University of California

Nitrogen Management Training

for Certified Crop Advisers

MODULE 6

Nitrogen Management and Irrigation

Part 2- Irrigation Systems

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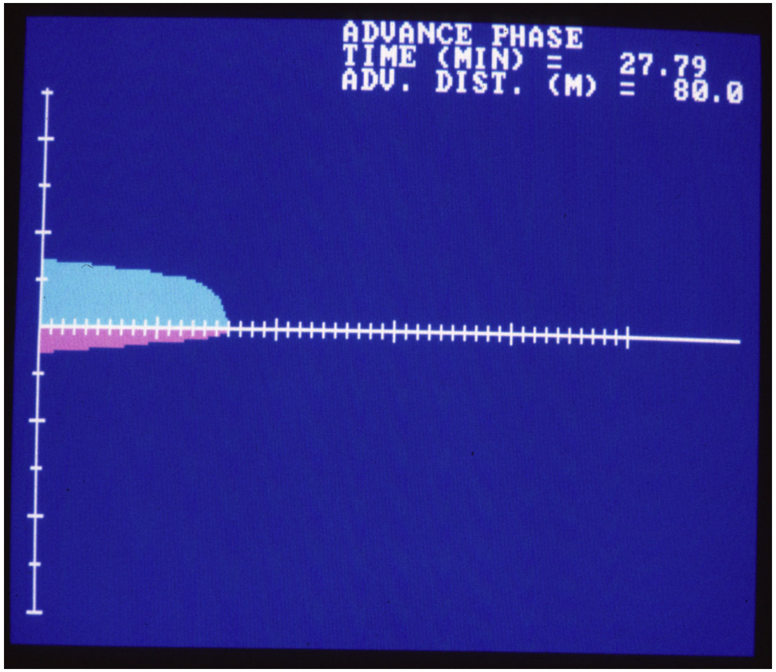
Types of Irrigation Systems

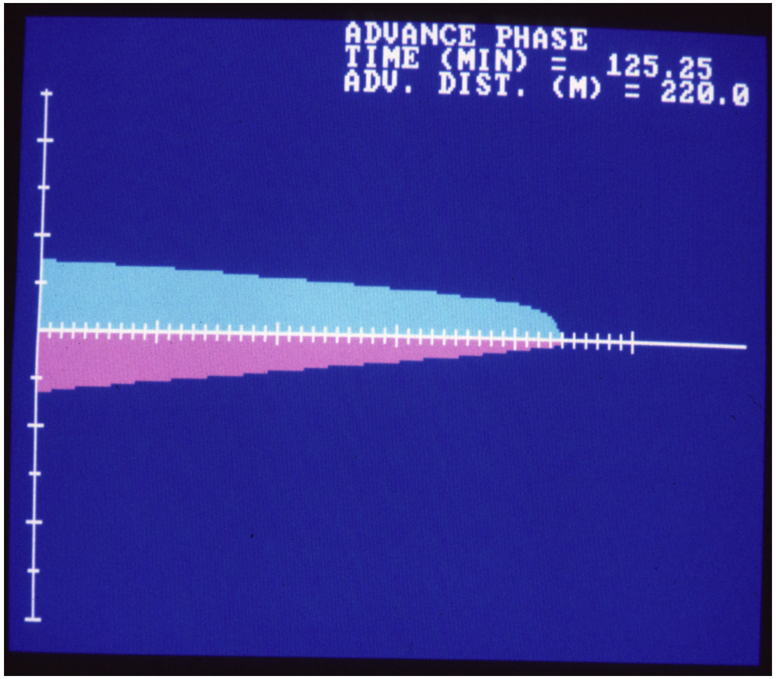
Surface Irrigation

Furrow and border strip irrigation

Surface Irrigation: Furrow Irrigation Example

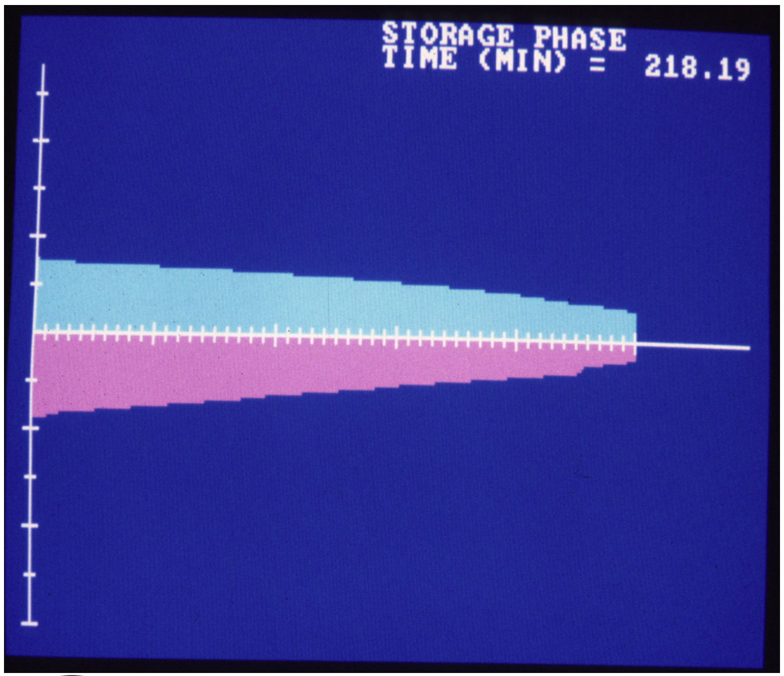


① Water flows field top to bottom in furrow irrigation. Blue segment represents water on field surface; pink is infiltration.

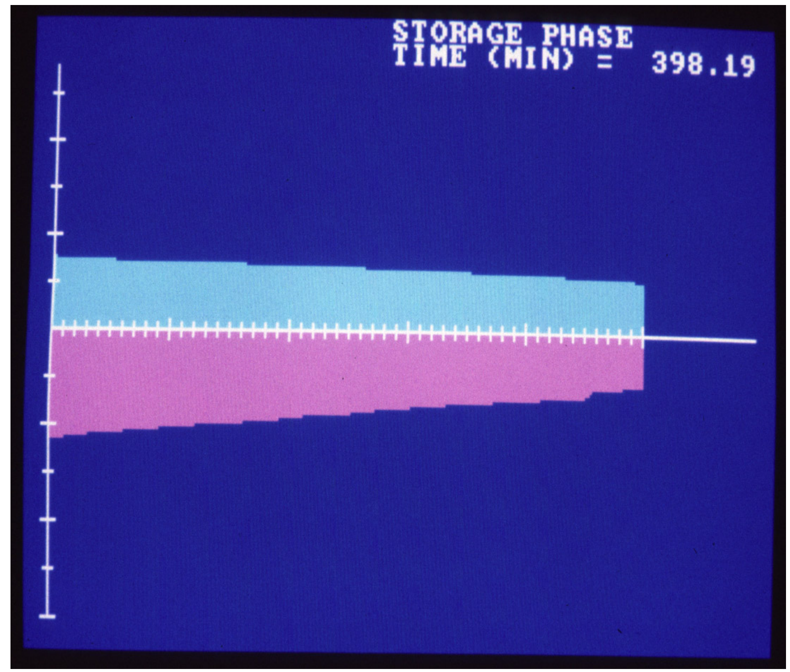


② More water has infiltrated at field head, where it has been present the longest.

Surface Irrigation: Furrow Irrigation Example cont'd.



③ Water is run off the field tail to allow enough to infiltrate there to satisfy the crops' needs. The runoff should be collected and reused.

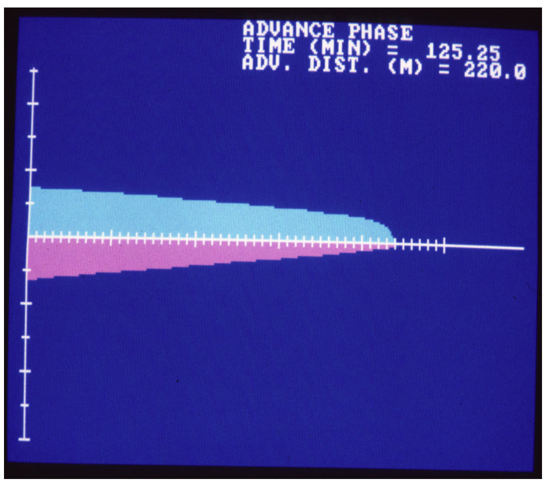


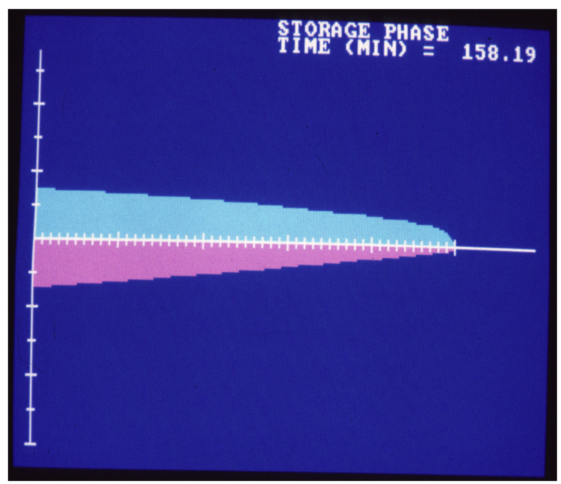
④ End of irrigation event. Water has infiltrated field tail, and field head has received excess. This water goes to deep percolation, leaching any N present.

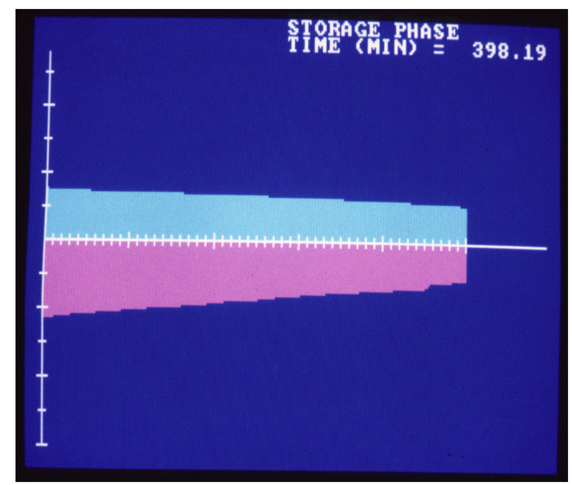
Surface Irrigation: Recognizing Non-Uniform Flood or Furrow Irrigation

$$\frac{\text{Total time water ran on an irrigation set}}{\text{Time it takes water to reach end of field}} = \text{Advance Ratio}$$

$$\frac{\text{398 minutes}}{\text{158 minutes}} = 2.5$$







Advance Ratio > 2 indicates reasonable uniformity

Surface Irrigation: Improvement with High Flow Rates

Water losses can be from deep percolation and tailwater runoff.

Losses from deep percolation and tailwater runoff are competing outcomes of surface irrigation management:

- Design steps that improve irrigation uniformity and reduce deep percolation probably increase tailwater runoof
- Design steps to reduce tailwater runoff probably cause more deep percolation and risk of N leaching

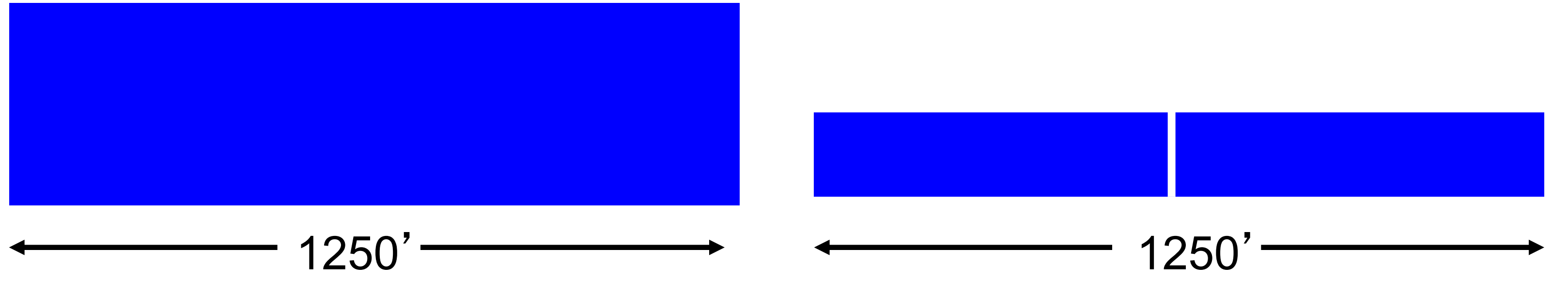
Surface Irrigation: Improvement with Shortened Field Length

Shortening field length gets water across the field more quickly, resulting in less deep percolation.

Surface Irrigation: Improvement with Shortened Field Length Example

- Reduce field length
  - Often the most effective option
  - Also often the least popular option

	1250' Field	2-600' Fields
Irrigation Amount	9.1"	5.4"



Surface Irrigation: Improvement with Increased Field Slope Example

	0.001 slope	0.002 slope
Irrigation Applied	5.1”	4.8”

Surface Irrigation: Improvement of Border Check Irrigation

Increase the flow per foot of border check

Field Study: Usually run 2 valves per check; make checks half as wide and run 1 valve at a time → more flow per foot of check width

	Wide check (200')	Narrow check (100')
Irrigation Applied	5.1"	4.3"

Surface Irrigation: Improvement with Torpedoes

Using a torpedo gets water across the field more quickly, resulting in less deep percolation.

Surface Irrigation: Improvement with Torpedoes Example

Field study: Newly cultivated furrows, some "torpedoed" and some not

	Torpedoed Furrow	Non-torpedoed Furrow
Irrigation Water Applied	9.4"	12.9"

Surface Irrigation: Improvement by Reusing Tailwater Runoff

Collecting and reusing tailwater runoff makes the best use of expensive and limited irrigation water (water and chemicals).

Water is collected and carried to a sump pump by underground pipelines, where it is pumped to a standpipe for use.

A small pond is used to collect tailwater, which is then pumped back to the head of the field using a sump pump.

Surface Irrigation: What if these options for improvement are not practical or effective?

- A change in irrigation method may be needed
  - Possibly target specific irrigation events (pre-irrigation of row crops)
  - Alternatively, make a wholesale change in methods
  - Often there will be a corresponding improvement in crop productivity when poorly performing irrigation systems are improved

Pressurized Irrigation

- Reduce the inherent control of the soils on irrigation efficiency
- Invest in irrigation hardware and sound irrigation system design to gain more management control of applied water






Pressurized Irrigation: Sprinkler

- How can sprinkler system performance be improved?
  - Know the **application rate**
    - We provide water use information in units of "inches of water use (per day or per week……..)"
    - Need to know the system application rate (in/hr) in order to know how long to run the system to meet crop water demands (ETc)

Pressurized Irrigation: Sprinkler Application Rate

Calculating system application rate:

$$i\ (\text{in/hr}) = \frac{96.3 \times (\text{nozzle discharge in gpm})}{\text{Spacing along lateral (ft.)} \times \text{Spacing between laterals (ft.)}}$$

Pressurized Irrigation: Sprinkler Application Rate

Nozzle Discharge (gpm):

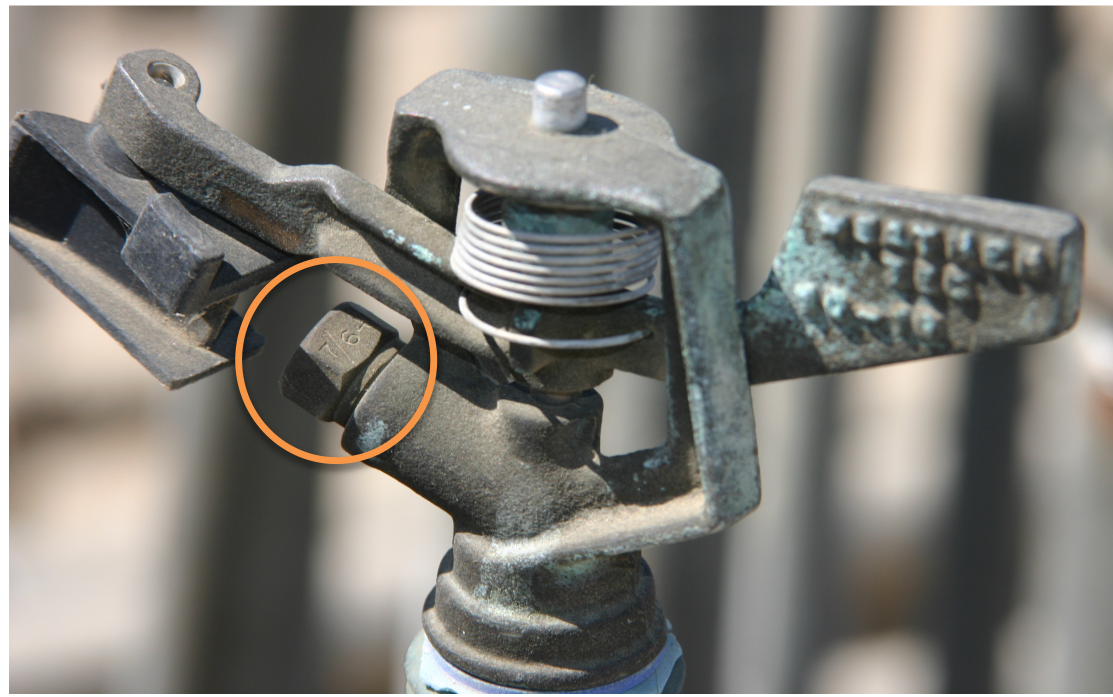
Pressure (psi)	Nozzle size (in)										
	3/32	7/64	1/8	9/64	5/32	11/64	3/16	13/64	7/32	15/64	1/4
20	1.17	1.60	2.09	2.65	3.26	3.92	4.69	5.51	6.37	7.32	8.34
25	1.31	1.78	2.34	2.96	3.64	4.38	5.25	6.16	7.13	8.19	9.32
30	1.44	1.95	2.56	3.26	4.01	4.83	5.75	6.80	7.86	8.97	10.21
35	1.55	2.11	2.77	3.50	4.31	5.18	6.21	7.30	8.43	9.69	11.03
40	1.66	2.26	2.96	3.74	4.61	5.54	6.64	7.80	9.02	10.35	11.79
45	1.76	2.39	3.13	3.99	4.91	5.91	7.03	8.30	9.60	10.99	12.50
50	1.85	2.52	3.30	4.18	5.15	6.19	7.41	8.71	10.10	11.58	13.18
55	1.94	2.64	3.46	4.37	5.39	6.48	7.77	9.12	10.50	12.15	13.82
60	2.03	2.76	3.62	4.50	5.65	6.80	8.12	9.56	11.05	12.68	14.44
65	2.11	2.88	3.77	4.76	5.87	7.06	8.45	9.92	11.45	13.21	15.03
70	2.19	2.99	3.91	4.96	6.10	7.34	8.78	10.32	11.95	13.70	15.59
75	2.27	3.09	4.05	5.12	6.30	7.58	9.08	10.66	12.32	14.19	16.14

Note: Metric conversions: 1 gal = 3.785 l; 1 in = 2.54 cm; 1 psi = 6.89 kPa

Pressurized Irrigation: Sprinkler Application Rate

Nozzle Size (diameter):

Where to find this information?



1. Engraved on side of brass/steel nozzle

2. For a worn nozzle, compare opening with drill bit sizing

3. Plastic sprinklers often color coded by manufacturer

Pressurized Irrigation: Sprinkler Application Rate

Determining Pressure:

Pressure gauge with Pitot tube attached (above), inserted into sprinkler opening (left)

Pressurized Irrigation: Sprinkler Application Rate

Determining Pressure (another method):

R10 Plate/Nozzle Options and Flow Performance in GPM and LPH

Plate Series	Plate Options	Recommended Nozzles	PSI						BAR						
			25	30	35	40	45	50	1.75	2	2.25	2.5	2.75	3	3.25
P2	**P2 9° Red** Radius 18-20′ (5.5-6.1 m) Stream Ht.14-23″ (36-58 cm)	Lt. Blue #40	—	—	.28	.30	.32	.34	—	—	61.4	64.7	68.0	71.3	74.6
		Lt. Purple #45	.29	.32	.35	.37	.39	.42	66.4	71.3	76.3	80.6	83.9	87.2	91.5
		Dk. Green #50	.36	.39	.43	.46	.48	.51	82.3	87.2	93.4	99.4	104	108	112
		.35 10FC	Within the recommended pressure range of 25-50 PSI (1.75-3.25 BAR), the .35 10 FC flow control nozzle is flow regulating within a flow range of no more than 0% greater and 10% less than the nominal flow of .35 GPM (79.5 LPH).												
P4	**P4 9° White** Radius 18-22′ (5.5-6.7 m) Stream Ht. 14-24″ (36-61 cm) **P4 15° Orange** Radius: 23-25′ (7.0-7.6 m) Stream Ht. 40-50″ (102-127 cm)	Dk. Green #50	—	—	.43	.46	.48	.51	—	—	93.4	99.4	104	108	112
		Lt. Yellow #55	.44	.48	.52	.55	.59	.62	101	107	114	120	125	131	137
		Lt. Red #60	.51	.56	.61	.65	.69	.73	117	125	133	141	147	154	161
		.50 10FC	Within the recommended pressure range of pressure range of 25-50 PSI (1.75-3.25 BAR), the .5 10 FC flow control nozzle is flow regulating within a flow range of no more than 0% greater and 10% less than the nominal flow of .5 GPM (114 LPH).												

Pressurized Irrigation: Sprinkler Application Rate

Calculating Application Rate (another method):

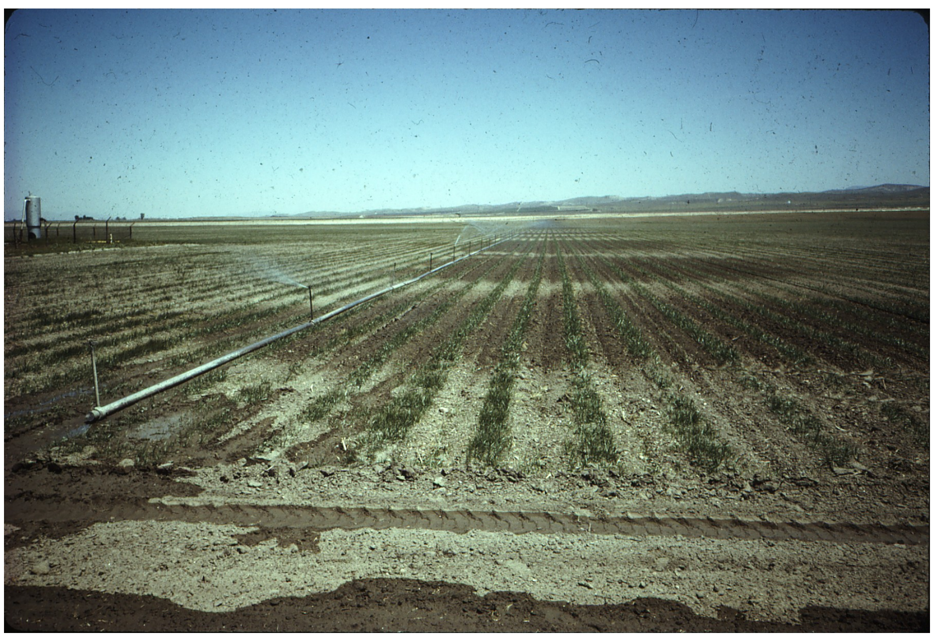
1. Time how long it takes to fill pale of known volume

1. This is the application rate in gpm

1. Plug into formula to get application rate in in/hr

Pressurized Irrigation: Sprinkler Application Uniformity

- How can sprinkler performance be improved?
  - Determine and improve sprinkler application uniformity (DU 80% or more, 85-90% great)



Pressurized Irrigation: Sprinkler Application Uniformity

Determining uniformity with a **catch can test**. A consultant or mobile team can be hired to conduct this type of test and provide suggestions for improvement.

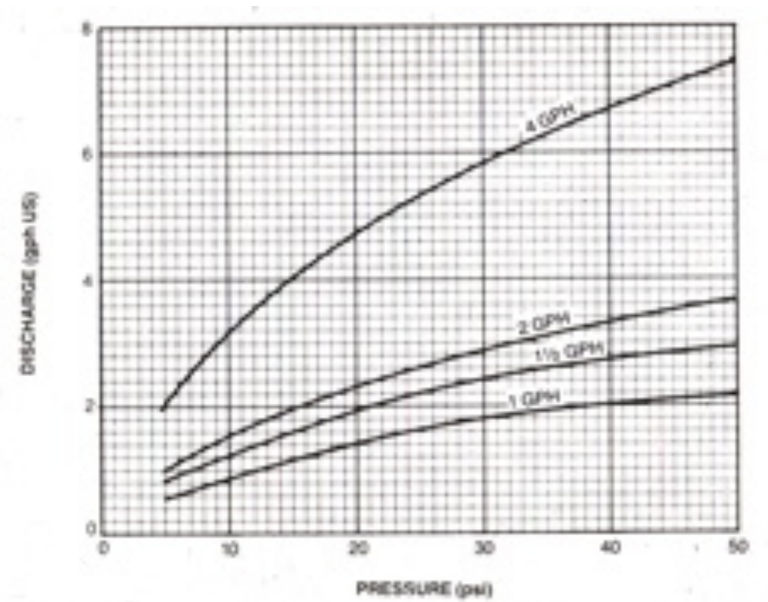
Run the system for fixed time 15-30 min, volume converted to depth (in)
App. Rate= in/hr

Pressurized Irrigation: Microirrigation Application Uniformity

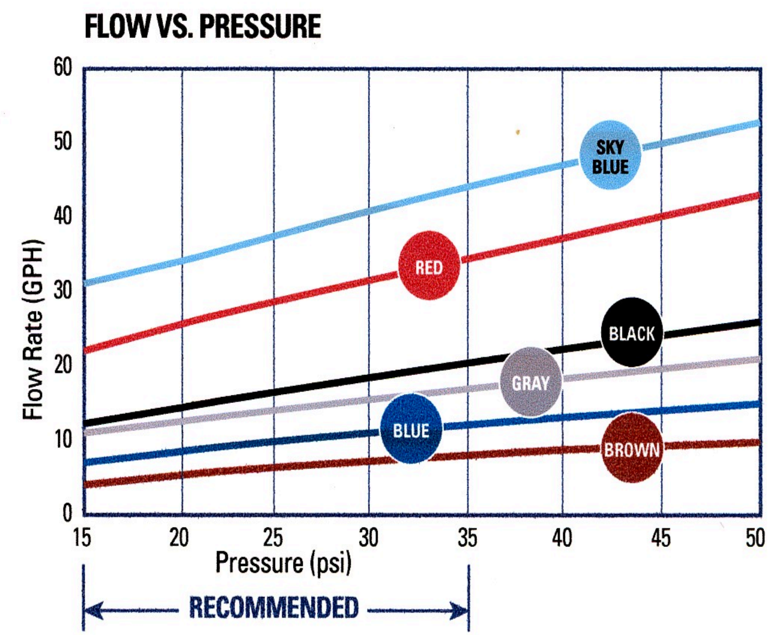
- Irrigation uniformity can be a problem with microirrigation systems too.
- What causes non-uniformity?
  - Poor microirrigation system design – pressure differences too great (may need pressure compensating emitters?)
  - Need to have the correct Pipeline size (design)

Pressurized Irrigation: Microirrigation Application Uniformity

Pressure differences cause changes in rates of discharge, affecting uniformity:



The discharge from a drip emitter is shown on the Y-axis. As pressure increases (X-axis), so does discharge.

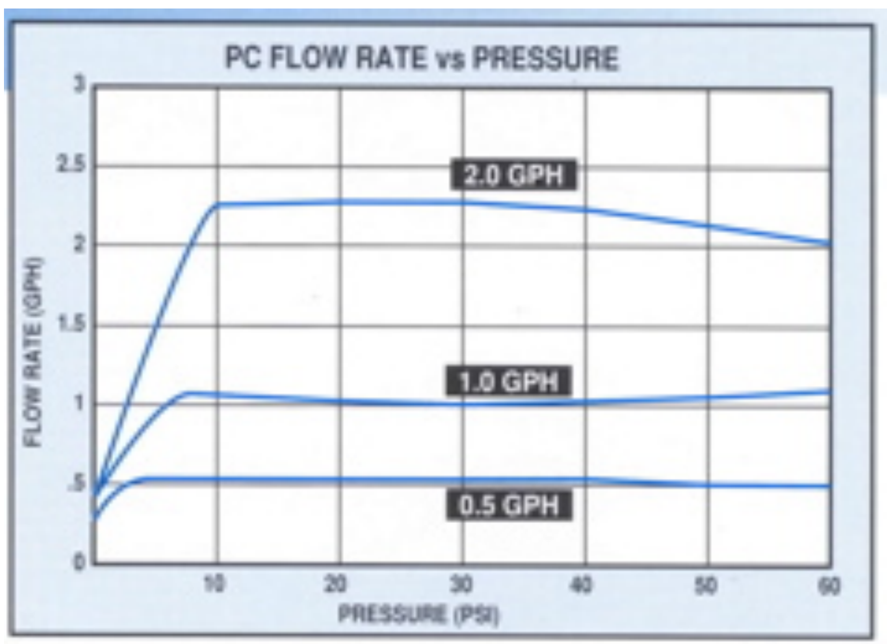


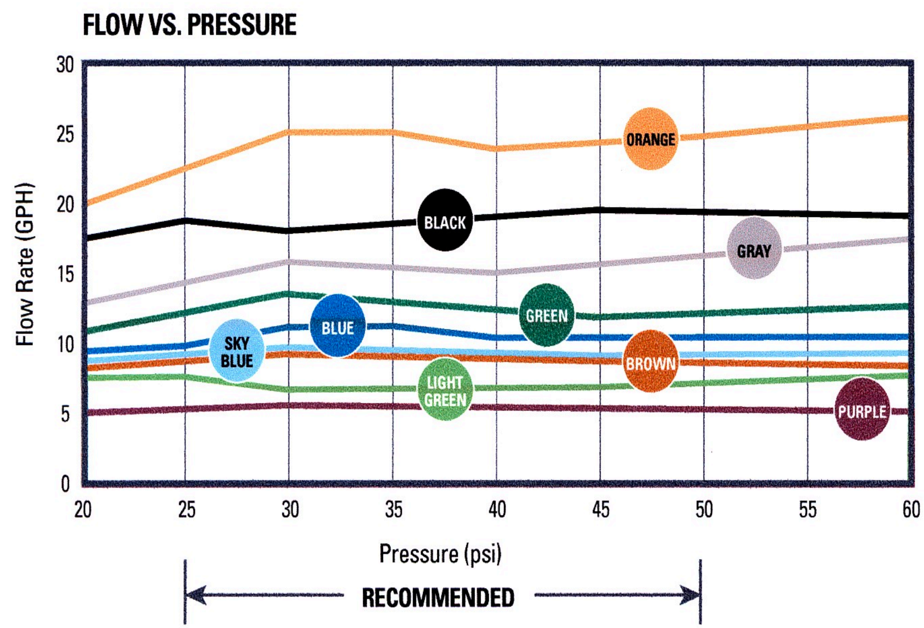
Similar to the drip emitter, the microsprinkler flow rate represented here increases as pressure increases.

Pressurized Irrigation: Microirrigation Application Uniformity

How do system designers address pressure differences that cause non-uniformity?

Pressure-compensating (PC) drippers (left) and microsprinklers (right) are used to equalize discharge when pressure is not constant.





Pressurized Irrigation: Microirrigation Application Uniformity

- What causes non-uniformity?
  - Maintenance problems
    - Clogging can lead to serious non-uniformity problems. Almost all clogging problems can be solved or prevented with good filtration and routine maintenance.

Pressurized Irrigation: Microirrigation Application Uniformity

Maintenance Tips:

Clean and flush filters regularly

Automatic backflush system

Flush lines regularly

Silt and clay are small enough to make it through filters but often settle in the lateral lines of drip tape and tubing.

Pressurized Irrigation: Microirrigation Application Uniformity

Maintenance Tips:

Monitor for leaks and breaks FREQUENTLY

Many of the most successful microirrigation system users check for leaks and breaks every time the system is turned on (changes in Q?). This picture shows where a microsprinkler has been broken off.

Check lines for chemical clogging at least twice per season

Check for bacteria or calcium buildup around emitters and nozzles. Surface waters are prone to organic problems (above right), and groundwater is more prone to chemical precipitation problems (above left).

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Part 2- Irrigation Systems

Summary

- Understanding the various type of irrigation systems
- Measures to improve efficiency and reduce leaching of nirogen

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