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Banana Cultivation at CARNARVON

By J. A. LAWSON, B.Sc. (Agric.), Agricultural Adviser, North-West Division

The banana is claimed by some authorities to be the first fruit ever used by man. Indeed, it is so widely scattered throughout the tropical countries of the world that it is very difficult to name its centre of origin. For centuries it has been regarded as one of the most useful fruits for treating patients with digestive ailments, and over the last few decades it has been recommended by doctors, particularly for infants. Although the protein content of bananas is low, the sugars of the ripened fruit are present in a most useful form, and the vitamin content, by comparison with other fruits, is of quite a high level.

The banana is actually a member of the order Iridales, that is, it is related to Irises, etc., and belongs to the family Musaceae. It has a tuberous underground stem or rhizome (erroneously known as a corm) and the above-ground "trunk" is actually a pseudo-stem composed of leaf sheaths. In most of the domestic varieties no fertilisation of the fruit takes place, and as a bunch emerges, three types of flowers are produced; females at the top, then a number of hermaphrodites, and the remainder at the "tassel" end, males. The ovules of the female flowers form the fruits, which, due to the lack of fertilisation, contain no seeds.

Until recent years, the most important banana variety of commerce has been the Gros Michel (Musa sapientum), but this, due to its susceptibility to a fusarium wilt (Panama disease), is now losing popularity, and Cavendish types (Musa cavendishii) are being planted in most of the world's commercial growing areas.

In Western Australia, the only commercial area of bananas in production is at Carnarvon, and as will later be mentioned, they are grown in most unusual conditions by comparison with those in other parts of the world.

In 1947 an excellent pamphlet was prepared by the Tropical Adviser at the time, Mr. G. B. Barnett, and this was a useful handbook for earlier banana growers. Some agricultural practices have changed in recent years, and the following article contains present Departmental recommendations.
DESCRIPTION OF THE AREA AND OF THE INDUSTRY

Carnarvon is situated 612 road-miles north of Perth, just 98 miles below the Tropic of Capricorn, at the mouth of the Gascoyne River. The surrounding area is typical "semi-arid zone," with a rainfall of less than 9 inches per year, and vegetated principally with hardy drought-resistant shrubs and scrub trees, the dominant tree type being the Acacia. This is "sheep-station" country, with a carrying capacity varying from one sheep to 15 acres, to one sheep to 50 acres.

The mean variation of the rainfall is very high, and although the average may be 9 inches, the actual falls can be as low as two inches in any one year.

The area is favoured with an extremely mild winter climate, but summer can be somewhat trying, due to the constant high winds which blow during most afternoons; these are sometimes known as "Southerly Busters," and Carnarvon is said by some to be one of the windiest towns in Australia. Then, on occasions, during windless periods, temperatures of up to 120 degrees are sometimes recorded. The average relative humidity is surprisingly high (63 per cent.), probably due to the moisture laden nature of the southerly winds.

The banana plantations are situated on alluvial soils on the banks of the river, for a distance of 12 miles from the mouth, and at the present moment there are 136 operative. Their size ranges from 4 to 100 acres, and, generally speaking, each block has frontage to the "A" Class Reserve on the river bank.

On the south bank of the river (where more than half the district's bananas are grown) the soil is a deep, fertile loam. North bank soils are principally sandy loams varying to loamy sands in some areas. Gully soils are usually clay-loams. Early soil analyses class the soils as being moderately supplied with phosphates, well supplied with potash, but poor to medium in nitrogen.

Since the first banana consignment did not leave the district until 1930, the industry is only of very recent origin. It has experienced periods of economic depression, but also in more recent years has known great prosperity.

Very few growers concentrate on bananas alone; during the winter period, "out-of-season" vegetable crops such as runner beans, tomatoes and cucurbit crops (in that order of importance) are also grown, but of the district's total income the bananas still represent two-thirds.

Prior to the disastrous cyclone of March, 1960, the area planted to bananas was approximately 330 acres, and in the 12 months up to the date of the cyclone 85,600 cases (average weight 78 lb.) were produced. It is worth noting that the district's average production (almost 260 cases per acre) is approximately 100 cases per acre higher than that of the better districts of northern New South Wales.

All the bananas produced are transported to Perth for sale, but this market's requirement is actually only half supplied by the Carnarvon fruit. Severe competition on the Perth Metropolitan Markets is sustained from northern New South Wales, and generally speaking, the numbers imported exceed those of the Carnarvon product every year.

Banana sales are subject to considerable fluctuation, and over the past few years, average prices for top lines have varied from 1s. 8d. down to 8d. Needless to say, periods of over-production in northern New South Wales drastically affect the Carnarvon prices. (The total area in banana production in New South Wales at the present time is 33,000 acres approximately, compared with 11,000 in Queensland). Many Perth consumers believe (erroneously) that the imported bananas come from Queensland. In actual fact Queensland bananas rarely, if ever, find their way into this State.
Since irrigation is necessary in the Carnarvon area, production costs per acre are considerably higher than those in New South Wales, but the distance of the Eastern States plantations from the Perth market allows a more-than-healthy competition in favour of Carnarvon.

Many natural hazards have to be contended with by Carnarvon planters. Cyclones of varying intensity may be expected every four to five years; the 1960 cyclone registered an intensity of up to 120 m.p.h., this being the highest on record for the district, and was most unusual in that the “centre” passed directly over the area.

Droughts drastically affected the supply of irrigation water in the sands of the river, and this subject will be dealt with in a later section. Three floods have been experienced in the past 10 years, but generally speaking, although they cause inconvenience, they do more good than harm.

Two or three winter frosts each year are not unusual, but these do not constitute a major hazard.

At the present time indications are that bananas will continue to be the most stable crop of the district for many years to come.

Plantation Layout.

The majority of plantations, as mentioned previously, have access to river frontage. However, approximately half of the quantity of water being utilised at the present moment is pumped from the river sands; and the remainder from bores and wells situated on the blocks themselves. Water is pumped from wells or bores by means of horizontal spindle centrifugal pumps of 2 to 4 inch outlet diameter, driven by diesel engines averaging 10 h.p.
In recent years many growers have changed over to fibrolite piping, for although this is more expensive than cement drains, it is easily transportable and can be shifted from one site to another. After several years of use, even the best of cement drains develop cracks, and require constant attention. After six to eight years the average cement drain is ready for renewal.

On some properties large irrigation tanks have been erected, some of them up to 150,000 gallons in capacity. The purpose of these is to increase the efficiency of water usage during the dry period, for when only a small flow can be pumped it is used far more effectively if a big head of pressure can be built up before the final stage of irrigation takes place. If a trickle of water is pumped into bays or furrows, the time taken for the completion of the watering of large areas is far greater than it would be were a large flow used. This means that far more water is lost through seepage into the soil at the end nearest the outlet.

Many inefficient pumping units can still be found in the area. The level of the pump should be as close as possible to the level of the water, since as the suction head increases, the efficiency of the pump drops off extremely, and small defects in joints, packing glands, etc., very rapidly show up. On the delivery side, as few bends as possible should be used. Growers should remember that in a 3 in. line, a right angle bend in itself is equivalent to 7 in. of pressure head.

Some properties, due to their undulating nature, do not lend themselves easily to simple irrigation layouts. However, where possible, the grower should attempt to use a series of centralised channels to simplify his irrigation system.

An "earth channel" being used for irrigation of a young patch. Thousands of gallons of water are wasted in such channels.

Although earth channels have been condemned for years by Agricultural Department representatives and growers
alike, many still exist. These can cost thousands of gallons of water in wastage each irrigation.

Channels should be arranged so that bays or furrows are moderately short. If practical, no bay or furrow should be longer than two chains. Beyond that length, wastage through seepage at the outlet end becomes an important factor, particularly as banana trash builds up.

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Packing shed with spinifex walls and roof sprinklers

The packing shed is a very important feature of each plantation. If possible, it should be handily placed from the point of view both of access to the crops and access to the carrier. Wet weather still causes much inconvenience to both grower and carrier where packing sheds are badly placed. The nature of the shed itself is important, particularly with respect to the care of bananas after harvesting. Many sheds in the Gascoyne are entirely iron or asbestos built, with very little ventilation, so that on hot days they actually raise the pulp temperature of the cut fruit, thus enhancing its chance of break-down on the journey to Perth or in the ripening rooms. An excellent scheme is the inclusion of spinifex, straw, rush or trash walls, through which air can pass, and which on extremely hot days can be sprinkled from slotted piping, so that the temperature can be decreased. In some sheds of this nature a drop of 20 degrees on very hot days is not unusual.

Plenty of bench space is necessary in a packing shed, so that fruit does not have to be stacked too high on heavy packing days. Sufficient room should be allowed for the packed cases to be stacked well out of reach of the sun and within easy reach of the carrier.

Water.

As mentioned earlier, Carnarvon is situated in a semi-arid zone of relatively low rainfall. In some years rainfall can be completely discounted so that the success or failure of a plantation is dependent entirely on the quantity and quality of the water available for irrigation.

Most of the earlier settlers, their properties fronting the river, depended entirely on the water contained in the surface sands. This water has always been referred to as “top water,” and its quality is usually very good. It is replenished completely whenever the river flows. However, there have been occasions in the past when, for up to four seasons, no river has flowed. The early settlers soon realised that in most parts of the river, top water alone was insufficient to see them through a long drought. Some bored through the first layer of clay beneath the top sands and struck lenses of sand below, many of which contained good supplies of excellent quality water. Also though, a salt bore would be encountered periodically.

For a time the area was favoured with good prices as well as with good and reliable water. At this stage, very few were involved in the industry; in fact, up till 1949 less than 50 were actively engaged in banana growing. The early 1950's brought a boom in land sales and a corresponding increase in land values. Bigger areas were opened by the Government for selection, and some of the larger freehold blocks were subdivided. As a result of this, in the present year 138 plantations are functioning, and of these 117 are growing bananas full time.

All this means a corresponding increase in the draw-off of water, both from the temporary top water system and the static “second water.” These second waters are referred to by the engineers as “static” due to the fact that they are not completely replaced with each river flow. It seems that they were formed thousands of years ago as the river channels changed course. In each change of course a virtual pool of sand would be left, and this would be slowly covered by consecutive layers of clay and silt from following floods. With the advance of time, it can easily be seen how successive layers of sand and
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clay have been formed beneath the delta area. It can also be understood, then, why the salinity of these second waters varies so greatly, not only in the quantity of salt contained therein, but in the chemical constitution of the salts themselves. Some, for instance, contain large quantities of gypsum (calcium sulphate); others magnesium sulphate, or perhaps even bicarbonates, which can be extremely injurious to crops.

It can also be seen why these lenses are not easily replenished by each running of the river; in fact, engineers have now established that within recent years the quantities of water contained in these have been steadily depleted, despite regular river flows, so that in 1959, the general second water levels were far lower than ever before, only nine months after the 1958 river had ceased flowing, despite the fact that most planters had carried on relatively easily during the 1951 drought.

Thus it can be seen that not only is water conservation and care in water usage essential, but also if the district's future is to be assured, some action on the part of the Government will be necessary to supply good quality waters to existing blocks. At the time of writing, a scheme has already been proposed, involving the utilisation of the large quantities of water contained in the sands beyond the Gascoyne River Bridge. Engineers have located deep, well-filled supplies here, and hope to pump from these through pipe lines to all points on both river banks. Some growers have criticised this scheme, since they believe that these waters actually continue to flow down the river bed to replenish their own supplies. This is not the case. All of these waters are contained in basins and are static once river flow has ceased. It is hoped that they will be sufficient to adequately supply the area until a dam or dams are constructed.

Restrictions have been imposed by the Minister for Works, by means of which it is hoped to reduce the draw-off from the present systems and so carry on all properties for longer periods without stress in times of drought.

Shortage of water penalises the grower in two ways. Firstly, if the river is extremely low, as pointed out earlier, the pumping unit will not be able to operate to its maximum efficiency, since it will be working against an increased suction and pressure head. This means that more and more fuel is necessary to pump the required quantity of water. Also, the grower's time must be taken into account. In times of shortage the affected growers must spend a great deal of time working on their wells and pumping equipment, or perhaps even in search for further supplies.

The danger of rising salinity is a very real one. Water containing 60 grains of common salt (sodium chloride) per gallon is considered marginal both for bananas and beans. Some waters, in fact, although they are far lower than this in the salt content, may contain other salts such as bicarbonates, which will also prove injurious to plants. The danger of salt accumulations in the soil also becomes evident. It is often impossible to avoid increasing salinity when one is pumping from a block bore or second water, but it is suggested that it is far better to maintain a light draw from a number of points rather than pump large quantities from one point. As the lens subjected to heavy draw-off is depleted, the increasing influence of saline seepages can be expected very rapidly.

Irrigation.

The normal means of banana irrigation in the Carnarvon district is by flooding. After levelling the area, a series of "bays" varying in width from 8 to 18 ft. are formed by the throwing up of banks. This is carried out with a mould-board
plough or “ditcher,” (two opposed discs; see illustration). An opening from the cement channel is made into each bay, with a cement spoon-drain to prevent water erosion of the adjacent soil.

It is recommended that a fall of 1 inch per chain be incorporated into these bays, so that even after trash accumulation has occurred, irrigation can still be carried out easily. As pointed out earlier, excessive bay lengths brings about inefficiency of water usage; therefore, the recommended (optimum) length is two chains.

-- Image --
Polythene sheeting being used to reduce water usage. See also the weed growth outside the edges and the clean area covered by the sheeting.

In the earlier years of banana growing in Carnarvon it was customary to plant into a series of furrows, which were later opened out into bays as the plants advanced in growth. This method was highly efficient in its water economy although it involved considerable work in the “opening out.”

At the present time, banana irrigation practices are as follows: On heavy soils, such as those found in the south bank area, the crop is watered by the average planter at least once every week in summer (to a depth of 4 in. in the bay) and once every 10 to 14 days in winter, dependent on rainfall.

On the light soils of the north bank where far more rapid drainage occurs, twice weekly watering in summer is standard practice, and weekly watering in winter if the season is rainless and dry.

Although not always practicable, irrigation is most effective when carried out during the night, to reduce the evaporation percentage.

A water usage trial was conducted at the Gascoyne Research Station, and in the course of this, depths and frequencies of application were investigated. One section was watered to a depth of 4 in. at each irrigation, but was divided into three series of bays, one receiving this 4 in. twice per week in summer and once per week in winter, the second once per week in summer and once every 10 days in winter, and the third once every 10 days in summer and once every three weeks in winter.

In another section water was applied only at 1 in. depths with each irrigation. (This was done with a large number of outlet pipes through the centres of the bays.) Again this was divided into three parts, the first receiving four applications a week, the second three, and the third two—this being the summer schedule; the winter schedule was half this quantity.

The last section received water at varying depths—6 in., 4 in. and 2 in. Broadly, the result of the trial was as follows: It was found that the 4 in. application was equally advantageous as the 6 in. application, but with 2 in. applied with each irrigation the stand was somewhat poorer. Where 4 in. was applied every week in summer, the bananas were equally as good as those in the area receiving 4 in. twice a week. It was noticed that although the 10 day section was somewhat slower to reach the “canopy” stage, once this had been reached the harvesting results were actually better than from any other section in the entire trial. Five bunches over 100 lb. in weight were harvested from these three rows alone. In the section receiving 1 in. applications, it was found that after canopy formation, two 1 in. applications per week in summer were equally as good as four 1 in. applications.

After the conclusion of this trial, the water situation in parts of the plantation area became very drastic in 1959, and many growers were forced by circumstances to reduce their frequencies of application. They found that even where waterings were spaced out to once every fortnight in summer, if the bananas were at the canopy stage they continued to produce as well as previously.

Thus it can be seen that if water economy is studied by the planter, his
pumping costs per acre will be substantially reduced, and if only a limited quantity of water is available a considerable area of bananas could still be maintained.

A trial is now in progress on a private property on the light soils of the north bank of the river, and in this a number of methods of irrigation and frequencies of application are being investigated.

The quality of irrigation water is extremely important. It is considered by this Department that a water containing over 60 grains of common salt per gallon is an extremely risky proposition for banana growing. Where a water has become saline (perhaps during a drought) and no other supply can be located, the depth of application should be increased and the frequency reduced. This method has been put into practice in previous years and found to be quite effective for carrying the plants on until better water is available. In the bay system of irrigation, very little salt accumulation occurs at the soil surface, but the average planter will notice some powdery accumulations occurring on the banks.

Planting.

When planting the grower must first decide which spacing system he intends to use. There are two orthodox spacings, and each has its purpose.

The "furrow" system of irrigating young bananas

The original "wide planting" system entails the planting of propagation material at 10 ft. centres—that is, bays are made up with banks 10 ft. apart, and the planting holes are dug 10 ft. apart in the bays. As the original parent plant becomes mature and suckers form around its base, three are left when gouging is carried out. These three then constitute the base number of pseudo stems on the area. It will be found that for the initial planting, 435 planting pieces per acre will be necessary, and after the first year, 1,305 stems will be the base number per acre.

The "furrow" system of irrigating young bananas

The "wide planting" system, showing parent plants. Three "followers" will be left on each parent

The "close planting" system was designed by Mr. W. D. Marr, Tropical Adviser, 1949-53 and at the present moment a little over 50 per cent. of Carnarvon's regular banana growers have adopted it. Under this system, bays are formed with the banks 12 ft. apart, and the plants arranged on a zig-zag pattern 5 ft. apart inside the bays, with a distance of 7 ft. across the bank to the next row of plants. (See illustration.) One sucker only is left on each parent plant. Here the base number of stems per acre is 1,355, thus it can be seen that if the measurements are closely adhered to, there is very

Extreme "wide-planting"—A 9 ft. x 7 ft. carrying one sucker only
little difference in the light intensity between the fully-developed wide planted patch and the close-planted patch in which the one-sucker system has been followed.

The advantages of the wide planting system are:

(1) A much smaller quantity of planting material is necessary and hence the total amount of labour involved is far less.

(2) Due to the higher light intensity in the earlier stages, the suckers develop very rapidly indeed, so that little, if any, time lag can be noticed in harvesting. That is, before all the parent bunches have been cut, the following bunches are already maturing.

(3) If the "trench" system is followed at planting, water usage in the earlier stages is reduced.

Disadvantages:

(1) Only 435 bunches can be harvested initially, and due to the greater exposure of the plants and the bunches, the initial bunch weight is not usually high.

(2) A large area of bay is being watered for a small number of parent bunches in the first year if the bay system is adopted from the outset.

(3) Since the plants take quite some time to form a canopy under this system, weed growth persists for far longer, making for greater labour involved.

The advantages of the close planting system are:

(1) A large number of bunches are harvested per unit of area from the initial planting, and since these have been protected by the closeness of the stems, the quality and weight are usually good.

(2) A far greater weight of fruit is harvested for the initial quantities of water applied, since it takes just as much water to produce 435 bunches under the wide planting system as it does to produce 1,355 under the close.

(3) Weeds are completely eliminated after approximately six months of active growth, since the canopy stage is reached quite early.

Disadvantages:

(1) A bad time lag occurs between the harvesting of the parent bunches and the harvesting of the first of the follower bunches. This is due to the fact that at an early stage the light intensity inside the patch is reduced, and with it the rate of sucker growth is decreased.

(2) Since the original parent crop is so even in its rates of growth (so that most of the bunches are thrown at once) a "burst" of production often occurs, and this can be a disadvantage from the economic viewpoint.

(3) Once again due to the even rate of growth, it will be found that the canopy formed by the parent plants reduces the light intensity far more than the canopy produced by the followers, since the rates of growth of the latter are much less even (first followers may be noticed in all stages of height and girth). Sometimes due to this low light intensity in the parent, close planted crop bunches fail to "fill" as they would if the light intensity were higher.

The major differences obviously only occur in the first two years of growth. Thereafter, the two methods are extremely similar. Each, of course, has its purposes.
If a grower wishes to have as large a sum of money as possible come in quickly from his banana crop, the close planting system offers the best avenue. If, however, he has the time to come somewhat more slowly into a production which is more regularly spaced over the first few years, he follows the orthodox wide planting system.

On certain sections of the river (particularly where light soils are encountered) patches often fail to carry on beyond the "first follower" bunch. (The probable reasons for this will be discussed later). Where this occurs, the close planting system is the only one which can be even considered.

Apartment from these two orthodox systems, many other variations have been practised. Many growers have planted in rows 9 ft. apart with a distance of 7 ft. between the plants and 8 ft. x 8 ft. on a square leaving three followers on each. After the parent crop, these are far too close, and sucker growth is reduced. Also, bunches fail to fill as they should, and fruit quality becomes poorer, due to the lack of light intensity. One particular grower has in recent years practised a 9 ft. x 7 ft. planting, leaving only one follower on each parent. As a result, the bunch size of each following crop was far greater than in most other patches in the area, and the individual fruit quality has yet to be bettered. Perhaps the only disadvantage is the excessive size of the individual fruits. It was found that sucker growth was extremely rapid, so that bunches were produced within a shorter time than in the orthodox systems. Although fewer bunches are harvested from the parents than in the close planting system, a patch such as this will rapidly "catch up" on the first and second follower crops.

Some people have attempted to bring bananas even closer than the orthodox 5 ft. x 5 ft. x 7 ft. (close planting). Admittedly more bunches are obtained per acre, but sucker growth is so drastically reduced that no reduction in spacing can be advocated.

Having decided which system he intends to use, and having applied a preliminary watering, the grower then digs the planting holes, either by shovel or mechanical post-hole digger (a tractor attachment). These are sufficiently deep to allow for the planting material to be set into the ground to a depth of 15 in. to 20 in. Where the post-hole digger is used, particularly in soil which has a relatively high clay fraction, the grower should be sure to "break in" the sides of the hole before planting the banana, since through the action of the digger these sides are inclined to set so hard that often the soft banana roots have considerable difficulty in passing through them.

In past years it was common practice to put a small quantity of fertiliser into each hole, but this is no longer considered necessary by this Department.

Types of planting material vary widely, and each type has its particular advantages. Maiden butts or suckers are usually well suited to spring and early summer, or very late summer plantings. (A maiden butt is a very advanced sucker which has not, at the time of digging away from the original stem, produced a bunch). Butts, and pieces of butts with "eyes," or small suckers are best used throughout the hotter months of the planting season, as they are less inclined to rot.

Actually, when planting material is scarce, growers have been obliged to use material of all kinds, some of which, years ago, would have been considered as being of very poor quality. It must be remembered, however, that genetically, all planting material is exactly the same, since the domestic banana species are reproduced by vegetative means only. This has been proven in recent years, as a result of the close planting system being used on such a wide scale. Old and so-called "run-out" suckers, old sections of butts from pseudo...
Planting a "spear-point" sucker

stems which have produced, and even what could almost be termed "water suckers" have been used in some of the larger patches, and yet at the time of harvesting no difference can be discerned, except where very advanced maiden butts have been planted. Here the bunches, although being produced far earlier, are usually much smaller due to the reduction in leaf area prior to the formation of the embryo bunch within the base of the pseudo stem.

It has always been considered poor practice to use suckers from a one-year old, or younger, plantation, as these are very inclined to rot (or "boil") in hot weather.

It is wise to dip all material to eliminate nematodes before planting. This will be discussed separately in a later section.

Planting material is obtained from old patches which have been or are being abandoned. It is normal practice to give the patch one irrigation to soften the soil just prior to removal of the material, then where possible a small hole is dug at the base of each pseudo stem on the side remote from the position of the old underground stem. The desuckering bar is then used to separate the standing stem from the old butt, and with leverage it is toppled in the direction of the hole. The purpose of the hole is to make this toppling easy and prevent damage to any small suckers which may be present. Suckers, if sufficiently advanced, may then be removed from the stem, and the butt may be cut off and if necessary, hacked into sections, each with an "eye" or small sucker. Cut surfaces should be allowed to dry (or cork) a little before planting.

Where suckers or maiden butts are used, the top of the stem is cut through so that all leaves are removed. This reduces the transpiration rate. On all planting material, all roots are "barbered" away; in fact, it has been found recently that sometimes even the outer "skins" of the butt or sucker can be peeled off almost like a potato skin. This reduces nematode infestation.

On the heavy soils of the south bank (and of the gullies on the north bank) it is advisable, after covering in the planting material, not to apply any irrigation water for several weeks. It will be found that moisture retained in these soils will be sufficient to encourage new roots to develop, and produce growth in whatever material happened to be used. If water is applied too soon, and hot days are encountered shortly afterwards (which is always a possibility) many misses will occur through "boiling." On the lighter soils, which dry out far more quickly, one watering can be applied immediately after planting, and then the patch can be left for a fortnight before further irrigations are made.

Banana planting is normally carried out from August to March inclusive, and as with planting material and spacing, there are advantages and disadvantages to the various planting times.

Early planting (August to December) usually gives an excellent "strike"; the plants are well advanced before the onset of winter, and thus better able to withstand the cold. However, bunches from such plantings are normally harvested when fruit is very plentiful—that is, in
the poorest marketing period, and it is found that the peak of production continues to coincide with this time.

Later planting usually brings peak harvesting into the winter shortage period, the advantages of which are obvious. However, planting in the hotter months often becomes a gamble, since many misses can occur. Also, the plants are still very small at the onset of winter, which means that they are more susceptible to cold weather damage and severe weed infestation.

Replacements are sometimes necessary if many of the planting pieces fail to "strike," and these should be planted at a very early stage if possible; otherwise they have little chance of producing if the remainder of the patch has decreased the light intensity of the environment.

Cover cropping trials have been carried out on private plantations with no beneficial results. Cover cropping amongst young bananas has been found less desirable than keeping bays clean of all growth other than the bananas themselves. However the intercropping of late season banana plantings with runner beans is recommended as a valuable practice. Added protection from wind and cold is afforded the young plants, and growth rate is increased.

Varieties.

In the Gascoyne area, only Cavendish bananas are planted. These are (1) the original Dwarf plant locally known as "Cavendish," and (2) a mutant from this, the Williams Hybrid or Golden Gros. The former have lost popularity in the Carnarvon district, despite the fact that the majority of them remain standing even after cyclones of high intensity. Their waning popularity is due to, firstly, the difficulty found in working amongst them — (the throats are often no higher than 5 ft.); secondly, they are extremely prone to cigar end rot and other secondary fruit damage brought about by the more compact nature of the arrangement of the hands which imprisons the bracts, preventing them from falling clear. Lastly they have a much greater tendency to "choke" when adverse growing conditions are encountered. This often means that as much loss can result after a cyclone in a "Cavendish" patch, even though it remains standing, as in a patch of Golden Gros which has been almost entirely flattened. They are most intolerant to cold conditions, and very often over 50 per cent of the plants will choke as a result of a cold winter.

It is worthy of note that in Queensland and Northern New South Wales a similar trend is taking place.

Wind Breaks.

As mentioned earlier the district is subject to extremely strong winds in summer. As a result of these strong winds, either the outer two or three rows of bananas on the southern aspect of the patch must suffer heavily from their effect, or a suitable windbreak should be grown or erected to minimise the effect of these winds.
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it was found that the tamarisks under certain conditions will rapidly accumulate salt in the leaves, and this salt is later spread around the surface of the soil in the near vicinity of the tree as dead leaves fall, and rain drops or heavy dew cause the leaves to drip.

Two other drawbacks to the tall-tree windbreaks which may cause damage to plantations are (1) the excessive shade produced, and (2) the enormous root spread throughout the damp banana patch. Tamarisk roots have been ploughed up 150 ft. from the nearest windbreak on occasions.

Plantain and lady finger banana windbreaks are unfortunately not regularly attended by growers, so that ripening bunches may often be found on them. Needless to say, this promotes an increase in fruit fly numbers. These plants also are susceptible to Panama disease, one of the most serious diseases of bananas in other countries. For these reasons windbreaks of this type are no longer recommended.

The Yellow Tecoma (Tecoma smithii) is considered an excellent windbreak for three reasons: firstly, it grows rapidly to its maximum height; secondly, it does not grow into a tall tree but remains at approximately the same height as the banana crop, and thirdly, it has to date shown no tendency to compete in any way with the bananas. It forms quite dense foliage, and in spring produces most attractive yellow bell-shaped flowers. It is easily grown from seed.

Pidgeon Peas are also most useful but, unfortunately, do not last much longer than two years. Little trial has been given on private plantations up to the present time to permanent windbreaks such as dates, macadamias, olives, etc., but all of these have possibilities. Bamboos and artificial windbreaks built of gidgee poles, wires and trash (which is later overgrown with a creeper) were used extensively some years ago, but are now rarely found since, in the case of the former, it is found that the bamboos compete too heavily with the crop, and that the latter rapidly become unkempt and difficult to maintain. They also harbour vermin.

**Nematodes.**

Recent investigations have shown that in the Carnarvon area, nematodes or eelworms seriously limit the production of bananas and are probably the most important pest of this crop.

Damage from this pest was first suspected some years ago when it became obvious that banana patches, particularly on the lighter soil types, were prematurely "fading out" after the production of the maiden bunch; and when an increasing number of abject failures resulted from replanting on old banana ground.

Plant pathological examination showed that banana roots grown under these conditions were heavily infested with nematodes of several different species. Some species, e.g., root knot, cause obvious root galls or swelling, while others, e.g., Radopholus, rot the roots and penetrate the underground stem giving rise to the condition known locally as black rot.

When the first control trials were initiated, fumigant materials were limited to D-D and E.D.B. compounds which had to be applied at least three weeks before planting by drip feeding into the plough furrow. It was also necessary to disinfect the planting material, and organic phosphate insecticides were used for this purpose.

In 1958 the Government Plant Pathologist obtained test quantities of a new water miscible fumigant composed of 1, 2 dibromo 3 chloropropane. A number of "spot trials" were commenced at Carnarvon on private plantations which had been previously affected by nematodes. After six months it was obvious that great benefit had been obtained, improvements being noticeable in several respects. The treated stools continued to produce healthy suckers which, in turn, produced healthy plants, instead of falling away drastically in vigour during the winter and then failing completely. The bunches produced
from these following suckers were often even better than those of the parents. Thirdly, the new suckers themselves, when dug up, were found to have clean white root systems with abundant fibre root, and clean healthy butts completely devoid of any black rot.

This water miscible fumigant is now advocated by this Department for regular use by planters. It should be applied during the warm months of the year (the first application preferably in spring) and the treatment repeated at least every 12 months. Its application is extremely simple. On young patches (up to two years old) a rate of one gallon per acre is normally advocated; for older patches, the two-gallon rate is recommended. After the quantity to be applied to each bay has been worked out on a per-acre basis, the fumigant is bulked up with water in an open top four-gallon tin, into which a petrol tap has been soldered. This tin is set up over the cement channel and the rate of flow of fumigant from the petrol tap is regulated as closely as possible so that the tin is emptied as the bay is completely filled. This means that the fumigant has been evenly dispersed throughout the entire flooded surface, and can penetrate to all the plant roots.

Just prior to the disastrous cyclone in March, Carnarvon's banana crop was looking its best ever, partly due to the widespread application of this fumigant. Since the cyclone, most of the patches which were previously treated are now making excellent recovery. It is believed that, with regular eelworm control practised on the plantation, the productivity per acre should rise by at least 25 per cent., and the life of the plantation will be extended very considerably.

Weeding.

To get the maximum first bunch production from a banana patch it should be kept free from weeds from the outset. Most weeds can compete far too vigorously with the soft and flabby-rooted bananas, and if allowed to run riot will retard them so badly that often they need to be replanted.

The easiest way to control weeds is to prevent them from ever reaching any size. Normally, chipping hoes are used to keep weeds down, although in wide planted patches the use of rotary hoes is also possible. (The use of the latter is not advised in summer, when the roots of the plants have come up almost to the soil surface, but in winter, when a semi-dormancy occurs, its use is often beneficial.)

In the Eastern States, weed control with arsenical weedicides is often practised, but this is not advocated for Carnarvon conditions due to the possible residual effects on following crops. The use of some of the newer weedicides is being investigated but it is still believed that to obtain the best results from the plants, regular control with the hoe until canopy formation, is still the most effective. After canopy formation, weeds no longer survive, due to the excessive shade.

Fertilisers.

For many years it has been believed by growers that since the banana plant is large and its growth is rapid, it must require large quantities of fertiliser, and this is reasonable to assume. No standard practice has been advocated, but most growers have usually applied one or more of the animal fertilisers such as blood and bone, whale meal, whale solubles, and some of the inorganics (super, sulphate of ammonia and sulphate of potash.)

The rates and times of application have varied from plantation to plantation, but one point has always been obvious: fertilisers have been one of the main items of expenditure on plantations. They would certainly constitute one of the major costs of production per acre.

A trial was initiated at Gascoyne Research Station in 1952, to investigate the main fertiliser constituents necessary for banana growth. Nitrogen, phosphate, and potash were applied to test rows singly and in their various combinations. Buffer rows and control rows were also incorporated. Up to the time that the patch was destroyed by the March cyclone, no difference in bunch weights had been recorded. That is, over the entire period, no benefit at all had been obtained from the use of fertiliser of any kind. In the last year of life of the patch, however, it was noticed that rows receiving nitrogen and potash together were slightly greener and the plants had a slightly greater girth measurement than those in the remainder of the patch. This was not transmitted to fruit weights.
These results seem extraordinary, and in fact are disbelieved by some banana growers. However, when the banana analyses are studied the reasons become a little more obvious. Principally, banana plants contain water and cellulose. There is relatively little nitrogen and practically no phosphate in any part (including fruit), and although eight times as much potash as nitrogen is present, this figure on a weight-per-acre basis is still extremely low.

Assessing just how much of each fertiliser constituent will leave the banana patch each year, fruit analyses must be considered. Typical analyses of Carnarvon fruit are as follows:

<table>
<thead>
<tr>
<th>Samples</th>
<th>Skin</th>
<th>Flesh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (grams)</td>
<td>400</td>
<td>632</td>
</tr>
<tr>
<td>Moisture %</td>
<td>90.8</td>
<td>75.4</td>
</tr>
<tr>
<td>Reducing Sugars % (as dextrose)</td>
<td>1.9</td>
<td>14.9</td>
</tr>
<tr>
<td>Starch %</td>
<td>1.0</td>
<td>7.9</td>
</tr>
<tr>
<td>Nitrogen, N</td>
<td>1110</td>
<td>Nil</td>
</tr>
<tr>
<td>Potassium, K</td>
<td>8300</td>
<td>4400</td>
</tr>
<tr>
<td>Calcium, Ca</td>
<td>393</td>
<td>75</td>
</tr>
<tr>
<td>Magnesium, Mg</td>
<td>149</td>
<td>435</td>
</tr>
<tr>
<td>Phosphate, P</td>
<td>303</td>
<td>240</td>
</tr>
</tbody>
</table>

This would represent 100 lb. of sulphate of ammonia, 500 lb. of sulphate of potash and 50 lb. of super, which must actually be replaced each year; a very small quantity by comparison with that normally applied by the average planter.

Recently a small number of planters had their fertiliser programmes on this basis, and experimentally applied little or none from the outset. To date no difference can be seen between plants receiving fertiliser and those which have been completely untreated.

A good healthy root system and good quality water are the two most important factors in banana production.

A number of well-mixed balanced concentrated fertilisers are now available, and a light dressing of such as these once or twice per year is advocated as a precautionary measure to cover replacement in the soil. Fortunately, Carnarvon's soils are inherently very fertile.

In some cases excellent response has been obtained to the application of sheep manure at extremely heavy rates. This is most probably due to the effect on the soil's structure, since weathered sheep manure actually contains very little of manurial benefit.

The effect of the various fertiliser constituents on fruit quality has been thoroughly investigated at the research station, and also in Perth with the cooperation of the Research Branch. No concrete results were obtained, since any variations were only slight.

During hot weather, though, there were indications that excesses of nitrogen fertiliser are deleterious, and can induce premature breakdown.

Desuckering.

As the plant advances in growth, suckers are formed around its base in the manner typical of all plants of this order. Surplus suckers must be removed so that the light intensity in the patch will not be excessively lowered, and so that individual stems will remain vigorous and produce large bunches. It is false economy to leave too many "followers" in a patch, as bunch size and rates of sucker growth are drastically diminished.

As mentioned previously, under the wide planting system three suckers are left on the original parent stem in the first year. Thereafter, one sucker only is left on each stem. Under the close planting system, one sucker per stem is left from the outset.

Under Gascoyne conditions, desuckering is normally carried out with a gouge. A simple but effective gouge is easily made from the main leaf of a car spring. This is straightened and cut to a length of approximately three feet leaving the shackel loop on one end to serve as an
aperture for the handle. The cut end is then drawn to a point and made slightly concave. (See illustration). A short piece of wood passed through the shackle loop serves as a handle. This implement is used by thrusting the point down between the sucker and the main stem, then rotating the handle so that a cone-like cut is made into the heart of the sucker. By this means it is completely detached, and can be pulled out and discarded.

When selecting the sucker or suckers to be left on the parent plant, it is wise to take into account positioning as well as size and vigour of the suckers themselves. If the wide planting system is being used, three suckers should be left as nearly equidistant from each other as possible. In the close planting system, an attempt should be made to keep all the suckers "heading in the same direction," this always being along the rows, not towards the bank or the centre of the bay. Sometimes this is not possible but it should be accepted as a general rule.

Concerning individual suckers themselves, those selected to be left on the parent should not be too close to the butt, since as they grow they will be constricted for room. The closeness of the parent also usually indicates that the sucker has come from a shallow depth, which is undesirable. Ill-shaped or off-type suckers such as so-called "water shoots" should be removed in any case.

Several other systems of desuckering are now being used on the Gascoyne. Some growers constantly keep unwanted suckers cut back to ground level, while others crush those which are newly emerging with the heel. Neither of these methods are recommended, as they are not sufficiently permanent. Due to its simplicity and speed of working, desuckering with a petroleum product is being used quite extensively. The unwanted sucker is cut off almost at ground level, and a small recess is made into the top with the point of the knife. A teaspoonful of kerosene, petrol or distillate is then squirted in with an oil-can or tipped in from a bottle. Some growers claim big successes with this method, whilst others have abandoned it and gone back to the gouge because they have found that too many survive the treatment.

### Trashing

As each individual pseudo stem progresses towards maturity and bunch production, the older outermost leaves die back. These are removed for two reasons: firstly, when hanging in quantity they can reduce the light intensity around the base of the plant and retard sucker production and growth, and secondly, the dead leaves can often damage young fruit between flowering and the time the fruit is harvested. Wind movement in the patch is often responsible for the scraping of a dead leaf over several hands of fruit, causing severe blemishing.

Trashing is the removal of these dead leaves by cutting off back to the live portion of the leaf sheath. Sometimes the entire sheath is dead, in which case it is cut off at the base of the pseudo stem. As they are removed, these leaves are usually heaped into the centre of the bay, where they progressively rot away with the constant watering and the action of fungi and bacteria. Usually, many earth worms may be found amongst the rotting trash, and in summer, if the bananas are in healthy condition, many of the young roots may also be found there in quantity. When trashing it is wise to keep dead leaves and stems away from at least one of the banks so that water flow is not impeded during irrigation. Drastic water wastage results from a big build-up of trash through which no channel has been left.

### Bunch Covering

In northern New South Wales banana growing districts, it is considered good policy during winter to cover maturing bunches with plastic "aprons." This sometimes results in a 10 per cent increase in bunch weight, and far less bunch marking and damage. Trials were carried out by the Department of Agriculture at Carnarvon, and increases in weight of up to 5 per cent were obtained under winter conditions, but due to the cost of the plastic bags at the time, it was extremely doubtful if covering was justified economically. It is noteworthy that fruit which had been covered was far cleaner and had much better "bloom" than that from control rows.
Pests and Diseases.

Nematodes have to-date been Carnarvon's most important economic pests, and these have been dealt with in an earlier section.

The Gascoyne settlement is well removed from other commercial banana growing areas. From the inception of the industry at Carnarvon strict quarantine measures have been adopted to minimise the chances of infestation by the many diseases which can affect the crop.

So far these have been very effective and the district has remained largely free from serious disease problems.

Harvesting.

It is very difficult to lay down any well defined rules for judging the maturity of the bunch which is ready for harvesting. Each planter will finally be able to judge, from constant experience, just how long his fruit will “hang” without becoming too full and prone to ripening in transit or breakdown. There are several good guides which could be useful to the inexperienced grower, however. The first is the appearance of the leaves of the plant. If very few healthy leaves remain on the pseudo stem, the bunch will rarely fill to any greater extent than it already has done. Secondly, if the “tassel” (which consists of a mass of bracts enclosing the male florets) has died off, the bunch is usually ready to be cut, and thirdly, when
the stigma (the last remaining portion of the female floret at the end of the banana itself) has completely dried off and shows no tendency to bleed when broken off, this also is considered a guide to maturity. The appearance of the fruit will finally be the main criterion upon which the planter will judge his harvesting, and as pointed out earlier, the development of this judgment will come with experience.

It is considered that to allow fruit to fill to its absolute maximum in the hot months of the year is unwise, as it leaves fruit very prone to premature breakdown after ripening. This is one factor which is blamed for the poor quality claims made against Carnarvon fruit in the Perth shops and markets. It must be remembered that New South Wales fruit being sent to W.A. is cut at the “full three-quarter” stage.

An article on fruit quality, packing and waxing appeared in the January, 1960, issue of this Journal.

Yields and Duration of Plantings.

As pointed out in an earlier section, Carnarvon’s average banana yield per acre is higher than that in northern New South Wales or Queensland. In the truly tropical countries where most of the world’s bananas are grown, yields are low.
by comparison with such areas as the Canary Islands and other countries where irrigation and more intensive cultivation is practised. In Central America and West Africa, for example, anything over 10 tons per acre per year (280 cases) is regarded as exceptionally good. In the Canaries, production has reached 19 tons (or 530 Carnarvon cases). But at Carnarvon, maximum yields have gone far higher than this. From a patch at Rokich Bros. plantation, over 1,000 cases per acre were produced in the nine months prior to the cyclone in March 1960. Two days after the cyclone, a bunch weighing 144 lb. was taken from the wreckage.

Carnarvon's annual average per acre can certainly be lifted by means of regular soil fumigation, weed control, and more care per acre. If an individual grower can exceed 1,000 cases, the district average could surely be raised to 500.

In recent years, the productive life of each banana planting has been reduced by nematode infestation on most areas of the Gascoyne. However, some of the older growers who have been relatively unaffected by this pest, held patches for 9 years up to the time of the cyclone. Over the next decade it is quite possible that retention of patches will be possible on most properties where fumigation is practised.

It is advocated that a small area of bananas be planted each season, so that in the event of a cyclone, the oldest section may be abandoned.

In some banana growing areas (i.e., parts of India), patches up to 100 years of age are not uncommon. This is achieved by judicious sucker positioning, and the complete removal of rotting butts, which are sometimes replaced with soil.

Transport.

All Carnarvon's primary products are transported to the Metropolitan Markets, in Perth, by the Gascoyne Trading Company, a subsidiary of Westralian Farmers' Co-operative. This Company operates a fleet of large, fast and modern diesel trucks, specially designed for the haulage of perishable produce under hot conditions. The metal sides of each body are fluted to allow the passage of air around bags and crates; and the front panel is entirely lowered, once again for ventilation purposes.

The trucks reach Perth after only 22 hours of travel, and since most of the highway is now bituminised, delays are most infrequent.

The company also maintains a staff of mechanics to cope with repairs, regular servicing, and breakdowns. Over the last three years these transports have never missed a market, which is a tribute to the efficiency of the organisation.

Freight rates for the cartage of primary produce from Carnarvon to Perth are surprisingly low, bananas 11s. 6d. per case, beans 5s. 1d. per bag (approximately 13d. per lb.).
transport. Firms manufacturing cartons, however, will quite probably produce a satisfactory container within the next few years, and this will further facilitate handling.

Prospects of the Industry.

Although a very few years ago the prospects of the Carnarvon banana industry seemed anything but bright, in view of falling productivity, shorter duration of patches, and the severity of New South Wales competition, it now seems safe to predict that its best years lie ahead, for the following reasons:

(1) The simple and effective control of eelworm through the application of water-miscible nematicides, giving the plant a clean root system each season, and increasing the productive life of a patch as well as its production per acre.

(2) The probability of increased supplies of irrigation water becoming available.

(3) The increase in efficiency of water usage by the average grower, reducing costs per acre (this is assisted by fumigation, which, in cleansing the root system allows more efficient water uptake by the plant from the soil).

(4) Through better packing, and waxing, a higher price for Carnarvon bananas can be maintained above that of the New South Wales article (which must be transported over greater distances).

(5) The opportunity to insure a banana crop in Carnarvon. Previously, no insurance company would take such a risk, but a scheme has now been formulated involving contribution by the Government and grower subscription by levy. This will give far greater security from impoverishment by cyclone.

(6) The constant improvement in the North-West highway, which will shortly be entirely bituminised. This will enhance the ability of the transport company to operate at lower costs.

For these reasons, it is quite possible that within the next five years, Carnarvon’s expanding banana production could completely satisfy the Perth market’s requirements (which, with increasing population, would be 160,000 cases annually—compared with 86,000 from Carnarvon in the 12 months up to the time of the cyclone).

This Department has an Agricultural Adviser stationed permanently at Carnarvon, and growers are reminded that much expense and trouble may often be avoided by discussing their banana problems with him.

ACKNOWLEDGMENTS

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Simmonds, N. W. (Bananas).
Barnett, G. B. (Banana Culture in W.A.).