MECHANICS OF SPRAY IRRIGATION

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The title is chosen for the sake of brevity, but I am forced to go beyond it to present a balanced picture of the subject.

1.0. Definition. It is valuable to start with a definition and the one I prefer is this:

"Irrigation is the process of supplementing natural rainfall so that adequate moisture shall be always available to the growing plant."

Whether we supply all the water or only a limited proportion brings us to the subject of economics.

2.0. Economics. It is impossible to consider the mechanical and hydraulic aspects of applying supplemental water to farm land without considering economic factors which tend to modify pure considerations of mechanical and hydraulic efficiency.

2.1. The design of an irrigation scheme must take place in relation to specific circumstances and will be influenced by such factors as the following:

Total estimated water supplement.

Potential cash return from the irrigated area.

Capital available, topography, water location and availability, hours to be worked, labour availability, power costs, nature of soil and climate, and type of crop to be irrigated, etc.

This is a formidable array of variables, but they are soon reduced in numbers when a specific project is considered. It is salutary to consider them, however, as an antidote to those promoters of irrigation equipment who, in happy oblivion, have only one answer which meets all conditions.

3.0. Plant Soil Water Relations. It is also necessary to touch briefly on this aspect as it affects the distribution. Any soil with a particular type of cover has a maximum rate at which it will receive "rain" without significant run-off. Similarly any type of crop, pasture included, imposes limits on the rainfall rate and quantity to be applied per application.

3. I. In the interests of reducing repetition of work to the minimum it is desirable to put on as much water per application as soil conditions allow and the growing plant can utilise. As labour is always an important factor, I suggest that rather larger than optimum applications are worth while. It is easy to buy fuel or

power, but a farmer cannot buy more hours in his week. I put it to you, then, that while extra water may waste a proportion of the power used, it gains you extra time. To put these thoughts in perspective for the Waikato: instead of the familiar I in. to 1½ in. in 7 to 10 days try 2 to 3in. and see whether your intervals cannot be nearly doubled.

3.2. Application rates on overhead sprinkler systems are usually kept down to a maximum of around 1in. per hour. In many cases with 10 degree slopes and heavy ground ½in. per hour may be too heavy. Extra low rates of application of 1/10in. per hour are sometimes available with smaller sprinklers, particularly for horticultural applications.

4.0. Methods of Application. While this paper is about sprinkler irrigation J think it is well to remember that gravity distribution methods are equally important under the appropriate conditions.

4.1. The principal gravity systems are summarised as wild flooding, border diking, contour race with or without siphons, and gated pipe for furrow irrigation.

4.2. Overhead irrigation methods may be summarised as follows:

Perforated pipe system and static multiple sprays along a pipeline. The area covered is small relative to rotary sprinklers and the labour and initial cost tend to be high, but working pressure and power costs are low. I suggest an economic working range would be from 3 to 10 acres.

4.3. Multiple sprinkler systems for -pasture application operate at pressures of 30 to 60 p.s.i. and are applicable to areas of practically any size. Individual outputs range from 5 to 70 g.p.m. It is always a compromise between saving power by lower pressure working and saving labour by using larger outputs at higher pressures with a consequent reduction in detail of reticulation. Sprinkler systems are more suited to level or near level ground conditions.

4.4 Rainer systems overlap with sprinkler systems, but in general will reduce labour by 25 to 50 per cent. They are applicable to practically any area and are specially suited to rolling or hilly country. Rainfall rates tend to be 50 to 75 per cent. of those with sprinkler lines. Part circle operation is available in several types. Rainers are more influenced by wind and in areas where wind is seldom below 10 m.p.h. sprinkler lines are likely to be preferable. Rainers usually work over a pressure range of SO to 80 p.s.i. with outputs from 100 to 450 g.p.m.

5.0. Pumps and Primemovers. The number of occasions when it is possible to utilise natural head for irrigation are extremely limited; hence pumping is usually required. Pumping may be briefly divided into two classes: (a) Surface pumps where the operating water level may be as much as 25ft. below the pump and (b) when water has to be extracted from greater depths. In such cases submersible or turbine pumps, air lift, or jet pumps may be used.

5.1. In the submersible pump the motor and multi-stage pump are close coupled and are both submerged. With the turbine pump the motor is at the surface and the pump is driven by a line shaft down the bore. Both types of pump are made for extractions to 500ft. or more and with ratings up to and over 500 h.p. Efficiencies range from 45 per cent. for 4in. pumps to 80 per cent. in the largest sizes.

5.2. Jet pumps are of limited application, as the output ranges up to only 40 or SO g.p.m. with depths of 50 to 200ft. Efficiency is low, ranging up to 35 per cent. hence the method is applicable to relatively small total water quantities.

5.3. Air lift pumping is most suited to relatively shallow extractions of 50 to 150ft. where large volumes of water are required from a high-yielding bore. As the depth of extraction increases the cost of the total installation rises sharply due to the large submergence necessitating a deeper bore than is required with a submersible pump. Pumping efficiency is usually less than 50 per cent.

5.4. The subject of surface pumps is very extensive. Suffice it to say that in sprinkler irrigation single stage and two-stage volute type centrifugal types are most commonly used. There is no special line of demarcation between single and two-stage, as their duties overlap. It is often a matter of choice of speed to suit the driving unit which determines the type of pump.

It is most important to realise that all pumps are subject to a reduction in performance as the working suction increases, It is not unusual to get a reduction in output up to 50 per cent. in raising the suction to say 26ft. Speed increases help little in maintaining the output at high suctions. My advice to anyone wishing to operate over 15ft. gauge suction is to consult a hydraulic engineer before committing himself to buying any pump for higher vacuums, as disappointments can be expensive. Extra high vacuums are possible under certain conditions. One scheme I recall has a two-stage pump where intermittent vacuums reach 29 and 30ft.

In irrigation, surface water containing a certain amount of silt, grit, or sand is often encountered. This affects the choice of pump and in the interests of the lowest long-term cost, it pays to select pumps having replaceable wear rings and shaft sleeves. These features provide for the simple reconditioning of the pump as wear takes place. Failure to have these features usually necessitates pump replacement.

5.5. The source of power may be by separate internal combustion engine, electric motor, or tractor p.t.o.

Owing to the fuel and maintenance savings possible with diesel, about 80 per cent. of mobile pumping units are equipped in this way. Tractor drives are valuable for small holdings or where the cost of a separate engine is to be deferred for a year or so.

The tractor set driven from the p.t.o. has obvious advantages over the pump mounted on the tractor itself. Electric drives are usually reserved for those occasions when pumping points are limited to one or two. The extra cost of providing power lines and plug points soon offsets the saving over diesel if many points are needed.

To put cost in its perspective refer to the bottom of Table 1, where the relative costs of 10,000 horsepower hours are set out against fuel and power charges.

Table 1.-Costs: Fuel/Power plus Depreciation on Plant per acre inch.

Acreage	Diesel	Electric	Petrol Tractor
10	.67	.51	.64
20	.42	.45	.58
40	.38	.36	.53
60	.32	.32	.49
100	.32	.30	.46
150	.28	.23	.44
200	.25	.27	.43
10,000 horsepower hours	£23/12/-	£55/-/-	£92/16/-

Based 10in. rain.
Open water schemes along stream bank.
Diesel 1/7 gal.
Petrol 2/2 gal.
Elect. power 1½d. unit.
System-Sprinkler.

5.6. Protective equipment is now available as a standard feature to prevent engine damage due to oil failure and overheating from any cause. To work with this equipment are special gauges which will shut down the primemover if the pump loses its prime for any reason. Compact automatic reset timing units specially designed for such applications can also be added to shut down a pumping unit after a selected interval of running.

6.0. Reticulation Methods and Accessories. This is also a very extensive field to cover in a short time. There is no set formula, as each scheme must be considered on its merits. The most common system in New Zealand uses portable aluminium pipes with quick couplings.

6.1. Buried main systems using asbestos concrete, concrete, or steel pipes may be used in conjunction with a system of portable pipelines. Once more the ratio of buried mains to portable lines is an economic one which is studied along with hydraulic design for the particular installation.

6.2. Where the annual total water quantities to be applied are great and returns per acre are high then an increased use of buried main may be justified, as it saves labour.

6.3. Various forms of automatic or semi-automatic equipment are available. One such system, originating in Canada, employs a 12-chain boom mounted on wheels and revolves by its own water power around a central hydrant point. It covers 10 acres. Such a system is not readily transferable and is intended to sprinkle that area only during the season. It requires particularly arid conditions or an acute labour shortage to warrant devices of this type.

6.4. Quick couplings for portable pipes are a very important part of an irrigation distribution layout.

Three basic types are:

(a) The pressure lock type where water pressure effects the locking of the two halves.

(b) The pre-lock type.

(c) Latch type. There are many variations of the latching principle, but all follow a substantially similar arrangement.

Type (a) and (c) are most suited to multiple sprinkler systems, but type (b) has advantages for rainers, as the line can be snapped open at any coupling without separating the pipes.

6.5. Labour saving in moving portable lines is achieved on flat to easy rolling country by using lines mounted on wheels with the pipe acting as an axle. In this way lengths of up to 1000ft. can be slowly rolled along from one set to another. Such systems were originally intended to operate in one area for a season and are not readily shifted from one paddock to another. Lines may be towed by a tractor when mounted on castor wheels or skids. A combination of ideas in the castoring skid provides the easy towing of a castor-mounted wheel coupled with the simplicity of a skid. The device is a pure accessory and can be fitted subsequently to the coupling.

6.6. Sprinklers and rainers have been briefly reviewed under section four, To give, however, something specific, Table 2 sets out what is current practice for pasture or lucerne on varying acreages. These data are not binding but in the absence of any special features such as long or short time to apply water or water limitations, etc., they may be taken as being a good guide.

Table 2.-Typical Rainer/Sprinkler Duties in Relation to Area.

Type	Rainer or Sprinkler duties Pressure	G.P.M.	Rainfall rate	Approx Plant output in g.p.m./area 15 ac.	30 ac.	SO ac.	100 ac.
	Sprinkler':'						
34/02	30	12.5	.48	g.p.m.	g.p.m.	g.p.m.	g.p.m.
	40	14.5	.55				
	SO	15.5	.59	100	150/200		
	Sprinkler?						
SA1	45	28	.91				
	SO	30	.96				
	60	33	1.04		150/200	200/300	400/500
	Sprinkler:						
SSLK	60	65	.94				
	70	71	1.01				
	80	76	1.09			200/300	400/500
	Rainer						
R 2	50	86	.31				
	70	100	.31				
	85	110	.29	80/110			
	Rainer						
R3	70	190	.34				
	85	215	.36		190/225	190/225	
	Rainer						
R4	70	380	.49				
	85	415	.50				380/415

* Spacing 60 x 50ft.
† Spacing 50 x 75ft.
‡ Spacing 80 x 100 ft.

6.7. Specialised equipment brings us to oscillating spraylines, specially designed for strip irrigation with relatively accurately defined boundaries to the water deposited. This equipment employs a nozzled pipeline which is automatically oscillated from side to side by a hydraulic piston motor operated by the water passing into the line. The application is essentially one for special crops, market gardens, and research.

6.8. Before leaving distribution it may be of interest to consider a research irrigator we built for Crop Research Division, Department of Scientific and Industrial Research, at Lincoln.

A boom approximately 38ft. long is mounted on four wheels. The boom carries a nozzle line with a centre feed from a trailing hose. The boom is winched along by a hydraulic motor driving two winch drums which in turn pull the boom by fine steel cables. Our problems were to give an even precipitation over the plot area of 8Oft. x 90ft. with an accuracy of ± 5 per cent. This accuracy had to include all variations in rate of travel, pressure drop, and supply pressure fluctuations.

7.0. Conclusion. In pointing out the large number of variables associated with irrigation considerations, I am also conscious of the need to be specific at some point, hence the introduction of essentially practical tabular information. A point which I feel we should keep constantly in mind is that we are always aiming at the **Economic** solution. It follows from this that while research workers establish certain optima, it does not follow that such values are directly applicable in our calculations for an irrigation plant to meet the specific requirements of a particular irrigator.

In my nine years of irrigation experience I have noted a definite change in requirement which in turn necessitates changes in our design approach.

To illustrate this point, if the return per acre of pasture could be trebled by price rises overseas, then future irrigation equipment would include more buried mains, greater power inputs, and greater water quantities discharged. There would also be a rapid move to semi- or fully automatic equipment to reduce labour. The converse of this is also true. Depressed returns per acre force us back into fuel or power savings and a higher labour content.

To save time, labour, power, and capital outlay, schemes have to be designed for specific applications and cannot be packaged.