DEPARTMENT OF
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Agriculture Notes

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Chlorination of Micro-Irrigation Systems

Water remaining in micro-irrigation systems after irrigation stops, provides an ideal environment for bacteria, and in some cases algae, to proliferate. Bacteria can cause fine clay particles to stick together or initiate reactions that convert soluble ions to insoluble ions and block emitters when irrigation resumes. Chlorine will overcome this problem by killing the bacteria and algae that accumulate in pipes.

Chlorination

Chlorine needs to be injected throughout a micro-irrigation system at a concentration of 500 ppm (that is, 0.05 per cent) prior to the start of the irrigation season. This treatment can be achieved by using sodium hypochlorite ("hypo"). As hypo contains 12.5 per cent chlorine it should be diluted by mixing 1 litre of hypo in every 250 litres of water to give the required chlorine concentration. The rate of injection per minute can therefore be determined by dividing the pump discharge in litre per minute by 250.

Note: For chlorination, calcium hypochlorite may be used instead of sodium hypochlorite. Most commercial formulations of calcium hypochlorite contain 650 grams of active chlorine per kilogram. Calcium hypochlorite should therefore be diluted by 1 litre of product for every 1250 litres of water. The rate of injection per minute will be determined by dividing the pump discharge in litre per minute by 1250.

The period of injection depends on the time it takes for the chlorine to reach the farthest outlet. When injection is completed the pump should be run for another minute or so to clear the pump of chlorine and then the pump should be stopped. After 24 hours the pump can be restarted to flush the lines.

Chlorine at a lower concentration (10 ppm) injected more frequently (monthly or fortnightly) has also been found effective in reducing blockages. It is usually not necessary to flush the lines after each of these injections. The injection rate for each chemical to achieve this concentration of chlorine can be found by dividing the higher rates (above) by 50.

With both the above methods of chlorination, considerable quantities of chlorine are unavoidably wasted. For instance, to obtain a concentration of 500 ppm chlorine most microjet and mini-sprinkler installations will require at least 12 to 15 litres of hypo per hectare, out of which 8 to 10 litres are not retained in the pipeline. The amount wasted will vary according to the layout of the block and the above figures could easily double.

Timing

To minimise this loss when high concentrations of chlorine are involved, and to ensure that the chlorine is evenly distributed throughout the block, it is essential that the injection period should be neither too long nor too short.

The speed with which water moves through a trickle system has been assumed as one-third of a metre per second. It is important to realise that this is only an average figure, as the speed with which water moves (velocity) through the submains and laterals decreases progressively towards the last outlet. In fact, towards the end of the laterals, water moves so slowly that in many cases the injection time could be reduced by 25% by ignoring the last few outlets on the lateral run. This explains the frequent discrepancy between the calculated and the actual times measured using dye or a chlorine test kit.

The figure of one-third of a metre per second depends on the trickle system being efficiently designed. Larger pipes than necessary will lengthen the time required for chlorine to move through the block. Conversely, as similar pipe sizes generally convey more water in microjet and mini-sprinkler than in trickle systems, the water moves through the former systems at a faster rate. The average velocity is thus closer to one-half than one-third of a metre per second for most microjet and mini-sprinkler systems.

To calculate the approximate injection time, measure the distance in metres from the pump along the main and submain to the end of the most distant lateral.

Divide this figure by 20 to estimate the injection time in minutes for flows of one-third of a metre per second and by 30 for flows of one-half metre per second. Both the above figures, however, can only be used to estimate the velocity in the submains and laterals. In many microjet and mini sprinkler installations, long mainlines connect blocks. The velocity in these mains is generally higher than the average given above and depends on pipe size and the quantity of water flowing through the pipe. Figure 1 can be used to estimate mainline velocity.

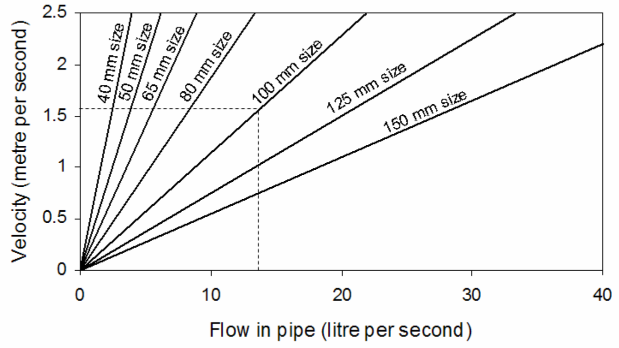

Figure 1. Mainline velocity as related to flow rate and pipe size for class C PVC pipe. To determine velocity calculate the flow in the pipe in litre per second and extend a perpendicular line from this point on the horizontal axis to intercept the appropriate pipe size. The velocity in metre per second can then be read from the vertical axis.

Given an accurate and detailed plan of the irrigation layout and an estimate of the average velocity within submains and laterals, Figure 1 can be used to calculate an efficient program for chlorinating. The calculations involved are somewhat complicated.

The following example is only included to illustrate how an efficient chlorination procedure can be achieved with minimum wastage of hypo and time.

Calculating an efficient chlorination program

Figure 2 shows the layout of an orchard with a 100 mm mainline connecting a number of blocks which, if required, can be irrigated separately. There are 320 trees per hectare and each tree is irrigated by two 40 litre per hour microjets. The pump normally irrigates two hectares at a time. To do this it must pump water at:

$$\frac{(2 \text{ x } 320) \text{ x } (2 \text{ x } 40)}{60 \text{ x } 60} = 14 \text{ litre per second}$$

With this discharge rate, two hectares can be chlorinated progressively down the mainline. Hypo can then be injected at a constant rate of 0.004 times the rate at which water is pumped. That is:

$$\frac{14}{250} = 0.056 \text{ litre per second} = 3.35 \text{ litre per minute}$$

Timing

It is important that the valves down the block are opened and shut at the correct time. To do this it is necessary to know how fast the hypo moves through the block. Figure 1 can be used to estimate the velocity along the mainline while it can be assumed that the hypo moves 1 metre every 2.5 seconds along the submains and laterals.

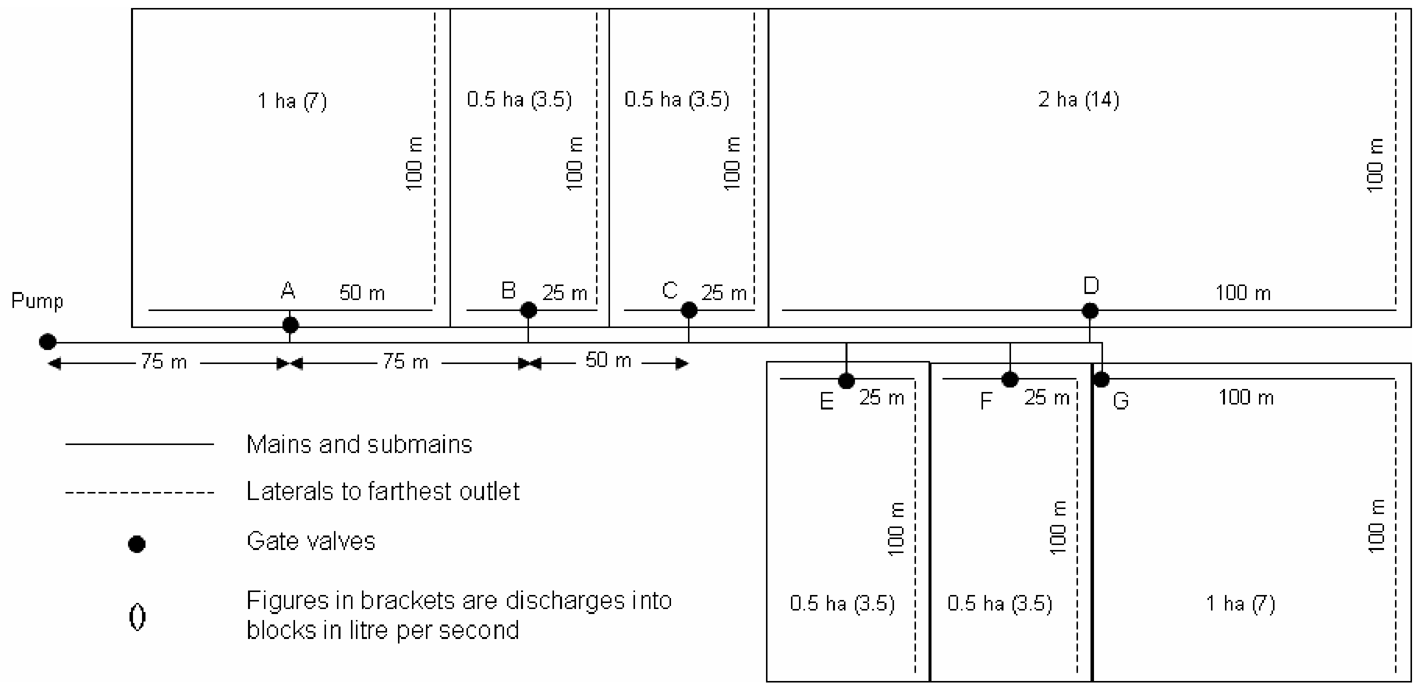

Figure 2. Plan of 5.5 m by 5.5 m orchard planting irrigated by two 40 litre per hour microjets per tree

Table 1. Time taken for hypo to reach last outlet in blocks A, B and C

Time for hypo to travel from pump to each gate valve			
	Pump to Valve A	**Valve A to Valve B**	**Valve B to Valve C**
Distance (*metre*)	75	75	50
Quantity of water flowing in pipe (*litre per second)*	14	7½	3½
Velocity in 100 mm pipe (*metre per second)*	1.60	0.80	0.40
Time taken (*second)*	47	94	125
		Pump to Valve B	**Pump to Valve C**
Time taken *(second)*		47 + 94 = 141	141 + 125 = 266
Time for hypo to travel from gate valve to last outlet			
	Block A	**Block B**	**Block C**
Distance to last outlet (*metre)*	150	125	125
Time taken at a velocity of 0.4 metre per second (*second)*	375	313	313
Total time to reach last outlet (*second)*	47 + 375 = 422	141 + 313 = 454	266 + 313 = 579

Blocks A, B and C are chlorinated first. With the above valves open, the time it takes for the hypo to reach the last outlet in each of the three blocks can be calculated as shown in Table 1.

The calculations in Table 1 show that the valves to blocks A, B and C should be shut at approximately 420, 450 and 590 seconds after injection begins.

When valves A and B are shut (after 450 seconds) valve D should be opened. The rate at which water flows into block D (14 litre per second) now determines the velocity at which hypo moves along the 100 mm pipe between valves C and D. Figure 1 indicates a velocity of 1.60 metre per second; it would take 78 seconds for the hypo to move the 125 metres between valves C and D.

Within block D the hypo has to move 200 metres to reach the farthest outlet and a time of 500 seconds should be allowed for. Thus, from the time valve D is opened (that is, 450 seconds after injection commenced) it takes 78 seconds for the hypo to move into block D and 500 more seconds to reach the last outlet. The valve to D is thus closed after 450 + 78 + 500 = 1028 seconds from the time injection began.

Blocks E, F, and G should be turned on as D is turned off. At this stage the mainline will be full of water with a concentration of 500 ppm chlorine. It is thus only necessary to calculate the time required for this concentration to reach the last outlets in these blocks (that is, 313 seconds for blocks E and F and 500 seconds for block G). The valves to E and F can therefore be shut at 1340 seconds from the time when injecting began and the pump stopped after 1540 seconds, when the chlorine should be close to the last outlets in block G.

Removing chlorine from mainline

In most cases it is not necessary to leave hypo solutions in the mainline. In our example, injecting could cease well before the 1540 seconds the pump must run. The hypo solution in the mainline would then move into the farthest blocks and be replaced by water.

The time taken for this to occur can be calculated from the velocity in the mainline towards the end of the chlorination procedure. After valves E and F are shut the velocity along the mainline is controlled by the flow of water into block G (7 litre per second). From Figure 1 this velocity would be 0.80 metre per second. Thus if injection were to cease with the closing of valves E and F, a front of water containing no chlorine would advance up the main (187 0.80) 150 metres in the 190 (1530- 1340) seconds remaining before the pump was stopped.

The mainline is 325 metres long, however, and to fully remove chlorine from the mainline it would be necessary to stop injecting while the valves E, F and G are open and the velocity within the mainline is 1.60 metre per second. At this velocity it would take 108 second for the hypo solution to move the extra 173 (325 - 152) metres to fully remove chlorine from the mainline. The injection of hypo could thus cease at (187 + 108) = 295 seconds before pumping ceased at the 1540 second mark (that is, after 1245 seconds).

Summing up

The procedure for the above example can be summarised as follows:

- Inject hypo at a rate of 3.36 litre per minute.
- Begin injecting with valves A, B and C open.
- Shut valve A after 7 minutes (420 seconds) followed by B, and turn on D.
- Shut valve C after 9½ minutes.
- Shut valve D at 17 minutes and open valves E, F and G.
- Stop injecting at 20½ minutes.
- Shut valves E and F after 22½ minutes.
- Stop pumping after 25½ minutes.

During this procedure the concentration of chlorine will drop to 400 ppm for 2½ minutes, while valves C and D are open.

However, this will not seriously jeopardise the cleaning process.

The above calculations are not so accurate that they necessitate valves being turned on and off at the precise second. As pointed out previously, water moves very slowly along the last section of the lateral and though chlorination based on calculating velocity will not ensure chlorine at the last outlet, the hypo nevertheless will be distributed satisfactorily throughout the block.

Seek advice

Growers who find the above calculations too involved should ensure that they have an accurate plan of their irrigation installation and seek advice from irrigation equipment suppliers, or officers from DPI.

Injection method

Safety hardware must be installed with any device that injects a chemical into a pressurised irrigation system. An irrigation check valve must be installed between the water source and the injection point to prevent chemicals from flowing backwards and entering the water supply. The installation of a vacuum relief valve further reduces the chance of backflow. A check valve must be installed in the injection line to prevent water overflowing and spilling out of the injection container. Injection cut-off at low pressure or pump failure and a normally closed solenoid on the injection line are essential.

The original and easiest method of injecting hypo is from a container connected to the suction side of the pump. This allows for a wide range of injection rates. Some experimentation will be necessary to obtain the appropriate rate. In recent years several types of injector have been developed which can be attached on the outlet side of the pump. Most of these injectors can be adjusted to a range of injection rates, although some have a maximum rate of only 3-5 litre per minute, which limits the area that can be chlorinated at one time (for example, two to four hectares of microjet irrigation).

Proper filtration

Chlorination does not replace the need for good filtration. When blockages occur the filtration system should be examined with regard to soundness, cleaning, mesh size and capacity to handle the required flow of water. Blockages should not be allowed to occur. Chlorination should thus be adopted as a regular maintenance practice early in the life of the irrigation system.

Acknowledgements

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