IRRIGATION FOR THE INCREASED PRODUCTION OF SUGARCANE

By C. HILL-LEWIS (Irrigation Engineer, Natal Estates, Mount Edgecombe).

On the Natal Estates, approximately 22,000 acres are planted with sugarcane, and of this area 11,000 acres are under irrigation—6,000 are irrigated direct from the Umgeni River pumps, and the remaining 5,000 acres from subsidiary pumps which are placed at strategic points for pumping seepage water, and in some cases repumping Umgeni water.

The River Works.

At the Umgeni pumphouse there are six Mirrlees-Watson five-stage, seven-cusec capacity centrifugal pumps, direct coupled to six three-phase A.S.E.A. motors of 600 h.p. each.

The electric current to drive these motors is generated at the factory and is run over a 22,000 volt line, seven miles long, to the river, where transformers reduce the voltage to 2,000.

About 400 yards upstream from the pumphouse there is a diversion weir, and about another 400 yards above this is the measuring weir. In the centre of this measuring weir is a rectangular measuring notch which measures up to 175 cusecs. Any flow above 175 cusecs is taken as flood and is not recorded. There is an electrical recorder on the bank which transmits to a graph in the pumphouse. Up to three years ago the intake at the diversion weir was situated in midstream about 30 feet above the weir, but this was found to be very unsatisfactory because water entered at such high velocity that heavy sand was carried down to the pumps. The sand caused tremendous wear on the pumps, and practically every week-end it was found necessary to clean out the sumps by hand.

This was a costly business and, with the war on and new parts hard to procure, it was soon realised that an alteration would have to be made. A completely new intake was therefore built on the river bank, with its intake gates parallel with the river flow. The same aqueduct was used as previously, to carry the water down to the pumphouse, but the new structure was so made that by the time the water enters the aqueduct all sand has been removed from it by the simple process of reducing the velocity of the flow. The floor of the intake chamber slopes down stream, the fall being 7 feet 6 inches in the total length of 131 feet.

A scour gate is situated at the lower end, and when the pumps are shut down this scour is opened and the force of the water cleans out all the sand that has been deposited. The pumps can run night and day for six days without any cleaning being necessary, and when it is done it takes about five minutes to complete the job.

The pumps raise the water straight into the main canal through a 3 feet diameter pipe, 1,000 feet in length, against a vertical head of 498 feet. The plant is capable of delivering a million gallons an hour to the main canal.

Canal System and Dams.

The main canal is not of a constant grade throughout, but varies according to circumstances and necessities. At one place it is as steep as 1 in 97; in another, 1 in 341; but quite 90 per cent. of it is on a grade of 1 in 1,000 to 1 in 3,000.

The canal is lined throughout its entire length of 14 miles, the first four miles in solid concrete, and the remainder with pre-cast concrete slabs. The slab principle cannot be recommended. They give a lot of trouble, especially when the canal is new, and I am of the opinion that, in the long run, solid concrete is the better investment.

The route of the main canal, from the top of the rising main to the large dam at its end, is through hilly country, and this has necessitated the building of a concrete-lined tunnel 200 yards long and nine inverted syphons of various lengths, the longest being 1,500 yards in length. All along this 14 miles of main canal the water is drawn off into subsidiary canals leading out on to the different estates, and at every take-off the water is measured and a record taken for statistical and other purposes. This is carried on day and night when irrigation is in progress.

In turn these subsidiary canals, all of which are cement plaster lined with wire netting reinforcement, ramify through the estates, and here again are many inverted syphons and flumes and measuring chambers. Three of these subsidiary canals are each about six miles in length. There are many others three to four miles long.

There are two distinct periods during the 24 hours of pumping, and they are referred to as 14 hours and 10 hours; the 14 hour period being the nightshift, when all water is being run from the main and subsidiary canals into the dams provided for the purpose. There are 35 of these irrigation dams scattered about the estates, varying in capacity from 3,000,000 gallons down to 250,000 gallons.

The 10-hour period is that in which all water accumulated in the dams during the night or 14-hour period is turned on to the fields, and also all the water in the main and subsidiary canals. This gives a maximum of efficiency because the pumps are running 24 hours, thereby giving their ultimate output, and yet all irrigation is done in daylight.

Years ago night irrigation was practised, but it was soon discovered that the application was not being properly done, and there were many outbreaks of fire in the cane caused by lamps being overturned. It is a physical impossibility for water to be controlled in the dark so as to eliminate completely the danger of soil erosion and at the same time make a thorough application.

Subsidiary Pumps.

The subsidiary pumps are used either to re-pump Umgeni water to higher levels which cannot be reached by gravity from the main canal, or to pump water which has seeped out from ground which has been irrigated higher up. The seepage water is allowed to run down a natural watercourse, as in the case of the Piezang River, which carries the water to estates further down, where it is collected in dams and pumped up to higher levels. In other cases it is run along canals dug for the purpose, but whichever method is used, no water is allowed to run to waste without first being put to good use before it runs beyond the boundaries.

Distribution.

The measuring of the flow of water is done by means of rectangular weirs, with a stilling chamber slightly above the weir in which an enamel plate shows the reading in cusecs. There are two sizes used, 18 inch and 3 feet, and, of course, different enamel plates are used for each size of weir.

A gang of Indian men patrols the canals day and night, one gang for the night and another for the day. They are under a sirdar, who arranges the day and night shifts. It is their duty to visit the weirs on their respective sections every two hours and record the readings on a form provided for the purpose, and also to keep the iron grids, which are situated in the canal at the intake end of every syphon, clear of trash and other debris.

Every measuring weir has its number painted somewhere on the concrete work, and at the top of the patrol record forms, space is provided for this number.

When irrigation is considered necessary, it is the duty of the irrigation engineer to find out the requirements of each estate and to make out a programme according to the circumstances prevailing at the time. It might be that only certain estates require water or that, on account of repairs at the factory or pumphouse or on the transmission line, not all six pumps are available. The distribution must be arranged accordingly.

When this programme has been compiled, each sub-manager is informed of the amount of water, in cusecs, his estate will receive. The sub-manager, in turn, arranges with his irrigation overseer where and in what quantities this water shall be applied. The overseer issues the necessary instructions to his irrigation sirdar, who, in turn, contacts the irrigation department's patrol man and tells him where the water is required.

In the meantime the irrigation engineer has given the programme to his sirdar, who instructs all the patrol men, both day and night shifts, what quantity of water is to go to each estate, and it is his duty to see to it that this amount is not exceeded anywhere.

An estate might be allotted five cusecs for the 10-hour period, and this amount will be split up and drawn off from six or eight different points, but the total must not exceed the five cusecs. Then, for the 14-hour period the allocation might be seven cusecs, and here again the amount will be split up and drawn from many different points; but it is very seldom that a shortage or excess occurs at the end of the canal, and in such cases as do happen, a short investigation will suffice to put the matter right.

The patrol record forms are also provided with space at the top, to show the name of the patrol man concerned, whether it is day or night shift, and also the date ending the current week. Below are columns for the actual date of the reading, a column for the time the particular valve was opened and closed. The next column is "hours run," which is calculated from the two preceding columns. Then there are columns for the several readings taken during the shift. Next comes a column for the "average" of these readings, which is worked out in the irrigation office, as are also the rest of the columns. They are "cusec hours," which is merely a computation of "hours run" and "average" reading and, finally, the amount for the shift in "acre feet," which is computed from a table worked out for the purpose.

All the measuring forms, from the various patrols, are handed in to the irrigation office every week. In this office are other forms in which the amount of water, in acre feet, taken by each estate at every measuring point, is recorded.

The estate sub-managers keep a record, in a duplicate book, printed for the purpose, of the acreage irrigated in each field every day and show from which measuring weir the water was drawn. From this and the patrol men's records taken at the weirs, the irrigation office staff computes the application of water, in inches, to each field. A record of the rainfall on each estate is also kept in the irrigation office, and this, together with the irrigation application, gives a close approximation of the total monthly application. A record is also kept, for purposes of costs, of the monthly consumption of water by each estate in acre feet.

Laying out Fields for Planting under Irrigation.

In order to lay out the planting lines correctly, each irrigated estate is provided with a dumpy level and staff. The planting lines must be graded, otherwise no control could be exercised upon the water and disastrous runaways would occur, causing irreparable damage.

Some years ago a system known as the Hawaiian short-furrow system was practised, in which the cane furrows were drawn on the contour or, in other words, were level. This proved unsatisfactory because it was too slow and also caused an excessive amount of seepage.

To-day, the Hawaiian long-furrow system is used, in which all the planting lines in the irrigated areas are drawn on a grade of from 1 in 75 to 1 in 200, depending upon the physical nature of the soil. The heavier the soil the steeper can be the grade. This system has now been in use for some years.

Where one has a large area to cover and a bare sufficiency of water, as is the case on these estates, the steeper the grade of the cane lines can be made within certain limits, the better, because more ground can be covered in a shorter time. I say within certain limits, because too steep a grade would be harmful in two ways. Erosion, though very slight and almost unnoticeable, might remove some of the finer surface soil, and also insufficient time would be given to the water in which to penetrate to the roots.

In laying out a field, not every line is graded with the instrument. Every 50 yards or so, down the field, a line is run at the desired grade, and reeds are placed on the grade line as markers for the tractor driver, who draws the lines with a double mouldboard ridging plough.

This first line acts as a marker, and all the other lines are drawn as parallel to it as possible until the next line of reeds is reached. Usually a few short lines have to be drawn to join up evenly with the next new marker line. At intervals of 75 or a 100 hundred yards down the slope of the field from the main subsidiary canal at the top, what are called water lines are laid out with tractor and ridging plough, at a grade of 1 in 300. These are drawn on a flatter grade than the planting lines because they are the main arteries carrying a larger amount of water than the planting lines, and they feed the planting lines at intervals of 20 to 40 yards along their length, depending upon circumstances of physical condition of soil and steepness of slope of the land in general. The lighter the soil or the steeper the slope of the land, the closer to one another will be the points at which water will be drawn from the arterial canal. All canals on a flatter grade than 1 in 300 are dug by hand to pegs.

At the side of the field, if the slope of the ground is such that, without it, erosion would be caused, what is known as a "straight ditch" is constructed This straight ditch is nothing more than a concrete chute, built in the ground and provided with sluice gates, at each intersection with an arterial canal, from which to draw off water.

On account of the high velocity of the water, which is usual in these straight ditches, they are constructed of concrete made from fine chips which gets very hard and they are reinforced with one-inch wire netting. As the slope is nearly always steep they do not need to be large in section, so one can afford to make them sturdy.

In most instances straight ditches are not required, the slope of the field or the nature of the ground permitting an ordinary earth canal, but in most cases the canal is plaster-lined. Ordinary sand plaster will not stand up to high velocities and will soon break up. None of the arterial canals running through the fields are lined. On most estates they are ploughed out with the cane, when the yield has fallen below standard, and they are resurveyed at planting time.

Application of Water

The water, when taken over by the estate concerned, is handled by expert irrigators. The amount of water one man can look after efficiently varies according to the physical nature of the land upon which he is working at the time, and also upon the plane on which the field, on the average, lies. There is no hard and fast rule.

In a heavy loam he might manage as much as half a cusec if the plane of the land is not steep; but if the land is of a sandy or loose nature and the field on a steep hill side, then an eighth might be as much as he can safely look after without the water getting out of control and causing damage by running from cane row to cane row down the hill. If this were to happen, dongas would form and the field would soon be ruined for further cultivation; but this very seldom does happen, and after fifteen years of constant irrigation it is amazing what little evidence there is of erosion, even on the very steep hill sides.

This has undoubtedly been achieved through so much care being taken to place the cane furrows on grades which, while allowing for the free flow of water, do not permit of velocities which could cause erosion of the soil, and also through the care which is exercised in not overtaxing the irrigators with too large quantities of water.

I have seen indescribable damage done to magnificent land in the course of a few years. This soil could have been irrigated for a hundred years or more, but it was rendered useless for anything in the short space of four or five years.

On the average it can be taken that four irrigators can handle one cusec, and this usually works out in practice, taking the various conditions of soil and slope together.

As regards the amount of water actually applied to the land at each application, it is very difficult to arrive at an estimate unless records are kept, as on these estates. Through the use of these figures, taken over a long period, I have arrived at an all round approximate figure of 2½ inches per application. There are usually two applications in a month.

Last year the average application, taken over all irrigated areas, was 50.389 inches for the twelve months, and the average rainfall over the same area for the same period was 34.628 inches, making a total application of 85.017 inches.

In other years, in which the figures have been reduced as above, the rainfall might be found to be greater, in which case the irrigation application will prove to be less; and *vice versa*, if the rainfall is less the application will be found to be greater.

The yearly figures show that our total application, including rainfall, is always somewhere between 80 and 90 inches, which is about correct for cane in such a hot climate as this.

Costs.

The all-important matter of cost of application will, I have no doubt, be of interest. Of all the forms of irrigation schemes, gravity is the cheapest in the long run, and much thought and investigation should be given to the matter before a decision is made as to what form of scheme shall be built.

On account of the massive weir and head works which are generally necessary, and the long length of the canal needed to bring the water up to a useful level, with command of a sufficiently large area, the initial cost of a gravity scheme is always high, where large areas are to be dealt with.

A pumping scheme, on the other hand, while needing, in some cases, a substantial weir and intake, does not require such protective headworks to guard against flood damage to the upper reaches of the canal, and in some cases no weir or headworks of any kind are needed, pumping being done from a pool. The water can usually be delivered from the rising main comparatively close to the first point of application, rendering unnecessary the need of a lengthy main canal passing through unirrigated land, as is often, in fact generally, the case with a gravity scheme.

The cost of running and maintaining, however, is in the latter case far above that of the former.

If, in the first instance, a gravity scheme capable of delivering the water to the point where the rising main now enters the main canal had been built here, the cost of the weir and canal alone would have been more than six times what the present headworks, pumphouse and rising main and electrical equipment have cost, but the difference in the maintenance cost would have probably made it worth while.

The maintenance cost on this scheme is approximately £2/10/- per acre foot. This, in itself, perhaps, is not very lucid, but let me put it this way. The 50.389 inches of water which was applied last year was, reduced to acre feet, 4.199, and at £2/10/- per acre foot cost £10/10/- to irrigate each of the 6,000 acres under the steam-electric plant.

On the other hand I estimate, from actual previous experience, that the gravity scheme would, at the outside, cost 25/- per acre per annum for maintenance, a saving of £9/5/- per acre on the 6,000 acres, or £55,500 a year.

The high cost of the steam-electric water is due to the large overhead expense of maintaining a qualified mechanical and electrical staff. When the mill is crushing, irrigation costs are slightly lower on account of a certain amount of steam from bagasse boilers being available; but out of season, all the burden has to be carried by the coal boilers. Without the bagasse boilers, then, the cost would be considerably higher than it is.

Between these two methods of making water available for irrigation is a third, which is coming more and more into use on these estates, and that is pumping with crude oil engines. It is proving much cheaper than the steam-electric, and the initial outlay is less because no wiring or transformers are required. In addition, unskilled labour, which can also be employed on other work, can be used to run the plants. The approximate running cost per acre per annum is £4.

Requirements.

When estimating one's requirements, care should be taken to over- rather than under-estimate, so as to provide for droughts.

On the average, one cusec of water will take care of a hundred acres of cane, provided the night flow is stored in dams. The steam-electric scheme here provides 43 cusecs and the area under it is 6,000 acres, making a ratio of 1 to 139. It is often felt that we are sailing rather close to the wind, and would welcome two more pumps during those very dry spells which come suddenly upon us with little or no warning.

It is largely a matter of circumstances, such as climate being hot or cool, moist or damp, and whether canals can be lined or not. If canals cannot be lined, then one cusec to every 75 acres in a hot climate is, in my opinion, the limit, because seepage and weeds will account for a large amount of water and, owing to the lower velocity, evaporation will also be high.

Application of Scum.

Scum, the waste material from the factory, is used extensively as a fertilizer, and the mode of application, on the irrigated areas, is in the irrigation water. Special trucks—scum trucks—are loaded with the waste material at the mill and are taken out to the various estates by locomotive. At convenient spots in the fields, scum chutes are constructed. These consist of a chute about 3 feet wide and some 60 to 90 feet in length, built of concrete, set at a steep grade so as to cause water flowing through it to travel at a high velocity. The bed of the chute—which, on account of the high velocity of the water, need be only 9 inches or so deep—is studded with hard rocks standing on end or pieces of old tram rails.

The scum is tipped into the fast-running water, which, together with the up-ended rocks, soon breaks it up. In this state it mixes readily with the water and is carried by it for great distances.

These chutes can only be constructed where a tramline or wagon can be brought to the top end of it and where water is available at a slightly higher altitude than where the scum is required. With the main canal so high up and so many re-pumping plants at work, this is usually found to be no obstacle, and there are a large number of these labour- and time-saving devices scattered about the estates. The scum is of great value as a fertilizer, and it is also invaluable for stopping excessive seepage on shaly land and in leaky dams.

Benefits Resulting from Irrigation.

Irrigation, on these estates, is looked upon, and with justification, as a sound insurance policy against loss of crop and a sound investment for increasing the yield.

This is clearly shown by figures. The average taken over the past five years, of tons of cane yield per acre, and the averages for the five years prior to the commencement of irrigation, show an increase of 106.36 per cent. on the irrigated estates.

The sections which are not irrigated also show an increase for the same period, but in this case it is only 70.42 per cent., a difference of 35.94 per cent.

In actual tonnages, the figures are as follows :—

The average for the five years prior to the commencement of irrigation, in 1931, was 18.7 tons per acre, with an average on one estate as low as 10.8 in 1927.

For the five years 1941 to 1945, inclusive, the average is 38.59 on the same area but now under irrigation, with averages as high as 53.9 in 1943.

On the unirrigated estates the average for the five years before 1931 was 21.3 tons per acre, with the lowest average of 15.3 in 1927.

The average, on the same area, for the period 1941 to 1945 inclusive, is 36.3, with the highest figure of 47.5 in 1944.

The phenomenal increase in the yield of the irrigated estates is not entirely due to irrigation, as the introduction of better cane varieties has led to increased yields, and an increased application of fertilizer also plays a part; but the unirrigated estates, which have received a similar fertilizer treatment, and are also planted up with new varieties, have not shown this high increase in tonnage.

It is, therefore, clearly shown to what extent irrigation has been responsible for increased yields. In fact, the beneficial results obtained from irrigation are even greater than shown here, because not all the estates classified as irrigated are under water to the extent of 100 per cent., and the comparison, therefore does not show such a big difference, in favour of the irrigated estates, as would have been the case if it were possible to contrast wholly irrigated sections with non-irrigated areas.

In 1943, which was a particularly good year for the whole sugar industry, as far as rainfall was concerned, the average yield per acre for the entire industry was 151 per cent. of what it was in 1926. For these estates, however, with only half its area under irrigation, the average yield for 1943 was 252 per cent. of what it was in 1926.

Four of the estates now under irrigation lie in an area of 30 to 35-inch rainfall, which is far too low for the economical production of sugarcane, and in addition the country rock is shale in most parts. But in spite of these facts this high average has been attained, and it is quite certain that if irrigation had not been possible, these areas would have been thrown out of production entirely.

It is sometimes contended that irrigation causes a decrease in sucrose. That is probably true, but the increase in tonnage more than looks after that.

Heavy applications of fertilizer will help to increase yields in normal rainfall, but in times of drought no benefit will be derived. Sound irrigation, however, with normal fertilizer application, will not only pull a crop through a drought with little or no loss, but with normal rainfall will bring about a heavy increase in tonnage.

Possibilities of Brak Formation.

In general, I would like to remark that, in my opinion, there is nothing that will yield to the cane planter or general farmer higher dividends on his capital expenditure than an irrigation scheme, preferably a gravity one.

But a few words of warning, I feel sure, will not be out of place.

A sound irrigation scheme *must* be accompanied by a sound and judicious system of drainage, especially if there is any possibility of there being injurious salts present in the subsoil, which might be brought to the surface if waterlogging of the soil should occur.

Whether injurious salts are present or not, efficient drainage is essential in order to keep the soil aerated, otherwise souring of the ground and eventual total loss will result. I have had actual experience of cane being killed out by brak, brought to the surface by inadequate drainage.

Once the soil has become brak or sour, there are few things of commercial value (except grape vines in the case of brak) which will grow in it, so too much stress cannot be put upon this all-important matter of adequate and yet prudent drainage. I say prudent because, if overdone, it will cause too much water to pass through the soil, causing leaching out and loss of valuable plant-foods and also direct financial loss, in that too frequent applications will become necessary.

Then again, much water can be saved by the wise use of cultivators after an application. If used too soon, the cultivator might do more harm than good by packing the soil and forming it into hard lumps; if too late, the water will have already evaporated through the crust. One must use sound judgment in all these things, and then he will find that irrigation will yield him a rich reward.

Irrigation Possibilities.

With the generous facilities which will shortly be available from the Government Irrigation Department, no cane planter or general farmer, who has any kind of stream on his farm, can afford to allow it to run into the sea without first putting it to work on his land, either by pumping or by means of a weir of some kind.

There are far too many rivers and streams in this country allowed to flow to the sea without paying their passage. On the contrary, they are allowed to flow to the sea, carrying with them the very life-blood of the country—the soil.

There are many simple and inexpensive ways of removing water from rivers for the purpose of irrigation. I have seen it taken out by the simple means of sheets of corrugated iron bolted on to upright poles driven into the river bed. This method is eminently suited to deep flowing rivers. Floods, of course, will render the structure inoperative at the time, but the sheets of iron can be recovered if anchored to the bank by means of a wire. It is a cheap way of getting the water out, so one must not complain of the inconvenience of having to rebuild it now and again.

Where a river bed is on a steep grade with many rapids and small waterfalls, it is often necessary to raise the water level only six inches to a foot in order to make it run along a canal which will serve quite a large piece of land.

Source of Water Supply.

As regards the source of water for irrigation, there are many. Gravitation from a river or stream; collection of water from springs, by means of small channels, into a dam; dam filled from catchment area. All these can be gravity schemes, but if the land is not suitably placed, then pumping can be added. Boreholes have even been used, with success, for small irrigation plots.

In any case, the cost and the possible benefits should first be estimated, before a potential scheme is condemned, because water, on the land, is worth a lot of money and justifies a good amount of trouble and expense in getting it there.

Care must, however, be exercised to make sure that the available water does not contain any injurious salts which might damage the crop or the soil. This problem, happily, can easily be solved by having the water analysed.

Along the coast, especially, one has to be careful. The water in many of the lagoons, while looking very tempting for irrigation, is, in many cases, quite unsuitable for the purpose and would soon ruin any land on to which it was put.

Erosion.

Irrigation, contrary to what many people think, and as fully illustrated on these estates, far from causing erosion, can actually help us to combat it, because what is necessary for the one is an essential for the other—contouring or, more accurately, grading.

The grades used in the planting lines are so light that they have, for all practical purposes, the same effect as contour trenches when heavy rain falls, and there is the added advantage that the cane is growing in them and binding the soil.

In closing, I would like to mention that I believe that the irrigation scheme which I have just described is the largest of its kind in South Africa.

There are gravity schemes handling larger amounts of water and irrigating greater areas of land, but, except for a few minor pick-ups, all the water used for irrigation on these estates is pumped, and I do not think there is any other scheme in this country which raises water so high or handles such a large amount by pumping.

When the Umgeni pumps and all the subsidiary pumps are working, 38,408,256 gallons of water are being raised daily to higher levels to do duty upon the land.

THE PRESIDENT expressed the Association's appreciation to the Director and Committee of the Experiment Station for putting the Station at the disposal of the Technologists' Association on this occasion. He hoped that this would become a regular feature of our conferences.

Dr. DODDS drew attention to the fact that when the Experiment Station was started about twenty years ago the yield of cane per acre was only about sixteen tons in the Inanda district—the lowest for any district along the coast. Now it was well over thirty tons of cane per acre and the highest of all districts in Natal. From Mr. Hill-Liews' paper it was evident that the establishment of the Experiment Station in this district was not the only reason for this remarkable progress. Irrigation and the enterprise of Natal Estates generally had played a most important part. It was noteworthy that this year's conference was outstanding because of two excellent papers written by employees of this Company, i.e. Mr. Hill-Lewis and Mr. Rault, which described some of the very varied activities of Natal Estates.

Mr. DU TOIT thought the cost of irrigation, ten guineas per acre per year, or £21 per acre, for a two-year-old crop was rather extraordinarily high to be economic.

Mr. COLEPEPER said he saw no mention of soil depths in the paper. He knew that the Government Department of Irrigation was most particular in this respect and insisted that soils to be irrigated should be of at least a certain depth. He would like to hear Mr. Hill-Lewis' opinion on this point.

Mr. GOODMAN was under the impression that for small areas portable pumping plants might be most effective.

Mr. RAULT said that Mr. Hill-Lewis referred to a possible lowering of the sucrose per cent. cane as a result of irrigation. He had no conclusive evidence of the depressing effect of irrigation on the sucrose content of canes from the irrigated areas as compared with the non-irrigated areas in the course of the same season. It was true that rainfall had that effect and further, it was also found that in very wet patches the sucrose in the cane was lower, but the effect of irrigation as applied at Natal Estates remained an open question.

Mr. DYMOND wanted to know whether the amount of irrigation water was controlled by the atmospheric temperature. At high temperatures the cane could utilise large quantities of water with a resultant response in growth. At lower temperatures, however, conditions of growth were unfavourable and heavy unfavourable applications of water then might possibly lead to lower sucrose results.

Mr. HILL-LEWIS, in reply to questions raised, said that natural rain and irrigation were hardly comparable. One would naturally prefer rain to irrigation, but irrigation could be just as effective. He had no doubt that excellent crops of cane could be grown with only say 18 inches of rainfall per year, provided it could be supplemented with the necessary irrigation.

He did not like the spray method of irrigation in a hot climate on sugarcane. The water particles were so finely divided that it facilitated evaporation and this process was further helped by a large proportion of water adhering to the leaves of the cane. He thought the best way of irrigating was to get the water to the roots of the plants.

It was possible that the cost of irrigation as given in the paper was slightly on the high side, but nevertheless he thought it a fair figure. It depended, of course, on the amount of irrigation applied, but even the cost per acre varied from about £2 to £2 15s. depending on the amount of irrigation applied—the larger the quantity applied the lower was the cost per acre foot.

It was quite correct that before approving of an irrigation scheme the Government send out survey parties to study the depth and physical and chemical conditions of the soil. They want to be sure that the soil would stand up to irrigation for at least fifty years. Nevertheless it had been found at N'kwaleni that soils that were not recommended for irrigation by the Government gave excellent crops of cane under irrigation. Whether that would last without ill effects for fifty years he could not say. A large part of the lands under irrigation at Natal Estates was very shallow, often no more then nine inches deep with shales underneath, but so far irrigation with proper drainage had been very successful on these lands.

The portable type of pumping plant was certainly very good and there was no reason why it could not be used, but its capacity was limited.

No soil moisture tests were done as a guide to irrigation control. Water was simply applied when the cane looked dry and was suffering from lack of water. Hudson Spence in 1929 held that sugarcane could be given up to 150 acre-inches of water per annum. Judging according to that standard it was quite impossible to over-irrigate on Natal Estates with the water available.

The speaker was not under the impression that irrigation water lowered the sucrose per cent. cane. He simply stated in his paper that it was sometimes thought to have that effect. In fact, Hudson Spence found that water application did not depress the sucrose but rather increased it. Not much irrigation was done on Natal Estates during the cold winter months except under exceptional drought conditions.

Dr. McMartin pointed out that, contrary to the generally held belief that plants could only get their water requirements through their roots, experiments conducted in Hawaii some years ago proved that moisture could also be absorbed by the leaf canopy of the sugarcane plant. All the water left on the leaves as a result of spray irrigation was therefore not necessarily lost. This absorption of water by the leaves might also explain why sucrose per cent. dropped after rain; the water absorbed by the leaves would have a diluting effect on the juice of the cane.

Dr. Dodds referred to the experiments carried out in Queensland which led to the conclusion that at soil temperatures of 75°F. and over it was hardly possible to irrigate sugarcane too much. Between 70°F. and 75°F., however, irrigation should be applied moderately, while at temperatures below 70°F. it was not advisable to irrigate sugarcane for the purpose of obtaining increased growth, but only to prevent drought conditions developing. According to these principles it would pay to irrigate most of the year in this country, except possibly during the months of July to September inclusive.

Mr. Feltham described irrigation practices in the Nile Delta and along the foothills of the Apennines. The Italians had adopted a system that this country would do well to emulate, and that was that they did not recognize defeat on contours. What they did was to adapt the soil to the irrigation rather than the irrigation to the soil. Down the hillside you would find that the whole of the hillside was levelled out and the irrigation channel would run at the top of the hill and then it was graduated down to the foothills. Every field was separate and each was saturated completely in turn. There he had seen no signs of soil erosion.

Mr. Dymond recalled an occasion at Empangeni when rain started at six o'clock in the morning and lasted for just about twenty-four hours with a total precipitation of one inch. It was therefore possible to determine the effect of rainfall very well with the drop in sucrose per cent. cane. It was done and found that the one inch rain per day caused a drop in sucrose per cent. cane of one per cent.