be drawn as to the effect of "ringing" on Bitter Pit.

VII.—THE EFFECT OF DRY AND SATURATED MOIST AIR ON DETACHED AND GROWING APPLES.

It is an undoubted fact that the pitted pulp-cells contain less moisture than the adjoining healthy cells. They are dry and shrivelled compared with the distended cells of the normal tissue. This loss of water can either be accounted for by greater transpiration in these particular cells or by a deficiency in the water-supply.

In order to throw light on this phase of the question, experiments were conducted with apples still growing on the tree and apples detached, both being kept in air saturated with moisture, and in dry air. It is well known that dry air encourages transpiration, while moist air retards it, and if the loss of moisture in the pitted cells was due to greater transpiration, then the apples kept in dry air would be expected to develop a greater proportion of Pit.

(*a*) DETACHED APPLES.

Experiments with clean detached apples were carried out independently by Dr. Rothera and myself, and the comparative results are instructive. The apples were all taken from the same tree of the Annie Elizabeth variety, which had already produced badly pitted fruit.

TABLE XVI.—AMOUNT OF PIT DEVELOPED IN DETACHED APPLES IN DRY AND MOIST AIR RESPECTIVELY.

Test.	Commencement.	Duration.	Temperature.	No. of Apples.	Pitted.
Dry Air ..	7th January	29 days	79°-87° F.	20	1 Apple
Moist Air .. (Rothera 1)	,,	,,	79°-83° F.	24	3 Apples
Dry Air ..	8th February	28 days	83°-85° F.	18	2 Apples
Moist Air .. (Rothera 2)	,,	,,	80°-83° F.	18	1 Apple
Dry Air ..	21st April	44 days	54°-55° F.(June)	8	—
Moist Air .. (McAlpine)	,,	,,	,,	8	1 Apple

With the comparatively small number of apples tested and the slight amount of Pit developed there was no striking difference between them. Two apples at the most were pitted in dry air, and three in moist air, so that there is no particular advantages shown one way or the other.

In order to make the test decisive, it would be necessary to experiment with a much larger number of susceptible apples, and to have them X-rayed at the outset so as to determine those which were already pitted without showing any visible sign.

It is worthy of note that the apples kept in moist air were juicy and crisp, and almost as good as when picked, while those in dry air were shrivelled in the skin and tough. This justifies the advice given in Report I., that when apples were kept in an ordinary store-room the air should not be too dry.

(*b*) GROWING APPLES.

This experiment was carried out to test the effect of keeping apples on the tree, constantly in an atmosphere saturated with moisture during the growing period, as compared with others on the same tree growing naturally. Under such conditions the transpiration is considered to be reduced to a minimum, and the effect on the growth of the apple and on the development of Bitter Pit was noted.

The tree selected in the Burnley Horticultural Gardens was Strathden, an obsolete variety, on account of one limb having been left unpruned and spreading out somewhat horizontally. This limb bore 22 apples, and a canvas hammock arranged beneath it was kept daily full of water, so that the growing apples were constantly surrounded by a moist atmosphere. This particular branch shed its leaves before the other portions of the tree, and the fruit reached a normal size.

There were eight windfalls, and the remaining 14 apples were picked on 4th February when ripe. Every apple was pitted and some of them very badly.

The rest of the tree bore 14 apples, of which 11 were pitted or 79 per cent. In order to properly appreciate this result, it is necessary to remember that while humidity of the air lessens transpiration, this effect is modified by the degree of heat which increases transpiration up to a maximum varying in different plants. The horizontal branch was fully exposed to the sun's rays, and the early fall of the leaves left the fruit unprotected.

The temperature of the air has therefore to be taken into account, and it is found that the action of insolation or exposure to the sun's rays is stronger when the air contains much water vapour than when it contains but little.

The exceptional season through which we have passed was noted for its high temperature, and Mr. Hunt, Commonwealth Meteorologist, remarks on the weather experienced in Victoria :—" These results have established no fewer than five new records, the highest maximum temperature on any one day, the highest mean daily maximum for the month, the highest mean temperature, the highest mean barometric pressure, and the lowest rainfall." So that before any definite conclusions could be drawn, the experiment would require to be repeated in a normal season.

VIII.—THE INFLUENCE OF SHELTER ON THE DEVELOPMENT OF PIT.

Four healthy Cleopatra trees growing in a row in rather an exposed situation were selected in North and Brady's orchard, on the Tamar (Figs. 9, 10). Two in the middle were surrounded by a screen of waterproof white duck cloth on 12th October, 1914, when the trees were in bud, but not in blossom. The other two on the outside were retained as a check.

As might have been expected, the sheltered trees grew towards the light, and the new growth for the season measured 39 inches. When the screen was removed the two trees were conspicuous by their height all over the orchard (Figs. 11, 12).

As compared with the adjoining trees, the leaves were of a pale green, but this was partly due to " Red Spider." Both " Red Spider" and Woolly Aphis were very bad on the screened trees, and the young wood looked as if sprinkled with snow. When examined in February the crop was lighter than on neighbouring trees, but the apples were quite as large, only still green and not coloured.

The apples were picked on 17th March, with the following result :—

	Yield. lbs.	Clean. lbs.	Pitted. lbs.	Pitted. %
Sheltered Trees ..	34	26	8	23
Unsheltered Trees	45	32	13	29

There was not a great difference in the relative amount of Pit, still the sheltered trees were least affected.

It is always an advantage to have the trees well sheltered from the prevailing winds, but in practice this is done by means of wind-breaks, which while breaking the force of the wind, allow a free circulation of air and sunlight. At the same time the transpiration is reduced, when the drying effects of the wind are moderated.

IX.—OLD APPLE AND PEAR TREES IN THEIR RELATION TO BITTER PIT.

Although the view that senile decay is the cause of Bitter Pit, is no longer seriously entertained, there is still an interest attaching to very old and generally neglected trees in relation to Bitter Pit. In very old apple and pear trees it is instructive to note their behaviour towards this disease.

TASMANIA.

While visiting the experimental plots on the Tamar in February, 1915, I also examined a very old apple tree at York Town (Figs. 16, 17). York Town, at the head of Western Arm, and about five miles from Beaconsfield, was founded in 1804, by Lieut.-Governor Paterson, who intended to make it the capital of Northern Tasmania. But by 1806 the site was found so unsuitable that Paterson moved his headquarters to the present site of Launceston. The following reference to the old apple tree at York Town is made in Ernest Whitfeld's "The River Tamar," reprinted from the Launceston *Examiner* of 1912:—"All that now remains of this settlement is a now ancient apple tree. It still bears fruit, some of which occasionally finds its way to the city, where it is exhibited in the windows as a curiosity." And again: "One apple tree still remains and bears fruit, in spite of many years of neglect."

The antiquity of the tree is undoubted, and I have verified this from various records. In West's "History of Tasmania" (1852) reference is made to Colonel Paterson, who had gained considerable reputation as a botanist, and it is there stated: "He planted trees; some are still growing amidst the desolation of York Town." The tree was cut back in 1907 by order of the Government Inspector, on account of the fruit being very subject to Codlin Moth, and grafted with a variety which only bore one apple this season. It had Codlin Moth, but no Pit, and the name of the variety was determined to be English Codlin or Kentish Codlin.

Fig. 17 shows it in 1904 before being cut back, and Fig. 16 as it appeared in February, 1915. The trunk was 38 inches in circumference, and the stump to the left was decayed in the centre and filled with cement to strengthen it. The bark on the older portion was cracking and peeling off all over, while the young wood was badly infested with Woolly Aphis. The tree was in full leaf with an abundance of healthy foliage. This is probably the oldest apple tree in Australia, and is now 110 years old, a living memento of the first of those apple trees grown on the Tamar, the banks of which are now studded with flourishing orchards.

In the City Park, Launceston, there is an old Jargonelle pear tree, shown in full bloom in Fig. 13. It produced this season about a dozen bushels of fruit, and the pears I examined and tasted were all healthy and well flavoured. I have made careful enquiries as to the age of this tree, and am indebted for information to Mr. John Gunning, of the *Daily Telegraph*, Launceston, and Mr. McGowan, Curator of the Gardens. It was planted about 1832, when a number of fruit trees were received at Launceston from the Royal Horticultural Society of England, so that it is now over 80 years of age. Trees of this variety often live 200 years in England.

NEW SOUTH WALES.

The old apple and pear trees planted at "Brucedale," Bathurst, in 1824, and referred to in Report II., are still vigorous and bearing. They are now over 90 years of age (Figs. 18, 19, 20).

With reference to the apple trees, Mr. Herbert C. Suttor, of "Brucedale," writes under date 28th February, 1915:—"The Stone Pippin apple trees are still alive and bearing. They had a big crop on this year, but the winds and hot weather have put most of the fruit off. I have never known the fruit pitted, nor anything the matter with it except Codlin Moth.

The Jargonelle and Windsor pear trees planted at the same time bear heavy crops each year, and the latter is sometimes badly affected with "Black Spot."

The land is rich alluvial black soil, and an adequate supply of water to the orchard is provided by means of irrigation. I am indebted for the excellent photographs to Mr. Peacock, manager of the Bathurst Experiment Farm.

VICTORIA.

Bailey's Bergamot pear tree is shown in Fig. 21, growing in Glenone Orchard, Dromana. It is 50 years of age, and in some seasons yields as much as 40 bushels of fruit. No trace of Bitter Pit or "Crinkle" has appeared in the fruit.

X.—THE PREVALENCE OF BITTER PIT IN ITS RELATION TO THE WEATHER—SEASON 1914-1915.

It has been a surprise to many orchardists that, during the season of drought through which we have passed, and the small crop of apples produced, in many instances total failures, there should nevertheless be a considerable amount of Pit. But as has already been pointed out, it is not a strong transpiration in dry air, nor a weak transpiration on dry soil, that induces Bitter Pit. It is the amount relatively to the water-supply which is the important factor, and when this amount fluctuates with the varying humidity, the conditions for Pit are most favourable. If the table of rainfall is examined it will be found that, notwithstanding the drought, during the two important fruit-growing months of November and December, there was a rainfall of from three to six inches at all the experimental stations, with the exception of Yanco. But the subsoil had become so dried up, that this rain did not produce the result in the fruit it might otherwise have done, and its growth was by fits and starts, not slow and steady. At the Burnley Horticultural Gardens, the first appearance of Bitter Pit was observed in the Williams' Favourite variety early in December, when the apples were between one-third and one-half grown. The disease was very pronounced even at that early stage. Lord Suffield was also observed to be pitted about the same time, and this tree affords a good illustration of the conditions under which Pit originates. It was grafted on to a Northern Spy stock in September, 1913, and bore a cluster of six fruits next season, two of which were removed in order to allow the remainder to grow properly. It is an early cooking variety, and Figs. 27, 28 show it in the middle of January, when ready for picking, with every fruit badly pitted.

The greatest amount of growth in the fruit took place in November and December, when after a very dry spell intermittent showers occurred, the rainfall reaching nearly three inches in December. The rank growth of the fruit on a young tree bearing only a few apples indicated an excess of moisture. Rapid growth of the tree is always accompanied by excessive transpiration, and when the loss of water by transpiration exceeded the amount of the water supply, it produced the degree of concentration of the cell-sap which resulted in Bitter Pit.

Perhaps the most convincing way of showing the prevalence of Bitter Pit last season will be not to make general statements which are necessarily vague, but to cite particular instances. In the various experimental plots in the different States, where fruit was produced, the amount of Pit has been accurately determined, and this will at least give some definite information as to its occurrence under known conditions.

The minimum and maximum amounts are as follows :—

Victoria—Burnley Gardens.	N.S.W.—Bathurst.	Queensland—Stanthorpe.	S. Australia—Blackwood.	W. Australia—Mt. Barker.	Tasmania—Tamar.	New Norfolk.
5-50%	1½-20%	4-33%	3-12%	15-40%	7-46%	46-100%

The above refers solely to apples, but in individual orchards the disease occurred in pears and quinces. I am indebted to Mr. Carmody, Chief Supervisor of Orchards, for the varieties of pears affected in Victoria. They were Beurré Bosc, Beurré de Capiaumont, Gansell's Bergamot, Golden

Beurré, Josephine de Malines, Marie Louise, Williams, and Winter Nelis. Bitter Pit does not usually occur to any great extent in pears.

It is very rare in the quince; and an illustration is given in Figs. 14 and 15.

LARGE APPLES.

I had a number of very large apples sent from Tasmania in April, belonging to different varieties, which are known to be subject to Bitter Pit, viz., Gloria Mundi, Alfriston, Peasgood Nonsuch, Prince Alfred and Lord Wolseley (Fig. 29).

The heaviest belonged to the Gloria Mundi variety, and weighed 1 lb. 10½ ozs., while it measured 5 inches in diameter. The five apples in Fig. 30, belong to the Gloria Mundi and Alfriston varieties, weighing individually from 1 lb. 9 ozs. to 1 lb. 10½ ozs. The seventeen apples shown in Fig. 29 comprise Gloria Mundi, Peasgood Nonsuch, Prince Alfred and Lord Wolseley, and weigh on an average 1 lb. 2 ozs.

The Gloria Mundi was pitted slightly, while Alfriston was very bad. Owing to the severe drought, this was not the most favourable season for producing large fruit, and the Gloria Mundi variety has been larger and heavier on previous occasions. The tree is 14 years old, and yielded five bushel cases of fruit, of which about 20 per cent. were pitted.

RAINFALL.

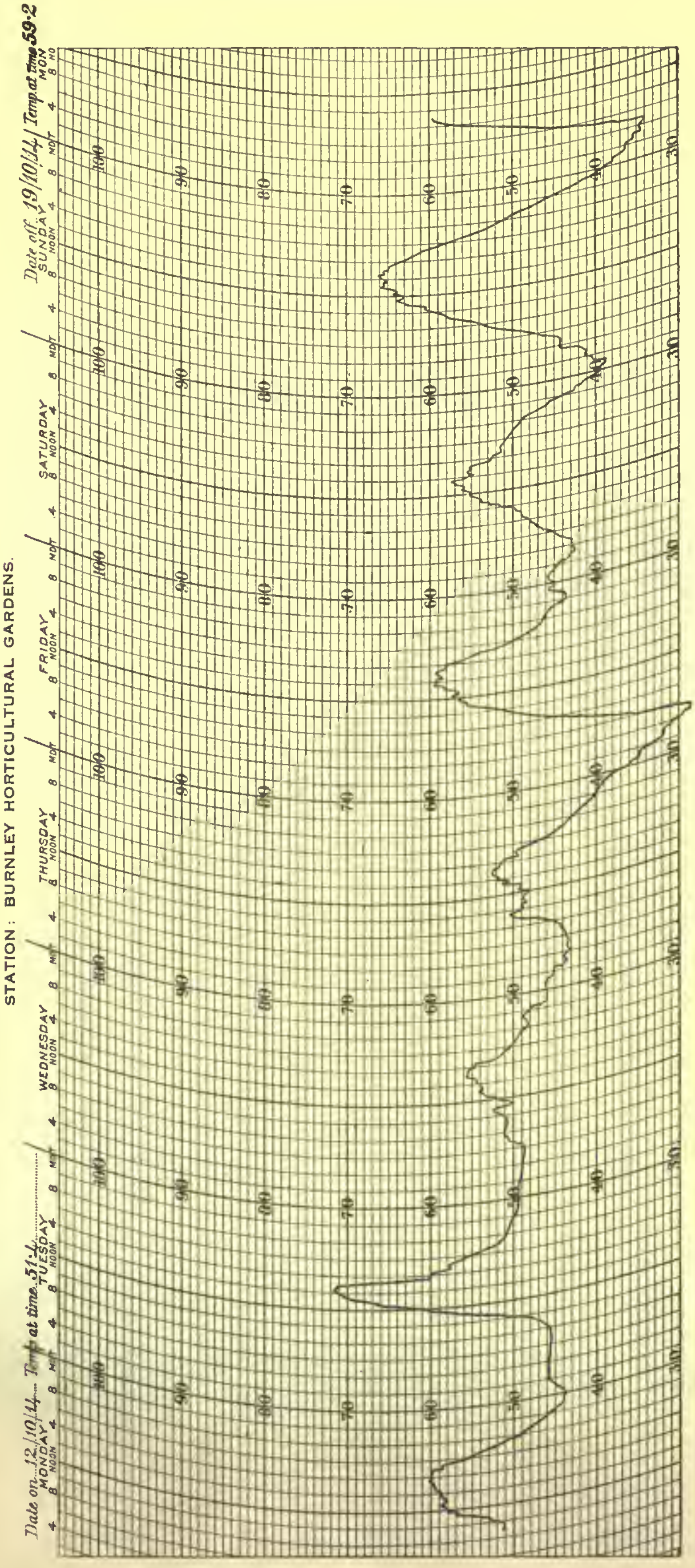
The monthly rainfall is here recorded for the past year, and for the first three months of the present year at the principal stations where experiments were conducted. Owing to the exceptional character of the season, it is considered more convenient to give the figures all together for comparison instead of recording them separately under their respective headings, as was previously done. This arrangement will show what a wide variation in the amount of rainfall occurred at the different stations during the 15 months covered by this return, ranging from 12½ inches at Harcourt, Victoria, to 32 inches at Stanthorpe, Queensland. A few general remarks on the nature of the season will be given in connection with each of the principal experiments.

I am indebted to Mr. H. A. Hunt, Commonwealth Meteorologist, for kindly supplying the necessary information, and a summary of the weather conditions during the fruit season is given in Appendix I.

MONTHLY RAINFALL, 1914-15.

1914.	Burnley (V.)	Box Hill (V.)	Harcourt (V.)	Dromana (V.)	Bathurst (N.S.W.)	Yanco (N.S.W.)	Stanthorpe (Q.)	Blackwood (S.A.)	Mt. Barker (W.A.)	Tamar (T.)	New Norfolk (T.)
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Jan. .	1·21	1·57	·15	1·74	1·34	·04	2·06	·81	·04	1·08	·49
Feb. .	—	·08	·03	·20	1·26	·42	1·80	·20	2·65	·04	·17
Mar. .	1·65	2·63	1·53	·85	4·46	2·05	6·08	1·06	1·80	·87	1·28
April .	1·61	·97	1·61	2·02	1·54	·72	2·88	2·35	1·36	4·79	3·84
May .	1·64	3·20	1·40	2·69	1·83	1·05	3·81	2·57	2·72	3·88	·91
June .	1·73	1·48	·47	1·65	·87	·43	2·03	1·17	2·31	1·53	·58
July .	1·50	2·35	1·42	4·17	2·01	·14	·68	2·72	4·18	1·73	1·76
Aug. .	·65	·60	·57	·86	·05	·07	·31	·48	1·31	·84	1·87
Sept. .	·93	1·35	·15	1·94	1·15	·09	1·04	·69	1·09	·58	1·31
Oct. .	·48	·30	—	·25	2·27	—	2·46	·18	1·81	·60	·38
Nov. .	1·63	1·72	1·15	2·43	3·46	·40	2·13	2·25	3·75	1·06	1·52
Dec. .	2·82	3·18	1·86	2·98	2·27	·84	3·00	·58	2·14	2·93	1·67
Total	15·85	19·43	10·34	21·78	22·51	6·25	28·28	*15·06	25·16	19·93	15·78
1915.											
Jan. .	1·50	1·51	·83	3·06	·26	·06	3·36	·45	·63	1·28	·39
Feb. .	·42	·77	·96	·76	1·08	·20	·43	·02	2·34	·67	·71
Mar. .	·38	·12	·37	·51	2·28	·26	·36	·47	1·37	1·15	1·68

*Average Rainfall for 6 years=27·94.



Thermograph Record, 12th to 19th October, 1914, showing temperature below freezing point on 16th.

XI.—RECORD OF RESULTS IN RELATION TO BITTER PIT FOR FOUR YEARS IN SUCCESSION.

It is a well-known fact that a variety may be subject to Bitter Pit under one set of conditions and free or comparatively free in another, that it may vary in its susceptibility from year to year, and that it is only after an experience of several years, the extent of its liability can be reasonably determined in any given locality.

In order to give practical demonstration of this, I have selected a hundred from the numerous varieties of apples grown in the Burnley Horticultural Gardens, and shown the presence or absence of Pit in each, during the four years covered by this investigation. In addition to this, in order to make the list as instructive as possible, I have given the stock on which each variety is grafted, the age of the tree, the date of full bloom, the ripening season of the fruit, and the yield (Appendix II.).

Eleven of these varieties showed no signs of Pit, viz., Dougherty, Etowah, Frogmore Prolific, Golden Reinette, Hoary Morning (English), Holding, Horn, Prince of Pippins, Ribston Pippin, Rosemary Russet, and White Winter Pearmain.

Of these the fruit generally ripens medium to late, and they are on a variety of stocks. Some are on Northern Spy stock, others on Paradise on Spy, and one (Dougherty) on Annie Elizabeth on Spy, both of which stocks are very liable to Pit.

While Dougherty was free from Pit for four years in succession at Burnley Gardens, a tree growing at Ringwood, 15 miles from Melbourne, in rather damp soil, bore pitted fruit to the extent of 24 per cent. The fruit was picked on 31st May, when ripe (Figs. 31, 32).

This variety was grafted on to Northern Spy stock, on Winter Majetin, growing on Spy roots, about three years ago. It bore fruit for the first time this season, and of the 25 apples on the tree, six were pitted.

Groups.—Although there is such an infinite variety among apples, yet when closely examined, it is found that some have such a general resemblance among themselves, that they may be arranged in types or groups. In this way we recognize a Northern Spy group, a Pomme de Neige or Fameuse group, a Baldwin group, and so on. It is worth while enquiring if these resemblances to each other also extend to their liability to Pit, and by taking those varieties which are grown under similar conditions in the Burnley Gardens, a fair comparison may be made.

The Northern Spy is seen to be pitted every year in succession, and Baldwin practically the same, while Pomme de Neige was either free or only slightly pitted.

Baldwin may be taken as the type of a variety liable to Pit, so much so that in America, Bitter Pit is known as "The Baldwin Spot." It is thus described by Beach and others in *The Apples of New York:* "The Baldwin Spot is the name given to brown flecks in the flesh of Baldwin apples. This is not caused by either insects or fungi. It is a physiological defect, which is more apt to appear in overgrown than in medium-sized fruit. No remedy is known."

Belonging to this Baldwin group there is Tuft's Baldwin, Esopus Spitzenburg and Jonathan. In the list of 100 varieties (Appendix II.) Baldwin and Tuft's Baldwin are badly pitted, while Esopus Spitzenburg and Jonathan are only slightly so. So that the grouping of apples according to their general resemblances is not always a guide to their pitting properties.

Stocks.—Every one of the 100 varieties listed in Appendix is on Spy stocks, some direct and some with intermediate stocks, so that we cannot compare the results among themselves with other stocks. But if the distribution of Pit is analyzed in the varieties on Spy stocks alone, of which there are 17, it is found that four are free, six are very slight to slight, and seven are bad to very bad with Pit.

The general evidence, therefore, does not favour the view that the stock influences the Pit, but that the nature of the scion is the determining factor.

XII.—THE PRACTICAL EXPERIENCE OF THE ORCHARDIST.

The experience gained by orchardists in the course of a long and successful career has been laid under contribution, and the value of it is shown in many of the practices followed out by them. The scientific spirit is always willing to learn, and the physiological principles which underlie practical horticulture can only be properly investigated when the facts based upon experience are recognised.

Thus Roger Bacon, in the thirteenth century, wrote :—"Many things are known to the simple and unlearned which escape the notice of the wise." And Faraday, in the nineteenth century, uttered a similar sentiment :—"Whilst passing through manufactories, we are constantly hearing observations by those who find employment in these places, and are accustomed to a minute observation of what passes before them, which are new or frequently discordant with received opinions. These are generally the result of facts, and though some are founded in error, some on prejudice, yet many are true and of high importance to the practical man. Such as come in my way I shall set down here, without waiting for the principle on which they depend."

One of the most prominent of our present-day Victorian orchardists is Mr. James Lang, of Harcourt, and I am fortunate in being able to give a summary of his views with regard to profitable apple-growing. Although Bitter Pit is not mentioned in this article, the various operations detailed, from the choosing of a site, the preparation of the land, and planting, leading up to the well-established orchard with trees carrying a regular crop of good fruit every year, illustrate in a practical way some of the best means for controlling Pit. Whatever influences the life of the tree, enabling it to produce regularly the best fruit of which it is capable, also influences the amount of Pit in varieties liable to it.

There is one important point, however, on which Mr. Lang has not touched, simply because it is too wide, and that is the varieties of apple to plant. One will be guided in his choice by the requirements of the market and the suitability of the district for certain varieties. The varieties grown in the principal apple-growing centres of each State have already been given in Report III. An old orchardist contends that the best advice to a man about to plant an orchard is, "Go where Bitter Pit is not prevalent, or to some district where it is prevalent only in a few varieties, which can be omitted from the planting list without seriously affecting the commercial prospects of the orchard."

THE CULTIVATION OF THE APPLE.—CHOOSING THE SITE OF THE ORCHARD.

The selection of the site of an orchard is a very important matter, as the success of an orchard depends in a great measure on the site selected. The best site to select is one having a north-easterly aspect, well sheltered from the west and southerly winds. The least suitable is one having a southerly aspect. In districts north of the Dividing Range (Victoria), where late spring frosts sometimes occur, the orchards facing south generally suffer severely from frosts, especially in low-lying localities, such as along the banks of a creek or low flat land. As the cold air settles down on these low situations on a calm frosty night, the young apples are very frequently destroyed. Such frosts may, in some districts, occur as late as the tenth of November, destroying the whole crop of fruit. In districts near the coast within the influence of the sea atmosphere, late spring frosts are unknown. Orchardists should, therefore, be careful in choosing a site to select one not subject to late spring frosts.

SOIL.

Apples will grow in a great variety of soils, the most suitable being a deep sandy loam of a granitic character. The granite soil around Mt. Alexander is eminently adapted for the growth of the apple, as in the many well-established orchards of that district the apple reaches its highest stage of development, and the longevity of the tree is frequent. In the oldest orchards, planted fifty years ago, the trees are still bearing heavy crops of fruit.

It is a mistake to plant an orchard on our rich agricultural land. The trees grow well for a few years, but they grow too much wood and do not develop fruit-buds and crops in reasonable abundance. It is now recognized by our experienced orchardists that fruit trees of all kinds grow and produce good crops of fruit on poor lands that are not suitable for agricultural purposes. Poor gravelly soil with a friable clay sub-soil about eighteen inches deep also produces good fruit.

PREPARATION OF THE LAND FOR PLANTING.

In preparing the land for planting, if virgin soil has been selected, all timber and stumps, roots, etc., should be cleared off to a depth of at least eighteen inches. Then the whole of the land should be ploughed to a uniform depth of at least six to eight inches, and if the subsoil be loosened up to a further depth of eighteen inches, it would be very much better, as the subsoil being stirred up thoroughly it would retain the moisture throughout the summer to the great advantage of the young trees. On no account should holes two feet or so deep be dug in which to plant the trees, as if the subsoil is at all stiff the water will be retained to the great injury of the tree. The preparation of the land should always be done thoroughly, as planting an orchard is not like planting a field of wheat. An orchard has to last a lifetime or more, and will well repay any extra care in the preparation of the land. The distance at which apple trees should be planted has caused considerable diversity of opinion in past years, but experienced orchardists now recommend twenty feet as the best distance at which to plant trees in a commercial orchard. This will take about one hundred trees to the acre.

In planting, a hole a little larger than the spread of the roots should be dug, then as much soil as will form a small mound should be placed in the bottom of the hole. The tree should be placed on the top of the mound, with the roots spread carefully out and with a downward tendency ; some loose soil may be filled in and trampled firmly around the tree, then the rest of the soil should be filled in after. When finished, the tree should stand at the same depth as it was when growing in the nursery bed. Deep planting should always be avoided, as trees deeply planted never thrive so well as when the operation is carefully done.

During the first year the ground should be deeply stirred by the scarifier, the spring tooth cultivator being the best implement for the purpose. This frequent stirring conserves the moisture and prevents evaporation. Land treated in this manner remains moist all through the driest summer, the trees getting the benefit of the moisture, making a strong growth for the first year of planting. This treatment should be continued in subsequent years. By this means the young trees make a vigorous growth and soon make large trees.

In the planting of new orchards the cultivation of the land is of far more importance than is generally recognized, as upon this operation depends, in a great measure, the success of the orchard in the early stages of development. Unless the trees make a strong growth when young, they are apt to become stunted and never make the satisfactory orchard tree. Indeed, in two adjoining orchards, one treated as above and the other looked after in a slipshod manner, the difference in a few years is marvellous. In the properly cultivated orchard the trees show a dark green, luxuriant foliage and clean, smooth stems, while the neglected orchard will have a sickly, stunted appearance, the trees having made but poor growth as compared with the other. It is this thorough cultivation of the soil which makes all the difference between a successful commercial orchard and one that is a comparative failure.

DRAINING.

Underground drainage is a great factor in the success of an orchard, for by draining off superfluous water in the winter time and thoroughly aerating the soil, the trees are enabled to resist the attacks of Black Spot (*Fusicladium dendriticum*) more successfully.

Money expended on a thorough system of drainage will give a handsome return for the outlay, and if orchardists, instead of planting and extending their orchards, would put the money into drainage, they would in many cases get a very much better return. The distance apart which drains should be constructed depends a good deal upon the nature of the soil. In soils that have a stiff clay subsoil, a drain should be laid between every row of trees twenty feet apart; while in soils that are fairly open, a distance of forty feet might be sufficient. In many cases it may be advisable to put the drains at forty feet, and if this does not effectively drain the soil, another drain might be put in between, making them twenty feet apart. Drains should be at least two and a half feet deep, and main drains three feet deep. Draining tiles form the most satisfactory drains, as they are not so liable to get choked as those made of stone. Tiles two and a half to three inches in diameter are mostly used; while four-inch tiles for main drains would be required.

PRUNING.

Pruning is resorted to in order to increase the vigour of the tree, as, by cutting back and reducing the branches, the whole supply of the sap goes to the remaining portion, causing a great luxuriance of growth. In pruning apple trees the pruner must have a knowledge of the habit of the particular variety he is operating on, as some of our apples bear chiefly on the lateral branches, such as Jonathan and Rome Beauty; while other varieties, such as Reinette de Canada and Ribston Pippin, form short fruit-spurs along the main branches. More mistakes have been made in pruning Jonathan than any other variety. This tree throws out a great number of lateral branches, and it has been the practice of many orchardists in the past to shorten back these lateral branches, and in many cases to cut them out altogether, with the idea that fruit-spurs shall, later on, be produced. But instead of doing so the trees throw out a large number of weaker lateral shoots. These are again cut off, with the result that no proper fruit-buds are formed, and as the main branches that continue to grow on the body of the tree, instead of being furnished with a good supply of fruit-bearing wood, become quite bare, it is then a very difficult matter to get a good supply of fruit-spurs. In pruning a Jonathan tree the first year, three or four branches should be left well spaced from the stem, so that they will form a well-balanced head, shortening these shoots back by cutting away about two-thirds, leaving about one-third on the young tree. The following year the trees will have made a fairly good growth, the main branches having thrown out a good supply of lateral shoots. It is these lateral branches which will go towards the forming of the future fruit-bearing wood. If these laterals are too numerous, a few of them may be cut out; the others should be left to their full length. On no account should the ends be cut off, as in that case they would grow only further without producing fruit-buds. The main branches should be cut back as in the previous year. The next year the lateral branches that were left to their full length will have developed a succession of fruit-buds. These laterals may now be slightly shortened back, cutting to a fruit and not to a wood bud. The main branches will have made further growth in regard to lateral branches, and these should be dealt with as in the previous year. The lateral branches that are left, as they form fruit-buds, will require to be shortened back a little every year, so that in a few years proper fruit-spurs will have been formed. A tree that has been pruned in this manner will in a few years be well furnished with fruit-spurs from the fork of the tree, along the main branches, and also along the laterals. Rome Beauty and other kinds of the same growth may be pruned in a similar manner to the Jonathan. The other varieties that naturally form short fruit-spurs on the branches may be improved by having a few of the smaller lateral branches left for a year or two, and when fruit-buds are formed they may be cut back for half their length. (In the matter of pruning there is room for difference of opinion, and the retention of the laterals has been found to reduce Bitter Pit. In Report III., p. 22, the position is thus stated:—"The lateral system of pruning must be adopted in place of the spur development of the leaders if Bitter Pit is to be kept in check. When the laterals do not overcrowd the tree, they should be retained and left untouched; when they are too numerous towards the centre, they can be thinned out; and when they require strengthening for the load of fruit they have to bear, they can be shortened back.")

STOCKS.

The stock now universally adopted for the propagation of the apple is the Northern Spy stock. This is perfectly immune from the attacks of Woolly Aphis, and as it makes very fibrous roots and is a strong, vigorous grower, it is an ideal stock on which to work the apple. The stock should be worked at least six inches from the ground, as if worked on the surface the scion is apt to throw out roots which will be attacked by Woolly Aphis. The Winter Majetin is sometimes used as a stock for the apple, but it is now losing favour with orchardists, as it has the habit of throwing out long naked roots without any fibres ; and sometimes one strong root will grow out at one side, so that, when the tree grows fairly large, with a crop of fruit it is very liable to be blown over by a gale of wind. For these reasons it is not advisable to use the Winter Majetin as a stock.

IRRIGATION.

To get the very best results from a full-bearing orchard, it is necessary that a good supply of water should be available during the summer months. Even in districts having an average annual rainfall of twenty-six inches a good supply of water during January, February, and March would be very beneficial, as it is during these months that the greatest drain on the soil for moisture occurs, and the rainfall at that time on an average is very light. The orchardists of Doncaster, Victoria, have now recognized this, and they are constructing dams at a great expense for the purpose of conserving all the water they possibly can to use during the summer for irrigation.

MANURING.

The manuring of orchards is of the greatest importance to fruit-growers, as when the orchard comes into full bearing it will be necessary to put back into the soil those substances that have been taken out by the various crops of fruit. If an orchard be planted on fairly good soil, well managed and cultivated, no manuring will be necessary until the orchard comes into full bearing and has produced good crops of fruit for a few years. When that time arrives it will be very necessary, if the orchard is to be kept in a good state of fertility and productiveness, to manure regularly every year. The most essential elements of plant food taken from the soil by a crop of fruit are nitrogen, phosphoric acid, and potash, and these have to be replaced by artificial manure. The best and most economical way to apply nitrogen to the soil is by green manuring with a cover crop of field peas. As early in autumn as possible, about the month of April, the orchard should be ploughed and sown with field peas at the rate of two bushels to the acre. They should be in flower and thus ready to plough in, the beginning of September. A heavy roller should first be run over the peas to crush them down, then they should be ploughed in. This should completely cover up the peas, and to assist, the plough should be fitted with a revolving coulter to cut the crop. By this method, not only is nitrogen added, but humus also. Phosphoric acid is best applied in the form of superphosphate of lime 16 per cent. and potash by sulphate of potash 52 per cent. These should be applied at the rate of three cwt. of superphosphate and one and a half cwt. of potash to the acre. Before applying, the two should be mixed together thoroughly and sown broadcast. As the roots of the trees in a full-bearing orchard are spread all over the ground, it would be a mistake to merely apply the manure under the trees. The best time to apply the manure is when the peas are being ploughed in. After the peas are rolled, the manure should then be applied and the crop ploughed under. Stable manure, wherever it is available, should be applied to the orchard, but the supply is generally limited. It is therefore necessary to substitute artificial manures in its place. Lime, applied at the rate of three cwt. per acre every second year, is also very beneficial. The chief value of lime lies not so much in its value as a manure, but in the mechanical effects it produces in the soil and its power to free unavailable potash salts.

THINNING.

When an orchard reaches the full bearing stage, the trees sometimes bear a very heavy crop of fruit one year and little, if any, the following year. To counteract this habit it is necessary to reduce the heavy crop, first by regulating the fruit-spurs, and secondly by thinning out the fruit. During the pruning season any trees that may have a large number of fruit-spurs should have them thinned out or shortened back. This should be done so that the spurs are evenly distributed over the tree, so that the crop of fruit for the trees to carry the following year may be somewhat restricted. Thinning the fruit is also carried out in many orchards with great advantage, especially with the Yates variety, which is naturally a small apple. If these trees are allowed to mature all of the crop of fruit that has set, the remaining fruits are of small size and of little commercial value. Whereas, had the crop been thinned by the removal of at least one-third, the remainder would grow to a much larger size and would be of very much greater value. It would also have the effect of regulating the crop of fruit, because if thinning is properly carried out, the trees carry a more regular crop of good fruit each year, instead of every alternate year as in the days of the old go-as-you-please method. (Figs. 33, 34, 35, 36, 37.)

XIII.—THE INFLUENCE OF THE SOIL ON BITTER PIT.

DROMANA ORCHARDS.

There are two orchards belonging to Mr. McKeown, about half a mile apart, at Dromana, on the shores of Port Phillip Bay. They are situated under the shelter of Arthur's Seat, with a northerly aspect. The one named "Glenone" was planted at intervals since 1892, and now consists of ten acres, about one-half of which is under apples. Jonathan is the most common variety grown, and Cleopatra comes next. The soil is a sandy loam, and it is undrained, since drainage is not considered necessary on account of the good depth of soil.

The Cleopatra trees generally bear good crops, and are subject to Bitter Pit, but it was noticeable that it was comparatively slight compared with the adjoining orchard.

As the two orchards are under the same management and receive similar treatment, and since the Bitter Pit is particularly bad in the one and comparatively slight in the other, it seemed desirable to account for the difference if possible, and thus throw some light on the conditions favouring the disease.

The other, named "Gracefield," was planted eight years ago, and the trees are consequently much younger, which would partly account for their greater susceptibility to Pit. But the soil is altogether different, having a stiff clay bottom at a depth of eighteen inches, so that it became necessary to determine how far the difference in chemical composition and physical condition of the soil affected the development of Bitter Pit. A visit to the orchards in the middle of February showed great differences in the amount of Pit in the Cleopatras.

In the "Glenone" orchard the crop was light, and there were only forty-eight apples on the tree photographed (Fig. 38). Of these, forty-one were clean and seven slightly pitted, or 14 per cent. of Pit. In a case of Cleopatras from the "Gracefield" orchard eighty-eight were found to be pitted, and only five clean, or 94 per cent. pitted.

ANALYSIS OF SOILS.

The soils from both orchards were carefully sampled by the Government Agricultural Chemist to a depth of two feet.

In the "Glenone" orchard there was a depth of eighteen inches of sandy loam, then nine inches lighter in colour, and below that it changed to a yellowish colour.

In the "Gracefield" orchard there was a depth of eleven and a half inches of light loam not so dark in colour as the other, then about six and a half inches whiter in colour, and at bottom five and a half inches of a stiff, yellowish-brown clay. At a depth of two feet the clay commenced to get marly. The following report on the samples of soil was received from Mr. P. R. Scott, Chemist for Agriculture :—

REPORT ON SAMPLES OF SOIL FROM DROMANA.

	Gracefield Orchard.			Glenone Orchard.		
	Surface—11½″	11½″—18″	18″—24″	Surface—8″	8″—17″	17″—24″
Nitrogen—parts per 100,000	136	34	50	150	45	28
Phosphoric acid ,, ,,	36	16	17	36	17	26
Potash ,, ,,	63	46	249	50	50	48
Lime ,, ,,	114	98	98	266	90	82
Magnesia ,, ,,	114	91	446	85	55	62
Chlorine ,, ,,	2	4	14	2	2	2
		Slightly Acid			Slightly Acid.	
	%	%	%	%	%	%
Fine gravel	2·88	4·04	5·13	10·09	12·00	13·12
Coarse sand	14·17	14·91	12·05	21·04	25·56	26·30
Medium sand	11·02	11·80	8·04	12·14	13·35	12·34
Fine sand	19·13	21·85	12·58	18·30	17·26	16·58
Very fine sand	16·80	17·84	6·01	15·76	10·71	8·39
Coarse silt	7·47	8·95	3·25	2·10	2·80	3·29
Fine silt	10·80	9·14	4·36	6·57	6·49	6·45
Clay	11·78	9·77	39·09	6·68	10·05	11·53
Moisture	1·21	0·45	3·50	1·10	0·36	0·51
Loss on ignition	4·74	1·25	5·99	5·62	1·42	1·49

GRACEFIELD.—This soil, when compared with what a good soil may be expected to contain, is found to have a fairly high percentage of nitrogen, with a poor content of phosphoric acid, potash, and lime. A typical good fruit soil, however, is generally found to be one that is considerably below the nominal quality of a first-class agricultural soil. A rich soil would be conducive to strong growth. A light soil having less abundance of plant food constituents is therefore more adaptable to the successful growth of the plant. Typical soil well adapted to fruit growing should contain the greater bulk of the earthy material as sand and silt—about 60 per cent, and about 10 per cent. of clay. This soil then contains more clay than would be considered as essential for a good orchard soil, and may be classed from its physical condition as of indifferent quality for fruit growing.

GLENONE.—This soil, when compared with what a good soil may be expected to contain, is well supplied with nitrogen, but its content of phosphoric acid and potash is poor. A soil suitable for fruit is generally low in plant food constituents, as more seems to depend on success to the mechanical composition of the soil. Better results are to be anticipated from a soil which contains about 60 per cent. of silt and fine sand, with about 10 per cent. of clay, and the balance as fine gravel and coarse sand. Soils of this description are generally poor in plant foods. The above soil will, therefore, be considered as one possessing good physical conditions for the cultivation of fruit.

The physical condition of the soil plays a very important part in the production of fruit, for it is well known that poor lands quite unsuitable for agricultural purposes are best adapted for the growth of fruit trees and the bearing of good crops of fruit.

The most important difference between the two soils lies in their physical condition. The soil from the "Gracefield" orchard, which is the worst for Pit, possesses only a poor physical condition, as the clay is in too large a proportion when compared with the other ingredients ; while the "Glenone" soil is in good physical condition, the clay being in that proportion essential to good fruit growing.

Whatever improves the physical or mechanical condition of the soil would seem, therefore, to aid in reducing the amount of Pit. The absorption and retention of moisture largely depends upon the texture of the soil, and suitable tillage increases its capacity, as well as the addition of humus, if necessary, in the form of green manuring. To maintain a regular supply of moisture, especially at the fruit-growing season, is one of the great requirements for the production of healthy fruit, and to keep this water moving in the soil, so as to carry with it the plant food in solution and to draw the atmospheric air after it, is promoted by drainage.

As regards the chemical constituents, the magnesia is in much larger proportion in the "Gracefield" soil, and in excess of the lime content; but what effect this may have on the fruit grown upon it we do not know. A considerable amount is known to exist in chlorophyll, and it is probably a constituent of the living substance itself. There are soils, however, such as those at Bacchus Marsh (see Irrigation Experiments), which contain a superabundance of magnesia, and yet the apples produced there are of high quality and not particularly liable to Bitter Pit. It is generally considered advantageous to have an ample proportion of lime in such soils, and Hilgard, in his work on "Soils," sums up our present knowledge :—"In general it is best that lime should exceed magnesia in amount."

MAY BROS.' ORCHARD, SANDFORD, TASMANIA.

In this orchard, where Cleopatras are grown every year in considerable quantities, even to the extent of thousands of cases, there has never been any serious loss from Bitter Pit.

The age of the trees varies from about ten to over thirty years. The system of pruning adopted is rather light. The orchardists state that "it would probably be considered rather on the light side, as we leave more branches on the tree than is usually the case." The nearest part of the orchard to the beach is just about eighty yards from high-water mark, and it is protected by sandhills, which are overgrown by a natural shelter of trees and bushes. The soil is a very light sand, not unlike that upon the beach, and most of it has a clay subsoil, which is frequently from eight to ten feet below the surface.

Although the season was the driest on record, the rainfall being under thirteen inches, there has seldom been a finer crop of Cleopatras, either for size or quality, with scarcely a trace of Pit.

The Cleopatra is well known to be superior to Yates in the quality of drought resistance, and the former thrives best in a rather dry climate and on a very light soil.

That soil and climate exercise an important influence on the development of the disease in varieties subject to Pit is evident from the above, which is given as a typical example.

XIV.—EXPERIMENTS CONDUCTED UNDER NATURAL CONDITIONS WITH A VIEW TO CONTROLLING THE DISEASE.

A.—MANURIAL EXPERIMENTS.

The main object of these experiments has been to determine the influences of the various fertilizers upon the development of Pit, and incidentally the yield in relation thereto. They have been conducted in each of the States, with the exception of Tasmania, under the most varying conditions of soil and climate. At the end of four years the manures have begun to produce their special effects and to give indications of the direction in which they act. All the various results have now to be compared and co-ordinated in order to see chiefly what fertilizers increase or diminish the Pit.

No attempt will be made to enter into detail as to the effect of the individual manures, but to give the essential points as a basis for comparison throughout. The fertilizers yielding the greatest and least amount of Pit in each State will be singled out and contrasted with the highest and lowest yields. In this way some general conclusions may be arrived at, as to the relation between Pit, yield, and fertilizers.

1.—AT H. H. HATFIELD'S ORCHARD, BOX HILL, NEAR MELBOURNE.

The manures were applied in early winter, towards the end of June. They were similar to the preceding year, only in plot 4 green manuring was omitted, and in plot 6 field peas were sown on 29th June, as well as fine unburnt limestone applied.

There was no crop this season, owing principally to a severe frost on 16th October, but a combination of hot winds and Thrips contributed to the result. The trees have not grown as much as usual, owing to the drought, but they are quite healthy, and have every appearance of a heavy crop next season.

There was a gradually decreasing rainfall during the four years over which the experiments extended, and the consequence was that the subsoil had become dried up. In the four years from 1911 to 1914 there were respectively 35, 25, 20, and 19 inches of rain annually, and if the important first six months of each year are compared, it is seen that the same order holds good.

TABLE XVII.—SUMMARY OF THREE YEARS' EXPERIMENTS, EIGHT TREES IN EACH OF THE NINE PLOTS.

Plot No.	Manure.	Yield. 1912 lbs.	Yield. 1913 lbs.	Yield. 1914 lbs.	Total Yield. lbs.	Per cent. Pitted. 1912	Per cent. Pitted. 1913	Per cent. Pitted. 1914	Total Pitted. lbs.	Per cent. Pitted for 3 years.
1	Sulphate of ammonia; Ordinary superphosphate; Sulphate of potash	1025	220	947	2194	·54	62	6	204	9
2	Sulphate of ammonia; Special bonedust; Ordinary superphosphate; Sulphate of potash	611	373	682	1666	·24	31	9	183	11
3	Sulphate of ammonia; Ordinary superphosphate; Kainit	825	377	633	1835	1·50	25	12	183	10
*4	Ordinary superphosphate; Sulphate of potash	895	130	910	1935	·28	36	7	118	6
5	Check—no manure	446	571	300	1317	1·30	33	10	228	17
†6	Fine unburnt limestone	865	284	856	2005	·61	32	8	166	8
7	Ordinary superphosphate; Sulphate of potash	894	11	757	1662	·67	63	6	60	4
8	Ordinary superphosphate; Sulphate of ammonia	645	173	412	1230	·15	44	6	102	8
‡9	Sulphate of iron	(627)	220	453	1300	(4·5)	26	8	121	14 (for 2 years)
	Totals ..	6833	2359	5952	15144				1365	

*Green Manuring, 1913-14. †Green Manuring, 1912-13. ‡No Sulphate of Iron in 1912.

SUMMARY FOR THREE YEARS.

In all the other manurial experimental plots the trees are of the Cleopatra variety. These are Esopus Spitzenburg, and at the beginning of the experiment in 1911 they were fourteen years old.

In summarizing these results, it has to be borne in mind that these manurial experiments have been undertaken to see the effect of certain manures or combination of manures on the development of Bitter Pit, and incidentally on the yield.

If the final year of bearing (1914) be taken as the standard, as one in which there had been a good average crop, after the manures had been applied for three years in succession, it is found that the amount of Pit is comparatively small, the highest being 12 per cent., and the lowest 6 per cent. Whereas, in the off season of 1913, when the crops were exceedingly light, the amount of Pit reached up to 63 per cent., and the lowest was 25 per cent.

If we compare the amount of Pit in 1914 in the various plots, it is found that the highest was in plot 3, where kainit replaced sulphate of potash in a complete fertilizer, and the lowest was in three plots equally, viz., 1, 7, and 8, consisting of a complete fertilizer, a complete fertilizer without ammonia, and a complete fertilizer without potash respectively.

The unmanured plot was next to the highest in the amount of Pit. The largest crop was produced in plot 1, with a complete fertilizer; and the lowest in plot 5, which was the check plot and unmanured.

If the average is taken for the three years during which the trees bore, the unmanured plot had the highest percentage of Pit, and the lowest was in plot 7, with superphosphate and sulphate of potash.

The highest average yield was in plot 1, with a complete fertilizer, and the lowest in plot 8, with superphosphate and sulphate of ammonia.

A complete fertilizer generally produces the largest crop, and the least amount of Pit occurs with a complete fertilizer without ammonia. The lowest yield was in plot 8, *with superphosphate and ammonia; and the greatest percentage of Pit in plot* 2, *with special bonedust added to the complete fertilizer. The unmanured plot had absolutely the greatest amount of Pit.*

2.—At Government Farm, Bathurst, New South Wales.

The experiments have now been continued for four years in succession, and the fertilizers should have produced their full effect.

The orchard comprises 41 acres, of which 35 were planted in 1896, and the Cleopatra trees used in the experiment are now about 19 years old. The manure was applied on 28th July, 1914, and the fruit was gathered from 11th to 23rd March, 1915.

The rainfall for the past year was 22½ inches, and as the average for the past 54 years is 23½ inches, it may be considered satisfactory. In the early spring the rainfall was comparatively light, and early frosts occurred—12 degrees on the 26th, and 9 degrees on the 27th September. On account of its earliness the crop was not affected. Early in the year the season was too dry to mature the crop properly, so that the fruit was generally of medium size.

Table XVIII.—Manurial Experiments with Cleopatra Apple Trees at Bathurst Experiment Farm—Season 1914-15.

Plot No.	Manure.	Tree. No.	Sound Fruit. lbs.	Pitted Fruit. lbs.	Total. lbs.	Per cent. Pitted.
1	Check—no manure ..	1	143	26	169	15·38
		2	106	9	115	7·82
		3	212	7	219	3·19
		4	127	9	136	6·61
		5	222	32	254	12·59
		6	70	10	80	12·50
		Total ..	880	93	973	
		Average ..	146·66	15·5	162·16	9·56

TABLE XVIII.—MANURIAL EXPERIMENTS WITH CLEOPATRA APPLE TREES, ETC.—*continued.*

Plot No.	Manure.	Tree No.	Sound Fruit. lbs.	Pitted Fruit. lbs.	Total. lbs.	Per cent. Pitted.
2	Ordinary superphosphate, Sulphate of potash ..	1	34	1	35	2·85
		2	191	5	196	2·55
		3	126	2½	128·5	1·94
		4	192	10	202	4·95
		5	147	10	157	6·36
		6	109	3	112	2·67
		Total ..	799	31½	830·5	
		Average ..	133·17	5·25	138·42	3·76
3	Ordinary superphosphate, Sulphate of ammonia ..	1	161	3	164	1·82
		2	151	2	153	1·30
		3	112	4	116	3·44
		4	137	19	156	12·18
		5	101	2·5	103·5	2·41
		6	155·5	12	167·5	7·16
		Total ..	817·5	42·5	860	
		Average ..	136·25	7·08	143·33	4·93
4	Check—no manure ..	1	162	7	169	4·14
		2	143	5	148	3·38
		3	179	15	194	7·73
		4	150	22	172	12·79
		5	56	3·5	59·5	5·88
		6	80	7	87	8·04
		Total ..	770	59·5	829·5	
		Average ..	128·33	9·92	138·25	7·17
5	Ordinary superphosphate, Sulphate of potash ..	1	129	16	145	11·03
		2	157	22	179	12·29
		3	126	11·5	137·5	8·36
		4	147	12	159	7·54
		5	125	17	142	11·97
		6	169	17	186	9·14
		Total ..	853	95·5	948·5	
		Average ..	142·17	15·91	158·08	10·06
6	Sulphate of ammonia .., Sulphate of potash ..	1	130	4	134	2·98
		2	177	11	188	5·85
		3	160	42	202	20·79
		4	214·5	25	239·5	10·45
		5	183	12	195	6·15
		6	144	8	152	5·26
		Total	1008·5	102	1110·5	
		Average ..	168·09	17	185·09	9·18

TABLE XVIII.—MANURIAL EXPERIMENTS WITH CLEOPATRA APPLE TREES, ETC.—*continued.*

Plot No.	Manure.	Tree No.	Sound Fruit. lbs.	Pitted Fruit. lbs.	Total. lbs.	Per cent. Pitted.
7	Check—no manure ..	1	207	1·5	208·5	0·72
		2	186	0·25	186·25	0·01
		3	211	17	228	7·45
		4	209	7·5	216·5	3·46
		5	134	29	163	17·79
		6	198	11	209	5·26
		Total ..	1145	66·25	1211·25	
		Average ..	190·83	11·04	201·87	5·47
8	Sulphate of ammonia .. Sulphate of potash .. Special bonedust ..	1	177	17	194	8·76
		2	169	6	175	3·43
		3	95	3	98	3·06
		4	172	7	179	3·91
		5	198	6	204	2·94
		6	170	16	186	8·60
		Total ..	981	55	1036	
		Average ..	163·5	9·17	172·67	5·31
9	Ordinary superphosphate Sulphate of ammonia .. Sulphate of potash ..	1	183	6	189	3·17
		2	139	21	160	13·13
		3	220·5	11	231·5	4·75
		4	133	4	137	2·92
		5	173	25	198	12·63
		6	212	8	220	3·64
		Total	1060·5	75	1135·5	
		Average ..	176·75	12·5	189·25	6·60
10	Sulphate of iron ..	1	404	20	424	4·71

SUMMARY FOR SEASON 1915.

The heaviest yield was obtained from a single tree, to which 1 lb. of sulphate of iron had been applied, and no tree in any of the other plots had approached it. The yield was 424 lbs., or 10½ bushel cases.

There were 3 unmanured plots of 6 trees each, and the average yield per tree was 167 lbs.; while in the manured plots it was 164 lbs.

The average percentage of Pit varied from 10 to 3·76, the lowest being in plot 2, which also had the lowest average yield, and the highest in plot 5, with superphosphate and potash.

Of the fertilized plots the highest average yield per tree, viz., 189 lbs., was obtained from plot 9, with superphosphate, potash, and ammonia ; and the lowest average yield, viz., 138 lbs., from plot 2, with superphosphate and potash.

In the three unmanured plots the percentage of Pit was 9·56, 7·17, and 5·47 respectively.

TABLE XIX.—RESULTS OF THREE YEARS' MANURIAL EXPERIMENTS WITH CLEOPATRA AT BATHURST EXPERIMENT FARM, NEW SOUTH SALES—SEASON 1911-15.

Plot No.	Manure.	Per Tree.	Tree No.	Sound Fruit.				Pitted Fruit.				Total.				Per cent. Pitted.				Per cent. Pitted for 4 years.
				1912.	1913.	1914.	1915.	1912.	1913.	1914.	1915.	1912.	1913.	1914.	1915.	1912.	1913.	1914.	1915.	
		lbs.		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.					
1	Check—no manure ..	..	1	219	119¼	132½	143	4½	¼	16	26	223½	119½	148½	169	2·01	0·20	10·77	15·38	
			2	228	163½	79	106	5	4	9	9	233	167½	88	115	2·14	2·39	10·22	7·82	
			3	181	198½	78	212	2	2	4½	7	183	200½	82½	219	1·09	1·00	5·45	3·19	
			4	244	55¾	83½	127	5	1	14	9	249	56¾	97½	136	2·01	1·76	14·36	6·61	
			5	277	37	84½	222	1¼	1¾	11¾	32	278¼	38¾	96¼	254	0·45	4·51	12·20	12·59	
			6	190	123½	30	70	1½	..	6	10	191½	123½	36	80	0·78	..	16·66	12·50	
			Total	1339	697½	487½	880	19¼	9	61¼	93	1358¼	706½	548¾	973	..	..	..	..	
			Average	223	116·25	81·25	146·66	3·208	1·5	10·21	15·5	226·37	117·75	91·46	162·16	1·42	1·27	11·16	9·56	5·0
2	Sulphate of potash .. Ordinary superphosphate	1½ 4¾	1	133	25	29½	34	¾	..	1¾	1	133¾	25	31¼	35	0·56	..	5·6	2·85	
			2	297	144¼	63	191	8	¼	4	5	305	144½	67	196	2·62	0·17	5·92	2·55	
			3	214	144	144½	126	9	..	8½	2½	233	144	153	128·5	4·04	..	5·55	1·94	
			4	234	55	30	192	¼	4	4	10	234¼	59	34	202	0·10	6·78	11·76	4·95	
			5	265	25¼	80	147	¾	2½	9	10	265¾	27¾	89	157	0·28	9·00	10·11	6·36	
			6	194	73	86	109	¾	2½	8½	3	194¾	75½	94½	112	0·38	3·31	8·99	2·67	
			Total	1337	466½	433	799	19½	9¼	35¾	31½	1356½	475¾	468¾	830·5	..	..	..	..	
			Average	222·8	77·75	72·16	133·17	3·25	1·54	5·96	5·25	226·08	79·29	78·12	138·42	1·44	1·94	7·62	3·76	3·0
3	Sulphate of ammonia .. Ordinary superphosphate	1½ 4¾	1	261	123	193½	161	10	..	13¾	3	271	123	207¼	164	3·69	..	6·63	1·82	
			2	284	142¼	144½	151	16	1¼	17	2	300	143½	161½	153	5·33	0·87	10·52	1·30	
			3	172	41¾	104½	112	1	1	5½	4	173	42¾	110	116	0·58	2·34	5·00	3·44	
			4	281	79¾	158	137	5	5¼	26½	19	286	85	184½	156	1·75	6·18	14·35	12·18	
			5	185	60½	85½	101	¾	2	5½	2·5	185¾	62½	91	103·5	0·40	3·2	6·04	2·41	
			6	219	110	141	155·5	1¼	½	12½	12	220¼	110½	153½	167·5	0·57	0·45	8·14	7·16	
			Total	1402	557¼	827	817·5	34	10	80¾	42·5	1436	567¼	907¾	860	..	..	..	..	
			Average	233·6	92·87	137·83	136·25	5·66	1·66	13·46	7·08	239·33	94·54	151·29	143·33	2·36	1·76	8·89	4·93	4·4
4	Check—no manure ..	..	1	273	109¼	157	162	12	¾	19	7	285	110	176	169	4·21	0·68	10·80	4·14	
			2	238	112½	160	143	1	¾	18½	5	239	113¼	178½	148	0·42	0·66	10·36	3·38	
			3	137	113¼	180½	179	8	1½	26¼	15	145	114¾	206¾	194	5·51	1·31	12·70	7·73	
			4	53	158¾	105½	150	1	1	18	22	54	159¾	123½	172	1·85	0·62	14·57	12·79	
			5	29	92	23	56	1¼	1¼	1¼	3·5	30¼	93¼	24¼	59·5	4·93	1·34	5·15	5·88	
			6	119	29¾	82½	80	3	2¾	11½	7	122	32½	94	87	2·46	8·46	12·23	8·04	
			Total	849	615½	708½	770	26¼	8	94½	59·5	875¼	623½	803	829·5	..	..	..	..	
			Average	141·5	102·58	118·08	128·33	4·37	1·33	15·75	9·92	145·87	103·91	133·83	138·25	3·00	1·28	11·77	7·17	6·0

5	Sulphate of potash ..	1½	1	268	112½	161	129	3	..	11	16	271	112½	172	145	11·1	..	6·40	11·03	
	Ordinary superphosphate	4¾	2	203	64	144	157	9	4	13	22	212	68	157	179	4·24	5·88	8·28	12·29	
	Fine unburnt limestone	16	3	195	74½	109½	126	12	10	12¾	11·5	207	84½	122¼	137·5	5·79	11·83	10·43	8·36	
			4	171	37	142½	147	4¼	1½	9	12	175¼	38½	151½	159	2·42	3·89	5·94	7·54	
			5	180	49	98½	125	1¾	3	21½	17	181¾	52	120	142	0·97	5·77	17·91	11·97	
			6	251	77	111½	169	1½	1	9	17	252½	78	120½	186	0·59	1·28	7·47	9·14	
			Total	1268	414	767	853	31½	19½	76¼	95·5	1299½	433½	843¼	948·5	..	..	..	..	
			Average	211·3	69	127·83	142·17	5·25	3·25	12·71	15·91	216·58	72·25	140·54	158·08	2·42	4·50	9·04	10·06	6·3
6	Sulphate of ammonia ..	1½	1	233	113¼	96	130	7	2½	12¼	4	240	115¾	108¼	134	2·91	2·16	11·32	2·98	
	Sulphate of potash ..	1½	2	293	84	211½	177	9	11	6¾	11	302	95	218¼	188	2·98	11·58	3·09	5·85	
	Fine unburnt limestone	16	3	152	51	56	160	8	3	5½	42	160	54	61½	202	5·00	5·55	8·94	20·79	
			4	317	61½	147	214.5	1¼	5½	10¼	25	318¼	67	157¼	239·5	0·39	8·21	6·52	10·45	
			5	220	54¼	82	183	1½	5¾	8¾	12	221½	60	90¾	195	0·68	9·58	9·64	6·15	
			6	237	38	76½	144	1½	5½	29	8	238½	43½	105½	152	0·63	12·64	27·49	5·26	
			Total	1452	402	669	1008.5	28¼	33¼	72½	102	1480¼	435¼	741½	1110.5	..	..	..	..	
			Average	242	67	111·5	168·09	4·70	5·54	12·08	17	246·71	72·54	123·58	185·09	1·91	7·64	9·77	9·18	6·2
7	Check—no manure ..	..	1	279	134	126	207	1¼	1	11¾	1.5	280¼	135	137¾	208·5	0·45	0·74	8·53	0·72	
			2	267	129½	90	186	..	1½	4¼	0.25	267	131	94¼	186·25	..	1·14	4·51	0·01	
			3	286	97	201	211	1	6	9½	17	287	103	210½	228	0·35	5·82	4·51	7·45	
			4	234	69¼	87	209	5	4½	3½	7.5	239	73¾	90½	216·5	2·09	6·10	3·87	3·46	
			5	227	15½	98	134	¾	1½	20½	29	227¾	17	118½	163	0·33	8·82	17·30	17·79	
			6	250	31	182	198	..	3¾	13¾	11	250	34¾	195¾	209	..	10·79	7·02	5·26	
			Total	1543	476¼	784	1145	8	18¼	63¼	66.25	1551	494½	847¼	1211.25	..	..	..	..	
			Average	257·1	79·37	130·66	190·83	1·3	3·04	10·54	11·04	258·5	82·41	141·21	201·87	0·52	3·69	7·47	5·47	3·5
8	Sulphate of ammonia ..	1½	1	294	77¼	128	177	1½	8¾	14	17	295½	86	142	194	0·51	10·17	9·86	8·76	
	Sulphate of potash ..	1½	2	286	91	221	169	1¾	..	7	6	287¾	91	228	175	0·61	..	3·07	3·43	
	Special bonedust	3½	3	149	65	132	95	..	1	5½	3	149	66	137½	98	..	1·51	4·00	3·06	
			4	119	24¾	107	172	3	2¼	16	7	122	27	123	179	2·46	8·33	13·00	3·91	
			5	310	64¼	177½	198	1½	7¾	15¼	6	311½	72	192¾	204	0·48	10·76	7·91	2·94	
			6	199	29¼	44½	170	4	10¾	10¾	16	203	40	55¼	186	1·97	26·87	19·46	8·60	
			Total	1357	351½	810	981	11¾	30½	68½	55	1368¾	382	878½	1036	..	..	..	..	
			Average	226·1	58·58	135	163·5	1·95	5·08	11·4	9·16	228·12	63·66	146·4	172·67	0·86	7·98	7·79	5·31	4·5
9	Sulphate of ammonia ..	1½	1	208	114½	180	183	4	¾	11	6	212	115¼	191	189	1·89	0·65	5·76	3·17	
	Sulphate of potash ..	1½	2	260	39	113	139	5	3	11	21	265	42	124	160	1·88	7·14	8·87	13·13	
	Ordinary superphosphate	4¾	3	272	76¾	158	220·5	14½	2½	4¼	11	286½	79¼	162¼	231·5	5·06	3·15	2·62	4·75	
			4	168	43	157¾	133	2	9¾	10	4	170	52¾	167¾	137	1·18	18·48	5·96	2·92	
			5	215	31¼	74	173	6	6¾	13½	25	221	38	87½	198	2·71	17·76	15·43	12·63	
			6	279	26	149	212	5	3	28¼	8	284	29	117¼	220	1·76	10·34	15·94	3·64	
			Total	1402	330½	831¾	1060·5	36½	25¾	78	75	1438½	356¼	849¾	1135·5	..	..	..	..	
			Average	233·6	55·08	138·62	176·75	6·08	4·29	13	12·5	239·75	59·37	141·62	189·25	2·54	7·22	8·57	6·60	5·6

NOTE.—Only in Seasons 1912-13 and 1913-14 was limestone applied to Plots 5 and 6.

SUMMARY FOR FOUR YEARS.

Taking the average yield per tree for four years to allow for the variation of the seasons, the unmanured plots (18 trees) show an average of 601 lbs.; while the manured plots (36 trees) show an average of 603 lbs.

There is practically no difference in the yield between the manured and the unmanured plots, but the effect of the manure is seen in the decidedly superior fruit.

The heaviest yield among the manured plots was given by the complete manure, consisting of superphosphate, sulphate of ammonia, and sulphate of potash ; while the lightest yield was from superphosphate and sulphate of potash.

As regards Pit, there is very little difference in the general average between manured and unmanured plots, the former being 5 per cent., and the latter slightly less, or 4.7 per cent. The use of fertilizers does not seem on the whole to influence Pit to any great extent.

The lowest amount of Pit was associated with the lowest yield in plot 2, with superphosphate and potash, just the same as in the final year of the experiment. The highest amount of Pit was in plot 5, with superphosphate and potash and fine unburnt limestone. It was practically the same in plot 6, with potash and ammonia and limestone added.

Highest yield in plot 9, *with superphosphate, potash, and ammonia. Lowest yield in plot* 2, *with superphosphate and potash. Largest percentage of Pit in plot* 5, *with superphosphate and potash, to which fine unburnt limestone was added in alternate years ; and practically the same in plot* 6, *with potash, ammonia, and limestone. Smallest percentage of Pit in plot* 2, *with superphosphate and potash.*

3.—At Mr. W. Roessler's Orchard, Stanthorpe, Queensland.

The manures were the same as those of the preceding year, only there was no green manuring in plot 5. They were applied on 22nd July, 1914.

The Cleopatra trees used in the experiment are 14 years old.

The rainfall for 1914 was 28 inches, just the average for the district, but it was exceedingly dry about the time when the fruit was maturing.

Although there was a good setting of fruit, there was a very poor yield in the plots, owing to the large amount of fruit which fell before maturing. This was no doubt partly due to the drought, which was considered to be more severe than any previously experienced. In addition to this, in the middle of January there were some high ranges of temperature and sudden changes, so that in the course of a few hours it fell from 105 to 58 degrees Fahr.

The size of the fruit ranged from medium to large. Although the crop was very light, the percentage of Pit was less than in previous years, and none of the apples were badly affected. Two cases of apples were forwarded to me on the 4th, and arrived on 17th March. When carefully examined, out of a total of 196 apples, 73 were pitted, thus showing a percentage of 37, which was much higher than that found in the fruit when picked from the tree.

Table XX.—Third Year's Manurial Experiments with Cleopatra at Mr. Roessler's Orchard, Stanthorpe, Queensland—Season 1914-15.

Plot No.	Manure.	Per Tree. lbs.	No. of Trees.	Clean Fruit. lbs.	Pitted Fruit. lbs.	Total. lbs.	Per cent. Pitted.
1	Sulphate of ammonia Ordinary superphosphate Sulphate of potash	1½ 4½ 1½	8	59	16	75	21
		7½					
			Buffer tree	10	5	15	33

TABLE XX.—THIRD YEAR'S MANURIAL EXPERIMENTS WITH CLEOPATRA, ETC.—*continued.*

Plot No.	Manure.	Per Tree. lbs.	No. of Trees.	Clean Fruit. lbs.	Pitted Fruit. lbs.	Total. lbs.	Per cent. Pitted.
2	Sulphate of ammonia Special bonedust Ordinary superphosphate Sulphate of potash	1½ 1½ 3 1½ — 7½ —	8	35	11	46	24
			Buffer tree	10	—	10	—
3	Sulphate of ammonia Special bonedust Sulphate of potash	½ 6 1½ — 8 —	8	82	10	92	11
			Buffer tree	18	3	21	14
4	Ordinary superphosphate Sulphate of potash	4½ 1½ — 6 —	8	32½	1½	34	4
			Buffer tree	6	1	7	14
*5	Crushed limestone		8	26	1	27	4
			Buffer tree	—	—	—	—
6	Ordinary superphosphate Sulphate of potash	4½ 1½ — 6 —	8	19½	1½	21	7
			Buffer tree	2	—	2	—
7	Sulphate of ammonia Ordinary superphosphate	1½ 4½ — 6 —	8	31	2	33	6

*No manuring 1912-13, and green manuring, in addition to limestone, 1913-14.

TABLE XXI.—SUMMARY OF THE LAST TWO YEARS' EXPERIMENTS.
EIGHT TREES IN EACH OF THE SEVEN PLOTS.

Plot No.	Yield. 1914. lbs.	Yield. 1915. lbs.	Total Yield. lbs.	Per cent. Pitted. 1914.	Per cent. Pitted. 1915.	Total Pitted. lbs.	Per cent. Pitted. for 2 years.
1	343	75	418	24	21	100	24
2	546	46	592	20	24	123	21
3	429	92	521	17	11	82	16
4	461	34	495	17	4	79	16
5	614	27	641	9	4	56	9
6	825	21	846	14	7	116	14
7	660	33	693	7	6	47	7

SUMMARY FOR TWO YEARS.

Under ordinary circumstances the last of the three years would have been chosen as a standard, but the amount of fruit on the trees was so small, compared with that which fell long before it matured, that it was out of the question. So I have taken the average of the last two years, both as to the amount of Pit and yield.

The highest amount of Pit was in plot 1, where a complete fertilizer was used. The lowest was in plot 7, in which potash was left out of the complete fertilizer.

As regards yield, the heaviest was obtained from plot 6, with superphosphate and potash; and the lightest from plot 1, with a complete fertilizer.

If the second year of the experiment be selected as a typical one, the results as regards Pit and yield are just the same.

The check row of 15 trees in the second year's experiment had 9·57 per cent of Pit; while the average of the manurial plots was 14·46 per cent., so that the fertilizers have not had the effect of diminishing the Pit. There were two plots slightly below the average of the check row—plot 7, with 7 per cent.; and plot 5, with 9 per cent. of Pit.

The average yield of the trees in the check row was 52 lbs., and of the manured trees 69 lbs. Ordinary superphosphate and potash gave the highest yield of 103 lbs. per tree.

A complete fertilizer gave the highest amount of Pit and the smallest yield. When potash was left out, there was the smallest percentage of Pit. The highest average yield was produced with superphosphate and potash.

4.—At Government Experiment Orchard, Blackwood, South Australia.

On account of the unpropitious nature of the season there has been a practical failure of the crops, each of the 39 trees only producing, on an average, 7 fruits. Nevertheless, the few fruits carried by the trees were carefully examined immediately they were removed, either by winds or by harvesting. The windfalls were considerably in excess, and the occasional pitted apple was found only among them.

The rainfall for the year was only 15 inches, as compared with 23 inches in 1913, and the average rainfall for six years has been about 28 inches.

The effect of green manuring with peas has not yet been tested at Blackwood, but Mr. Quinn informs me that a new plot will be established for this purpose later.

Table XXII.—Results of Manurial Experiments with Cleopatra Apples at Government Experiment Orchard, Blackwood, South Australia—Season 1914-15.

Test No.	Manure.	Per Tree. lbs.	No. of Trees.	No. of Fruits.	Clean. On Trees.	Clean. Windfalls.	Pitted. On Trees.	Pitted. Windfalls.	Per cent. Pitted.
1	No manure	—	3	42	30	12	—	—	—
2	Superphosphate	1	3	22	7	15	—	—	—
3	Superphosphate Lime	1 2	3	34	5	28	—	1	3
4	Superphosphate Sulphate of potash	1 $\frac{1}{4}$	3	28	10	18	—	—	—
5	Superphosphate Sulphate of potash Sulphate of ammonia	1 $\frac{1}{4}$ $\frac{1}{4}$	3	23	8	15	—	—	—
6	No manure	—	3	19	4	15	—	—	—
7	Superphosphate Sulphate of potash Sulphate of ammonia Lime	1 $\frac{1}{4}$ $\frac{1}{4}$ 2	3	24	11	13	—	—	—
8	Lime	2	3	18	8	10	—	—	—
9	Sulphate of potash Sulphate of ammonia	$\frac{1}{4}$ $\frac{1}{4}$	3	18	8	10	—	—	—
10	Superphosphate Sulphate of ammonia	1 $\frac{1}{4}$	3	19	5	13	—	1	5
11	Stable manure	56	3	14	3	11	—	—	—
12	No manure	—	3	25	9	16	—	—	—
13	Sulphate of iron	$\frac{1}{4}$	3	3	—	3	—	—	—

The yield was so small, and the amount of Pit so infinitesimal and so restricted, that no indication was afforded of the action of the manures.

TABLE XXIII.—SUMMARY OF FOUR YEARS' EXPERIMENTS.
THREE TREES IN EACH OF THE THIRTEEN PLOTS.

No.	Number of Fruits. 1912	1913	1914	1915	Total No.	Per cent. Pitted. 1912	1913	1914	1915	Total No. Pitted.	Per cent. Pitted for 4 years.
1	61	7	473	42	583	8	14	1	—	12	2
2	58	29	492	22	601	—	21	1	—	11	2
3	3	10	247	34	294	—	10	2	3	8	3
4	26	37	412	28	503	—	21	4	—	25	5
5	14	21	350	23	408	7	5	3	—	12	3
6	1	1	119	19	140	—	—	7	—	8	6
7	10	32	347	24	413	—	25	3	—	18	4
8	5	5	193	18	221	—	20	6	—	12	5
9	14	15	327	18	374	—	33	2	—	12	3
10	21	10	454	19	504	5	30	3	5	19	4
11	21	7	272	14	314	5	28	2	—	8	3
12	28	33	311	25	397	3.5	15	5	—	22	5.5
13	—	1	11	3	15	—	—	—	—	—	—
Totals	262	208	4008	289	4767					167	

SUMMARY FOR FOUR YEARS.

The trees are now six years old, and the results have been recorded for four seasons. Seeing that the same manures have been applied continuously since the trees were planted in 1909, the comparative results should afford some indication of their effects upon the fruit. But the value of this experiment will only be fully realized in the future, when the trees have come into full bearing and the differences in yield and Pit are more pronounced.

The heaviest yield was in plot 2, *with superphosphate only, and the lightest in one of the unmanured plots, but where fertilizers were used, it was in plot* 8, *with lime alone.*

The least amount of Pit was in plots 1 *and* 2, *the one with superphosphate and the other unmanured, and the greatest amount was also in the unmanured plots.*

5.—AT MOUNT BARKER ESTATE ORCHARD, WESTERN AUSTRALIA.

This is now the third season in which the manurial experiments have been conducted at this orchard. The trees were planted in the winter of 1905, so that they are nine years of age. The manures were applied on 14th and 15th July, and the crop was gathered in the beginning of March, the season being about three weeks earlier than the last. There was no spraying of any kind, as Codlin Moth is unknown in the district.

The rainfall in 1912 was 28·77 inches ; in 1913, 35·24 inches ; and in 1914, 25·16 inches. The rainfall was comparatively light during the winter, and the ground was so hard in the spring months that ploughing was exceedingly difficult. Then in November about 4 inches of rain fell, and 2 inches in December. After that the season was comparatively dry, only about half an inch falling in January ; and some of the hottest weather in the history of the State was experienced towards the middle and end of February. Otherwise the conditions were extremely mild. (Figs. 42, 43, 44, 45, 46.)

A severe storm raged in the district just the night before my arrival, littering the orchards with windfalls. This will account for the large proportion of windfalls in the experimental plots—about one-fifth of the whole. But as they were gathered immediately before any Pit could develop, the results were not affected in any way.

The soil of the orchard is variable, but samples were taken for analysis from the portion in which the experiments were conducted. The rubble was on the ridge, and the loamy soil adjoining. The subsoil was almost yellow sand with an average depth of 18 inches, with friable yellow clay beneath ; while the soil varied in depth from 9 inches to a foot.

CHEMICAL ANALYSIS OF SOILS.

	Rubble.		Loam.	
	Soil.	Subsoil.	Soil.	Subsoil.
Nitrogen—parts per 100,000	118	28	146	56
Phosphoric acid ,, ,,	71	104	84	86
Potash ,, ,,	4	9	45	49
Lime ,, ,,	218	124	206	104
Magnesia ,, ,,	72	94	88	105
Chlorine ,, ,,	7	6	8	6
Litmus paper reaction ,,		Slightly acid.		

Mr. P. R. Scott, Chemist for Agriculture, remarks:—"These soils would be considered of moderate quality. Whether they require an application of a complete fertilizer will largely depend on the age of the trees and the growth of same since planting. I should be inclined to the opinion that, given sufficient moisture, they would make steady growth. If the trees are inclined to make wood, an application of phosphoric acid and potash appears to be the ingredients required to encourage fruiting."

The conditions under which the following results were obtained have just been stated, and as the manures have been applied three years in succession, they should now have produced their full effect on the crop. The difference in the trees that had received no manure during the same period was very striking. The growth was poor and the foliage only medium, while the bulk of the fruit was of small size and non-commercial.

The application of manure ensures a crop every year in this particular variety, but in every instance the proportion of Pit was greater in the manured than in the unmanured, with the exception of the plot where peas had been sown in alternate years and dug in. And this suggests that in estimating the value of a manure for fruit production, the growth of a good crop of green stuff should be taken into account. For this reason I have indicated those manures which encouraged the greatest amount of green growth under the trees for ploughing in, although it must be remembered that such growth would rob the trees of a certain amount of moisture. On the other hand, the humus added to the soil would help to retain the moisture.

TABLE XXIV.—THIRD YEAR'S MANURIAL EXPERIMENTS WITH CLEOPATRA AT MOUNT BARKER ESTATE ORCHARD, WESTERN AUSTRALIA—SEASON 1914-15.

Plot No.	Manure.	Per Tree.	No. of Trees.	Yield.	Clean. On Trees.	Clean. Wind-falls.	Pitted. On Trees.	Pitted. Wind-falls.	Per cent. Pitted. On Trees.	Per cent. Pitted. Wind-falls.	Per cent. Pitted.
		lbs.		lbs.	lbs.	lbs.	lbs.	lbs.			
1	Sulphate of ammonia Ordinary superphosphate Sulphate of potash	1½ 4½ 1½ — 7½	8	889	304	76	333	176	52	70	57
2	Sulphate of ammonia Special bonedust Ordinary superphosphate Sulphate of potash	1½ 1½ 3 1½ — 7½	8	983	562	95	240	86	30	47	33

TABLE XXIV.—THIRD YEAR'S MANURIAL EXPERIMENTS WITH CLEOPATRA, ETC.—*continued.*

Plot No.	Manure.	Per Tree. lbs.	No. of Trees.	Yield. lbs.	Clean. On Trees. lbs.	Clean. Wind-falls. lbs.	Pitted. On Trees. lbs.	Pitted. Wind-falls. lbs.	Per cent. Pitted. On Trees.	Per cent. Pitted. Wind-falls.	Per cent. Pitted.
3	Sulphate of ammonia Special bonedust Sulphate of potash	½ 6 1½ 8	8	1136	578	95	303	160	34	63	41
4	Sulphate of ammonia Ordinary superphosphate Kainit	1½ 4½ 6 12	8	863	540	66	215	42	28	39	30
5	Sulphate of ammonia Thomas' phosphate Sulphate of potash	1½ 4½ 1½ 7½	8	641	418	38	148	37	26	49	29
6	Ordinary superphosphate Sulphate of potash (Green manuring with peas, 1913-1914)	4½ 1½ 6	8	935	304	76	407	148	57	66	59
7	Fine unburnt limestone alone	15	8	338	171	47	92	28	35	37	35
8	Ordinary superphosphate Sulphate of potash	4½ 1½ 6	8	1197	665	76	333	123	33	62	38
9	Sulphate of ammonia Ordinary superphosphate	1½ 4½ 6	8	1421	741	76	444	160	37	68	42
10	Special bonedust Sulphate of potash Sulphate of iron	6 1½ ½ 8	8	1291	722	76	370	123	34	62	38
11	Sulphate of iron	1	8	358	209	57	74	18	26	24	26
12	No manure (Green manuring with peas last season)	—	8	538	342	85	74	37	18	30	21
13	Fine unburnt limestone (Green manuring with peas last two seasons)	15	8	447	266	42	74	65	22	61	31
				11037	5822	905	3107	1203			39

TABLE XXIV.—THIRD YEAR'S MANURIAL EXPERIMENTS WITH CLEOPATRA, ETC.—*continued.*

CHECK PLOTS—NO MANURE.

Plot No.	Manure.	Per Tree.	No. of Trees.	Yield. lbs.	Clean. On Trees. lbs.	Clean. Wind-falls. lbs.	Pitted. On Trees. lbs.	Pitted. Wind-falls. lbs.	Per cent. Pitted. On Trees.	Per cent. Pitted. Wind-falls.	Per cent. Pitted.
14			8	318	194	57	49	18	20	24	21
15			8	394	277	57	42	18	13	24	15
16			8	488	323	50	92	23	22	31	23
		Total ..		1200	794	164	183	59			20

SUMMARY OF MANURIAL EXPERIMENTS—1914-15.

Plot No.	Clean Fruit. lbs.	Pitted Fruit. lbs.	Per cent. Pitted.	Remarks.
1	380	509	57	Fruit of very good size and healthy leaf.
2	657	326	33	Fruit of good size, and leaf firm and healthy.
3	673	463	41	Fruit slightly larger than 2, and growth better, with more foliage.
4	606	257	30	Fruit of good size, and leaf healthy.
5	456	185	29	Fruit very small, and leaf poor.
6	380	555	59	Fruit fairly large, and foliage bright and abundant.
7	218	120	35	Fruit small and firm, and foliage dark green.
8	741	456	38	Fruit large, and foliage good and bright.
9	817	604	42	Fruit a good commercial sample, but of small size ; foliage good and ample.
10	798	493	38	Fruit and foliage similar to 9.
11	266	92	26	Fruit very small, foliage poor, and colour medium.
12	427	111	21	Fruit average size, and foliage healthy.
13	308	139	31	Fruit small, and foliage rather poor.
		General average ..	40	

Confining our attention to this season's results, when the fertilizers will have had time to act, the effect upon the yield and the amount of Pit will be considered.

As regards the yield, the average per tree in the manured plots is 106 lbs., while it is only 50 lbs., or less than half, in the unmanured plots.

The heaviest yield was obtained from plot 9, with superphosphate and sulphate of ammonia ; and it is interesting to notice that the same plot had the heaviest yield for the three years in succession. The lightest yield was obtained from plot 7, with fine unburnt limestone alone ; and when green manuring with peas was added, there was not much improvement.

The check plots, where no manure was used, had all very light crops, and the bulk of the fruit was undersized and unmarketable. As regards the amount of Pit, it may be stated at once that it was least in the unmanured plots, but here it must be remembered that this was to be expected, since the trees bore a light crop with fruit of small size.

The highest percentage of Pit occurred in plots 6 and 1, with 59 and 57 per cent. respectively. In both cases the essential elements of phosphoric acid, potash, and nitrogen were present, the nitrogen having been supplied to plot 6 by means of green manuring with peas last season.

The least amount of Pit was in plot 12, where green manuring alone was carried out last season.

TABLE XXV.—SUMMARY OF THREE YEARS' EXPERIMENTS. EIGHT TREES IN EACH OF THE THIRTEEN PLOTS.

Plot No.	Yield. 1913. lbs.	1914. lbs.	1915. lbs.	Total Yield. lbs.	Per cent. Pitted. 1913.	1914.	1915.	Total Pitted.	Per cent. Pitted for 3 years.
1	166	1077	899	2132	46	24	57	849	40
2	146	913	983	2042	32	19	33	545	26
3	151	917	1136	2204	30	30	41	787	36
4	115	794	863	1772	33	19	30	448	25
5	156	638	641	1435	32	7	29	282	20
6	172	1185	935	2292	43	15	59	810	35
7	233	944	338	1515	36	5	35	254	17
8	289	1100	1197	2586	38	8	38	657	25
9	373	1370	1421	3164	51	22	42	1097	35
10	270	1228	1291	2789	47	18	38	841	30
11	237	1139	358	1734	36	9	26	276	16
12	189	867	538	1594	45	6	21	251	16
13	178	737	447	1362	41	7	31	264	19
Totals	2675	12909	11037	26621				7361	
				CHECK PLOTS—NO MANURE.					
14	112	378	318	808	40	5	21	132	16
15	139	468	394	1001	42	7	15	152	15
16	287	976	488	1751	39	9	23	320	18
Totals	538	1822	1200	3560				604	

SUMMARY FOR THREE YEARS.

There is a decided difference in the average yield per tree between the manured and unmanured plots. The manured plots (104 trees) yield an average of 256 lbs.; while the unmanured plots (24 trees) only gave an average of 148 lbs. per tree.

On the other hand, the percentage of Pit is greater in the manured (27 per cent.) than in the unmanured plots (17 per cent.), but as already pointed out, this may be correlated with the light crops and the small size of fruit.

The heaviest yield is in plot 9, with superphosphate and ammonia; but the next is plot 10, with a combination of potash, bonedust, and sulphate of iron.

The smallest yield is in plot 13, with limestone and green manuring; but this does not differ much from that of plot 5, with potash, ammonia, and Thomas' phosphate.

The amount of Pit varies from 40 to 16 per cent., and while the highest percentage is with a complete fertilizer, the lowest is with sulphate of iron.

The Pit is worst in plot 1, *with a complete fertilizer; and least in the sulphate of iron plot and the plot which had only green manuring last season.*

The highest yield is in plot 9, *with superphosphate and ammonia; and the lowest in plot* 13, *with limestone and green manuring.*

THE INFLUENCE OF FERTILIZERS ON BITTER PIT.

A summary has been given at the end of each set of experiments, which shows that the effect of the various treatments on the yield and Pit is very variable. Thus in Victoria and New South Wales superphosphate, potash, and ammonia produced the largest yield; while in Queensland it was superphosphate and potash; in West Australia, superphosphate and ammonia; and in South Australia, superphosphate alone (Table XXVI.).

TABLE XXVI.—INFLUENCE OF MANURES ON YIELD AND PIT.

Orchard.	Highest Yield.	Lowest Yield.	Greatest Percentage of Pit.	Least Percentage of Pit.
Box Hill (3 years)	Superphosphate, potash, and ammonia	Superphosphate and ammonia	Unmanured	Superphosphate and potash
Bathurst (4 years)	Superphosphate, potash, and ammonia	Superphosphate and potash	Superphosphate and potash + limestone	Superphosphate and potash
Stanthorpe (2 years)	Superphosphate and potash	Superphosphate, potash, and ammonia	Superphosphate, potash, and ammonia	Superphosphate and ammonia
Blackwood (4 years)	Superphosphate alone	Unmanured	Unmanured	Unmanured Superphosphate
Mt. Barker (3 years)	Superphosphate and ammonia	Limestone + green manuring in alternate years	Superphosphate, potash, and ammonia	Sulphate of iron green manuring alternately

Again, in Western Australia every treated plot showed an increase in yield over the average of the unmanured plots ; while in New South Wales the highest average yield of the season was in one of the unmanured plots. These results emphasize the fact that they have only a local significance, and that the question of manuring depends so much on local conditions, the nature of the soil, the amount of rainfall, the age of the trees, etc., that the most profitable fertilizer for a particular orchard can only be determined by actual tests. But these experiments were undertaken mainly with the view of testing the influence of fertilizers on Bitter Pit, and a tabulated statement, showing their relation to the percentages of Pit in each State, will help to make this influence clear.

TABLE XXVII.—PERCENTAGE OF PIT IN RELATION TO MANURES.

	MANURES.	Box Hill (V.) Per cent.	Bathurst (N.S.W.) Per cent.	Stanthorpe (Q.) Per cent.	Blackwood (S.A.) Per cent.	Mt. Barker (W.A.) Per cent.
1.	Superphosphate, potash, ammonia	9	5.6	24	3	40
2.	,, ,, ,, + Special bonedust	11	—	21	—	26
3.	,, ,, ,, + Lime ..	—	—	—	4	—
4.	Superphosphate, ammonia, and kainit	10	—	—	—	25
5.	Superphosphate and potash	4	3·0	15	5	25
6.	,, ,, ,, + Alternate green manuring	6	—	—	—	35
7.	,, ,, ,, + Limestone	—	6.3	—	—	—
8.	Superphosphate and ammonia	8	4.4	7	4	35
9.	Superphosphate and lime	—	—	—	3	—
10.	Superphosphate alone	—	—	—	2	—
11.	Potash and ammonia	—	—	—	3	—
12.	,, ,, ,, + Special bonedust ..	—	4·5	16	—	36
13.	,, ,, ,, + Thomas' phosphate ..	—	—	—	—	20
14.	,, ,, ,, + Limestone	—	6·2	—	—	—
15.	Potash, sulphate of iron, and special bonedust	—	—	—	—	30
16.	Sulphate of iron alone	9	—	—	—	16
17.	Lime alone	—	—	—	5	—
18.	Limestone alone	8	—	9	—	17
19.	,, with green manuring alternately ..	—	—	—	—	19
20.	Green manuring alternately	—	—	—	—	16
21.	Stable manure	—	—	—	3	—
	Unmanured	17	5	9	4	17

If we take a broad and general view, and compare the manured with the unmanured plots as regards Pit, it is found that at Blackwood, where there is very little Pit, there is practically no difference. At Box Hill and Bathurst there is less Pit in the manured plots, although at Bathurst, where limestone has been added to the manure, Pit is increased. At Stanthorpe and Mt. Barker there is decidedly less in the unmanured plots, so we are forced to the conclusion that in the case of Pit, as in that of the yield, the effect of the manure is modified by the accompanying conditions. In the Western Australian experiments for the past season, green manuring with peas gave the lowest percentage of Pit. Since humus is the best regulator of moisture, and therefore of prime importance in preventing violent vicissitudes, the loss from Pit would probably be much reduced if the practice of green manuring were generally adopted. It is especially important, of course, in non-irrigated orchards.

B.—PRUNING EXPERIMENTS.

Of all the operations of the orchard that of pruning seems to have the most direct effect upon the development of Bitter Pit. It can increase or diminish the crop ; it can determine its distribution upon the tree ; and to a certain extent it can secure an average-sized fruit. No fact has been more clearly established in practice than this : when there is a good average crop, with the fruit generally of normal size and well distributed over the tree, the conditions are least favourable for pitting. It is in the ready response which the well-nourished tree makes to judicious pruning that the possibility of controlling this disease mainly lies. And this pruning has to be attended to, not by fits and starts, but from the time of planting right through the period of bearing. Increased vigour and luxuriant growth are not the only objects to be aimed at, but the distribution of the fruit upon the tree has to be so arranged that each receives its due share of sun and shade, of air and nourishment.

LONG AND SHORT STEMMED APPLE TREES.

On pruning the tree in its early stages, the height of the trunk as well as the shape of the tree has to be considered.

The apple may be grown on Paradise stock as bushes or dwarfs, or as orchard standards with a single upright stem of varying height supporting the head.

The British and Continental type of "standard" apple tree with a stem up to five or six feet in height does not suit our sunny Australian conditions, and is seldom, if ever, seen in commercial orchards.

The "standard" apple trees shown in Fig. 54, consisting of Northern Spy and Winter Majetin, are growing at Wandin, Victoria, and were planted by Sir E. Holroyd, in June, 1885. They were yearling trees when planted, and not pruned, but trained up to about six feet, and from twelve to thirteen branches are given off irregularly from the upper end of the trunk. Both varieties bore good crops, and the Northern Spy fruit was of good quality and colour, but in recent years only a few apples were produced of poor quality.

There is a difference of opinion as to the best height of trunk for apple trees, but I have observed that short-stemmed trees make the best growth and produce abundance of fruit. The shorter the butt the better the tree, other things being equal, for picking the fruit, pruning the branches, protecting the fruit from wind and the tree trunk from the action of the sun. In long-stemmed trees the scalding of the bark causes it to split and peel off, with the result that the wood dies. The scalding of the stem retards growth and ultimately shortens the life of the tree. Wherever relatively long-stemmed apple trees occur, especially Rome Beauty and Jonathan, I find them nearly always weak, compared with short-stemmed trees of the same variety grown in the same orchard. The stem should be at least a foot or fifteen inches in height, and ploughing can be done quite close to the tree without interfering with the branches. The short stem will enable a greater amount of sap from the roots to reach the leaves in a given time, and the equal diffusion of the sap throughout the entire extent of the branches will tend to promote uniform and regular growth.

6.—At Burnley Horticultural Gardens, Victoria.

The London Pippins or Five Crowns are about 13 years old, and since they have been systematically pruned on a definite system for four years, the results for the present season should give some indication of the effects of the different methods as regards Pit.

The larger yield in the unpruned trees and the smaller size of the fruit should tend to reduce the Pit ; still, making due allowance for all this, the amount of Pit and crinkle is comparatively small. On the other hand, the severe pruning has produced 50 per cent., and although the light crop would favour it, there is still the great contrast in the amount of Pit between the pruned and unpruned trees.

Where the trees have been girdled with a zinc band, there is no indication so far of a lessening of the Pit.

The trees were pruned on 5th July and the fruit was picked on 24th February, with the results shown in the following table :—

Table XXVIII.—Results of Different Methods of Pruning on London Pippin—Season 1914-15.

No. of Tree.	Pruning.	Yield.	Clean.		Pitted.		Crinkled.		Per cent. Pitted (including Crinkle.)	Remarks.
			On Tree.	Windfalls.	On Tree.	Windfalls.	On Tree.	Windfalls.		
		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.		
2	Severe	20	5	6	—	—	8	1	45	Zinc band
3	,,	24	3	8	—	3	10	—	—	
		44	8	14	—	3	18	1	50	
5	Light	33	12	9	—	—	10	2	36	Zinc band
8	,,	12	3	2	—	—	7	—	—	
9	,,	24	5	6	—	—	13	—	54	Zinc band
		69	20	17	—	—	30	2	46	
10	Leader	46	24	9	—	1	12	—	—	
12	Leader	114	53	35	—	5	21	—	—	
		160	77	44		6	33	—	24	
13	Unpruned	143	65	67	—	3	8	—	8	Zinc band
14	,,	144	71	69	—	—	4	—	—	
		287	136	136	—	3	12	—	5	

SUMMARY.

In the first and third year of the experiment the amount of Pit was too small to allow of any distinction being drawn between the different plots. In the second season (1912-13) there was a fair amount, and the percentage of the severely pruned trees was just double that of the unpruned, as shown in the following :—

Unpruned, 15 per cent. Pit ; leader pruned, 17 per cent.; light pruned, 25 per cent.; and severely pruned, 30 per cent.

Unpruned and leader-pruned trees invariably showed less Pit on the average than light and severely pruned trees.

7.—At Albert Smith's Orchard, Deepdene, near Melbourne.

Although special efforts were put forth to make the final year a success, unfortunately not a single apple has been produced in any of the experimental plots. The trees themselves are vigorous and healthy with abundance of foliage, but the blossoming was interfered with, so that not a single fruit set. Owing to the dry weather and the unusual heat early in October, the Thrip pest was very bad, and this, combined with a severe frost on 16th October, prevented the setting of the fruit. The pears have borne a fair crop, particularly the Williams, because they blossomed earlier than the apples and had their fruit set before the Thrips were able to injure them. The experimental plot was specially manured with 3 cwt. of gypsum to render the stiff clay friable, together with a liberal dressing of fertilizers. The water was also laid on in order to ensure the proper action of the fertilizers.

TABLE XXIX.—SUMMARY FOR TWO YEARS OF DIFFERENT METHODS OF PRUNING.

Pruning.	Yield. 1913.	1914.	Total Yield.	Pitted. 1913.	1914.	Total Pitted.	Per cent. Pitted.
	lbs.	lbs.	lbs.	lbs.	lbs.		
Severe ..	220	386	606	140	42	182	30
Light ..	240	425	665	120	21	141	21
Leader ..	160	476	636	80	36	116	18
Unpruned	160	281	441	60	42	102	23

There are three trees in each plot, and they are about twelve years old. In the first year of the experiment only comparatively few apples were produced, so that the results of the second and third years' crops are here given.

Severely pruned trees had the most Pit, but the other methods of pruning did not show a marked difference among themselves.

8.—AT GOVERNMENT FARM, BATHURST, NEW SOUTH WALES.

The pruning experiments have been carried out for four years in succession on Cleopatra trees of the same age as those used in the manurial experiments. There are two rows of Cleopatras, divided into 3 plots. In the first year the first plot contained 12 trees and was heavily pruned, the second plot of 10 trees was light pruned, and the third plot of 12 trees was left unpruned. Owing to the death of trees from various causes in the light-pruned plot, the number was reduced, but, unfortunately, in after years trees were included in this plot which did not originally belong to it. So only the results of severe pruning and no pruning will be taken into account.

TABLE XXX.—SEVERE PRUNING—TEN CLEOPATRA TREES IN TWO ROWS.

Row.	Tree.	Fruit. Sound.	Pitted.	Total Fruit.	Percentage Pitted.
		lbs.	lbs.	lbs.	
1	1	160	16	176	9·09
	2	277	29	306	9·47
	3	182	9	191	4·71
	4	184	6	190	3·16
	5	178	12	190	6·32
2	1	207	13	220	5·91
	2	168	7	175	4·00
	3	254	18	272	6·62
	4	154	29	183	15·85
	5	190	12	202	5·94
Totals ..	.. ..	1954	151	2105	
Averages ..	.. ..	195·4	15·1	210·5	7·17

TABLE XXXI.—NO PRUNING. TWELVE CLEOPATRA TREES IN TWO ROWS.

Row.	Tree.	Fruit. Sound.	Fruit. Pitted.	Total Fruit.	Percentage Pitted.
		lbs.	lbs.	lbs.	
1	1	278	16	294	5·44
	2	181	7	188	3·72
	3	190	9	199	4·52
	4	310	12	322	3·73
	5	223	20	243	8·23
	6	213	10	223	4·48
2	1	144	9	153	5·88
	2	250	11	261	4·21
	3	221	11	232	4·74
	4	233	10	243	4·11
	5	241	8	249	3·21
	6	261	10	271	3·69
Totals ..	.. ..	2745	133	2878	
Averages ..	.. ..	228·75	11·08	239·83	4·62

SINGLE TREE. UNPRUNED FOR THIRTEEN YEARS.

Fruit. Sound.	Fruit. Pitted.	Total Fruit.	Percentage Pitted.
lbs.	lbs.	lbs.	
283	$4\frac{1}{2}$	$287\frac{1}{2}$	1·56

The average yield per tree in the severely pruned plot is less than that in the unpruned, and the amount of Pit is also considerably less in the latter. In the single unpruned tree the yield was above the average, but the fruit was rather small. The Pit was practically a negligible quantity, being only $1\frac{1}{2}$ per cent.

SUMMARY FOR FOUR YEARS.

TABLE XXXII.—SUMMARY OF PRUNING EXPERIMENTS.

Pruning.		Sound Fruit. Average Yield per Tree.	Pitted Fruit. Average Yield per Tree.	Per cent. Pitted. Average per Tree.
		lbs.	lbs.	
Severe ..	1912	176·9	3·64	2·02
	1913	113·04	2·59	2·23
	1914	81·77	8·7	9·61
	1915	195·4	15·1	7·17
Unpruned	1912	206·1	2·4	1·16
	1913	190·58	0·27	0·14
	1914	142·92	5·35	3·61
	1915	228·75	11·08	4·62

As will be seen from the above, the average yield per tree was invariably larger in the unpruned plots, and the amount of Pit was smaller.

9.—At Yanco Government Farm, New South Wales.

This is the second year of the pruning experiments, and although there are only four young Cleopatra trees, and it is too soon for the full effects to show, the general bearing on the yield and amount of Pit may be indicated.

The apples were picked on 2nd February, fully three weeks earlier than the previous season, and the trees were irrigated during August, October, November, December, and January, in all, five times. The amount of water to each irrigation was approximately three inches of rain.

The rainfall for the winter, spring, and summer months up to the time of picking was only 2·03 inches, distributed as follows :—

	Inches.		Inches.		Inches.
June	·43	September	·09	December	·84
July	·14	October	—	January	·06
August	·07	November	·40		
	·64		·49		·90

Table XXXIII.—Results of Different Methods of Pruning on Cleopatra—Season 1914-15.

Pruning.	Yield.	Clean. On Tree.	Clean. Windfalls.	Pitted. On Tree.	Pitted. Windfalls.	Per cent. Pitted.
	No.	No.	No.	No.	No.	
Severe ..	105	69	29	2	5	7
Light ..	187	95	78	7	7	7
Leader ..	348	194	135	10	9	5
Unpruned	588	385	187	2	14	3

The trees were pruned in August, and the fruit is reckoned by number and not by weight. This is not considered an apple district, and the crop was not large on any of the trees. The severely pruned tree blossomed about six days earlier than the others, and the unpruned tree carried most fruit, since there were so many laterals.

The yield varied in regular gradation from the unpruned, which was the highest, to the severely pruned, which was the lowest, in the ratio of 48, 28, 15, and 9 per cent.

There was comparatively little Pit, so that no general conclusions can be drawn. However, the least amount occurred in the unpruned and leader-pruned trees.

Table XXXIV.—Summary for Two Years of Different Methods of Pruning.

Pruning.	Yield. 1914.	Yield. 1915.	Total Yield.	Pitted. 1914.	Pitted. 1915.	Total Pitted.	Per cent. Pitted.
	No.	No.	No.	No.	No.	No.	
Severe ..	56	105	161	7	7	14	8·7
Light ..	43	187	230	2	14	16	7
Leader ..	112	348	460	18	19	37	8
Unpruned	135	588	723	7	16	23	3·9

The results for the two years during which these experiments were conducted show that the unpruned trees had the smallest percentage of pitted fruit.

10.—At Government Experiment Orchard, South Australia.

In the pruning tests this season none of the apples were pitted. There were only a few fruits on the various trees, and in some cases none at all, with the exception of Rome Beauty and Jonathan, which produced a little more than the others. In 1913 there was only an odd fruit on some of the trees, but in 1914 there was a considerable number. Jonathan, which had never been pruned after the first year and the fruit not thinned, produced 163 apples free from Pit. Other varieties had only one or two apples at the most pitted, so that the results as regards Pit will only be of value when the trees are a little older.

The continuation of these experiments will afford results of exceptional interest, because the pruning work has been started on newly set trees, and the effects of particular methods of pruning will be demonstrated for a series of years.

1.—Pruned Every Year—Fruit Not Thinned. (Trees Planted August, 1910.)

Tree No.	Variety.	No. of Fruits.	Clean. On Tree.	Clean. Windfalls.
1	Cleopatra	2	2	—
2	,,	1	—	1
7	Scarlet Nonpareil	3	—	3

2.—Pruned Every Year—Fruit Thinned. (Trees Planted August, 1910.)

Tree No.	Variety.	No. of Fruits.	Clean. On Tree.	Clean. Windfalls.
1	Cleopatra	—	—	—
2	,,	1	—	1
5	Jonathan	3	—	3
6	,,	2	—	2

3.—Never Pruned—Fruit Not Thinned. (Trees Planted August, 1910.)

Tree No.	Variety.	No. of Fruits.	Clean. On Tree.	Clean. Windfalls.
1	Cleopatra	—	—	—
2	,,	1	—	1
3	Dunn's Favourite	—	—	—
4	,, ,,	2	2	—
5	Jonathan	4	3	1
6	,,	3	2	1
7	Scarlet Nonpareil	—	—	—
8	,, ,,	1	—	1

4.—Never Pruned—Fruit Thinned. (Trees Planted August, 1910.)

No fruit on any of the trees.

5.—Pruned Every Winter, and Summer Pruned. (Trees Planted August, 1909.)

Tree No.	Variety.	No. of Fruits.	Clean. On Tree.	Clean. Windfalls.
1	Rome Beauty	51	32	19
2	,, ,,	65	46	19
3	Dunn's Favourite	7	5	2
4	,, ,,	8	7	1
5	Cleopatra	6	2	4
6	,,	4	2	2
7	Jonathan	19	5	14
8	,,	11	4	7

6.—Pruned Three Winters after Planting, then Every Second Winter only.
(Trees Planted August, 1909.)

Tree No.	Variety.	No. of Fruits.	Clean. On Tree.	Clean. Windfalls.
1	Rome Beauty	41	30	11
2	,, ,,	43	35	8
3	Dunn's Favourite	1	1	—
4	,, ,,	6	6	—
5	Cleopatra	1	1	—
6	,,	1	—	1
7	Jonathan	1	—	1
8	,,	—	—	—

11.—At Messrs. North & Brady's Orchard, West Tamar, Tasmania.

This is the second year of the experiment, and the Cleopatra trees are now seven years old from the time of planting. They were pruned on 31st July, 1914, and the fruit was picked on 17th March, 1915.

The annual rainfall was only about 20 inches, as compared with 25 inches the previous year. The summer rains were very light, and the season altogether was a very dry one.

While the trees generally yielded from 1 to 1½ bushel cases, it was noticeable that the unpruned trees were the most prolific, and yielded on an average 2½ cases. This was in striking contrast to the first year of the experiment, when they yielded only about one-third of a case. The remark was then made, and the results justified it, "It sometimes happens that where strong growing trees are left unpruned they bear very light the first year, but have a good crop the next."

Table XXXV.—Results of Different Methods of Pruning on Cleopatra Apple Trees—Season 1914-15.

Pruning.	No. of Trees.	Yield. lbs.	Clean. lbs.	Pitted. lbs.	Per cent. Pitted.
Severe	6	206	111	95	46
Light	6	357	259	98	27
Leader	6	361	332	29	8
Unpruned	5	517	478	39	7

These results show that severe pruning encourages the Pit, and when I inspected the trees early in February, not only was it very conspicuous, but its effect on the fruit was very pronounced. When the crop is relatively light and the fruit rather large, as in the unpruned trees the previous season, the Pit may develop badly in spite of the absence of pruning.

12.—At G. S. Carruthers' Orchard, New Norfolk, Tasmania.

Although the trees are 14 years old the crop was practically a failure, since the 24 trees only yielded altogether about one bushel case of fruit. No manure had been applied, and the soil is undrained, so the conditions were unfavourable for cropping ; still this would not account for such a low yield. During the month of October the weather was hot and dry during the day, followed by frosty nights, and this destroyed the blossom. The rainfall for October was only 38 points, and this is the lowest in the last six months of the year. In the previous season the unpruned trees gave the lowest yield and the largest amount of Pit, and in order to ensure a crop if possible they were liberally supplied with fertilizers during the winter. The soil on analysis gave an acid reaction, and each tree received a dressing of 20 lbs. of fine unburnt limestone.

The trees were pruned on 29th July and the fruit was picked on 20th March, with the following results :—

TABLE XXXVI.—RESULTS OF DIFFERENT METHODS OF PRUNING ON CLEOPATRA—SEASON 1914-15.

Pruning.	No. of Trees.	Yield. lbs.	Clean. lbs.	Pitted. lbs.	Per cent. Pitted.
Severe	6	$2\frac{1}{2}$	—	$2\frac{1}{2}$	100
Light	6	6	$1\frac{1}{4}$	$4\frac{3}{4}$	79
Leader	6	$6\frac{1}{2}$	2	$4\frac{1}{2}$	69
Unpruned	6	30	16	14	46

The yields are too small on which to base conclusions, but every apple on the severely pruned trees was pitted.

GENERAL SUMMARY.

Severely pruned trees had invariably the most Pit, and at the other extreme of no pruning there was comparatively little Pit. Experienced orchardists who have devoted some attention to this disease have also arrived at the conclusion that when the trees are in bearing they should be left alone, except to prune for regular growth and shape in order to minimise the trouble. (Figs. 47, 48, 49.)

An equable flow of sap is more likely in a tree in which the branch system is in full harmony with the root system, and this harmony of root and branch must be disturbed by heavy pruning of the branches without any pruning of the roots. As the tree ages, heavy pruning is used for keeping up the size of the fruit, but this end might perhaps be more safely achieved by leaving the tree alone, except removing superfluous wood and thinning the fruit, at least for some years. In Report III., Fig. 51, an illustration is given of very severe pruning. An old Champion tree was severely cut back, almost to the stump, for regrafting, and the two branches which were left of the original tree bore fruit with 92 per cent. of Pit. If the orchardist could see that the heavy pruning which is so common in vigorous trees is just a milder form of the same operation, he would realize that in the one case, as in the other, there is a disturbance of the equilibrium between root and branch.

C.—EXPERIMENTS WITH STOCKS.

There is a suspicion in the mind of the orchardist that the stock might have an influence upon the disease, for he reasons that since the Northern Spy stock is the one most commonly used, at least in Victoria, and since the tree itself is a liable variety, therefore the disease is likely to be transmitted through the stock. But this raises the whole question of the mutual influence of stock and scion, and I have endeavoured to settle experimentally if there is any evidence of the stock influencing the graft as regards Bitter Pit. Of course, to carry out such experiments thoroughly would require longer time than the course of this investigation allows, but the results obtainable in four years are here presented. They are discussed under the following headings :—

(1) Blight-proof stocks (including Northern Spy) with grafts each of four Pit-liable varieties.

(2) Various stocks (including seedling stocks) in screen with grafts of varieties liable and non-liable.

(3) Cleopatra budded and grafted on to pear stock.

(4) Varieties on their own roots—Gravenstein, Magg's Seedling, and Winter Majetin.

(5) Reciprocal grafting of Cleopatra and Yates.

(6) Winter Nelis and Josephine varieties of pear with grafts from badly affected to Pit-free trees, and vice versa.

13.—At Burnley Horticultural Gardens and Campbell's Creek, Victoria.

(1) Blight-proof stocks with grafts each of four Pit-liable varieties.—Of the original stocks used French Paradise and Duchess of Oldenburg died during the past season.

Northern Spy bore no fruit, and the four healthy grafts were also barren.

Of the remaining three stocks the results are shown in the following table :—

Table XXXVII.—Blight-proof Stocks, with Grafts Liable to Bitter Pit.

Stocks.	Grafts.	Fruits Gathered.	Sound Fruit.	Pitted Fruit.	Remarks.
Winter Majetin	.. .. ..	10	8	2	
	Annie Elizabeth ..	2	1	1	Only 1 graft, poor
Coral Crab	.. .. ..	5	5	—	
	Cleopatra ..	2	2	—	2 grafts, with thrifty growth in the one and vigorous growth in the other
Lord Wolseley	.. .. ..	1	1	—	
	Cleopatra ..	—	—	—	Dead
	Annie Elizabeth ..	—	—	—	2 grafts, poor growth
	Cox's Orange Pippin	1	1	—	2 grafts, both excellent
	Bismarck ..	2	1	1	1 graft, poor growth
Northern Spy	.. .. ..	—	—	—	
	Cleopatra ..	—	—	—	2 grafts, good growth
	Annie Elizabeth ..	—	—	—	2 grafts, stocky growth
	Cox's Orange Pippin	—	—	—	2 grafts, very vigorous growth
	Bismarck ..	—	—	—	1 graft, stocky growth

SUMMARY FOR THREE YEARS.

The scions were Cleopatra, Annie Elizabeth, Cox's Orange Pippin, and Bismarck, and were grafted on 5th September, 1911. They are all very liable to Pit in the Burnley Gardens, although Cox's Orange Pippin was the least liable. They did not produce fruit on all the stocks, but the results, where fruit was produced, are shown in the following table :—

Table XXXVIII.—Yields of Scion in Relation to Stock.

Scion.	Stock.	Sound Fruit.	Pitted Fruit.
Cleopatra	Winter Majetin	1	—
	French Paradise	2	—
	Coral Crab	12	1
Annie Elizabeth	Winter Majetin	2	4
	Lord Wolseley	3	3
	Northern Spy	—	1
Cox's Orange Pippin ..	Coral Crab	9	—
	Lord Wolseley	1	—
	Northern Spy	—	1
Bismarck	Winter Majetin	11	2
	French Paradise	2	—
	Coral Crab	2	1
	Lord Wolseley	2	2
	Northern Spy	2	1

The only stock on which the graft never bore pitted fruit was French Paradise, and the only one on which the fruit was always pitted was Northern Spy.

(2) Various stocks in screen with grafts of liable and non-liable varieties.—Of the 54 varieties only 8 yielded fruit, and the results are given in the following table :—

TABLE XXXIX.—YIELD OF VARIETIES ON VARIOUS STOCKS.

No.	Variety.	Stock.	Sound Fruit.	Pitted Fruit.
5	Ribston Pippin ..	Northern Spy	2	—
6	King David ..	,, ,, ...	1	—
7	Bismarck ..	Paradise on Spy	2	—
12	Cleopatra ..	Duchess of Oldenburg ..	—	1
16	Clerome	Annie Elizabeth on Yarra Bank	—	1
41	Cox's Orange Pippin	Magg's Seedling	1	—
53	Duchess of Oldenburg	Northern Spy	4	—
54	Prince Alfred ..	,, ,, ...	4	—

The varieties grown in the screen and budded or grafted on to different stocks are now nearly four years old. They were pruned last season about the middle of August, and this season on 5th July. I have selected the most luxuriant-growing tree, viz., Blenheim Orange, and it has been pruned by Mr. Pescott in order to illustrate the method of pruning adopted at this stage. Clerome of the same age, but with more upright and compact growth, is also shown. (Figs. 50 and 51.) On comparing the pruned and unpruned trees, it will be seen that the surplus sub-leaders have been removed in order to give the tree a fair shape and to strengthen the main leaders already in existence. The centre of the tree has been cleaned out to leave it open, and the lateral system has been allowed to remain so as to develop fruit-spurs. Both trees have been treated alike, except that in the case of Blenheim Orange, where the laterals were very long and without fruit-buds towards the tips, they were shortened back. (Figs. 52 and 53.)

SUMMARY FOR THREE YEARS.

The varieties were, with a few exceptions, budded or grafted on to the various stocks in August, 1911. A number have not yet borne any fruit, and the yield, where produced, has been so light that it is premature to draw conclusions. It is only when the trees have reached the regular bearing stage that the influence of the different stocks on the development of Pit will become evident.

If we select Bismarck, which has borne fruit for the last three years, and compare the results obtained on the Northern Spy stock and with the intermediate stock of Paradise respectively, it is found that in 1913 on the Spy stock five apples were produced which were badly pitted ; in 1914 25 apples, of which 7 were pitted ; and in 1915 no fruit was produced. With the intermediate stock of Paradise in 1913 only one apple was produced, and it was badly pitted ; in 1914 ten apples and one pitted ; and in 1915 two apples which were clean.

(3) Cleopatra budded and grafted on to pear stock.—The budding and grafting was done on to seedling pears in 1913 and 1914 respectively. Since the pear is practically free from Pit in the Burnley Gardens, this stock should eliminate any risk of transmission from that source.

The two grafted Cleopatras have made fair to good growth, and the one budded has also made fair growth. They will be planted out in July, 1915.

(4) Varieties on their own roots.—These are Gravenstein, Magg's Seedling, and Winter Majetin. Of the six Gravensteins the growth has varied from good to fair. Of the three Magg's Seedlings the growth in all is good, and in the two Winter Majetins it is from good to very good.

(5) Reciprocal grafting of Cleopatra and Yates.—The trees chosen for this experiment have both died from root-rot. The experiment will, however, be repeated with young and healthy stock.

(6) Pear trees with grafts from badly affected to Pit-free trees, and vice versa.—It sometimes happens that in trees of the same variety and age growing alongside each other and to all appearances similar, the fruit produced by some are pitted, and by others perfectly sound. When this has occurred for a number of years, the question arises : Is there something in the constitution of the tree which enables it to resist Pit?

Josephine and Winter Nelis varieties of pear tree were found growing at Campbell's Creek fulfilling these conditions.

The grafting was successfully done in September, 1912—grafts from the Pit-free on to the Pit-producing trees, and the reverse.

No definite results have yet been obtained, and, unfortunately, in the past season there was no fruit on either of the varieties, owing to the drought. The trees look healthy and promise a good crop for next year.

14.—At Government Experiment Orchard, South Australia.

The influence of different stocks on the development of the disease is being thoroughly tested by Mr. Quinn in an elaborate series of experiments, which should yield definite results when the trees come into full bearing. At present, of course, the details simply show their behaviour in the early stages, and their value chiefly lies in enabling a complete record to be given later of the results obtained throughout the life of the tree.

The stock tests are arranged in three series :—

(1) Northern Spy roots with intermediate stocks. The trees were planted in August, 1908, and the varieties are given in Table XL., with a summary up to date.

(2) Intermediate stocks with Paradise, Winter Majetin, and Northern Spy roots. The stocks were originally planted in August, 1910, when they contained the dormant buds of Baldwin, Cleopatra, Esopus Spitzenburg, Jonathan, and Shockley worked direct into the stocks. Where, however, an intermediate stock was used, that is double worked. The above varieties were not budded until the middle of February, 1911. Only a few bore fruit during the past season, and the highest yield was 11 apples. None were pitted when gathered.

(3) Rome Beauty with Northern Spy roots. This variety was worked direct on to Spy, planted in August, 1911, and budded over to Baldwin, Cleopatra, Esopus Spitzenburg, Jonathan, and Shockley, as in Series 2, in the middle of February, 1912. Only Esopus Spitzenburg and Jonathan bore 4 and 1 apples respectively without Pit when gathered.

Table XL.—Testing the Influence of Different Stocks—Season 1914-15.

Series 1.—Northern Spy Roots with Intermediate Stocks.

No.	Variety.	Stocks.	No. of Fruits.	Clean.		Pitted.	
				On Tree.	Windfalls.	On Tree.	Windfalls.
1	Baldwin	Dunn's Favourite on Spy	7	7	—	—	—
2	Baldwin	Rokewood on Spy	1	1	—	—	—
3	Baldwin	Spy	—	—	—	—	—
4	Cleopatra ..	Dunn's Favourite on Spy	—	—	—	—	—
5	Cleopatra ..	Rokewood on Spy	3	1	1	1	—
6	Cleopatra ..	Spy	—	—	—	—	—
7	Cleopatra (Q.) ..	Dunn's Favourite on Spy	2	1	—	—	1
8	Cleopatra (Q.) ..	Rokewood on Spy	4	2	2	—	—
9	Cleopatra (Q.) ..	Spy	5	—	4	1	—
10	Esopus Spitzenburg	Dunn's Favourite on Spy	67	60	7	—	—

TABLE XL.—SERIES 1—NORTHERN SPY ROOTS WITH INTERMEDIATE STOCKS—*continued.*

No.	Variety.	Stocks.	No. of Fruits.	Clean. On Tree.	Clean. Windfalls.	Pitted. On Tree.	Pitted. Windfalls.
11	Esopus Spitzenburg	Rokewood on Spy	40	37	3	—	—
12	Esopus Spitzenburg	Spy	3	1	2	—	—
13	Jonathan ..	Dunn's Favourite on Spy	15	6	9	—	—
14	Jonathan ..	Rokewood on Spy	8	5	3	—	—
15	Jonathan ..	Spy	13	3	10	—	—
16	Shockley ..	Dunn's Favourite on Spy	1	1	—	—	—
17	Shockley ..	Rokewood on Spy	16	10	6	—	—
18	Shockley ..	Spy	9	8	1	—	—

SUMMARY—SERIES 1.

The trees were planted in August, 1908, so that they were between three and four years old when the first results were recorded. Several of the varieties had not fruited, and the highest yield was 58 apples, with 2 pitted.

In 1913 the highest yield was 57 fruits, with 41 pitted.

In 1914, when the highest yield was between 300 and 400 fruits, only 2 to 4 per cent. were pitted ; and in 1915 the highest yield was 67, with none pitted ; but the yield on the whole was so small and the Pit so trifling that no definite results were obtained.

THE EFFECT OF THE STOCK ON THE SCION.

In *The Garden* for 22nd May, 1915, an instance is given of the stock influencing the scion in the direction of preventing disease. Mr. E. Molyneux, of Swanmore Park, Hants, found that while Cox's Orange Pippin succeeds fairly well, it is very liable to canker in the branches. Some ten years ago he grafted trees of Irish Peach with Cox's Orange Pippin, with the result that they grew well, bore freely, and did not show the slightest trace of canker. Formerly, it was worked on the free or seedling stock, but by introducing the Irish Peach as an intermediate the distinct advantage was gained of having the trees free from the devastating canker.

D.—TILLAGE TESTS.

15.—AT GOVERNMENT EXPERIMENT ORCHARD, SOUTH AUSTRALIA.

These trees are only five years old, and from the small amount of fruit produced no conclusions can be drawn. It is only when the trees have reached full bearing that the effects are likely to become evident of subsoiling and of ploughing once or twice in the season.

TABLE XLI.—TILLAGE TESTS.

Test.	Tree No.	Variety.	No. of Fruits.	Clean. On Trees.	Clean. Windfalls.	Pitted. On Trees.	Pitted. Windfalls.	Per cent. Pitted.
Land subsoiled, ploughed once, and summer tilled.	1	Cleopatra	1	—	1	—	—	—
	2	Jonathan	4	—	4	—	—	—
Land subsoiled, ploughed twice and summer tilled.	1	Cleopatra	13	2	11	—	—	—
	2	Jonathan	18	—	18	—	—	—
Land not subsoiled, ploughed twice, and summer tilled.	1	Cleopatra	16	1	13	—	2	12
	2	Jonathan	12	1	11	—	—	—

E.—IRRIGATION EXPERIMENTS.

16.—At Bacchus Marsh, Victoria.

Owing to the very dry season and the scarcity of water for irrigation purposes, the experimental plot of Sturmer Pippins at Bacchus Marsh was a complete failure. The trees blossomed freely, and they were all irrigated once in October, but as a result of the long drought, heat, and Thrips, there was no crop in this particular variety.

The rainfall for 1914 and the past three months of 1915 shows the nature of the season.

	1914. Inches.	1915. Inches.		1914. Inches.
January	1·75	1·34	July	1·12
February ..	·03	·40	August ..	·35
March ..	·91	·26	September ..	·83
April	1·69		October ..	·38
May	1·14		November ..	1·16
June	·94		December ..	4·30
			Total for 1914	14·60 Inches.

The average rainfall for the past 35 years is 20·51 inches, the highest, in 1911, being 29·23 inches; and the lowest, in 1898, being 12·54 inches. The past season is the second lowest on record.

Result of Analyses of Soils from Mr. Cowan's Orchard, Bacchus Marsh.

Sample No. 1—Heavy Soil. Sample No. 2—Light Soil.

The samples on analyses were found to contain :—

	No. 1.		No. 2.		A Good Soil should contain :—
	1st ft.	12″ to 36″	1st ft.	12″ to 36″	
Nitrogen—parts per 100,000	180	64	129	104	150
Phosphoric acid ,, ,,	267	219	230	204	150
Potash ,, ,,	603	251	221	245	250
Lime ,, ,,	722	488	790	536	500
Magnesia ,, ,,	989	946	779	865	Not more than lime content.
Chlorine ,, ,,	10	12	10	10	Not more than 35.
Reaction		Slightly alkaline.			Neutral.

Mechanical Analysis.

	%	%	%	%
Stones	—	—	—	—
Fine gravel	3·12	8·29	2·58	1·67
Coarse sand	3·09	11·31	11·82	7·25
Medium sand	2·88	7·26	12·49	8·53
Fine sand	12·58	21·24	25·57	16·54
Very fine sand ..	20·78	16·30	17·05	16·59
Silt	18·01	12·06	7·00	13·75
Clay	28·29	15·19	16·11	25·83
Moisture	4·26	3·53	2·33	3·66
Loss on ignition ..	6·99	4·82	5·05	6·18
Humus	·89	·51	·66	·82

Judging from the content of plant food found in these soils, I should say that neither is in any immediate need of any particular fertilizing ingredient. They are very similar in composition, excepting that the light soil contains a higher percentage of sand ; otherwise they might be considered to be one and the same soil. Both may be expected to produce good crops of fruit.

SUMMARY FOR IRRIGATION.

The comparative experiments conducted at Bacchus Marsh with Sturmer Pippins, irrigated once and twice respectively, do not show any great differences in the amount of Pit. In the first season, 1911-12, when the rainfall was the highest recorded for 35 years, there was a difference of 5 per cent. in favour of the twice irrigated, but in the two succeeding seasons the rainfall was comparatively low, and very little Pit developed.

	Irrigated Once. Bitter Pit.	Irrigated Twice. Bitter Pit.	Rainfall. Inches.
1911–12	8 per cent.	3 per cent.	29·23
1912–13	2·87 ,,	2·06 ,,	15·78
1913–14	5 ,,	4 ,,	16·07

F.—COLD STORAGE EXPERIMENTS.

As a preliminary to keeping the fruit in cold storage, I had the freezing point of the juice of apples and pears determined by Mr. P. R. Scott, Agricultural Chemist. The varieties of apples were selected when they were ready for picking for export, and two early varieties were chosen in the first instance.

The freezing point of Gravenstein was determined as 28·31 degrees Fahr.; and of Lord Suffield, 29·15 degrees Fahr.

Two samples of Cleopatra, which is a mid-season variety, from irrigated and dry areas were also tested, with the following results :—From the irrigated orchard, 28·98 degrees Fahr.; and from the dry orchard, 28·80 degrees Fahr., so that there was very little difference in their freezing points.

A variety of pear was also taken at the same time for comparison—Beurré de Amanalis—and the freezing point was slightly lower than that of Cleopatra, being 28·65 degrees Fahr.

These tests serve to indicate that apples and pears are able to stand a temperature of 32 degrees Fahr. without freezing, and it has already been shown in Report III. that they may be continuously kept in cold storage with a variation in temperature of only one to one and a half degrees.

From the experimental plot at the Yanco Government Farm, the first irrigation farm started by the New South Wales Department of Agriculture under the Great Northern Murrumbidgee Irrigation Scheme, the produce of the four Cleopatra apple trees was placed in cold storage on 21st February. They were all wrapped and carefully packed as for export, and there was no visible sign of Bitter Pit. They were kept at a temperature not exceeding 32 degrees Fahr., and not falling below 30 degrees.

At the end of three months they were removed on 21st May, and every apple examined. They were all found at the same stage of ripeness as when packed, and no rotting occurred. The case containing 130 apples had no trace of Pit ; that with 108 had two pitted ; another, with 55, had no Pit ; and the fourth, with 62, had 1 pitted.

The pitting always developed towards the "eye" end of the apple, and only one was distinctly pitted with 10 depressions ; while the other two had only a few pits and would be considered quite marketable.

These were the results obtained after keeping for three months ; and Mr. W. French, Engineer-in-charge of the Government Cool Stores, informs me that he has kept Jonathan and Five Crown apples for nine and ten months in splendid condition after being wrapped and nailed up.

XV.—THE CAUSE OF BITTER PIT.

If an engineer has to repair some defect in the working of a steam-engine, he must overhaul the machinery, and the more he knows about the structure of the various parts and the work they perform, the better able will he be to determine the nature of the defect and the cause of it. Similarly, if a medical man has to deal effectively with some disease of the human body, he must not only be familiar with the structure and functions of the organ concerned, but he must also know its relations with other parts of the body. He must be acquainted with the means whereby it is nourished in order to perform its functions properly and the various arteries and veins, nerves and muscles connected with it. He must also take into account the environment, which exercises such an important influence on the harmonious working of the various factors.

So, in dealing with this disease, our first efforts were directed to a thorough investigation of the structure of the apple and the way in which this structure is related to the building up of a sound and healthy, palatable, and succulent fruit.

After this study of the apple in the normal condition of health, the way was prepared for the study of the abnormal condition of disease, and the various symptoms of Bitter Pit were determined. In seeking for the cause of this defect there were a number of theories which required to be examined and tested in order to exclude those factors which are not concerned in it, and to narrow down the probable causes as much as possible by the method of exclusion. Plants, or parts of plants, are often subject to diseases due to invasion by parasites, which may deprive the plant of necessary food, interfere with its proper water supply, or derange some vital function. Or diseases may arise from the disturbance of function caused by external agents, such as the nature of the climate, soluble materials in the soil, or gases in the air.

It has already been conclusively shown that this is not a parasitic disease. and therefore not infectious. The agency of insects, of fungi, and of bacteria has been excluded, and while this advance has narrowed down the enquiry and made it easier, it has not removed all difficulties from the path. In the case of a parasitic disease there is always a definite basis from which to start—the study of the parasite, its life history, and its mode of action. But when there are functional disorders, as in this instance, without any definite clue to start from, the study becomes more difficult, and it is little wonder that scientists have often spoken of "the mystery" of Bitter Pit.

It is sometimes called a physiological disease to indicate that it is not parasitic in its origin, but from the point of view of the nature of the disease itself this distinction cannot be strictly maintained. All diseases, however caused, are physiological in the sense that they are disturbances of the normal physiological functions, but there is a certain convenience in retaining the term for non-parasitic diseases.

The same method of exclusion has been followed in dealing with external agencies as with parasites.

The theory of spraying with poisonous compounds was brought forward as a direct and definite cause, and the general use of arsenate of lead for spraying in the treatment of Codlin Moth seemed to favour this view. But it was at once pointed out that this disease was well known in Australia long before spraying was adopted, and that it was very bad in districts of Western Australia where no Codlin Moth existed and consequently no spraying for it.

That theory has now been abandoned, and the absorption of poison from the soil in infinitesimal quantities through the roots has been substituted for it. An experiment to test this theory was made last season at Burnley Horticultural Gardens, and the results have been already given by Dr. Rothera in his report.

There still remain for consideration those diseases included under the general term of *Necrosis*, from a Greek word meaning "dead." This applies to those cases where the tissues die and dry up, gradually becoming brown or black in patches; and these dead patches sometimes spread slowly and invade the surrounding healthy tissues. The name is usually applied in plant pathology to the appearances presented by the slender stems or branches or thin twigs, and may be due to the action of frost or sunburn or to the bruising of the tissues by hailstones.

Bitter Pit in the fruit occurs in the absence of frost or hail, and sunburn or scorching is easily distinguished, since it involves the skin as well as the underlying tissues.

The action of hail, when not sufficiently strong to rupture the skin, might easily be mistaken for Bitter Pit, since the pulp tissue immediately beneath the skin is brown and spongy. There is this important difference, however, that Bitter Pit occurs without any such external injury to the fruit, and the origin of the appearances must therefore be sought for from within.

If pressure is applied from the outside of an apple by the rounded end, say, of a glass rod, so as not to break the skin, some of the meshes of the vascular net are broken, and in the course of twenty minutes the pulp-cells beneath the skin at that point are collapsed and brown, just as in Bitter Pit.

This brings us to the point where the origin of Bitter Pit may be profitably discussed, since here also the vascular network is interrupted wherever the brown flecks in the flesh occur.

In dealing with the causes of disease, we have always to consider those of a general nature as well as those which are special in their character.

All sorts of general statements are made as to the cause of Bitter Pit, and there is a certain amount of truth in many of them. It is said to be due to disordered nutrition, and the affected pulp-cells bear evidence of interference with the normal functions. Dr. Rothera has pointed out that Pit has always been associated with starch in his experience, and that the critical time for the apple is when the pulp-cells are loaded with starch and before the starch has been converted into sugar. It is only when the insoluble starch is converted into soluble sugar that it can be assimilated, and whatever prevents this interferes with the process of digestion. In ninety-nine cases out of a hundred starch is present in the cells of the pitted tissue, so that "starch metabolism and Pit are evidently closely associated" is the conclusion of Dr. Rothera.

Again, it is said to be a disease of the vascular or conducting system, and no doubt the vessels are involved. It is in the neighbourhood of the vessels that the disease begins, and they become discoloured like the affected pulp-cells.

Further, a superabundance of sap is said to cause it, and it is often in the overgrown apple that the disease manifests itself. A striking illustration of this was given in Report II., p. 42, where, in a Western Australian orchard, Cleopatra trees only showed Bitter Pit in the clusters of fruit at the tips of the branches, and the larger apple in the centre of the cluster was the worst. It is well known that the highest or terminal bud receives the largest amount of sap, and so constant is this that during one season I was unable to find a single instance of the unusual case of the smallest apple being in the centre among all the numerous trees in the Burnley Horticultural Gardens.

Finally, it is said to be a constitutional disease, and when one considers that the plump, succulent, and sweet cultivated apple has been derived from the small and sour crab, and that in this process the hardy nature of the ancestor has been sacrificed, particularly in the direction of a softening of the fibre, it must be confessed that the penalty paid for the increased attractiveness is a weakening of the constitution.

Our present knowledge does not, in my opinion, warrant dogmatism as to the cause of Bitter Pit, but after a close study of the structure and functions of the tissues of the fruit, and after excluding a number of supposed causes found to be no longer tenable, I have come to the following conclusion as to the immediate cause :—

In Bitter Pit tissue the pulp-cells have collapsed, and the brown flecks in the flesh contain much less water than the neighbouring healthy tissue. Owing to this loss of water, the acids and other constituents of the cell-sap have become concentrated, and the amount of concentration reaches a point where the living substance of the cells is injuriously affected, and finally death ensues.

The concentration of the cell-sap is therefore, in all probability, the immediate cause, acting directly upon the protoplasm, and it must not be forgotten that this concentration is increased by an insufficient supply of water as well as by excessive transpiration. How this loss of water is brought about in isolated patches requires explanation. When there is an even flow of sap the loss of water by transpiration is regular and continuous, but when there are violent vicissitudes in the weather the sap flow becomes irregular. The growth of the apple will therefore vary, and when the growth becomes too rapid for the delicate network of vessels surrounding the pulp to keep pace with it, meshes of the net here and there are not formed, and the loss of water at these spots cannot be fully met by a fresh inflow of sap. This loss of water without a corresponding supply causes the cells to collapse, and the oxidizing enzyme in the presence of tannin turns them brown.

In the above view the loss of water in localized spots is accepted as the primary cause of the disease. But it is also possible that the loss may be a consequence of the death and collapse of the cells, and this alternative view will now be considered.

Undue pressure of water in the tissues beneath the skin, as evidenced by the gaps in the meshes of the vascular network where Bitter Pit occurs, might conceivably cause the death of the cells, and the subsequent deficiency of water would be a post mortem appearance. There are various facts which strengthen this view.

In the case of very rank growth of fruit on a young tree bearing only a few apples, as shown in Figs. 27, 28, the conditions are most favourable for the development of Pit, and in this instance every apple was pitted. There is an excess of water in the tree as well as in the fruit, that is to say, more water is received from the roots than that given off by transpiration. But with the rapid growth of the fruit there is excessive transpiration from its surface, and it is only when the amount of transpiration is relatively greater than the water supply that Bitter Pit is produced. Where there is a strong flow of sap, as in the young fruit-bearing tree or in older trees when the fruit is mostly confined to the main branches, there the Pit is increased. On the other hand, when the flow is checked by cincturing, the Pit is reduced, and it would seem that the over-pressure of water in a variety unable to withstand the strain might be the exciting cause.

This extra pressure would probably lead to death by the rupture of the cells and produce the characteristic appearance of Bitter Pit. Although it has been shown that the dead pitted cells may again take up water, this absorption may be a purely physical phenomenon, as in the case of blotting paper. That Bitter Pit appears in the first instance immediately beneath the skin would favour this view, since the external layer of the pulp-cells would be most subject to sudden fluctuations in their water content, and a sudden access of water would cause excessive turgidity at localized spots.

The rapid transportation and production of soluble substances in the cell-sap of the growing fruit would also affect the result. The osmotic absorption under such circumstances must be very rapid and the strain set up very strong.

In either case the outstanding fact remains, that attacks of Bitter Pit are most virulent where the sap flow and transpiration are subject to violent vicissitudes.

Hence Bitter Pit is ultimately traceable to the varying nature of the climate and to a certain extent to the nature of the variety itself.

Fortunately, in the case of Bitter Pit other factors than the weather enter into the problem, and it is by the control which the intelligent orchardist can exercise over the growth of the tree and the formation of the fruit that the disease can be kept within manageable limits. When the fruit is removed from the tree we can still prevent the development of the disease by means of cold storage. And even when the difficult problem of altering the constitution of the tree has to be faced, we can still adopt the slow but sure process recommended in a letter to me, under date February, 1915, from Luther Burbank, the foremost plant-breeder in the world :—"From your report I am more than ever convinced of what I have long believed, that all fruit diseases and defects must in the end be *bred out* of them, rather than combated in varieties which are susceptible *to* them."

XVI.—THE CONTROL OF BITTER PIT.

The practical problem of Bitter Pit is not, as many suppose, the eradication of a pest. It is the problem of growth "gone wrong," and we must study the mechanism of growth "gone right" in order to control and prevent it. Hence the wide scope of the enquiry and the numerous experiments necessary to deal with every phase in the growth of the tree and the proper development of the fruit.

It may be stated at the outset that there is no royal road to the control of Bitter Pit in the growing fruit. There is no single operation which will ensure freedom from it, and there is no one method of treatment which will satisfy all the requirements. From the constitutional nature of the disease, and from its being located in the fruit, which is the final outcome of the tree's activity, every factor which makes for healthy growth has to be considered. As the result of experiments, and from the collective experience of practical orchardists, such measures may be recommended for adoption as will minimize the effects of it.

From the nature and mode of development of this disease it appears not only when the fruit is growing, but also after it is picked clean and stored. so that the means of control have to be considered both for the fruit on the tree and the fruit in store.

CONTROL IN STORE.

It was largely owing to the serious losses incurred in the over-sea shipment of fruit that this investigation was suggested by the fruit growers. Thousands of cases of apples of the best varieties, carefully picked and packed and visibly free from Pit, would be shipped under cool storage conditions. On arrival at the other end the fruit would sometimes be so badly pitted and decayed as to be unmarketable, and the grower would, in some instances, be actually out of pocket. This state of affairs can now be absolutely prevented, and it lies with the shipping companies to carry out the measures shown to be a perfect safeguard against loss from this disease.

There is no fact more clearly demonstrated during the course of this investigation than that when apples are kept in cool storage at a uniform and constant temperature of 30 to 32 degrees Fahr. the development of Bitter Pit is retarded and the process of ripening is arrested.

This ensures not only that apples can be carried without becoming pitted in transit, but that they can be delivered at the same stage of ripeness as when placed on board. If these conditions are not fulfilled, it is evident that the fault lies in the proper regulation of the temperature not having been carried out.

CONTROL ON TREE.

While the fruit is still growing and receiving a supply of nourishment from the parent tree, it cannot be directly controlled as when detached. But in the various operations conducted by the intelligent orchardist there are so many possibilities of influencing the production of the fruit, that through them a large measure of control can be exercised. How this control may be directed towards the lessening of Bitter Pit will now be shown.

When the crop is light and the relatively few apples are rather above the average size, the conditions are favourable for the development of Pit. Therefore it should be the aim of the orchardist to secure regular cropping and to have the fruit well distributed over the tree.

When the fruit is mostly confined to the main branches, so that a strong flow of sap is directed towards it, it is generally found that there the Pit is worst. On the other hand, when a limb was cinctured so that the flow of sap was checked, the amount of Pit was reduced and sometimes entirely prevented. Therefore, by a judicious system of *pruning* the fruit ought to be so distributed that each will receive, as far as possible, a regular supply of nourishment so as not to be over-gorged.

The lateral system of pruning was found by experiment to considerably reduce the Pit; and the retention of the laterals, as far as practicable, is therefore recommended on the following grounds :—

1. In the case of 14 laterals on 14 different varieties selected indiscriminately at an early stage in the Burnley Horticultural Gardens, it was found that when the fruit was picked not a single apple borne on the laterals was pitted, although in some cases (*e.g.* Shockley) the fruit borne on the fruit-spurs arising from the main limbs was badly pitted. Last season there was only one of these selected trees in bearing, and the same lateral bore only two fruits, of which one was pitted.
2. It is a matter of common observation that there is a greater liability to Pit when the lateral is pruned than when left unpruned.
3. It has also been observed that the Pit is worse on spurs arising from the main branches than on the laterals of the same tree.
4. It is found that when trees are laterally pruned and well spread out all round, they carry more fruit than when it is produced only off the main branches.
5. The Statesman is a variety which sometimes Pits very badly, and one tree 18 years old was cropped for the first time on the laterals last season. The bearing surface was thereby at least doubled, and the crop was not only more than twice that of any previous record, but not a trace of Pit was discovered.

It has been invariably found that severe pruning of the fruit-bearing tree increases the Pit. Therefore a system of light pruning is to be recommended.

Besides the pruning, the general management of the orchard in respect to manuring, draining, and cultivation has a bearing upon the development of Bitter Pit.

Active nitrogenous *manures*, such as stable manure and fish manure, are found to increase the Pit when applied in excess. They cause rank growth with superfluity of water, and such conditions when the fruit is growing are eminently favourable to Pit. Such manures should be avoided and nitrogen supplied in the slower form of green manuring.

In an apple orchard we cannot adopt a system of rotation of crops, but there may be a rotation of manures, which will practically serve the same purpose. Every year, when the orchard is in full bearing, an application of ordinary superphosphate and sulphate of potash at the rate, on an average, of 2 cwt. and 1 cwt. per acre respectively will be found beneficial.

Every second year green manuring with field peas to supply nitrogen and humus, which will conserve moisture, is recommended. Also a dressing of fine unburnt limestone, such as is supplied from Curdie's Inlet, at the rate of, say, one ton per acre can be usefully applied.

Lime may also be applied as burnt or slaked lime at the rate of 10 to 12 cwts. per acre instead of unburnt limestone. Such lime acts more quickly, and should be applied in autumn. In connection with lime, it should be remembered that on soils well supplied with humus the lime, by accelerating nitrification, may obviate entirely the need for nitrogenous manures. In such cases a further application of nitrogenous manures by undue stimulation of growth may encourage Bitter Pit.

In wet soils *drainage* is necessary to keep the roots healthy and active by getting rid of the surplus water and thus allowing the air to enter. It is found as a matter of practical experience that drainage tends to reduce the Pit, and it is observed that in those portions of an undrained orchard which lie low and are very wet in winter the disease is worst.

Ploughing and *cultivating* the land is sometimes said to encourage Pit, owing to the strong and vigorous growth produced. But it will be found that the ill-effects are not due to cultivation, but to some other faulty treatment of the tree itself.

Apart from its influence in the improved physical condition or the increased chemical activity of the soil, tillage has an important effect on the transpiration of the tree. It increases the capacity of the soil for holding moisture, and by forming a soil mulch wasteful evaporation from the soil is checked, so that the roots of the tree have a more regular and constant supply of moisture ; and as a consequence there is a more regular and constant transpiration from the leaves and fruit. If the transpiration is properly regulated there is less liability to Pit.

The influence of the *stock* on the development of Pit has not yet been experimentally determined. The Northern Spy stock, so generally used for budding or grafting as it is thoroughly proof against the attacks of Woolly Aphis at the roots and produces a dense mass of fibrous roots, has a beneficial effect on the transpiration of the variety grafted on to it.

In the stock test being conducted at Burnley Horticultural Gardens, while the varieties on other stocks required artificial watering, the same varieties growing alongside on Spy stocks did not require it.

It may be stated generally that for the prevention of Bitter Pit the most up-to-date treatment of the tree and the soil must be followed. Excess has to be avoided and moderation practised in the various orchard operations such as pruning, manuring, and irrigation, so as to maintain as uniformly even conditions as possible. The injudicious application of water after a dry spell may result in Bitter Pit. Uniform moisture conditions are of prime importance, and the practice of cultivating after rain so as to prevent the moisture rapidly evaporating has much to recommend it.

There is one final method of preventing Bitter Pit which must never be lost sight of, although it is a slow process, and that is the breeding of Pit-proof varieties, breeding the disease out, instead of "dodging" it as we are trying to do by our present methods. This would be a work of time, of patience, and of skill, but while we are breeding wheats, for instance, to suit our conditions and be rust-resisting, I do not see why a Federal Bureau of Agriculture should not encourage the breeding of fruit trees, in connection with which the susceptibility to Bitter Pit would be one of the factors considered.

XVII.—PRACTICAL APPLICATIONS.

As a result of the experimental tests and the knowledge we now possess of the wonderful structure of the fruit, with its intricate network of vessels permeating among the pulp-cells in every direction, it is possible to suggest such measures as will ensure oversea shipments arriving in a perfect condition. Also such practical operations in the orchard as will reduce to a minimum the liability to Pit while the fruit is still growing and maturing on the tree.

1. In picking and packing apples they should be handled as carefully as eggs, since the delicate network of vessels immediately beneath the skin is easily ruptured, and the slightest bruise produces a flaw in the flesh.
2. Do not allow trees to bear too early, since the practice not only tends to weaken the tree, but the very rank growth of fruit on a quite young tree bearing only a few apples is very liable to Pit. Rapid growth is always accompanied by excessive transpiration, and the ebb and flow from rapid to slow growth are the most favourable conditions for the disease.
3. Since the respiration of the apple is slowed down at 32 degrees Fahr., and the fruit is in a state of suspended animation, the development of Bitter Pit is retarded. For a similar reason the ripening process is arrested, and if the fruit is shipped on the green side or just as it is beginning to turn to the ripening stage, and kept at this temperature in an atmosphere necessarily dry, it will reach its destination without any danger of becoming over-ripe. It is not sufficiently recognized that the apple continues to breathe for a considerable time after it is picked, since it is a common delusion that only animals respire.

4. The freezing point of the juice of the apple has been determined as from 28 to 29 degrees Fahr. Hence, if a uniform temperature is maintained in cold storage of 30 to 32 degrees Fahr., the oversea export of apples can be profitably carried out without any risk on the one hand of freezing, or on the other of developing Bitter Pit. When the fruit has first been cooled down to a proper temperature, it is found that subsequent changes of temperature during storage may, with care, be confined within narrow limits. After repeated trials and a careful record kept, temperature has only varied from one to one and a half degrees Fahr. during a period of six weeks, the average time taken for a shipment to reach its destination.
5. Varieties vary considerably in their susceptibility to Bitter Pit, as some are very liable in one district, while fairly free in another. The commercial varieties best suited to the district should be considered on planting, and a suitable site chosen.
6. Nitrogenous manures in excess or large applications of well-made stable manure are found to encourage pitting. Nitrogen can be best supplied by means of green manuring—sowing field peas in the autumn and ploughing them under in the spring. The humus thus supplied will assist in retaining soil-moisture and encouraging the steady, as opposed to the spasmodic, growth of the fruit.
7. Lime will remove sourness in land resulting from the decay of humus, and thus enable stable manure and green manures more rapidly to act. Its effect will be largely found in a hastened liberation of nitrogen for the use of the trees ; in a smaller degree it will help to liberate potash and phosphoric acid, the last particularly on ironstone country. Except in exceptional cases, lime will never altogether obviate the need for phosphoric acid, but it may do so for nitrogenous manures. An application every second year is desirable.
8. If the soil is in good physical condition and well cultivated, manuring should be necessary only when the orchard comes into full bearing. Then the necessary phosphoric acid and potash should be supplied every year, the phosphoric acid in the form of super-phosphate of lime and the potash as sulphate of potash.
9. Low-lying swampy land is known to favour Bitter Pit ; whereas well-drained land, by promoting healthy root action and preserving the balance between the supply of crude sap from below and transpiration from above, tends to lessen it. The great regulator in the absorption and emission of water by the plant, including the fruit, is drainage.
10. The experiments with different methods of pruning under similar conditions on the same variety of apple have now reached a stage where the cumulative effects of each may be estimated. The net result is that severe pruning tends to produce a virulent form of Pit, whereas light pruning either reduces Pit or prevents it altogether.
11. An artificial supply of water, as in irrigation, enables the orchardist to keep his trees "going" during the fruiting season when necessary, and thereby preventing a sudden change from dry to wet conditions, which is the best known means of producing Bitter Pit. By preserving uniform moisture conditions and never allowing the tree to flag, the size of the fruit is regulated when properly distributed on the tree, and the development of Bitter Pit prevented. Water can also be applied at the proper time to develop the fruit-buds for next season.
12. In order to reduce Bitter Pit to a minimum, it is necessary to have the tree well shaped, so as to be equally developed all round, to have a strong framework for carrying the fruit, to prune it so that the fruit is well distributed over the tree and not confined to a few main branches, and to uniformly nourish by suitable manures so that there is

regularity in the size and in the growth and ripening of the fruit. It may be stated generally that for the prevention of Bitter Pit, excess has to be avoided and moderation practised in the various orchard treatments, such as pruning, manuring, and irrigation. The object is to maintain, so far as possible, steady and uniform conditions of growth.

13. An instance has been given of the stock influencing the scion in the direction of preventing disease at page 70, and it remains to be seen how far the use of, say, the wild crab apple as a stock might render liable varieties immune to Bitter Pit.

XVIII.—EXPERIMENTS WORTHY OF BEING CONTINUED.

From the wide scope of this investigation, dealing with every phase in the life and growth of the tree, it was inevitable that a number of experiments could only be initiated, and in the short space of four years over which my engagement extended, could not possibly yield results in every branch of permanent value. Continuity was a factor essential to their success, and I therefore make the suggestion in this, my Fourth Report, that certain of the experiments be continued in the respective States so that the valuable results which they undoubtedly promise may be realized.

I refer more particularly to those over which the orchardist can exercise control, such as manuring, pruning, stocks, and breeding new varieties. And not only to the orchardist should these results prove of value, but it is necessary to have accurate knowledge so that the great body of teachers and experts engaged in the work of instruction may be able to utilize it. This point of view has been forcibly stated by Dr. Russell in his latest report (1914) on Agricultural Research at the Rothamsted Experiment Station :—"Before the expert adviser and the teacher can do their work satisfactorily, it is evident that definite systematic knowledge must be obtained of the subject with which they have to deal. Until this has been done, much of their teaching must be purely conjectural, and may even be unsound. The only safe foundation on which their work can be built up is sound accurate knowledge gained by systematic investigation."

It has also to be remembered that in these orchard experiments one is to a certain extent at the mercy of the weather. In the past droughty season, for instance, some of the experimental plots did not produce a single apple. Altogether, the time is far too short in which to expect a final result.

I will therefore make a few remarks on each of these experiments to indicate the direction in which they may prove valuable.

MANURING.

The manurial experiments were planned so as to give the maximum of results in a limited time. Sometimes the available trees of the same variety had already been manured, and I could only continue the same manures, with the one difference of using definite quantities in each experiment. Although a summary of results has been given, it is evident that if the experiments were continued, there would be more reliable data from which to draw conclusions, and a greater certainty given to the practice recommended.

To take the single instance of liming the land, it is important for the orchardist to know the quantities to use and the form in which it is best applied, whether as quicklime or crushed carbonate of lime. The different action they sometimes exhibit upon the soil requires to be cleared up, and there is a considerable difference in the cost.

PRUNING.

Perhaps there is no operation in the orchard requiring more careful attention than that of pruning, and yet while there are plenty of books of instruction there is a decided want of experimental evidence extending over a series of years for the methods advocated.

I have chiefly confined myself to a single variety, Cleopatra, because it is very liable to Bitter Pit, and it is necessary to test the cumulative effects of a system of pruning for a number of years.

Thus the fact that the London Pippin naturally produces spurs on the main and secondary leaders has been taken advantage of by growers to the extent that all laterals are pruned off, or at least shortened in to short spur systems.

Another cogent fact is this, that London Pippin is increasingly suffering from "crinkle."

Pruning experiments show clearly that the retention and extension of the lateral system resulted in a considerable reduction of "crinkle."

This should be carried out still further to prove to the satisfaction of every one that laterals should either be removed or retained in this variety.

The different methods, continued for four years, have already shown decided differences in the amount of Pit, and it is very desirable to continue the experiments already begun. The four systems adopted for experimental purposes have already been explained in the previous reports. They were "heavy," "light," "leader," and "no" pruning. The two latter have served their purpose, as far as the experiments have gone, and it might be wise to drop these, confining further work to tests of heavy and light pruning, especially in such cases and in such varieties where Pit or the confluent form of Pit, or "crinkle," have shown themselves to be very prevalent. The pruning experiments might be further elaborated so as to allow those varieties which produce spurs freely to be pruned to fruit-spurs only, allowing for no lateral system whatever.

STOCKS.

In experimenting with stocks there are a number of important questions to be answered concerning the reciprocal relation between stock and scion, and the experiments now under way should at least answer some of these questions. We know that the changes induced by the stock do not alter the identity of the variety, but slight modifications may be produced which make one stock more valuable than another.

The standard apple stocks are grown from seed, and in each case we enquire, How does the stock modify the size of the tree? How does it influence fruitfulness? And how does it affect the period of ripening, as well as the size and colour and flavour of the fruit? Some stocks may be better suited to a particular soil and climate than others and thus tend to increase the length of life of the tree.

From the very nature of the case a considerable time must elapse before results are available, and the stock tests contain such immense possibilities of securing more and better fruit that they should receive special attention.

At the very outset of this investigation I felt the necessity and importance of studying the wild crab apple in its relation to Bitter Pit, both as a stock and as a cross with cultivated varieties. I wrote to Luther Burbank, the famous plant breeder, as the most likely source for getting the necessary material, and he kindly replied :—"Most of my experiments with crosses with wild, native, and cultivated apples have been eliminated, but I have made arrangements to send you some things in this line which may be of interest to you."

There is here a special investigation of great promise for the future, but, of course, with the limited time at my disposal there are no results of value at present to record.

BREEDING OF NEW VARIETIES AND SELECTION.

The breeding of sorts resistant to disease is now a promising line of investigation, and from the results obtained in France with the grape there is a possibility of successful control. A beginning has been made in this direction by the mutual crossing of Yates and Cleopatra, the Yates being comparatively immune to Bitter Pit and the Cleopatra very susceptible. There was a definite object in view here to secure a Cleopatra apple with all the good qualities of the type, with the added quality to be derived from the Yates parent of being Pit-resistant. While the normal standard of the variety is maintained, the one object is kept in view of rearing a Pit-resistant Cleopatra.

A large number of plants must be raised to afford material for selection, and they must be continued to the fruiting stage. It may require a decade or more to bring a new generation of apples into bearing, and then those showing the greatest immunity to Pit would be selected.

The largest and most mature seeds from the cross should be chosen, to ensure uniformity in the crop and a quicker germination to give a good start to the young plant.

The experiments should be conducted in as many of the States as possible to have a variety adapted to different conditions of soil and climate, heat and moisture.

I have confined my attention to the one character of Bitter Pit, because that is the object which immediately concerns us, but there are other diseases which might be similarly treated, such as Woolly Blight.

There is a wide field and immense possibilities in the work of systematic breeding and selection, and it is worthy of the undivided attention of thoroughly capable experimentalists.

CONCLUDING REMARKS.

In carrying out a work of this magnitude within a limited time, there was necessarily a number of experiments, from their very nature, which could not be completed. I refer more particularly to such experiments as the influence of the stock on the development of Bitter Pit, the effects of different methods of pruning, and the application of different fertilizers. It is to be hoped that these will be continued and extended by the Agricultural Departments of the respective States. In the case of pruning alone there has been a sad lack of experimental work. Each expert is a law unto himself, and while it is useful and educational to have pruning demonstrations, it is only by continuous treatment extending over a series of years that the commercial success of a method can be proved. A particular variety could be chosen for the purpose, as they vary in their habit of growth, and a definite system followed, always leaving untreated trees or checks to show the benefit of the method of treatment adopted.

In South Australia there is an Experiment Orchard, where the various operations are being submitted to the test of experiment under the superintendence of Mr. G. Quinn, Horticultural Instructor. It is the most complete experiment station of its kind in the Commonwealth, and a record of results is being kept from the earliest stages.

In the case of perennials, such as orchard trees, which take a number of years to reach the fruit-bearing stage and continue in bearing for a long period, it is absolutely necessary to extend the test over a series of years, and for the sake of completeness, to prolong it as long as the tree continues to bear.

There is one form of experiment which has an important bearing on Bitter Pit, and which is necessarily a slow process. I refer to the crossing of varieties so as to secure new ones adapted to our conditions and with the liability to Pit eliminated. It is an operation requiring patience, skill, and aptitude for the work in order to get the best results ; and just as the crossing of annuals, such as wheat, is being pursued with success, I trust that the equally important breeding of fruit trees will receive attention. The amount of patience required will be at once understood by those who know that to breed a new variety of commercial value, even of an annual like wheat, often demands experiments and tests running up to ten or more years.

As I was appointed by the Commonwealth and State Governments to conduct this investigation, the co-operation of each of the States was assured, and I desire to put on record my appreciation of the services rendered.

In Victoria my best thanks are due to Dr. S. S. Cameron, Director of Agriculture, who provided me with every facility in the shape of laboratory and office accommodation for carrying out the work. Also to Messrs. C. C. Brittlebank, Vegetable Pathologist; E. E. Pescott, Principal, School of Horticulture; P. J. Carmody, Chief Supervisor of Orchards, and the various Orchard Supervisors; W. French, Superintendent Engineer-in-Charge of Cool Stores; J. Lang, Harcourt; H. H. Hatfield, Box Hill; Wm. Gillies, M.A.; and Dr. Paterson, Professor of Agriculture, University of Western Australia.

I was also ably assisted in the experimental work by Mr. C. Wedge, who had been trained under Principal Pescott, of the School of Horticulture, Burnley.

In New South Wales Mr. G. Valder, Director of Agriculture, kindly placed suitable experiment farms at my disposal, and I am much indebted to Mr. W. R. Peacock, at Bathurst, and Mr. F. G. Chomley, at Yanco, for superintending the experiments and supplying the results.

In Queensland the Under Secretary for Agriculture also co-operated, and Mr. W. Henderson, Orchard Inspector, supervised the experiments at Stanthorpe.

In South Australia, where the Experiment Orchard at Blackwood is a model of its kind, Mr. G. Quinn, Horticultural Instructor, placed the results of the numerous experiments freely at my disposal and aided me in every possible way.

In West Australia, Mr. J. F. Moody, Fruit Commissioner, took a very active interest in the work, and I am deeply grateful to him for the valuable help afforded. Mr. J. McNeil Martin, of the Mount Barker Estate Orchard, was also keenly interested and spared no pains in carrying to a successful issue the experiments which he supervised.

In Tasmania I was also much indebted to Mr. A. H. Benson, Director of Agriculture, who fully realized the importance of the investigation to Tasmania; and to Mr. J. Osborne, Horticultural Instructor, for assisting me in the selection of suitable orchards for experimental purposes. To Messrs. North and Brady, West Tamar, and Mr. G. S. Carruthers, New Norfolk, for the use of their orchards, I express my gratitude.

In conclusion, it is my pleasing duty to thank the great body of orchardists all over Australia for the kind and courteous manner in which they invariably welcomed my visits, and for the amount of local and practical knowledge which they freely gave in order to assist in the solution of the Bitter Pit problem. These cordial relations will always remain a pleasant memory.

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FRONTISPIECE.

FRONTISPIECE.

Dunn's (Munroe's) Favourite, picked on the green side for export when quite free from Pit and placed in cold storage on 1st February. The temperature in the cool store was allowed to fluctuate between 34 and 45 degrees Fahr., with the result that after about six weeks the apples were badly pitted when removed.

London Pippin, grown at Dromana, Victoria, and picked by myself on 15th February. The specimen shows both Pit and "crinkle" or confluent Bitter Pit.

Seedling apple, named "Glenone," grown in the same orchard, suitable for culinary and dessert purposes, and which has not so far shown any sign of Bitter Pit.

Plate I. Figs. 1-4.

PLATE I.

Figs.

1. Cleopatra apple, showing no sign of Pit or bruise externally, but revealing a flaw in the flesh internally when X-ray photograph was taken (Dr. Lemon).
2. The same when X-ray photograph was taken in April after the apple had developed Pit. The flaw in the flesh is still seen to persist (Dr. Lemon).
3. Photograph of same apple, showing Pit developed towards eye end and in longitudinal section (13/4/15).
4. Cleopatra apple from the six that were kept as check—the only one showing Pit. Median longitudinal section of same for comparison with Fig. 3.

Plate I.

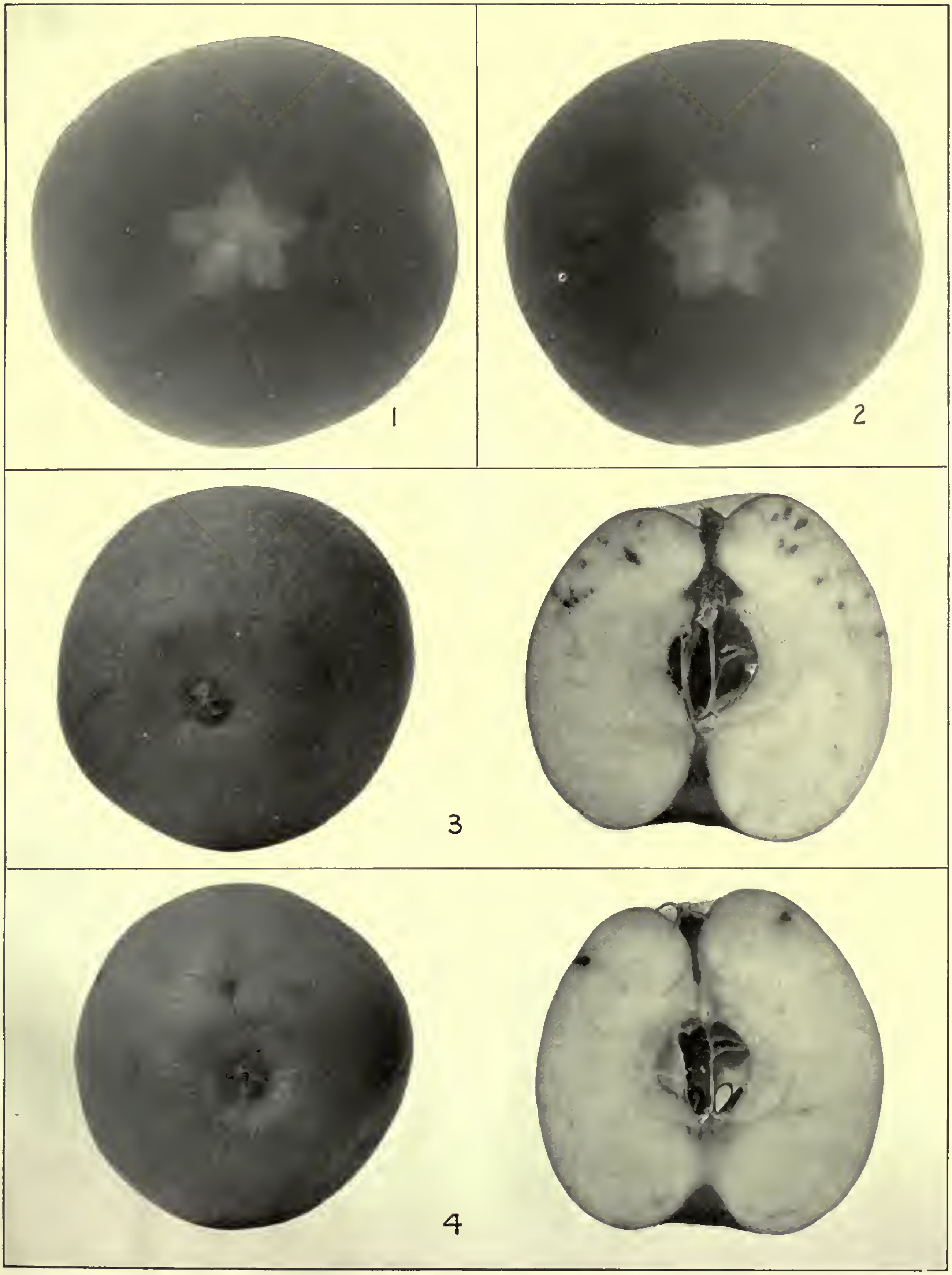

PLATE II.

Figs.

5. Annie Elizabeth apple (No. 14), showing no external Pit, but revealing disease when X-rayed (Dr. Lawrence).
6. The same when X-ray photograph was taken after Pit had developed on keeping for three weeks (Dr. Lawrence).
7. Photograph of the three Annie Elizabeth apples (Nos. 13, 14, and 15), apparently sound, but showing indications when X-rayed, and afterwards developing Pit externally and internally.

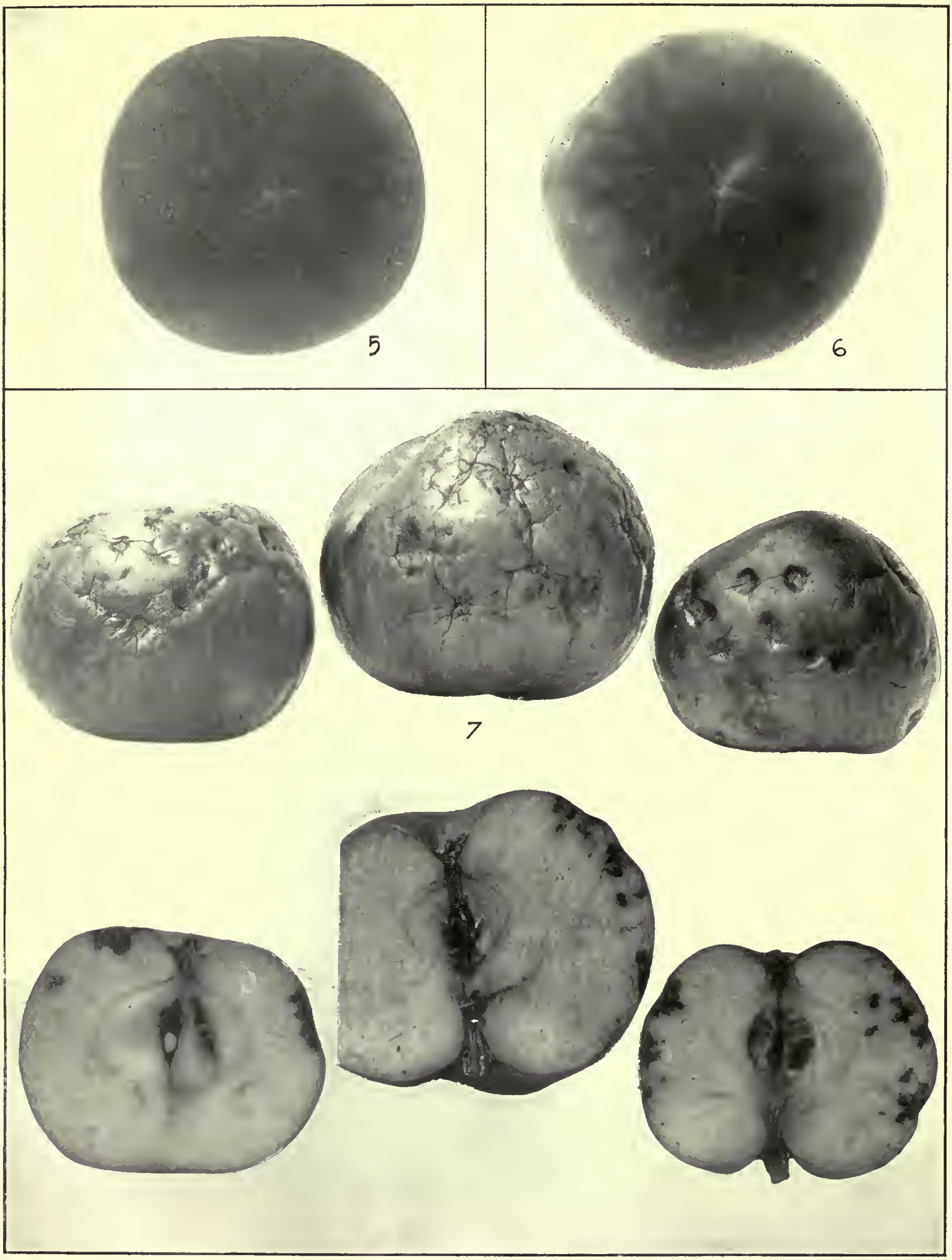
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PLATE III. FIG. 8.

PLATE III.

Fig.

8. Annie Elizabeth tree, the cinctured limbs of which have shed their leaves, while the rest of the tree still retains them (19/5/15). Leaves of tree completely dropped by 8th July.

Fig. 8.

PLATE IV. FIG. 9.

PLATE IV.

Fig.
9. General view of North & Brady's orchard on the Tamar, showing two Cleopatra apple trees surrounded by white duck, to test the effect of shelter on the development of Bitter Pit. The experiment plots are also shown to the right.

PLATE IV.

Fig. 9.

PLATE V. FIG. 10.

PLATE V.

Fig.
10. Near view of the same two trees, which were surrounded by duck waterproof screen before blossoming.

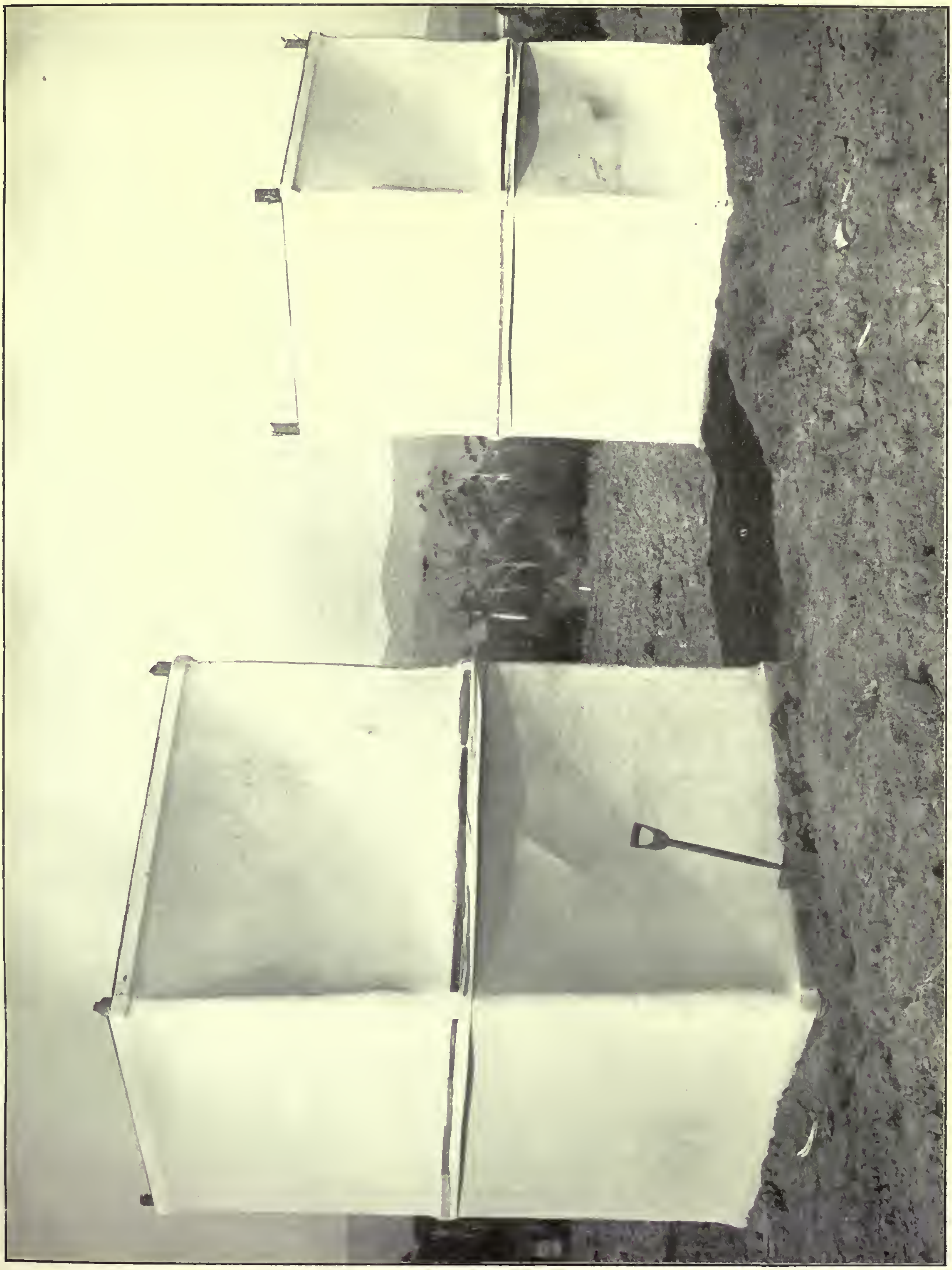

Fig. 10.

PLATE VI. FIG. 11.

PLATE VI.

Fig.
11. Tree shown when screen was removed on 9th February, with remarkable upright growth.

Fig. 11.

PLATE VII. FIG. 12.

PLATE VII.

Fig.
12. Adjoining Cleopatra tree grown without shelter.

Fig. 12.

Plate VIII. Figs. 13-15.

PLATE VIII.

Fig.

13. Old Jargonelle Pear tree, growing in the City Park, Launceston, over 80 years of age.
14. Quince (Manning's Early), growing in Burnley Gardens, showing Pit and confluent Pit or "crinkle." This is the first time Quinces have shown the disease here (17/2/15).
15. Transverse section of same, showing isolated and continuous brown patches beneath skin.


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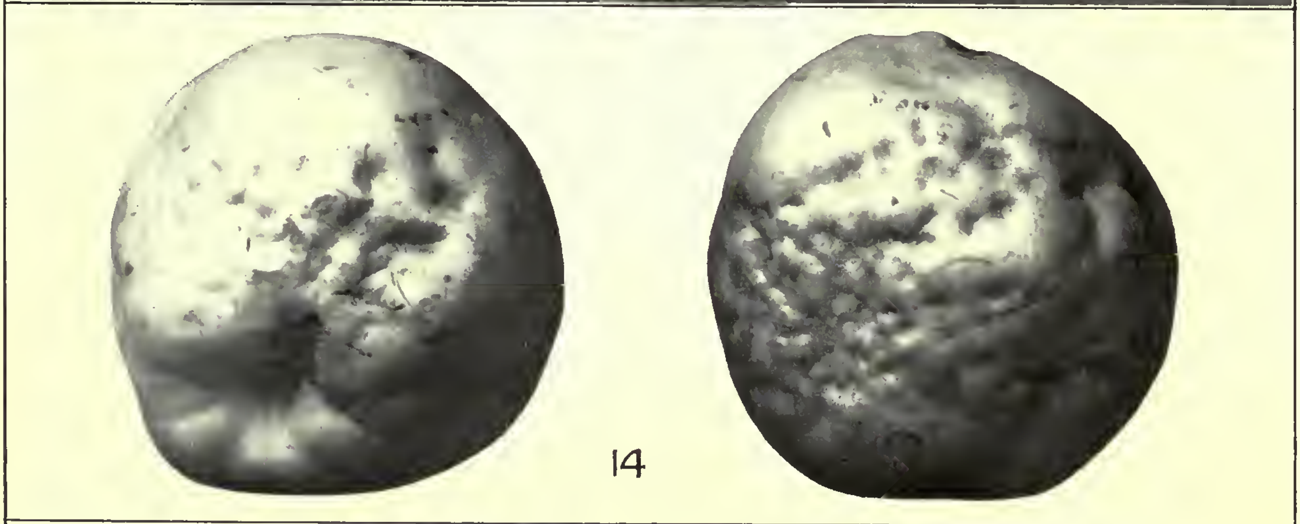
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PLATE IX. FIG. 16.

PLATE IX.

Fig.
16. Old apple tree at York Town, Tasmania, photographed in February, 1915, when 110 years old, probably the oldest apple tree in the Commonwealth of Australia.

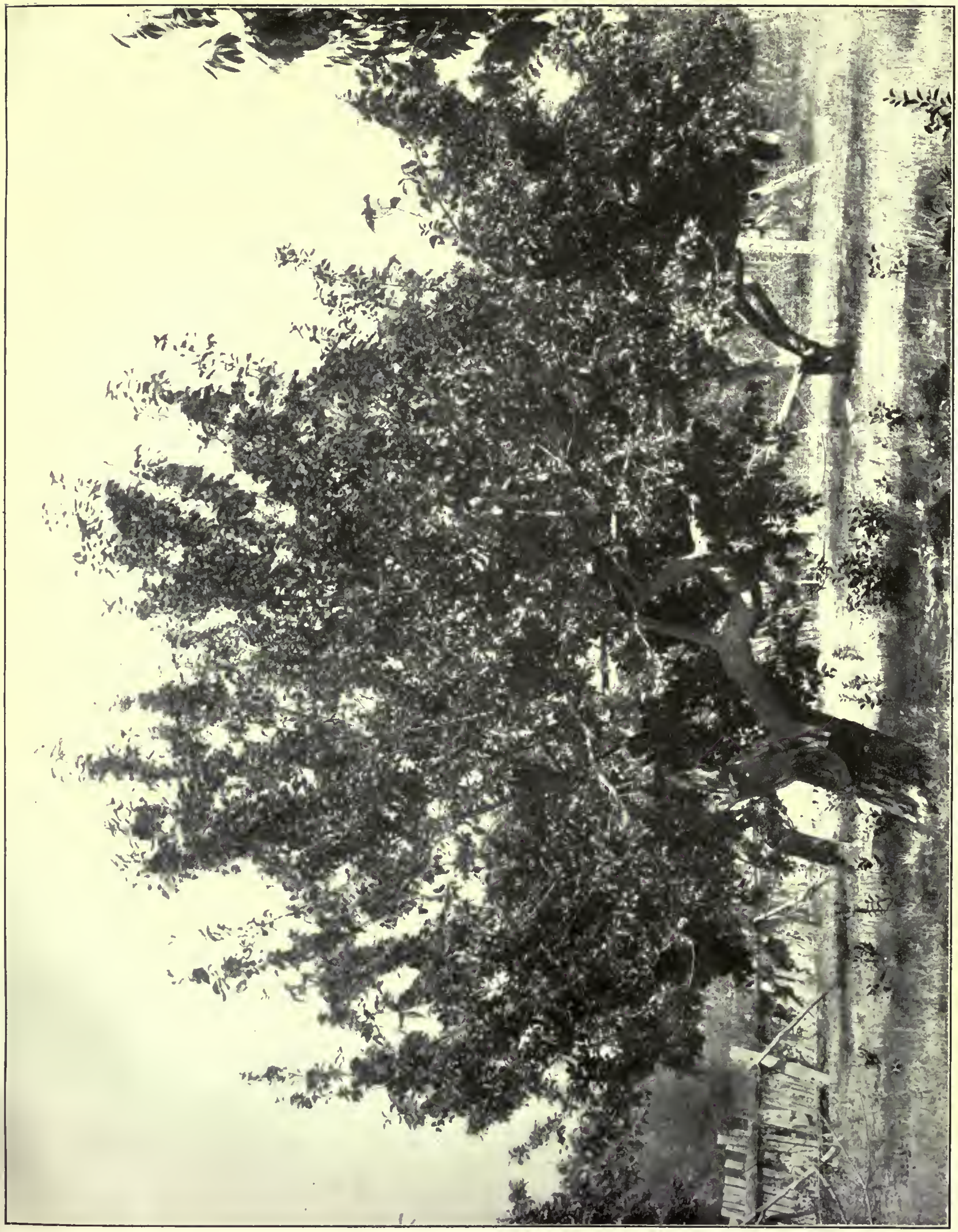
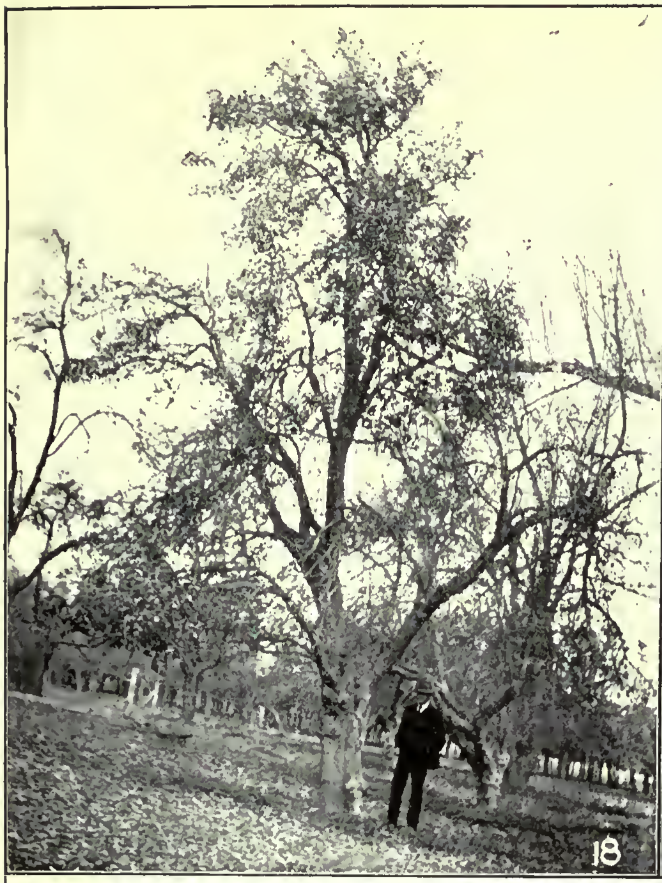


Fig. 16.

PLATE X.

Figs.

17. The same photographed in 1904 before being cut back on account of Codlin Moth.
18. Stone Pippin apple tree at "Brucedale," Bathurst, planted 1824. Bore a heavy crop last year, and the fruit was not diseased.
19. Jargonelle Pear tree in same orchard, planted 1824. It bears heavy crops of healthy fruit each year.
20. Windsor Pear tree in same orchard, planted 1824. Also bears heavy crops each year, but is subject to "Black Spot" (*Fusicladium*).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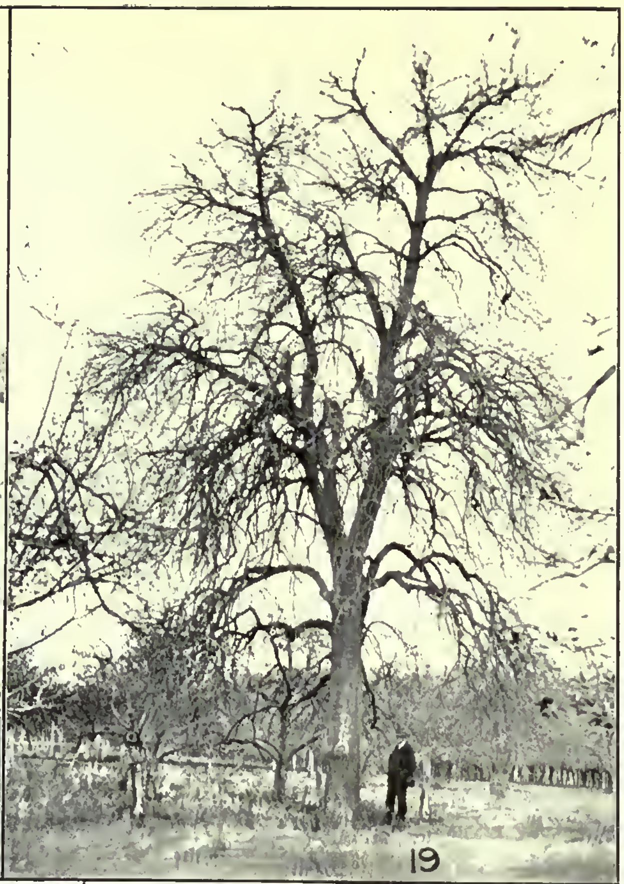
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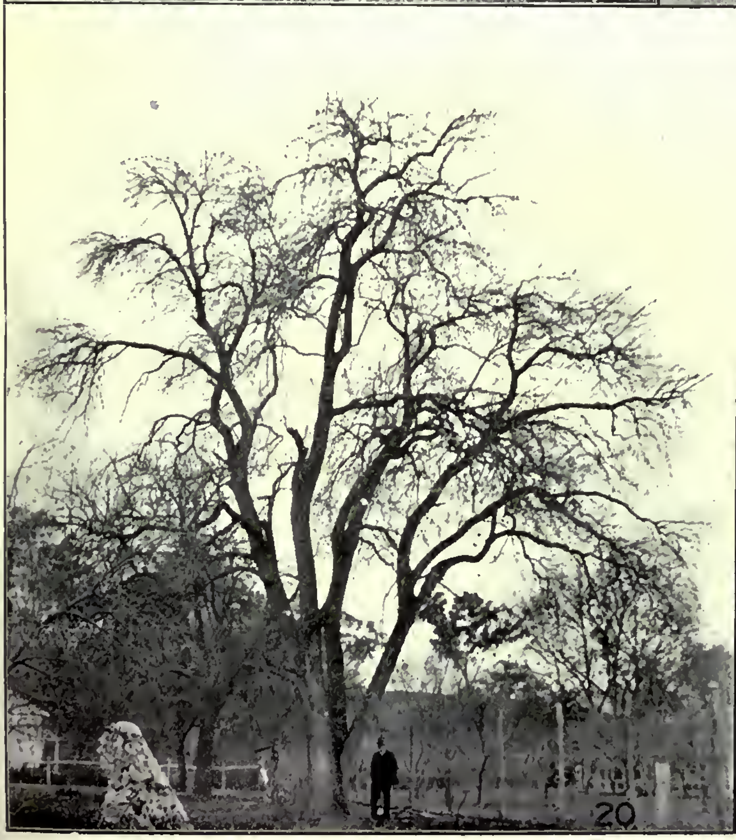
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PLATE XI. FIG. 21.

PLATE XI.

Fig.
21. Bailey's Bergamot Pear tree, 50 years old, some seasons yielding 40 bushel-cases of healthy fruit. Glenone orchard, Dromana (15/2/15).

PLATE XI.

Fig. 21.

PLATE XII. FIG. 22.

PLATE XII.

Fig.

22. A number of Dunn's Favourite apples badly pitted, after being kept in cold storage at fluctuating temperatures. No sign of Pit when placed in store.

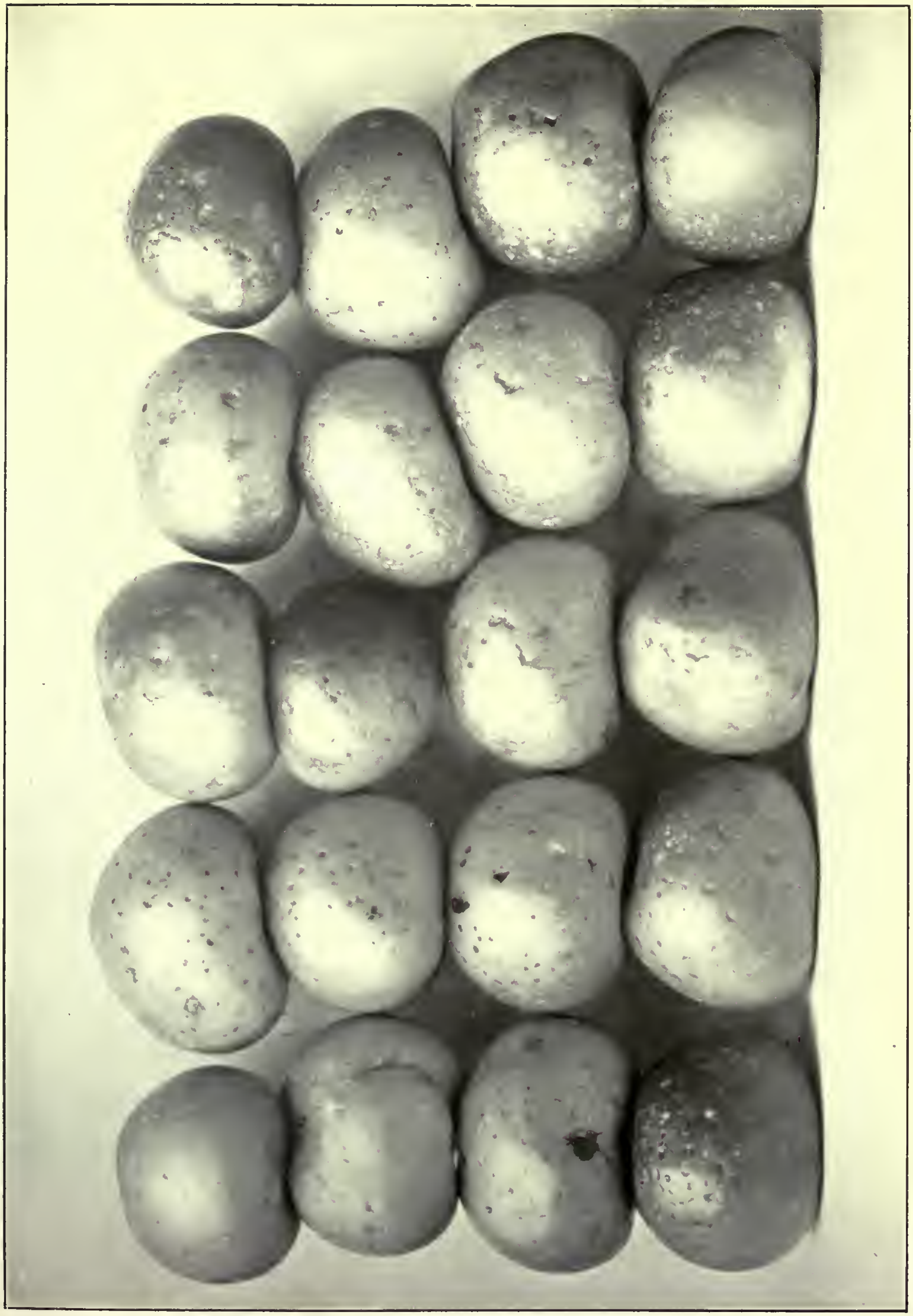

Fig. 22.

PLATE XIII.

Figs.

23. Single apples of Dunn's Favourite, showing brown flecks inside and directly beneath skin.

24. Clerome, with isolated and confluent Pit, from tree growing in Burnley Horticultural Gardens, between 3 and 4 years old (30/1/15).

25. Small's Seedling apple with sun-scald and "glassiness" combined, simulating "crinkle" externally. Depression at the eye end due to sun scald.

26. Longitudinal section of same, showing distribution of "water-core" or "glassiness."

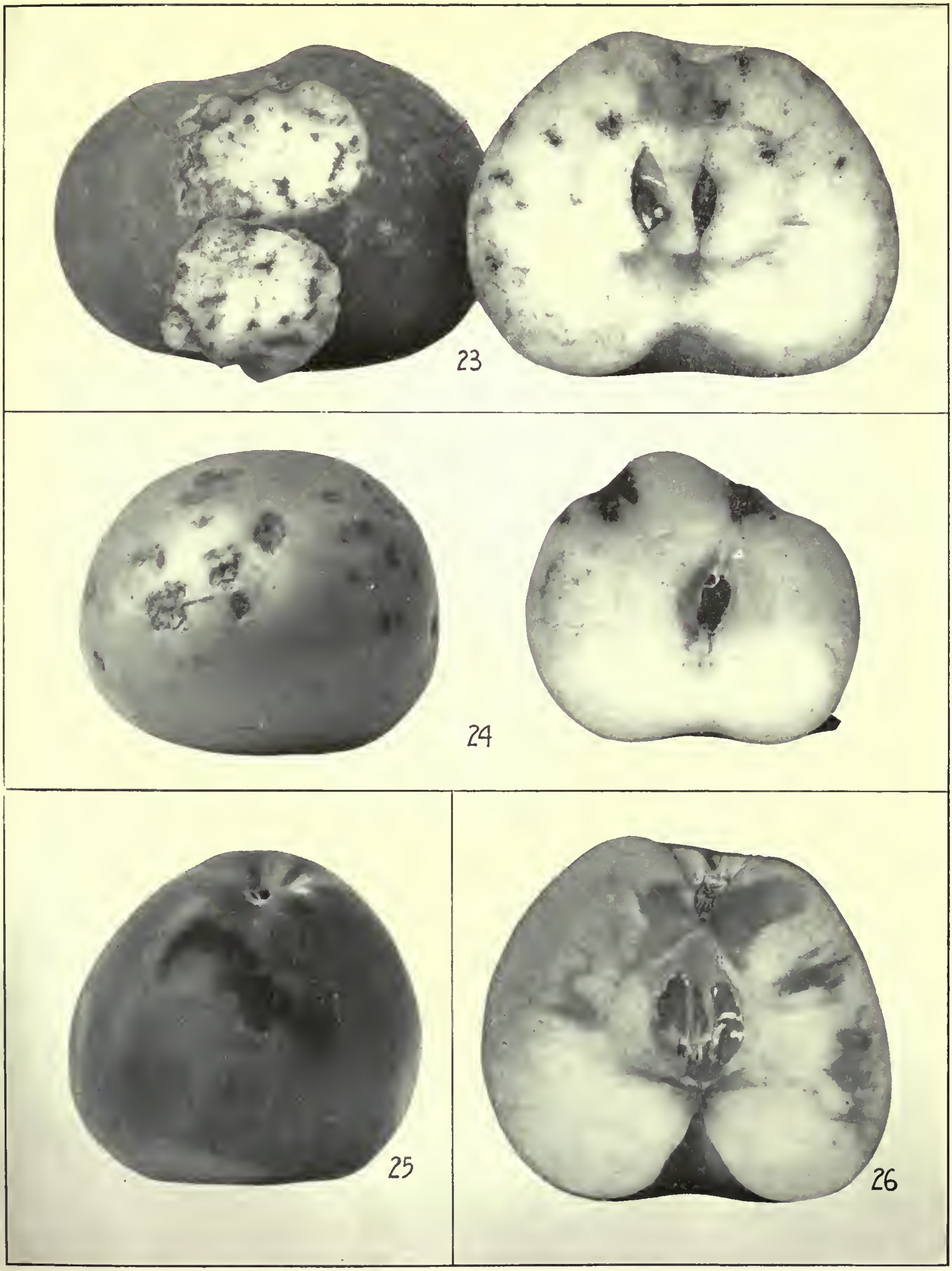
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Plate XIV. Fig. 27.

PLATE XIV.

Fig.

27. Lord Suffield, grafted on to Northern Spy stock in September, 1913, and bearing four badly pitted apples. The leaves have been removed on one side to show fruits. (15/1/15).

Fig. 27.

Plate XV. Fig. 28.

PLATE XV.

Fig.
28. Portion of same with fruits enlarged to show pitting.

Fig. 28.

PLATE XVI. FIG. 29.

PLATE XVI.

Fig.

29. Seventeen large Tasmanian apples, weighing on an average 1 lb. 2 oz.; and some of them badly pitted.

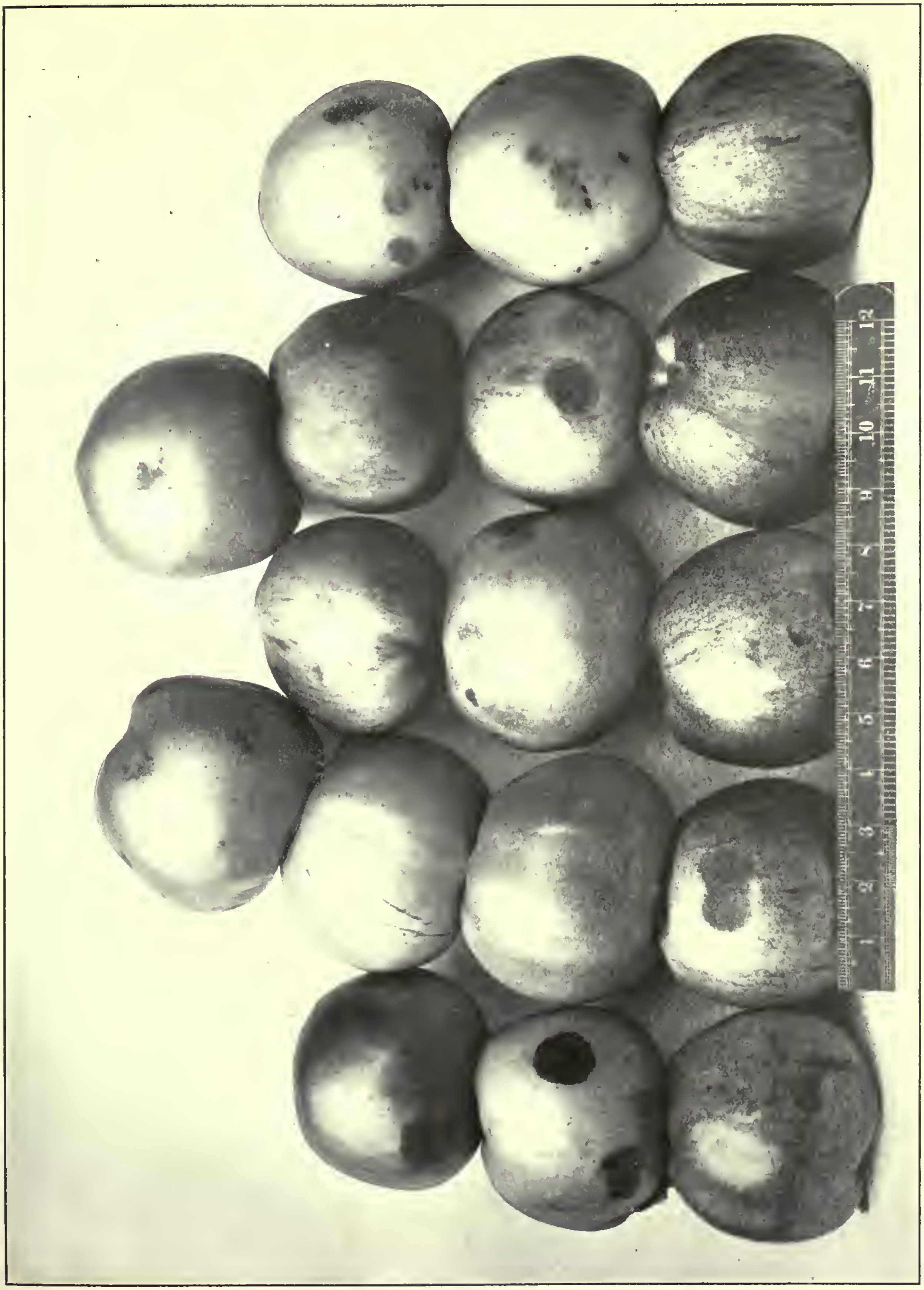


Fig. 29.

PLATE XVII.

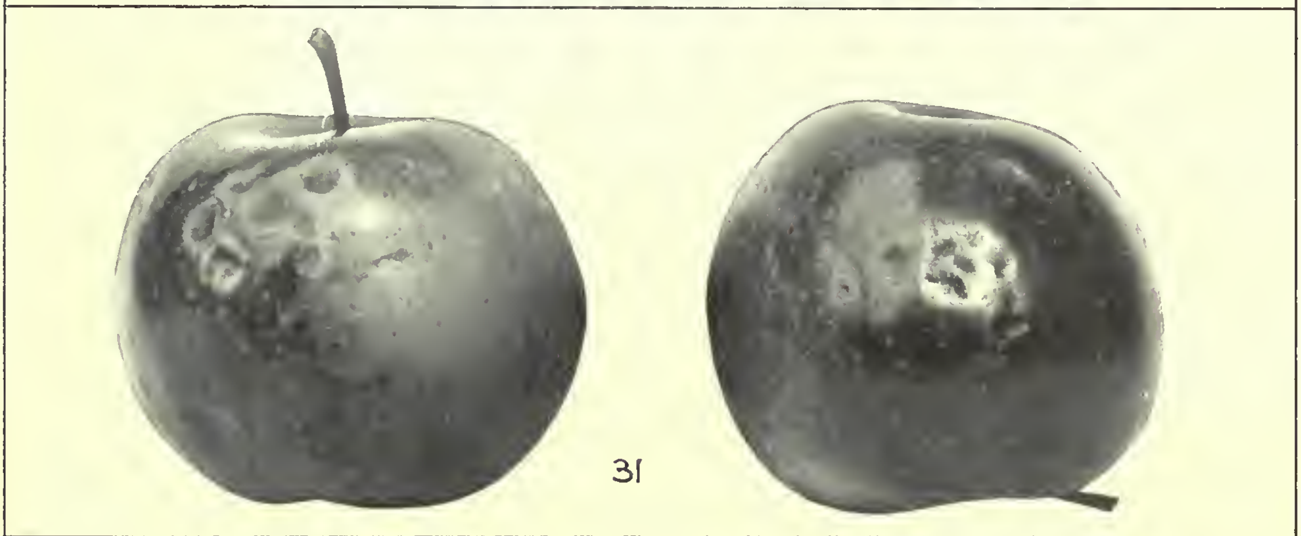
Figs.

30. A group of five Gloria Mundi and Alfriston apples from same, badly pitted.

31. Dougherty apples from Ringwood, Victoria, showing Pit, although the same variety was free for four years in succession at Burnley Horticultural Gardens.

32. Longitudinal section and skin removed from surface to show Pit.

30



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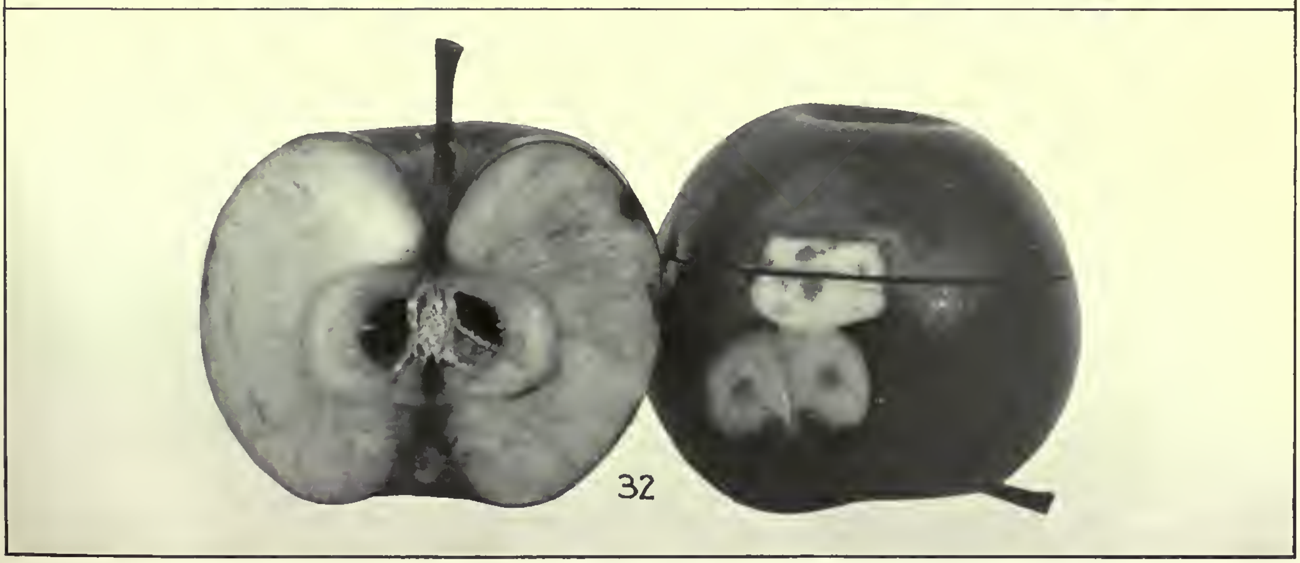

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Plate XVIII. Fig. 33.

PLATE XVIII.

Fig.

33. Jonathan tree at Mr. Lang's orchard, Harcourt, 12 years old, and yielding 5 bushel-cases, with only moderate pruning and without artificial water (3/2/15).

Fig. 33

PLATE XIX. FIG. 34.

PLATE XIX.

Fig.

34. Stone Pippin at same orchard, about 30 years old, and yielding 6 bushel-cases, with medium pruning.

Fig. 34.

Plate XX. Fig. 35.

PLATE XX.

Fig.

35. Cleopatra at same orchard, about 30 years old, and yielding 3 bushel-cases, with light pruning.

Fig. 35.

Plate XXI. Fig. 36.

PLATE XXI.

Fig.

36. Cleopatra, at Mr. Rash's orchard, Harcourt, about 20 years old, and yielding 12 bushel-cases under irrigation. The fruit was practically free from Bitter Pit, and even apples kept till June did not develop it.

PLATE XXI.

Fig. 36.

PLATE XXII. FIG. 37.

PLATE XXII.

Fig.
37. Dunn's Favourite at same orchard, about 20 years old, and yielding 10 bushel-cases under irrigation ; free from Pit.

PLATE XXII.

Fig. 37.

PLATE XXIII. FIG. 38.

PLATE XXIII.

Fig.

38. Cleopatra in Glenone orchard, Dromana, with fruit removed. Yield, only 48 apples, of which 7 were pitted, or 14 per cent.

PLATE XXIII.

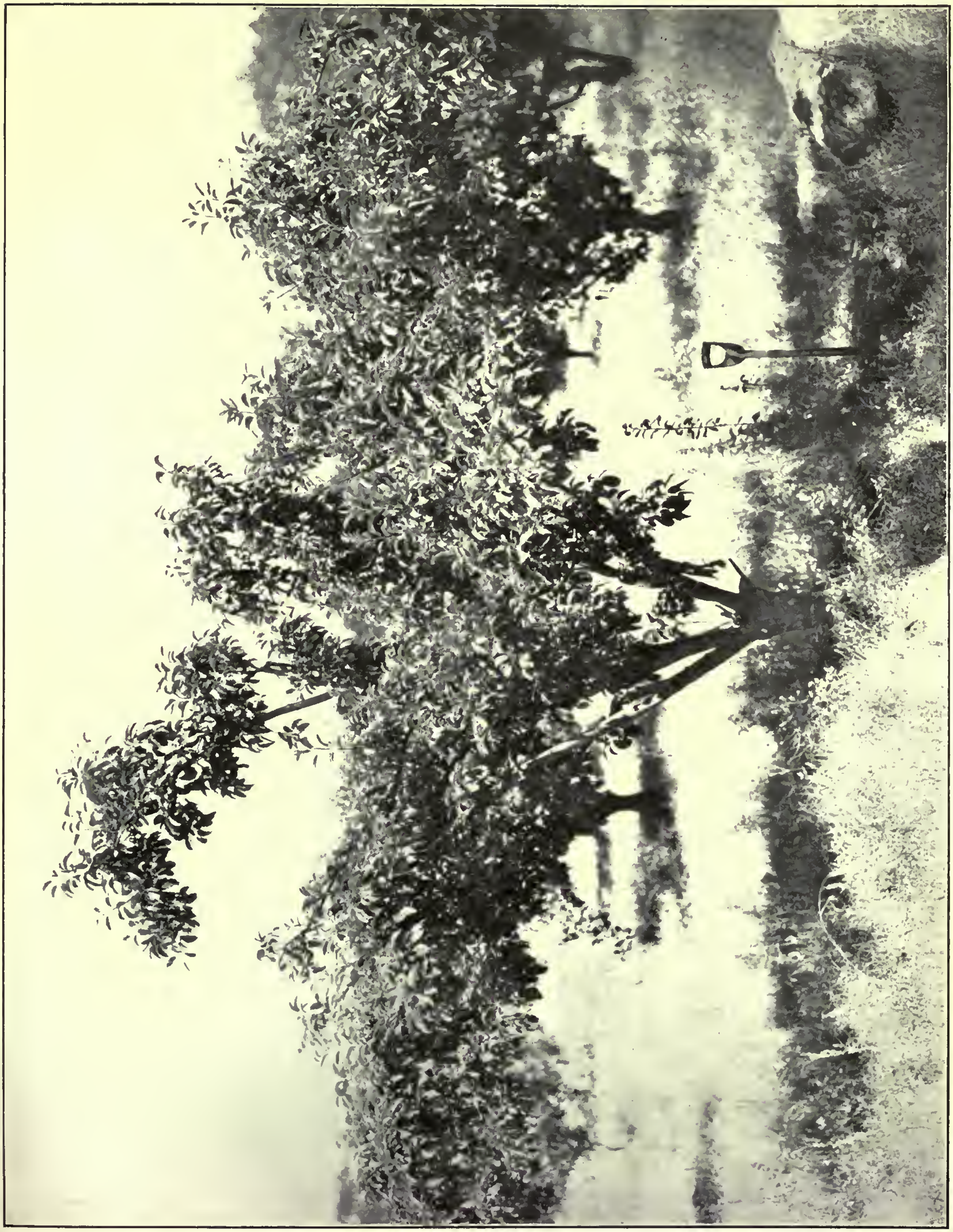

Fig. 38.

PLATE XXIV. FIG. 39.

PLATE XXIV.

Fig.

39. Cleopatra, in Gracefield orchard adjoining, yielding 3 bushel-cases of fruit, with 75 per cent. of Pit.

Fig. 39.

Plate XXV. Fig. 40.

PLATE XXV.

Fig.

40. Jonathan in Glenone orchard, 8 years old, with 2 bushel-cases of fruit, apparently free from Pit.

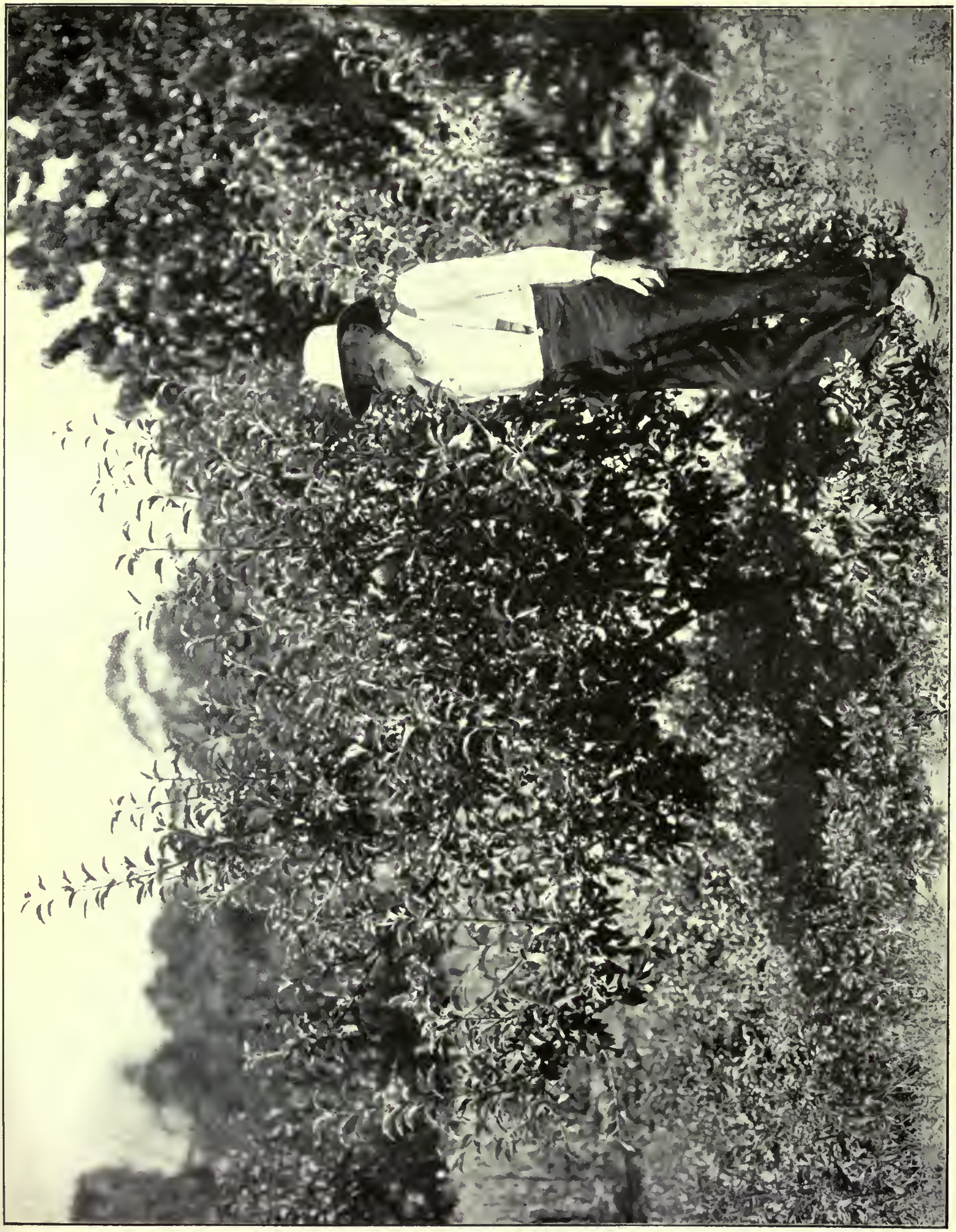

Fig. 40.

Plate XXVI. Fig. 41.

PLATE XXVI.

Fig.
41. Jonathan in Graeefield orchard, of the same age, with 3 bushel-cases of fruit, apparently free from Pit.

Fig. 41.

Plate XXVII. Fig. 42.

PLATE XXVII.

Fig.
42. Unmanured row of four Cleopatra trees in Mount Barker Estate Orchard, West Australia.

Fig. 42.

PLATE XXVIII. FIG. 43.

PLATE XXVIII.

Fig.
43. Manured row of four Cleopatra trees in same orchard.

Fig. 43.

Plate XXIX. Fig. 44.

PLATE XXIX.

Fig.
44. Individual tree in the same row loaded with fruit.

Fig. 44.

PLATE XXX. FIG. 45.

PLATE XXX.

Fig.
45. The same tree with fruit picked, showing 6 bushel-cases off tree and half a case of windfalls.

Fig. 45.

PLATE XXXI. FIG. 46.

PLATE XXXI.

Fig.

46. Stone Pippin in old orchard of the same estate, about 23 years old, and yielding 16 bushel-cases of fruit.

Fig. 46.

PLATE XXXII. FIG. 47.

PLATE XXXII.

Fig.

47. Rome Beauty at Ringwood, Victoria, between 3 and 4 years old, on Winter Majetin stock, and severely pruned in the winter (5/2/15).

Fig. 47.

Plate XXXIII. Fig. 48.

PLATE XXXIII.

Fig.
48. The same showing fruit picked, consisting of 162 apples, with 138 pitted and "crinkled," or 85 per cent.

Fig. 48.

Plate XXXIV. Fig. 49.

PLATE XXXIV.

Fig.

49. Rome Beauty of same age, but only leaders topped. There was no fruit, but the branches showed a growth of about 2½ feet.

Fig. 49.

PLATE XXXV. FIG. 50.

PLATE XXXV.

Fig.

50. Blenheim Orange on Spy, planted in August, 1911—the most luxuriant-growing tree among Stock Experiments in screen (19/5/15).

Fig. 50.

PLATE XXXVI. FIG. 51.

PLATE XXXVI.

Fig.

51. Clerome of the same age, on Annie Elizabeth on Yarra Bank, showing more upright and compact growth (19/5/15).

Fig. 51.

Plate XXXVII. Fig. 52.

PLATE XXXVII.

Fig.
52. Blenheim Orange in screen at Burnley Gardens.—Unpruned and Pruned. (3/7/15).

Fig. 52.

PLATE XXXVIII. FIG. 53.

PLATE XXXVIII.

Fig.
53. Clerome in screen.—Pruned and Unpruned. (3/7/15).

Fig. 53.

Plate XXXIX. Fig. 54.

PLATE XXXIX.

Fig.

54. An orchard of "Standard" apple trees with trunks nearly six feet high, at Wandin, Victoria (23/7/15).

Fig. 54

PLATE XL. FIGS. 55-58.

PLATE XL.

Figs.

55. Seedling apple tree named "Glenone," first grown from seed 15 years ago at Dromana —on own roots. The knobs visible on the trunk and branches are adventitious or dormant buds (15/2/15).

56. Calipers with self-recording arrangement whereby the amount of growth of apples on the tree was measured.

57. Double Cleopatra apple, perfectly sound, with two stalks, two eyes, and two cores.

58. The Mistletoe (*Loranthus pendulus*) on Lady Daley apple tree in Burnley Gardens. This appeared towards the end of August, 1914, but owing to the hot weather and the drought it gradually shrivelled up. This is the first record in the Gardens for apple trees, and Mr. Lang informs me that he only observed it at Harcourt some years ago on Merritt's Royal Pearmain.


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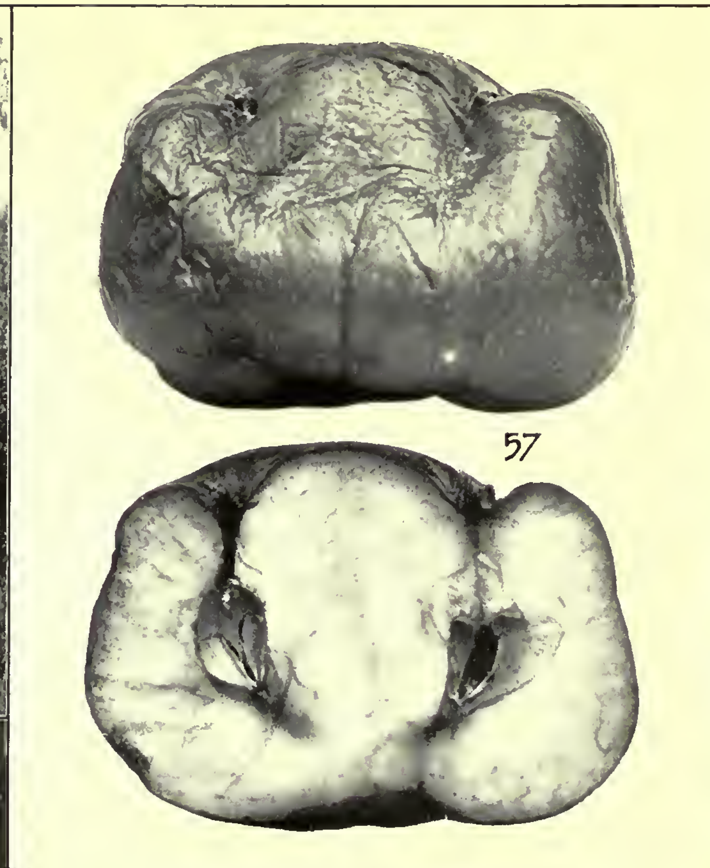
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APPENDICES.

APPENDIX I.

WEATHER CONDITIONS FOR NINE MONTHS IN VICTORIA, NEW SOUTH WALES, AND SOUTH AUSTRALIA, UP TO AND INCLUDING MARCH, 1915.

I am indebted to Mr. H. A. Hunt, Commonwealth Meteorologist, for reports of the weather conditions prevailing throughout the States of Victoria, New South Wales, and South Australia up to the end of March, 1915.

From these I have selected the general features for nine months commencing in July, 1914, and ending in March, 1915, when the fruit season was practically over.

VICTORIA.—For the three months of July, August, and September, 1914, the rainfall was generally scanty, although, with the exception of the Northern areas, the July rains were generally sufficient, while Gippsland had a large excess. In August the rainfall summary shows the phenomenal dryness of the month, and in September the rainfall was also very deficient in the South, not to so great an extent as in the North, but still sufficiently so to threaten serious effects.

NEW SOUTH WALES.—There was also a general deficiency of rain throughout these months. In July heavy rains were experienced in the Coastal districts, and in the Tablelands there was a fair amount of rain, but in districts such as the Riverina very dry conditions still prevailed. In August, with the exception of the North Coastal districts and a small area to the south, a most unusually small rainfall was experienced over the whole of New South Wales, most of the stations in the Western Division and Plains not recording even one point. In September, except in the Hunter, Metropolitan, and South Coast Districts, the rainfall was again far below the average.

SOUTH AUSTRALIA.—The drought was very pronounced. July was very dry with severe frosts, August exceptionally dry, and the exceedingly dry conditions of winter, which had culminated with the driest August on record, had been further intensified by the end of September.

VICTORIA.—For the months of October, November, and December there were good rains during the last two months. In October, however, the drought lost none of its intensity, making the sixth month of the severest drought ever known in Victoria, certainly since 1858. One result of the generally dry and quiet conditions of the air was the occurrence of several frosts, one of which on the 16th had disastrous effects, especially on the apple crop. A summary of the rainfall in November shows a considerable improvement on any of the previous six months, and no severe weather occurred. Monsoonal activity, which was becoming very noticeable in October, and which resulted in the break-up of the drought in November, still further increased during December, with the result that this month has been unusually wet, almost throughout the State. Throughout the State fruit crops are light, partly due to the Thrip pest and partly to spring frosts, one of which occurred on 27th November, in addition to the October one.

NEW SOUTH WALES.—There were good spring rains, with the exception principally of the Riverina and Western District. In October, as a result of the unusually heavy rains, the reports received from all the Coastal districts were of a most satisfactory nature. From the North Coast to the South the outcome proved one of the best springs for years. In Western Riverina and in the Western District, however, drought of unparalleled severity prevailed. November was characterized by frequent thunderstorms, which provided patchy, but generally good, rains over the greater part of the State, excepting a few isolated areas and the Southern District, including the Riverina. During December frequent storms, providing good, but irregular and patchy, rains, occurred over almost the whole State. In the Riverina and portions of the Western Division there was only sufficient rainfall to give partial relief by filling household tanks and causing a slight spring in grass.

SOUTH AUSTRALIA.—There was very little rain in October, but during the two succeeding months good rains were generally recorded. October was marked by the continuance of the severe drought which had held sway during the preceding winter and spring. The rainfall was everywhere very scanty and of little benefit. The extemely dry conditions were greatly relieved during November by monsoonal disturbances, which practically controlled the weather through the month. With the exception of a few isolated places, the monthly rainfall totals throughout the State were above the average. At the end of December the outlook over the whole of the State had appreciably brightened through a continuance of the monsoonal conditions which prevailed during November.

VICTORIA.—For the months of January, February, and March the conditions were generally dry. In January the State generally was drier than usual, but not to any great extent. The eastern half of Gippsland had a rainfall well above normal. February and March were both very dry months on the whole, and the effect was seen in the ripening of the fruit, which was generally three weeks earlier than usual.

NEW SOUTH WALES.—There was a very scanty rainfall during these three months. In January the low rainfall, combined with the great heat during the latter half of the month and the unusual amount of windy weather which gave rise to frequent dust storms of exceptional severity, all militated against good seasonable conditions, and consequently reports were of a more or less unfavourable character. February proved a very disappointing month, for, owing to the scanty rainfall, the droughty conditions of the interior were still further intensified, and even in the Coastal districts, where conditions were more favourable, the scarcity of rain was beginning to be felt. Throughout March continued heat and dryness were again the prevailing weather conditions, with the inevitable result that all the ills of the droughty period were still more intensified.

SOUTH AUSTRALIA.—The first three months of the year were very dry, and the fruit crop seriously suffered through lack of moisture. During January the good rains recorded in the latter two months of last year had not continued, and only the far North and North-West received falls above the average, the excess being up to half an inch. At the end of February the outlook over the whole of the State was very unpromising, owing to the exceptionally dry character of the month. In March the rainfall was again everywhere far below the average, and throughout all the inland pastoral areas and the more inland parts of the agricultural districts it was practically rainless.

APPENDIX II.

LIST OF 100 VARIETIES OF APPLES GROWING IN BURNLEY HORTICULTURAL GARDENS, GIVING AGE, STOCKS USED, TIME OF FLOWERING, YIELD, AND RELATIVE AMOUNT OF PIT FOR FOUR YEARS IN SUCCESSION.

ABBREVIATIONS USED:

Ripening Season	Yield	Bitter Pit
E=Early.	L=Light.	F=Free.
M=Medium.	M=Medium.	S=Slight.
L=Late.	H=Heavy.	B=Bad.
VL=Very Late.	0, 1, 2, 3=Number of Apples.	VB=Very Bad.

No.	Variety.	Stocks.	Age 1915	Full Bloom. 1912	1913	1914	Ripening Season	Yield. 1914	1915	Bitter Pit. 1912	1913	1914	1915
1	Allsop's Beauty	Paradise on Spy	26	12/10	14/10	5/10	L	M	L	F	F	S	F
2	Allington Pippin	Lord Wolseley on Spy	5	9/10	10/10	9/10	M	M	VL	B	S	S	S
3	Annie Elizabeth	Northern Spy	36	22/10	18/10	11/10	M	M	M	VB	VB	VB	VB
4	Autumn Pearmain	Paradise on Spy	36	30/9	10/10	7/10	L	M	L	S	VB	S	S
5	Baldwin	Paradise on Spy	36	18/10	8/10	30/9	ML		VL	B	B	B	S
6	Bascombe Mystery	Paradise on Spy	36	22/10	14/10	16/10	L	M	O	S	S	F	*
7	Black Ben Davis	Northern Spy	7 or 8	5/10	6/10	3/10	M	M	L	F	S	F	B
8	Blenheim Pippin	Paradise on Spy	36	18/10	10/10	..	M	M	VL	VB	S	S	S
9	Bismarck	Northern Spy	17	9/10	8/10	9/10	M	—	M	VB	VB	B	S
10	Borrowdale	Paradise on Spy	31	30/9	26/9	28/9	E	M	VL	B	B	B	S
11	Boston Russet	Paradise on Spy	36	19/10	7/10	5/10	M	—	VL	S	S	S	S
12	Brabant Bellefleur	Paradise on Spy	36	23/10	20/10	17/10	L	M	VL	VB	S	S	F
13	Bunce	Paradise on Spy	36	2/10	6/10	14/10	L	M	L	F	S	F	S
14	Buncombe	Paradise on Spy	36	9/10	10/10	7/10	L	M	O	B	B	B	—
15	Cammack's Sweet	Paradise on Spy	31	5/10	8/10	7/10	L	M	L	VS	S	S	S
16	Cannon Pearmain	Paradise on Spy	31	27/9	8/10	15/10	L	M	L	F	S	S	F
17	Capper's Pearmain	Paradise on Spy	31	24/10	28/10	29/10	L	M	L	S	S	S	S
18	Carolina	Paradise on Spy	31	1/10	7/10	—	L	H	L	S	S	S	S
19	Cellini	Paradise on Spy	16	18/10	16/10	16/10	M	M	VL	S	S	S	S
20	Chattahoochie Greening	Paradise on Spy	36	18/10	14/10	17/10	L	L	L	F	S	F	S
21	Chenango Strawberry	Northern Spy	31	9/10	10/10	7/10	E	L	1	VS	VS	F	F
22	Cobrico	Paradise on Spy	31	2/10	2/10	9/10	L	L	VL	F	F	F	F
23	Compton	Paradise on Spy	31	17/10	14/10	12/10	M	L	VL	S	S	S	S
24	Cox's Orange Pippin	Northern Spy	17	19/10	10/10	5/10	M	M	VL	S	S	S	S
25	Delicious	Perfection on Spy	6	18/10	10/10	20/10	E	L	VL	S	S	B	S
26	Dietzer's Golden Reinette	Paradise on Spy	36	19/10	16/10	16/10	M	L	1	S	F	S	F
27	Dougherty	Annie Elizabeth on Spy	5	16/10	10/10	3/10	VL	—	M	F	F	F	F
28	Dumelow	Cox's Orange Pippin on Spy	5	12/10	10/10	17/10	M	L	1	B	B	VB	F
29	Ecklinville Seedling	Paradise on Spy	36	7/10	8/10	16/10	E	—	2	S	S	F	S
30	Elarkee	Paradise on Spy	31	5/10	7/10	9/10	L	L	VL	F	S	S	F
31	Emperor Napoleon	Paradise on Spy	36	18/10	14/10	9/10	E	L	L	S	S	S	F
32	Esopus Spitzenburg	Northern Spy	17	18/10	10/10	9/10	L	H	L	S	S	S	S
33	Etowah	Paradise on Spy	31	16/10	10/10	16/10	L	L	O	F	F	F	—
34	Forge	Paradise on Spy	36	19/10	27/10	2/10	L	L	VL	S	S	B	F
35	Frampton	Paradise on Spy	31	—	3/10	—	M	—	1	S	S	F	S
36	Frogmore Prolific	Magg's Seedling on Spy	36	19/10	29/10	14/10	M	M	M	F	F	F	F
37	Garden Royal	Lord Wolseley on Spy	36	9/10	8/10	2/10	E	—	M	VB	VB	VB	VB
38	George Neilson	Paradise on Spy	31	9/10	—	—	M	—	M	F	F	F	F
39	Golden Reinette	Northern Spy	31	19/10	—	—	M	—	VL	F	F	F	F
40	Granny Smith	Dunn's Favourite on Paradise on Spy	21	12/10	10/10	5/10	L	—	L	S	S	S	S
41	Gravenstein	Northern Spy	17	5/10	7/10	30/9	E	L	L	S	S	S	B
42	Hamilton	Paradise on Spy	31	7/10	7/10	16/10	L	L	VL	F	S	S	S
43	Hawthornden (Murray's)	Paradise on Spy	36	11/10	10/10	23/10	L	H	O	S	S	S	—
44	Herefordshire Beefing	Paradise on Spy	31	25/10	12/10	14/10	M	L	VL	F	S	S	F
45	Hoary Morning (English)	Paradise on Spy	36	30/10	10/10	16/10	M	—	3	F	F	F	—
46	Holding	Paradise on Spy	31	19/10	—	14/10	M	M	L	F	F	F	F
47	Hoover	Paradise on Spy	31	28/10	21/10	22/10	L	M	L	B	B	B	F
48	Horn	Paradise on Spy	31	5/10	7/10	—	L	L	VL	F	F	F	F
49	James Grieve	Gravenstein on Spy	5	22/10	8/10	8/10	M	L	1	B	VB	B	S
50	Jonathan	Northern Spy	17	7/10	14/10	3/10	M	M	M	F	S	S	S
51	Kentish Filbasket	Paradise on Spy	36	18/10	10/10	14/10	E	M	L	VB	B	VB	B
52	Kentucky	Paradise on Spy	31	12/10	10/10	16/10	M	L	L	B	B	S	B

Appendix II.—List of 100 Varieties of Apples, etc.—*continued.*

No.	Variety.	Stocks.	Age 1915	Full Bloom. 1912	1913	1914	Ripening Season	Yield. 1914	1915	Bitter Pit. 1912	1913	1914	1915
53	Keswick Codlin	Paradise on Spy	36	9/10	—	9/10	E	L	L	F	S	S	S
54	King of the Pippins ..	Paradise on Spy	36	9/10	10/10	14/10	M	L	L	S	S	F	S
55	Lady Sweet	Paradise on Spy	36	16/10	8/10	9/10	L	L	O	F	S	F	—
56	London Pippin (Five Crown)	Northern Spy	17	28/10	27/10	15/10	E	L	VL	B	B	S	B
57	Lord Suffield	Perfection on Spy ..	36	9/10	10/10	7/10	E	L	VL	VB	B	VB	B
58	Lord Wolseley	Northern Spy	17	18/10	14/10	6/10	M	M	VL	VB	VB	VB	B
59	Majetin	Paradise on Spy	9	21/10	24/10	17/10	L	L	VL	S	S	S	F
60	McLellan	Paradise on Spy	31	2/10	7/10	9/10	M	L	VL	F	S	S	S
61	Mela Carlo	Paradise on Spy	31	30/10	25/10	13/10	L	L	I	F	F	F	S
62	Mueller's Spitzapfel	Paradise on Spy	31	19/10	10/10	14/10	L	L	L	F	S	S	S
63	Northern Spy	Paradise on Spy	21	23/10	—	17/10	L	L	O	B	B	B	—
64	Occident	Paradise on Spy	31	5/10	7/10	7/10	L	M	L	F	F	F	F
65	Pomme de Neige	Cox's Orange Pippin on Spy	5	9/10	7/10	3/10	E	M	VL	F	F	S	S
66	Prince Alfred	Perfection on Spy	5	5/10	7/10	9/10	E	M	L	S	VB	S	B
67	Prince of Pippins	Northern Spy	—	—	30/9	14/10	M	—	VL	F	F	F	F
68	Prince Rudolphe d'Autriche	Northern Spy	—	—	14/10	13/10	M	L	O	VB	B	VB	—
69	Reinette de Canada ..	Annie Elizabeth on Spy ..	5	19/10	10/10	9/10	M	M	VL	VS	S	B	B
70	Reinette Kroone	Paradise on Spy	36	9/10	10/10	7/10	M	L	M	F	S	F	S
71	Rhode Island Greening ..	Paradise on Spy	36	12/10	10/10	13/10	M	M	VL	VB	B	B	S
72	Ribston Pippin	Northern Spy	5	30/9	7/10	12/10	M	—	—	F	F	F	—
73	Rokewood	Northern Spy	31	9/10	10/10	3/10	VL	M	VL	F	F	S	F
74	Rome Beauty	Dunn's Favourite on Northern Spy	5	31/10	24/10	16/10	L	M	VL	B	B	S	B
75	Rosemary Russet	Paradise on Spy	36	19/10	8/10	—	L	L	VL	F	F	F	F
76	Shepherd's Perfection ..	Paradise on Spy	31	5/10	6/10	14/10	M	M	O	F	VS	F	—
77	Shroeder's Apfel	Esopus Spitzenburg on Northern Spy	5	18/10	10/10	—	ML	—	M	F	VS	VS	S
78	Shiawassee Beauty	Gravenstein on Northern Spy	5	18/10	8/10	12/10	M	M	L	B	B	B	B
79	Shockley	Esopus Spitzenburg on Northern Spy	5	18/10	14/10	3/10	L	M	VL	VB	VB	VB	VB
80	Simmond's Winter	Paradise on Spy	31	6/10	3/10	14/10	E	L	L	F	F	F	F
81	South Carolina Greening ..	Paradise on Spy	31	1/11	27/10	29/10	M	L	L	F	F	S	F
82	Statesman	Dunn's Favourite on Northern Spy	26	22/10	8/10	12/10	L	M	O	B	B	S	—
83	Stewart's Seedling	Lord Wolseley on Northern Spy	26	7/10	10/10	3/10	M	M	L	B	B	B	VB
84	Sturmer Pippin	Bismarck on Northern Spy ..	5	7/10	18/10	5/10	M	—	L	B	B	B	B
85	Summer Rose	Paradise on Spy	31	27/10	28/10	16/10	M	—	L	F	F	F	F
86	Sutton's Seedling	Paradise on Spy	31	—	10/10	12/10	L	H	O	F	F	F	—
87	Tuft's Baldwin	Paradise on Spy	26	12/10	10/10	14/10	M	—	M	VB	B	B	VB
88	Twyford Beauty	Paradise on Spy	31	5/10	8/10	9/10	M	—	L	F	S	F	S
89	Villener's Golden Reinette ..	Paradise on Spy	31	18/10	—	16/10	M	—	L	F	F	F	S
90	Wandiligong Favourite ..	Paradise on Spy	31	18/10	10/10	20/10	M	H	VL	VB	B	B	B
91	Wealthy	Northern Spy	5	12/10	18/10	16/10	E	L	2	B	B	B	S
92	White Transparent	Paradise on Spy	31	5/10	18/10	7/10	E	L	L	B	B	B	S
93	White Winter Pearmain ..	Paradise on Spy	31	18/10	6/10	—	L	M	O	F	F	F	—
94	William Anderson	Ecklinville Seedling on Paradise on Spy	26	7/10	14/10	16/10	L	M	VL	VB	B	F	B
95	Williams' Favourite	Bismarck on Spy	5	9/10	10/10	7/10	E	—	VL	B	B	B	B
96	Winter Peach	Paradise on Spy	31	3/10	16/10	—	L	M	—	S	S	F	—
97	Winter Strawberry	Paradise on Spy	31	—	10/10	12/10	L	M	O	B	B	B	—
98	Yarra Bank	Northern Spy	36	28/10	20/10	22/10	M	L	L	B	B	B	F
99	Yates	Dunn's Favourite on Spy ..	5	9/10	10/10	12/10	VL	L	L	F	VS	F	F
100	Yeates Nonpareil (Gowan)	Paradise on Spy	31	9/10	3/10	14/10	M	L	O	B	B	B	—

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