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William John Toms
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Cover Page Footnote
The assistance given by the personnel of Kimberley Research Station particularly Messrs. N. Thomson and A. Gray and the Public Works Department, particularly Mr. R. Hamilton, in the growing of the 1962-63 crop is gratefully acknowledged. The exercise would not have been possible without Mr. G. Arbuckle who ably assisted with all the farming operations.

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COMMERCIAL COTTON GROWING

The recommendations given in this article have been built up from the experience of the author in growing 200 acres of cotton in the Ord River area during the 1962-63 season for the Department of Agriculture, from findings made by Kimberley Research Station, and from discussions with the present farmers in the area.

When a new form of agriculture is introduced into a new area techniques and ideas change rapidly as farmers become acquainted with their new environment and the new crops. The recommendations will therefore require constant revision.

By W. J. TOMS, B.Sc. (Agric.), Research Officer, Plant Research Division

IN the extreme north-east corner of Western Australia the development of about 150,000 acres of "black" soil suitable for irrigation has begun. Some idea of the magnitude of this task is given by the fact that at present there are only 28,000 acres of land irrigated in the irrigation districts of the south-west of Western Australia.

Sufficient water for 30,000 acres of farming land can now be stored in the diversion weir built across the Ord River at Kununurra, and, by the beginning of 1964, 12 farmers will be working their farms, each comprising some 600 acres.

In its natural state the land supports an open formation of small trees with a grass undercover. Clearing is not difficult.

The Soils

The soils were originally formed under a lake and the area of black "Kununurra clay" is relatively flat with a varying fall to the north averaging perhaps half an inch to the chain. Land grading has been easy and inexpensive.

The black soil is largely uniform over the area to a depth of 5 ft. or more, but, as expected, becomes shallower towards the edge of the deposits. The organic matter content of the soil is very low, despite its colour, but it is a self-mulching soil and has a high content of calcium; free calcium carbonate occurs in many places. Even hard structureless clods break down to give a pleasing soil structure after a few wetting and drying cycles. Loss of soil structure is unlikely to be a problem with repeated cultivation.

Capillary action is strong in this soil and the tops of 8-inch ridges are rapidly wetted by furrow irrigation. The rate of infiltration of water drops off markedly as the soil is wetted beyond a depth of 3 ft.—so much so that losses of water through the profile should be insignificant.

The soil does not supply enough nitrogen and phosphorus for maximum yields of crops recommended for the area and these
elements must be supplied by using urea and superphosphate. Agriculturally, the soil is good and no problem has arisen when it has been continuously cropped. It has proved suitable for a large range of crops and fodders tested at Kimberley Research Station.

Crops
Crops at present recommended for the area are cotton, safflower, rice and linseed. These crops have been selected both for their suitability for the area and because satisfactory markets can be found. Of these crops, cotton should be the most profitable on an acreage basis, but requires the greatest capital outlay.

First Year Operations
In the early stages of the Project the State Government will contract to have 400 acres of land prepared over a two year period for each incoming farmer. This preparation of land is carried out during the “dry” season from May to November. The land is cultivated during the following wet season by the farmer to control weeds and fill depressions caused by subsidence.

In March or April, after the wet season, the farmer completes the cultivation and land planing of his land and is ready to grow a dry season crop of safflower or linseed, before growing a wet season crop of cotton on the same land at the end of the year. At present therefore, cotton grown by new farmers will be on land that has just matured a crop of safflower.

This practice has a number of advantages. Farmers have the opportunity of getting used to strange farming methods on a low-cost crop; poorly graded areas can be corrected and weeds are practically eliminated before the cotton is grown.

The recommended procedure for growing cotton is outlined below

A cotton crop being watered. Water flows into the channel in the foreground and is siphoned into the furrows. The land slopes away from the channel so the water runs down the furrows and into the drain at the far end of the field. The furrows in this crop are 15 chains long. A siphon is placed in every second furrow and when these are watered the siphons are flipped into the dry furrows.

This system allows watering to proceed easily at night as no siphon has to be started, and channel stops do not have to be touched. The siphons are 11 ft. long and 11 in. in diameter. They are the smallest bore that can be started satisfactorily by hand pumping.
Constructing the "gin" at Kununurra. The initial equipment installed will treat about 10,000 lb. of seed cotton an hour. The process removes the lint (the fibre used for making cloth) from the cotton seed, drying and cleaning the product in the process. The lint is then baled ready for shipment. A gin is big business. The press used for baling the lint is alone worth more than £20,000.

COTTON GROWING OPERATIONS

1. Destroy safflower stubble

If the stubble were not destroyed extra nitrogenous fertiliser would be required and cultivations for weed control in the crop would be more difficult because of the trash fouling the weeding knives.

The stubble should be burnt. If a running fire cannot be obtained fire harrows should be used.

2. Cultivate the soil to a depth of about five inches

It has been usual in the area to cultivate the dry land with a heavy disc plough or large offset disc cultivator, followed by cross discing. Although this has proved satisfactory it requires heavy machinery which most new farmers will not have.

Two cultivations with chisel-pointed coil shank tynes will also do this job but not as well as the discs.

An alternative procedure is to irrigate the land using the old furrows in the safflower. A week or more is allowed for soil to dry out and it is then worked with heavy rear mounted chisels. Spring or friction release tynes are necessary because of the number of stumps. The chisels are spaced at about 15-inch intervals so that the ground between is shattered by the working.

It is essential that the soil be allowed to dry sufficiently before working. Generally, Kununurra clay dries out well to depth because of extensive cracking and good capillary action. When the top inch or two are dry the next few inches are sufficiently damp to give a good structure on cultivation. If the soil is cultivated dry, large rocklike clods are produced. If the soil is too moist ribbons of soil give the same unsatisfactory structure, and once a mulch of cultivated soil is formed, drying by capillary action and by way of cracks is greatly reduced. It is then difficult to cultivate at a depth greater than that achieved with the first cultivation.
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Kununurra clay cracks markedly on drying. Water from this 2 in. siphon ran into this crack in very dry soil for over two hours. Lateral penetration through cracks was noted up to a chain away from the siphon.

After the initial working the broken soil is allowed to dry out and a cross working using either coil shank cultivators with chisel points, or disc harrows, is given. Land prepared in this manner should be in better condition for cropping than that prepared as in the first method above. Also, virtually all weeds are destroyed. However, the preparation takes a lot longer and additional water is used, though this is partly offset by a lower requirement at the time of the first watering.

Both methods should give satisfactory results.

Before the land is irrigated the channel system should be cleaned out, using a mounted blade. Not only is this necessary to deepen the structures and to remove any weeds but it also seals the banks which crack appreciably on drying.

3. Level the ground

Any irregularities in grade that were obvious during the growth of the safflower should be removed by land planing. An overall land planing up and down the row should also be given.

During this operation enough soil should be dropped adjacent to the channel bank (see later description of irrigation practices) so that there is a reasonable fall from the channel bank into the field. It is essential that there is no low spot at this critical point otherwise it will be difficult to confine water to individual furrows.

4. Ridge up and apply urea

Ridges with a maximum overall height of 8 in. and at a spacing of 40 in. are then thrown up with middlebusters mounted on the rear toolbar and fitted with a friction release mechanism (see illustration). Four ridges are thrown up at each pass of the machine. Although smaller ridges are quite satisfactory where the land has been prepared well, a large ridge can have a definite advantage where the slope is.
irregular and small. Because of the good capillary action in Kununurra clay ridges 8 in. high are readily wetted.

During this ridging operation 80 lb. per acre of urea are placed in the soil, using mid mounted equipment. The urea is dropped on the surface of the ground in a band one inch to one side of the centre of the ridge being formed. It will be covered by about 4 in. of soil as the following middlebusters throw up the ridge. To obtain a correctly positioned band of urea the knife applicators must be just touching the ground.

If the urea is applied before planting, considerable time is saved during the actual planting operation.

The superphosphate could also be applied at this time if appropriately placed in the row. An application of 20 lb. of superphosphate per acre would then be drilled with the seed at planting so that the germinating plant would have adequate phosphorus while its roots were growing out to the main superphosphate band. This method should be quite satisfactory but as it has not been tried it cannot be recommended at present.

It is an obvious advantage to apply the fertiliser before planting if possible. One ton of fertiliser is used on each seven acres and the planting machine must be frequently stopped to fill the bins.

Urea has been recommended as the source of nitrogen rather than sulphate of ammonia because when transport costs are added to purchase price, sulphate of ammonia costs one and two thirds times as much as urea containing equivalent nitrogen. Although hot, humid conditions and an alkaline soil favour loss of nitrogen to the atmosphere from urea it is most unlikely that losses from urea placed a few inches deep in Kununurra clay would be sufficient to make it as costly a source of nitrogen as sulphate of ammonia. However, no quantitative experimental evidence is available on this matter.

At Kununurra, cotton responded very well to applications of urea in the 1961-62 and 1962-63 seasons.

In 1963 it was obvious that no matter whether it is applied to the surface of the soil and washed in by rain, applied in solution in the irrigation water or banded and placed 2 in. deep close to the plants, urea takes two and a half to three weeks to give a visible response on cotton plants. Therefore application of urea before planting could be more beneficial than application at seeding.

Only part of the total requirement of urea is applied at this time. As November-planted cotton tends to be tall, it is an advantage to not over-stimulate early growth by excessive application of nitrogen at planting. However, the cotton plant will use up two thirds of its total plant nutrients in the first third of its growth period and in the U.S.A. side dressing is recommended within 45 days of planting.

6. Plant, and apply superphosphate (November 10-20)

See discussion on time of planting (page 767) and rate of seeding (page 768.)

The seed is sown \(\frac{1}{2}\) in. deep down the centre of the ridge, using a four-row cotton planter. A runner type opener is used. When planting into wet soil a rubber tyred drive wheel (zero pressure) is needed. However, old car tubes wired to the wheels have performed satisfactorily in an emergency. In dry soil the small open centre press wheel may be superior. This wheel gives a loose ridge of soil over the seed. Polythene or rubber delivery tubes are recommended.

Shallow seeding gives a quicker emergence and a stronger seedling. Although plants will often grow through 2 or 3 inches of soil it is advisable to make quite certain that seeds are not planted more than 1 in. deep. A ruler should be used when measuring the depth of planting; seeds planted at a depth of an inch or more give the impression of being much shallower when viewed in the field.

Planting of each section of crop should be carried out as quickly as possible so that the seed does not lie in the soil for long periods before irrigation.

At the time of planting, 224 lb. of superphosphate per acre is banded along the ridge 2 in. below and 1 in. to the side of the seed. Positioning of the superphosphate is not critical as long as it is not placed with the seed or directly below it. It should be deeper than the seed and no further than three inches from it.
To get the superphosphate applicator standard to fit on its tool bar, close enough to the centre of the ridge (1 in. to the side of centre) it is necessary to grind off the raised metal former where the tool bar is bent.

Rate of Superphosphate

An application of 224 lb. of superphosphate to cotton grown on “new” land has been shown to be adequate at Kimberley Research Station, although the position is not clear for cotton following safflower crops. As an average crop of seed cotton (lint and cottonseed) removes phosphorus equivalent to about 250 lb. of super per acre, it is likely that even more than 2 cwt. of super per acre will be required when cotton is grown continuously on the same land, particularly as yields are increased.

As 2 cwt. of super costs about £2 9s. at Kununurra and this is only a small item in the total cost—the whole outlay being covered by an increased yield of only 50 lb. of seed cotton per acre—no less than the recommended 2 cwt. of super should be applied.

Fertiliser units on cotton planters have a vertically opening slide over each of the feed stars. The degree of opening of this slide determines the rate of application of fertiliser. This method of varying the rate of application is unsatisfactory. Any small lumps of fertiliser sit on top of the star and block the slide opening, giving variable rates. The slide should be completely closed and the rate varied by changing drive sprockets and size of the fertiliser star. The fertiliser is then forced through the opening by the teeth of the star and any lumps are crushed.

7. Form up ridges adjacent to the channel banks

During the ridging operation, the tractor, with rear mounted middlebusters, approaches the channel bank every second pass it makes across the field. This means that every alternate group of four ridges is not formed up for a distance equal to the length of the tractor from the channel bank.

This area is levelled by a cultivation with rear mounted tynes with chisel points, and a machine which may be called a “head ditch furrower” is then pulled along the area across the direction of the furrows. This machine drags the soil into a ridge, is manually tripped at the appropriate time so that it deposits its load in line with a ridge in the paddock and then locks to collect a further load. The head-ditch furrower has worked satisfactorily and farmers have made machines large enough to cover the unridged area in two passes across the field (see illustration.)

8. Irrigate planted areas (November 13-November 22)

(See section on page 771 concerning method of irrigating).

When a complete bay has been planted it should be watered while planting continues on another bay.

All furrows should be watered simultaneously. If the land has not been watered since harvesting the safflower, about 6 in. to 8 in. of water should be needed to wet the soil and two 1½ in. siphons per furrow should be used.
In any case watering should not be allowed to take longer than 18 hours on any one area, otherwise a poor germination could result on sections of row adjacent to the channel. This first watering is the most critical as regards the effect of time taken to irrigate, on plant growth. This first watering cannot be too rapid as long as the ridges are wetted right to the top. Thorough wetting is most important as the seed is planted shallow and temperatures of over 100° F. can be expected every day at this time of the year.

Excellent germination and emergence can be expected in the Ord River Project area. Capillary action in Kununurra clay is most pronounced and even large ridges are wetted quite satisfactorily.

9. Give second irrigation

A second irrigation is given five days later, or at a time determined by growth of the seedling in relation to the drying of the soil surface.

One siphon in every second row is used and when these rows are watered, the siphons are shifted into adjacent furrows. If watering is delayed longer than five days (two to three days after emergence) the seedlings could be temporarily set back. Surface temperatures of dry “black” soil are high and accentuate the effect of shortage of moisture on the plants.

10. Cultivate for weed control (November 23-December 3)

Using mid-mounted row cultivators the the inter-row area is cultivated for control of weeds.

Knife weeder or sweeps are used to cultivate the ridge. The knives are so attached that they throw dirt into the rows smothering young weeds, rather than having the shanks operating near the cotton so that dirt is thrown away from the row.

Two knife-weeder are used in each side of each ridge, although in some cases one weeder each side has been satisfactory. Protection of the young seedling from being covered with soil is generally unnecessary, although shields can be used. A rotary weeder wheel should shield the plants yet still allow small clods to fall between the plants and control weeds within the rows, however this has not been tried. During this operation, ridges are reshaped and furrows are cleared out by rear mounted Alabama sweeps or similar implements.

Turning the tractor on the furrows near the head ditch during this operation should not do enough damage to warrant the use of the head ditch furrower.

11. Irrigate weekly

The cotton is watered at weekly intervals after the first two waterings.

About 2 1/2 in. are required each watering. Using 1 1/4 in. siphons with a head of about 8 in. it takes about nine hours to water rows 15 chains long. At night the irrigator uses a battery powered light attached to a plastic helmet. The battery is carried on a belt around his waist. This leaves both hands free. Cotton planted in November should require about 36 in. of water apart from that received as rain.

These Alabama sweeps are carried on a rear mounted toolbar and re-form the furrows and ridges when used behind mid mounted cultivating equipment. A sweep in approximate operating position is seen on the right of the picture.
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During the very hot weather of December plants will often wilt early in the afternoon even though they have been recently watered, but their growth does not appear to be affected greatly by this. As water is being removed from the tops faster than the roots can take it up and transport it, there is nothing that can be done about it anyway.

If the cotton is severely stressed it may have to be watered every five days for short periods.

12. Side dress urea (December 14-24) and cultivate

A side dressing of urea at 160 lb. per acre is given about four weeks after emergence. The urea is placed 2 in. to 3 in. deep about 6 in. to one side of each row, using knife applicators on mid mounted equipment.

The distance the urea is placed from the plants should vary depending on the growth made. If the application is delayed until the plants are taller than 2 ft. 6 in. the fertiliser can be applied into the furrows rather than into the ridges.

This dressing will probably supply enough nitrogen to mature the crop. However, if the plants begin to pale off prematurely a further application can be made, the rate used depending on the colour and maturity of the crop. Because of the time lag between application of urea and response by the crop any late dressing should be given as soon as it is apparent that the plants are short of nitrogen. At this stage of growth it would even be sufficient to drop the urea on the surface of the furrow and allow rain or irrigation water to wash it in.

This dressing of urea can also be satisfactorily applied in the irrigation water.

Applying Urea Through Irrigation Water.

An open-topped 44 gal. drum is supported on a stand over one of the Detheridge wheels (wheels which measure the rate of flow of water onto each farm). The drum is filled by pouring urea through a sieve supported by an old wire bed base. The urea drops from the drum through a tube, the size of the tube used determining the rate of flow. The urea dissolves in the water entering the farm through the Detheridge wheel and mixing naturally occurs in the channel before the solution is siphoned onto the field.

Particularly at night the surface of the urea in the drum tends to cake, with consequent blocking of the tube. This was corrected by introducing a wire down the inside of the drum and through the tube so that the end was agitated each time a vane of the turning wheel knocked it. This agitation was sufficient to break up the soft lumps of urea.

The drum requires filling about every two hours. Of course the time between fills depends on the desired rate of application of the urea, the volume of water passing through wheels and the amount of water needed to irrigate the field. This latter is known fairly accurately from previous waterings. By measuring the rate...
of flow of urea into a bucket and adjusting
this flow the required rate per acre can be
readily achieved. If a plastic sheet is
pierced by the wire so that dropping urea
hits the sheet and is diverted into the
bucket, agitation can proceed while the
measuring is taking place.

A disadvantage of this method of
application is the waste of urea in the
drainage water. However, with constant
supervision this can be kept very low.

The method is very satisfactory for use
on tall cotton, as mechanical damage to
the plants is avoided.

Urea might also be able to be applied
by aircraft in the wet season. However,
cotton is susceptible to urea burn and if
dry urea lodges on the plant it soon
deliquesces and the concentrated solution
formed burns the plant. This method
should be tested when suitable equipment
is available in the area. Another possibility
is the use of urea in the insecticide spray
each week. Applicable quantities could
be applied in this manner but again
thorough testing is necessary before any
recommendation is made.

Final Weed Control Cultivation

At the time of side dressing with 160 lb.
of urea per acre a final cultivation for
weed control is given using the same
equipment as for the first cultivation.
During this operation the soil should be
thrown up around the bases of the plants
to help support them. Heavy rains during
the wet season can reduce the size of the
ridges considerably, although this is not so
noticeable when the plants are big enough
to give protection to the ridge.

For cotton following safflower these two
inter row cultivations should be adequate
for controlling the weeds and moulding
the ridges. On more weedy ground at least
one other cultivation is recommended.
Naturally the cultivations must fit into
the schedule for irrigation. The lands should
be in good condition for cultivating about
five days after irrigating.

Any grass, or tall weeds growing within
the rows on top of the ridges should be
pulled by hand. This can be done in the
months of January and February when
very little has to be done to the crop by
the farmer.

Insect Control

The crop must be sprayed with insectici­
cide during the growing period. Recom­
mendations are set out by K. T. Richards
in a separate publication.

The Final Irrigation

Irrigation should cease when the last
formed bolls required to be included in the
harvest are almost half mature, about 3½
weeks prior to picking. A good natural
leaf fall should be obtained and no chemi­
cal defoliation should be necessary unless
two picks are contemplated. Leaves re­
main remaining on the plant after natural leaf
drop are leathery and are little problem
as regards "green leaf stain."

If defoliation is considered necessary
D.E.F. is satisfactory at rates recommended
by the manufacturer.

In general both defoliants and desic­
cants give good results in this area because
of high temperatures. It is possible that
dusts requiring dew for activation will not
be satisfactory in the April-May period.

Picking the Crop

Mechanical pickers can work a long day
in this area without being troubled by
excessive moisture. Generally cotton in
the picker bins runs at a low 5 to 6 per
cent. moisture and drying at the gin should
rarely be necessary.

Single row pickers should cover about
five acres of cotton in an eight hour day
exclusive of servicing time.

Growing Cotton on "New" Land

The above recommendations would also
apply to cotton grown on virgin land except
that at least two preplanting irrigations
would be recommended for weed control.
After each of these irrigations the weeds
would be killed by cultivating with mid
mounted equipment, keeping the ridges
intact.

These operations may be complicated if
local subsidence of the land occurs, neces­
sitating further land planing. If such new
land is to be used for growing cotton it
should be ready for watering in September
to ensure that planting can take place in
November.
Dethridge wheels measuring the flow of water from the supply in the foreground into the farmer's channel system in the left background. Up to 5 cusecs can flow past each wheel. The crop in the background is safflower which is being watered through siphons over the channel bank in the left background. One operator can handle 10 cusecs by himself, but generally two irrigators are used for this flow.

Time of Planting

Mid November plantings are the most satisfactory when the following points are considered.

Cotton will grow all the year at Kununurra. However it would be undesirable to have many open bolls in the field during December, January and February because of the likelihood of heavy rains. Rain can also be expected early in March, and in November.

It is a definite advantage to plant the cotton during a dry period of the year so that initial cultivations for weed control are possible and a side dressing of nitrogenous fertiliser can be given.

It is also an advantage to have the crop growing over the wet season, thereby largely obviating the need for irrigation for many weeks. Also, if the crop is grown during this period weeds are controlled without the need to cultivate a non-productive fallow in the wet season.

In June and July, shorter days and lower temperatures cause the rate of growth to slow down appreciably but some flowering and boll setting continues.

If the crop grows during these months the cost of controlling insects is greater because the length of the period of growth is extended. The cost of irrigating the crop is not greatly increased by this increased period of growth as waterings every fortnight are required compared with weekly irrigations at the hottest time of the year.

If the weather permits, plantings in December, January and February on land fairly free of weeds should still give maximum yields.

If the crop is planted in December or January most of the nitrogenous fertiliser should be applied at planting as there is no certainty that machines could get on the land for long enough to complete side-dressings in January or February.

Plantings in late March complete their growth in the dry period of the year and despite some disadvantages it is suggested that this time of planting will receive attention in future years.

It is possible to plant cotton at Kununurra over a considerable period of the year, and still obtain full yields. This extended planting period gives advantages in handling the crop from the point of view of both farmer and ginner.

Although it is probable that a large part of the crop will be planted in November, additional later plantings, if weather permits, will enable the farmer to grow larger acreages with a resultant lower capital outlay per acre. However, difficulty in achieving control of insects in an area growing cotton most of the year could make it necessary to restrict growth to a definite period.

The long growing period is of extreme value if for any reason the crop suffers a setback during the growing period. As long as sufficient nitrogen is available, the plants continue to grow until a good crop
is set. Damage to plants resulting in shedding of squares (flower buds) has resulted in plants growing up to 5 ft. high without setting bolls, yet these plants have finally set about 2,000 lb. of seed cotton per acre.

**Effect of Time of Planting on Disease**

If cotton is planted from November to March, diseases are not likely to be important.

Seedling rots give little trouble as temperatures are so high that seedlings emerge two to three days after the seed is watered and commence to grow vigorously.

Bacterial blight (*Xanthomonas malvacearum*) will not be a problem as the resistant variety “Rex” has been supplied to farmers by Kimberley Research Station.

In 1963 a small area of cotton growing under wet conditions was wiped out by the fungus *Macrophomina phaseoli*. The area was resown and an excellent stand was obtained. This disease is not expected to be of importance in the area.

**Planting Rate**

It has been shown at Kimberley Research Station that yields from different densities of stand are similar within the range of one to four plants per foot of row.

Close plantings tend to produce somewhat taller plants, which is a disadvantage in insect control and picking the crop, but they also encourage shorter fruiting laterals and have the lower bolls higher on the plants, which is an aid to picking. The main advantages of denser plantings are, first, if emergence is poor there are still enough plants to give maximum yield, and second, weeds within the rows are better controlled by competition from the cotton plants.

It is recommended that the rate of seeding be such as to supply four germinating plants per foot of row. The seeding rate can be calculated by weighing 1,000 representative seeds and determining their percentage germination, remembering that one acre has 198 chains of ridge. It is likely to be about 13 lb. per acre.

Naturally the resultant stand will be a little less than four plants per foot of row. In places some seedlings could be eaten by grasshoppers or other insects or damaged by rots, or weak seeds may not emerge; a few could also be buried during the first cultivation for control of weeds.

**Seed Dressing**

The seed should be treated with a fungicide and an insecticide. White ants, leaf eating ants and wire worms can cause damage to seed or seedlings.
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Rogor 40 is absorbed and carried to all parts of the foliage. This systemic action not only ensures control of those parts of the plant not covered by the spray but also gives protection to new growth formed after spraying.
A cheap channel crossing constructed of girders and pipes by a farmer, Mr. B. Arbuckle. The channel stop beyond, diverts water down the lateral channel in the right middleground to water the safflower in the background. Land is being prepared for cotton in the left background.

**STRUCTURES**

**Channel Stops**

A semi-circular sheet metal channel stop opening radially from the top was chosen by the Irrigation Branch of the Department of Agriculture as being most suitable for the area. These stops are readily adjustable and very satisfactory. A similar type has subsequently been used by four of the five farmers. Stops which open from the top are a definite advantage. They can act as a "safety valve." The scouring caused by the water dropping through the stop into the next bay is prevented by placing rock below each stop.

It was found helpful to mark on the stop the average level of the bottom of the furrows adjacent to it. When the water was about an inch higher than this level, the irrigator would know that the siphons could just be started.

By marking off lines on the stop one inch apart, above this base line, the irrigator can tell at a glance what head the siphons are operating at and make sure that all the bays are giving about the same head. If a level is not available a simple method of getting the base level is to dig a hole a few inches deep in about five furrows adjacent to the stop; then start filling the channel with water and start the siphons into the holes when possible. The water level in the hole then rises with the level in the channel and when the water flows out of say three of the holes and down the furrows the water level on the stop is roughly the base line required.

**Cross Overs**

Where roadways cross the channel, concrete or galvanised iron culverts have been used. However, farmers have done the job much more cheaply with scrap piping and angle iron.

**Drain Crossings**

When the soil is compacted, vehicles are able to cross drains satisfactorily even when they are wet. A permanent crossing can be made by digging a shallow hole across the drain and filling with a layer of rock. Care must be taken not to have the rocks raised above ground level, otherwise the water will be ponded in the drain.

**Farm Layout and Irrigation Practices**

Water is gravitated to the farms and is let into the farmer's channel through Dethridge wheels which measure the rate of flow and record the amount of water used. Each wheel can handle up to 5 cusecs.

The channels are V shaped and when newly formed are about 12 ft. across and about 3 ft. 6 in. deep.

They are built to carry 10 cusecs of water and to supply a reservoir from which water can be drawn off through siphons into the furrowed field.
A typical ideal layout is shown in the sketch.

Here each bay (e.g., ABEF) is about 27 chains long and will therefore feed about 500 furrows at 40 in. centres. About 50 1¼ in. siphons require 1 cusec, so 10 cusecs will feed one bay if a siphon is placed in every furrow and two bays with a siphon in every second furrow. Four such bays each with rows about 20 chains long would comprise one block of just over 200 acres of irrigable land. There is a road between each lateral drain and lateral channel.

Water flows onto the property from the Dethridge wheels at point L, the highest part of the block. Siphons are used to get the water out of the channel and into the furrows. The water wets down the furrows and runs into a shallow drain. These lateral drains feed into the drain BG which takes the water off the farmers property.

Adjustable channel stops at E, F and H pond the water in the lateral channels EA, FB, etc., to give the requisite "head" and further stops are inserted at appropriate intervals along these laterals so that there is a maximum of 2½ in. fall between stops. That is, if there is 2½ in. to 5 in. of fall between E and A one channel stop will be required between E and A. A fall of 5 in. to 7½ in. would require two stops.

If these stops were not used, siphons at E would operate at a much lower head than siphons at A. The furrows would then be wetted at markedly different speeds and the irrigators would consequently have a great deal of work.

If a high head is used, say 14 in., at the lowest point in the channel, then the lowest head in this section (using a 3 in. drop between stops) will be 11 in. and the siphons operating at these two heads carry fairly similar quantities of water. However,
if the heads are 5 in. and 2 in. respectively the difference in rate of flow will be great. It is therefore an advantage to operate at a high head.

When the fall down a lateral drain is not steep the drain can be temporarily blocked with thin metal sheeting so that water running from furrows that have watered quickly will turn back and water dry furrows, with consequent saving of water. The water should not be ponded for longer than 12 hours.

The siphons are about 11 ft. long and are made of high density polythene. They are started by using the hand as a valve. The siphon is thrust into the water with the hand removed at the other end. The hand is then placed over this end of the tube to form a seal and the siphon is then partly pulled out of the water. This gives the water in the tube momentum, and at the end of the pull the hand is removed and the tube again thrust into the water. Two or three pumps are generally required to get the water running through the siphon which is then dropped into the furrow towards the end of a forward pull.

Labour Requirement for Irrigation

An average operator can start six siphons a minute. One operator can handle 10 cusecs of water by himself but it is preferable to have two irrigators for this flow of water. They will only be occupied for a part of the irrigating period.

The irrigation of 200 acres should take about 48 hours when 10 cusecs are used.

Obviously the amount of work involved depends to a large degree on the layout, the length of row and the size of siphon used.

Layout

Rectangular blocks with all the fall down one side of the rectangle are ideal for easy watering. No stops are required in the lateral channels and all the fall is down the furrow. Triangular blocks are wasteful of land and any tapering section causing the length of furrows to vary markedly either makes a lot of work for the irrigator or wastes water. A good slope is an advantage. The author would much prefer a slope of 2 in. per chain to a slope of ½ in. per chain. Slopes of only ½ in. per chain could give trouble.

Row Length

The length of furrow used appreciably affects the economics of the overall farming operation. The longer the row the smaller is the capital outlay on siphons, channels, drains, and roads between the channels and drains. It follows that maintenance of these items is reduced with longer rows. Turning time is reduced for all operations involving tractors, and there is a smaller amount of waste land along the edge of the channel where the tractor turns.

Perhaps the greatest benefit from longer rows is the smaller amount of labour required to do the watering. Fewer siphons have to be operated.

Lengths of row tested during 1963 varied from 10 to 23 chains; rows 23 chains long appeared quite satisfactory. It was found necessary to speed up the first watering if long rows were used so that the cotton seed was not held in very wet soil near the channel, for long periods. As long as slopes of 1 in, or more per chain are used, rows up to 25 chains long should be satisfactory. However, if safflower is to be grown on this land it may be advisable to limit the length of row to 20 chains so that plants near the channel are not waterlogged for long periods.

Size of Siphon

From the operator's point of view siphons of small bore are best.

The limit on size is determined partly by their rigidity, which affects their ease of starting by pumping. A siphon with a bore size of 1⅞ in. is the smallest with enough rigidity to pump by hand. Other factors are that the operators could not start enough very small siphons quickly enough when handling 10 cusecs, and very small siphons would take too long to water long furrows and plants adjacent to the channel would be excessively waterlogged.

Ideally, watering should take about 12 hours. This is certainly not too long for the plants near the channel to be watered, but is long enough to make watering overnight very easy.

Siphons are used in alternate furrows so that during the night the operator merely has to shift the siphons into the adjacent furrows when the majority of the furrows have been wet into the drain.
next day he can shift the siphons back into any furrows which are still dry. This means that the channel stops do not have to be touched during the night and siphons do not have to be started.

It takes about 13 hours to water 23 chains of row with 1½ in. siphons on a head of about 8 in. Such siphons have proved very satisfactory and are strongly recommended in preference to those with larger bore, which of course are also dearer to buy.

TWO CROPS OF COTTON IN ONE YEAR

The system of taking two crops of cotton off the same bushes in the one year was suggested as an interesting possibility by Mr. N. Thomson of Kimberley Research Station, who showed in preliminary investigations that excellent yields could be harvested from two crops.

The system entailed picking the first crop, then trimming the bushes if necessary, applying nitrogenous fertiliser and watering for a second crop.

The author cropped 20 acres in this manner during 1963. Cutting the bushes delayed the maturity and it did appear that uncut bushes could give the best result. It was apparent that insects should be controlled throughout the period when the first crop is being picked so that there is no build-up at the beginning of the growth of the second crop.

A similar system to that tested at Kununurra, is used in the Imperial Valley of California. Here watering is continued after the first crop has been set, and the second crop is grown on top of the first crop without any picking or topping being done.

As the variety Rex holds seed cotton in the boll fairly securely this method could even be the most satisfactory at Kununurra.

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factor for taking two crops in the one year at Kununurra.

A great deal more work remains to be done before definite recommendations can be made concerning second cropping. However, the system has definite possibilities and will no doubt be tested by farmers in the near future.

Machinery

Tractor, row crop. Must have single front wheel and be able to take the mid mounted and other equipment.

Grubber tynes (5 only rigid end on, with chisel points).

Middlebusters (5 only with clamps and release shanks).

Markers used in conjunction with middlebusters (2 only).

Gauge wheels (2 only, rubber. For use with middlebusters and Alabama sweeps, depending on type of tractor purchased).

Tool bar (14 ft., with headstock, to mount middlebusters and Alabama sweeps).

Cotton planter, four row.

Tool bar and headstock (12 ft. x 3¾ in. square for cotton planter).

Tyres, zero pressure (4 only) jockey ties, seed press wheels (4 only for planter).

Fertiliser units (4 only) with applicators (4 only) and polythene delivery tubes (4 only).

Fertiliser stars (4 only to allow variation in rates of application).

* Cultivator, mid mounted, with spring release tynes.

* Hydraulic cylinders (2 only for the mid mounted cultivator depending on type of tractor purchased).

* Alabama sweeps (5 only).

* Knife weeders (16 only).

* Cultivating sweeps or duckfoots (5 only).

* Tool bar (12 in. x 4¾ in. square for cultivator).

Single row picker, or double row picker if more than 200 acres of cotton will be grown each year.

Trailer (2 only to carry seed cotton to gin. Steel framed approx. 28 ft. x 8 ft. x 8 ft.).

Rotary slasher, 6 ft., for chopping remains of cotton bushes.

* Repeat these items if more than 200 acres of cotton are grown.

Harrows, covering (12 ft.), for firing stubbles.

Spray boom with pump, tank and droppers.

Tank for mixing insecticides, carting water (300 gals.).

Blade, rear mounted. For cleaning up roads and channels.

Consumer Items for Cotton Crop—200 ac.

Superphosphate, 20 tons.

Urea, 22 tons.

Water, 600 ac. ft.

Insecticide, as required.

Defoliant, 330 U.S.A. pints D.E.F. if required at all.

Fuel, greases, etc.

Items Required to Grow Safflower and also Needed for Cotton

Shed. Steel framed iron roof, 80 ft. x 32 ft. x 12 ft.

Landplane (10 ft. 6 in. x 28 ft. Wheels at rear).

Siphons (11 ft. long x 1¼ in. diam. high density plastic. Number depending on length of row. Perhaps 1,500 only).

Coil shank cultivators 24 only, each with clamps (4 bolts).

Welding plant and selected tools.

Tool bar 12 ft. x 3¾ in. square. Double bar required if much trash.

Head ditch furrower (8 ft. To be made by farmer).

Vehicle for transport. Four wheel drive.

Chisel cultivator points, 24 only.

Light truck, or trailer for four wheel drive vehicle.

Tractor, row crop, single front wheel, capable of being used for cotton row crop work.

Lights (2 only with batteries, belts and helmets for irrigating at night).

Channel stops (sheet steel, semi circular, radially opening with wings. Number depending on layout of the block. Perhaps 10 only).

Channel crossovers. Concrete culverts 10 ft. x 4 ft. x 2 ft. or steel girders and ties; number depending on layout of the block.

In addition to this equipment it is likely that a heavy tractor and heavy cultivating
equipment (plough or offset discs) for cultivating dry soil, or a reversible mouldboard plough for working moist soil, or both, will be required for preparing the ground for future crops.

When purchasing any machine the farmer must be certain that service and parts for it are available locally. The importance of the availability of spares cannot be overstressed.

ACKNOWLEDGMENTS

The assistance given by the personnel of Kimberley Research Station particularly Messrs. N. Thomson and A. Gray and the Public Works Department, particularly Mr. R. Hamilton, in the growing of the 1962-63 crop is gratefully acknowledged. The exercise would not have been possible without Mr. G. Arbuckle who ably assisted with all the farming operations.

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