SUGGESTIONS AS TO THE USE OF PIPES IN THE DISTRIBUTION OF IRRIGATION WATER AND THE COMPARISON OF COST BETWEEN THE CONSTRUCTION OF FURROWS AND THE LAYING OF PIPES

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The subject of irrigation has been discussed at these meetings at various intervals. Some of the leading irrigation schemes in Natal have been described in detail, as in Mr. Hill Lewis' paper in 1946, and the possibilities of the use of water on cane were thoroughly discussed when Mr. Hudson Spence read his paper in 1929.

I would refer you to this paper and will refresh your memory by one quotation with which he ably and concisely describes the water resources of the Natal sugar belt.

"Topographically, the area is characterised by the land surface descending abruptly to the sea from high altitudes, incidental to the proximity of the Drakensberg Mountains. The steep sloping land surface has been deeply eroded by numerous rivers and thus we find the bulk of the arable land lies at a considerable elevation above the river beds."

The source of water thus placed by nature well below the levels at which irrigation of crops is applicable, introduces the first major problem confronting the planter. Two courses are open to him to get the water where it is wanted: (1) by taking levels from the highest point of his land and along a line with a gradient of about 1 in 1,000 to 1 in 3,000, and constructing a canal to a point higher up the river so that water may be gravitated on to his land, or (2) by building a pump-house on the banks of the river and raising the water through pipes to the required level.

Whichever course is adopted, a considerable capital outlay is needed, but it would appear that the extra initial cost of installation of a pumping plant would be justifiable, because for every foot of lift required at the start of the distribution to the fields, the intake point on the river would have to be moved several hundred yards up-stream. There is under consideration an irrigation scheme taking water from the Tugela River, and the canal to supply this water by gravity feed would be somewhere in the neighbourhood of 40 to 45 miles in length. Any canal of this nature would of necessity have to cling to the hillsides, and the distance traversed by the canal is considerably greater than that traversed by the river of supply.

The construction, maintenance and cleaning of such a canal is initially costly and a recurring expense, to which servitude must be added.

Once the desired height above the arable land to be irrigated is reached, the water can be distributed by furrow or pipe. Referring to Mr. Hill Lewis' paper, it will be seen that Natal Estates have a main furrow running some 14 miles and capable of carrying, at its start, up to a million gallons per hour. It would need a pipe some 4 to 5 feet in diameter to cope with this water, and to think of converting this canal to pipes would be out of the question. The canal, for 90 per cent. of its course, is at a grade of from 1 in 1,000 to 1 in 3,000 and it traverses slopes well above fertile flat valley bottoms. From this source smaller canals, some constructed of plaster and wire, some earth, distribute the water, and it is here that much valuable power in head of water is lost and where a considerable quantity of water is also lost through seepage and damage to the canals.

Let it be assumed, then, that the initial lift is overcome and that the first major distribution is carried out by a solid concrete canal, and the land to be irrigated lies below this concrete furrow.

Water passing from the concrete furrow will probably be held in night dams and distributed from these by contour furrows following the undulations and curves of the countryside at a gradient of 1 in 1,000. These will be further divided into plaster or earth furrows leading to the fields and then to the rows of cane. The total length of furrows, even excluding those giving the final distribution to the cane, will, on quite a moderate area of land, run into several miles of water course.

Canals vary in width with the amount of water they are required to carry. The land occupied by such canals must be measured to include any bank or excavation slope that cannot grow cane. It will be appreciated that a canal 2 feet wide at the surface of the water may have a total width of some 6 or 7 feet to where cane can be grown.

In one scheme that was being contemplated the total width of a plaster canal to carry 1 cusec of water was 8 feet, and on the earth canals acting as sub-mains from this plastered canal the width was not a great deal reduced. The total length of canal needed to supply some 60 acres amounted to 14,440 feet.

Thus the canal area for such a scheme would occupy some 2.31 acres, or 3.83 per cent. of the available land.

In this particular scheme it was important to guard against the leaking or seepage of water from any watercourse, and it was contemplated to put in somewhat more substantially built concrete furrows than would be the practice in the field. These furrows would have cost approximately £830 per mile if made in solid concrete, or £386 per mile if made of cement and netting. As the field practice would be to construct the furrows of cement and netting, the following cost would be applicable :—

Concrete and Wire Furrows:			
Digging, 3 cubic yards per unit at 4/-, furrow 2′ 6″ x 2′ 6″	£135	16	0
Concreting:			
4′ wide, surface 4″ thick, 85 cubic yards at £1	£85	0	0
4′ wire netting at £3/10/- per roll of 50 yards	126	0	0
Laying concrete	40	0	0
	£386	16	0

The initial cost of £386 per mile must be studied in the light of the life of the furrow and subsequent maintenance. Taking the life of a furrow at 15 years, the following annual costs can be arrived at:

Depreciation per annum	£25	0	0
Maintenance	25	0	0
	£50	0	0

To this figure must be added the loss of cane that could have been grown on the land occupied by the furrow. Whether this figure should be the profit derived from cane grown on similar area, or whether it should be the total income from the cane is disputable. It can be maintained that cultivations have to be carried out on cane grown where a furrow would be, and therefore only the profit figure should be considered. It can also be maintained that the furrow occupies the land and therefore the total income should be charged against the furrow. As any obstructions, such as furrows, inconvenience the general field cultivations and necessitate turning of implements, with a loss of time and efficiency, and the fact that the banks of a furrow have to be weeded, it would appear that the total income derived from a similar area should be charged against the furrow. Thus a 7-foot furrow one mile long occupies 0.84 acres. Taking an average crop of 25 tons cane per acre at £1 10s. per ton of cane, the income lost by a mile of furrow would be £31 10s. every two years, or £15 15s. per annum. Thus the annual cost of a furrow may be taken at £65 15s.

Compare this with the cost of piping the same area. Again referring to the scheme mentioned earlier, where 14,400 feet of canal were needed on 60 acres, the same 60 acres could be covered by 7,500 feet of underground pipe-main, and with some 750 feet of portable overground pipe any portion of the 60 acres could have water delivered to it by pipe.

Taking as a basis for costs a commercial pipe in common use, 6 inches in diameter, to stand 200 feet head pressure, a mile would cost—

Pipes at 6/9 per foot	£1,782	0	0
Digging and filling at 4d. per foot	88	0	0
Laying	40	0	0
	£1,910	0	0

Pipes once laid would have a life of 50 years, so a comparative figure of annual cost might be:

Depreciation	£38	5	0
Maintenance	5	0	0
	£43	5	0

There is now a direct comparison of costs between the use of pipe and furrow.

	Pipe.			*Furrow.*		
Initial capital	£1,910	0	0	£386	15	0
Annual charge	43	5	0	65	15	0

It will be appreciated that in the case of pipes no replacement will be needed for 50 years, and in the same period the furrows will need renewing at least twice after the initial laying. If the long term costing is taken for a 50-year period, pipes will cost :

Initial	£1,910	0	0
50 years at annual cost...	2,162	10	0
	£4,072	10	0

for a 50-year period on furrows:

Initial	£386	15	0
2 replacements	773	10	0
50 years annual cost	3,287	15	0
	£4,448	0	0

Even this will give the furrows roughly 17 years' life rather than the 15 estimated earlier, and the final cost is £375 10s. more expensive than the pipes. At this point it must be emphasised that the piping taken in these figures is guaranteed to stand a head of 200 feet of water and is not the cheapest form of pipe that can be used. Another form guaranteed to stand up to the same pressure can be obtained at about two-thirds of this cost, but is not so convenient to assemble and as yet has not the same range of adapters and fittings. This latter type of pipe could be used by anyone interested enough to do a bit of improvisation.

It would appear from the above that the pipes have the advantage of cost, over a long period. There is also the advantage of uninterrupted areas for cultivation, ease of control of flow of water, and of measuring through fixed meters if required. Pressure water can be carried to any part of the field. The power used in the initial lift from the river again can be harnessed and used for the final distribution of the water by the overhead sprinkler system. This system would appear to have many advantages over the furrow systems when the cane is small and the majority of the land planted is not covered by vegetation. The quantities of water needed with our overhead system to give a full coverage are not nearly so great as those required when furrows are used. The minimum coverage requirement for the furrow system is between 3 and 4 inches, whilst the sprinklers can apply from ¼-inch upwards, according to the time they are allowed to operate on a given area. It is obvious that whilst the cane is small, and even up to the time it is 6 feet in height, large applications of water, such as 3 to 4 inches, are not only excessive and wasteful but are probably harmful to the crop. It is during this stage of growth that a great saving in water can be effected by the judicious use of an overhead system. Overhead irrigation is erroneously considered to be a system where water under considerable pressure is hurled colossal distances through the air to effect a distribution. This is one method. There are also sprinkler heads constructed to cover a circle of 105 feet in diameter and discharge 12.3 gallons a minute, whilst the operational pressure is only 30 lbs. per square inch. A battery of ten of these would cover, at one set-up, 1.39 acres and deliver 123 gallons per minute, and this would operate on any land 70 to 80 feet below the source of take-off, whether it be canal or night dam. Such batteries would be easily moved in young cane, and if worked in conjunction with furrow irrigation when the cane is giving a full cover to the ground, could effect a very considerable saving of water as well as providing more beneficial applications of water to the young cane. If the high-pressure big-diameter sprinkler heads are to be used they should not be opened up on bare or almost bare land, because of the puddling effect they have on the soil. They must of necessity have their own pump and engine to provide the correct high pressure required for successful operation.

In Natal the greatest amount of irrigation is done during the period of high temperature. It must be borne in mind that during this period water in canals is evaporating at a considerable rate and as much as 1,098.2 gallons per day will be lost from a mile canal with a still 2-foot wide surface. A ruffled surface will give an even greater evaporation figure, and where several miles of canal are in use this amounts to an extra charge on the cost of irrigation as well as a wastage of water. During similar weather conditions, the evaporation from a sprinkler system of distribution must be very considerable, but the evaporation on the primary distribution could be saved by the use of pipes.

Summary.

The installation of a system of pipes not only gives an alternative method of application and utilizes power expended in initial pumping, but could effect a saving of water. At the same time no wastage of water will occur, as is the case with earth and even plaster furrows, whilst the control of flow is easily and rapidly governed by stopcocks.

The full development of water under pressure in pipes, both for the use in overhead sprinkler and furrow methods of application, needs thorough investigation, but the potential of this method of water distribution should not at any time be ignored by the planter.

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The President said Mr. Pearson had had experience of irrigation in England and was naturally interested in applying his knowledge to the irrigation of sugar cane in Natal. He regretted that the paper had not been read before a larger audience of cane planters and engineers. It was obvious from conversations at the Experiment Station that growers were becoming more irrigation conscious. Mr. Pearson, since joining the Experiment Station as senior agricultural officer, had always been of the opinion that the best way to use our limited water supplies was by underground pipes and in this paper he made out an economic case for pipes as against furrows. Incidentally, Mr. Pearson considered that the water could be spread over three times the area at present covered.

Mr. du Toit said that in the comparison of the cost between pipes and the open furrow the initial cost of furrows was shown at about £400 and pipes at about £2,000 per mile. At five per cent. the interest would be £20 and £100 respectively, which increased the charge against pipes as compared with open furrows by £80 a year. He asked whether that had been taken into consideration.

Mr. Pearson replied that it had not, because if the factors governing labour cost were considered, he thought that one would heavily offset the other, although he had no definite experience of the labour requirements to enable the water to be delivered by pipes as against that delivered by furrows. In the case of pipes there was a stopcock; in the case of furrows it was necessary to go to the original source of supply to turn the water off and, therefore, if the interest figure on the layout and labour charges were taken he felt they would almost offset each other.

Mr. Bechard said the paper was of great advantage in drawing attention to the best use of water. He referred to previous papers presented to the Association and suggested that it might be useful to take all papers on the subject of irrigation together. He questioned Mr. Pearson's cost figures in making furrows. When it came to irrigation the biggest problem was possibly drainage, unless what was called "brak" was built up. He thought Mr. Pearson should not neglect the interest on capital which he felt an important point in considering the application of water. The main point to be remembered was that control in overhead irrigation was infinitely better than in furrow irrigation where the quantity of water wasted was tremendous.

Mr. Pearson said the figure of 4/- per unit digging three cubic yards was arrived at by consultation with planters up and down the coast. He felt it was somewhere between the maximum and minimum costs. He thought it one of the biggest disadvantages of furrow irrigation that the minimum quantity of water applied could not be controlled whereas with the overhead system is was possible to start with a $\frac{1}{4}$-in. application and work this up to give full coverage.

Mr. Renaud said he was inclined to agree with Mr. Bechard, but pointed out that he was comparing work in soft soil with the heavier soils more commonly met with on the coast. Nonetheless, he still thought Mr. Pearson's excavation costs were high. The cost comparison was incomplete as Mr. Pearson had only given costs from the top of the lift. Irrigation by furrow required much more water than by piping and the cost of lifting this extra water should be taken into consideration.

Mr. Barnes said the subject was of importance not only to Natal. In Jamaica there had been the same experience with particular reference to concrete and earth furrows and the loss which could occur in their use. He thought Mr. Pearson's estimate of the loss per mile of furrow too low; he had worked it out on a basis of evaporation at 0.2 in. per day and made the figure over 1,000 gallons a day. Irrigation schemes he had seen in Natal involved costly water and it was essential to see that this reached the plant in the correct amount and that loss, whether by seepage or by evaporation, was reduced to an absolute minimum. Better distribution, therefore, seemed necessary. A number of points had to be considered in laying pipes, especially where they were carried under agricultural roads, because of the present high degree of mechanisation. When using syphons such as on The Natal Estates it seemed important to make provision at the bottom of the syphons for flushing out the pipe in order to remove material which might accumulate there and reduce or completely stop the flow of water. It might seem elemental, but it was not sufficient just to put down a pipe without taking precautions against choking up and internal silting. Mr. Barnes referred to Jamaican trials with overhead rotating sprinkler systems and illustrated the effects of moderate winds on such systems, suggesting that this was important in any consideration of overhead irrigation. Irrigation water was cheap in Jamaica and the maximum limit of lift about eighty feet. At The Natal Estates water was lifted 498 feet and still paid handsome dividends. Where rainfall was deficient and water was available, irrigation appeared to be the answer to profitable cane cultivation.

Mr. Pearson said he had studied the effect of various American types of sprinkler heads. He felt that smaller sprinklers might be the answer in Natal to even distribution in high winds.

Mr. Fowlie described the water control system used on reclaimed flat lands in Holland where large ditches separated the fields. Tile drains leading to the ditches were laid at depths and distances apart to suit the types of soil; the drains were laid with the ends of the tiles against each other so that water could enter and leave them easily. During wet weather these drains led water from the lands into the ditches, from which it was pumped away. In dry periods the ditches could be filled with water which was allowed to soak back into the lands through the drains. It was a simple scheme but rather costly and could work only on really flat lands.

Mr. Barnes said that where levels existed and drainage had to be carried out it was possible to put in systems either to take water off or put it back on the cane when it was dry. Cane in Florida and South America was irrigated by mole drains about 2 ft. 6 ins. deep.

Mr. Lewis said he was doubtful about the cost figures and felt it would have been of great value if Mr. Pearson had set out the cost of components. He asked whether the costs included cartage of stone, sand and cement. What size of stone was used and what type of sand, and were the furrows made right through the cane field ? He asked what pipes were envisaged and said that while steel pipes were easily laid, concrete or asbestos cement demanded good foundations, especially at the joints. He asked Mr. Pearson whether the cooling effect of the high evaporation figure in sprinkler irrigation had any effect on the cane.

Mr. Pearson said the sand contemplated was local river sand and the stone $\frac{1}{2}$-in. chip. He considered that transport would considerably affect the cost. The piping quoted was asbestos piping for farm use, but reinforced concrete piping had been used successfully on irrigation schemes in Natal. He was unable to give any figures on the effect of evaporation and cooling for South Africa.

Mr. Lewis asked where the wire netting was put in the concrete furrows.

Mr. Pearson replied that on the South Coast there were different methods; it could be done in three separate sections with the wire between the layers; another method was to put down concrete then wire netting and then a top layer of cement; in other instances the netting was laid and concrete poured on to it.

Mr. Bechard said that he had built a semicircular furrow using cement and stone and, taking into account the cost of transporting sand from the river, the cost of the furrow was 7d. per yard. In certain sections he was using furrows for underground drainage which cost half that amount per yard. He had at present eighteen miles of drainage. Furrow formations with chippings and one in ten of cement and sand made a porous furrow useful for underground drainage.

He asked whether it was possible to apply fertilisers in irrigation water.

Mr. Pearson replied that it had been done by private enterprise and applied in England and America to growing crops. One difficulty was that with soft crops like lettuce the percentage of dissolved fertiliser had to be in the region of .1 per cent. of the irrigation water and even this damaged the crop. With a hardier crop a greater percentage might be used.