Irrigation system evaluation Report #2

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Date: April 28, 29 and May 5, 2021; **Nursery**: Altman Plants; **Address**: 2575 Olive Hill Rd, Fallbrook

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Read only this page if you do not have time! The other pages explain each recommendation.

1- The pressure at the field A30 is highly variable and the irrigators do not have control over it. This is one the main issues to be addressed. Each irrigator needs a pressure gauge (see report #1) to measure the pressure. When the pressure is too high, the irrigator needs to adjust it down by partially closing the block valve. Alternatively, pressure regulators can be installed at the block valves. When the pressure is too low, the irrigator needs to call Pedro to turn on the booster pumps. If the pressure is still too low, the irrigator should not irrigate.

2- The pressure measured at valve 4 (north end of field A30) is low (15 to 25 psi), probably due to a small (2") diameter pipe serving the block. I recommend using smaller nozzles (2 gpm) and running the block a longer time (40 min). The other option is installing a larger pipe (3" or 4").

3- The plant trays are spaced with about 6 to 12" of space between them. I was told that that space is used to space out every other pot in tray later in the season as plants grow bigger. I also have seen in other blocks plant arranged pot-to-pot. Leaving space in between pots reduces irrigation efficiency in sprinkler systems because half of the water lands where there aren't any pots.

4- The sprinkler head risers in all blocks need maintenance. Some are short than the others and some are tilted. Poorly maintained risers decrease distribution uniformity substantially.

5- The distribution uniformity of the 4 gpm nozzles on the Hunter PGP Ultra sprinkler heads is very poor (0.61 overall), and it did not improve significantly by changing nozzles to 1.5 gpm (that give an appropriate radius for the sprinkler spacing) and by correctly adjusting the nozzle screw. I suggest experimenting with different sprinkler heads, such as the Senninger Xcel wobblers or the Nelson Windfighters.

6- Irrigation scheduling at the monitored block (Valve 3, Field A30) for the period Mid-March to end of May followed closely reference evapotranspiration from the CIMIS weather station in Escondido. Thus, little or no runoff is expected to discharge from the monitored block (field A30, valve 21), despite the poor distribution uniformity. Also, the containers never reached a weight above saturation, so little or no leachate is expected. This could be a problem, since typically a 10%-15% leaching fraction is recommended. I also recommend that we work on irrigation blocks that are known to produce runoff, that is the main problem at this site.

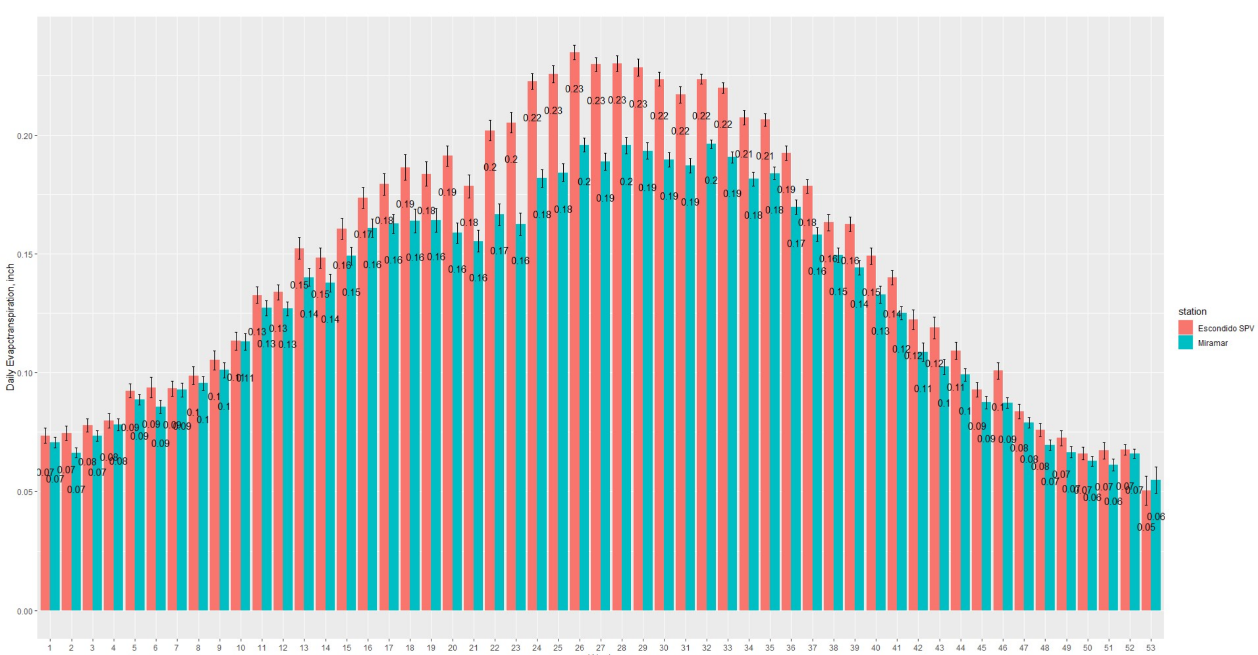
7- The irrigation water contained relatively low concentrations of nitrate (56 ppm of NO_3^- or 12 ppm of NO_3^--N). However, the leachate water contained high nitrate concentrations (130 ppm of NO_3^- or 29 ppm of NO_3^--N). The recommended concentration for Lavandula angustifolia is 87 ppm NO_3^--N (Source: Container Nursery Production and Business Management Manual, chapter 6, page 74.).

Recommendation 1:

Nozzle	Pressure	Radius	Flow	Precip in/hr	
	PSI	ft	GPM	■	▲
4.0 ● Blue	25	37	3.0	0.42	0.49
	35	39	3.5	0.44	0.51
	45	40	4.0	0.48	0.56
	55	41	4.5	0.52	0.60
	65	41	4.8	0.55	0.63

The table above (from www.hunterindustries.com) shows the flow produced by the Hunter PGP Ultra sprinklers with 4 gpm nozzles. The nozzles produce 3 gpm at 25 psi and 4.8 gpm at 65 psi. All nozzles and all emitters (except pressure compensating) produce more flow at higher pressure. There are 30 sprinklers in the block (valve 21) and the block dimensions are about 185 ft x 149 ft and its area is 27,640 ft^2 or 0.63 acres. In a 20-minute irrigation event, 30 3-gpm sprinklers produce (20 x 30 x 3) 1800 gallons of water if the pressure is 25 psi and they produce (20 x 30 x 4.8 gpm) 2880 gallons of water if the pressure is 65 psi. The difference is substantial, that's why it is very important to maintain a constant pressure.

A volume of 1800 gallons equals 240 ft^3 and on an area of 27,640 ft^2 gives a depth of 0.0087 ft or 0.1 inch, while a volume of 2880 gallons gives 0.17 inch.



If the pressure were constant, one could know unequivocally that a certain depth of water is applied in one hour (this quantity is called application or precipitation rate). Then, one could use the historic evapotranspiration data as a guide to decide how many minutes to irrigate in every season. As a reference, I plotted the daily average reference evapotranspiration from the Escondido and Miramar CIMIS stations (cimis.water.ca.gov). For example, all other things being equal, if one irrigates 20 minutes in April, when ETo is 0.18 inch (from table above), they need to irrigate 29 minutes in August when the ETo is 0.23 inch. Having a non-constant pressure is challenging because it adds an additional variable so that it becomes impossible to know how much water the irrigation system applies during each irrigation event.

How to solve the variable pressure problem? To reduce the pressure, pressure regulators can be installed at each block. Senninger irrigation makes affordable fixed pressure regulators that can handle high flowrates (model PRU https://www.senninger.com/product-line/solid-set-pressure-regulators). Low pressures are more difficult to address. There needs to be a centralized management of irrigation events where management (Javier or Edgar) knows that at any moment, which blocks are being irrigated. So one can ensure that not more than, for example, 2 irrigation blocks per injector can be open at the same time. Irrigators cannot be given the liberty of opening irrigation valves as they please, or else they'll drop the pressure for everybody else. Alternatively, irrigators could be given a pressure gage and they could be told to open an irrigation valve only if there is enough pressure. How to enforce such a system I don't know. Perhaps, one could install pressure transducers at each injector to monitor pressure remotely. One could install check valves at each irrigation block that open only at a certain minimum pressure so if the pressure is low, the irrigator can't irrigate not even if they open the valve, but this solution seems extreme.

Recommendation 3:

Sprinkler head risers need maintenance, they all need to be at the same height, and they need to be vertical or else the distribution uniformity will be low even with the best sprinkler.

Figure 1. Example of tilted riser

Recommendation 4:

In an attempt to improve the distribution uniformity (DU), we changed the nozzles of the Hunter PGP Ultra sprinklers to 1.5 gpm, and the DU it improved slightly. The idea was that a smaller flowrate would give smaller pressure losses in the pipes and hence more unform irrigation. Additionally, smaller flowrate nozzles apply less water in time and require more time to apply the same water depth.

On 4/29/21 we evaluated the 4 gpm nozzles, measuring DU in three areas. The results were:

Area A: DU= 0.58; Area B: DU=0.78; Area C: DU=0.66; Overall: DU=0.61

These DU are poor, an average DU for a sprinkler system is 0.75 to 0.80.

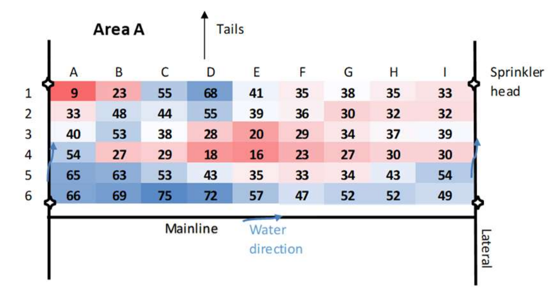
On 5/5/21 we evaluated the 1.5 gpm nozzles, measuring DU in one area. The other two areas were turned off by workers during the evaluation so we couldn't collect the data. The results were:

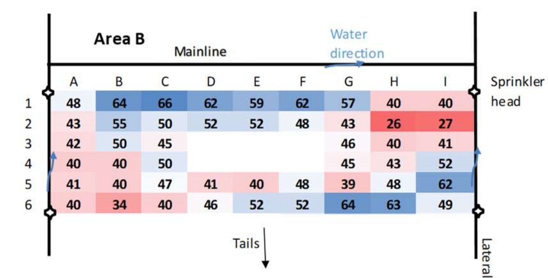
Area A: DU= 0.77. This DU is good.

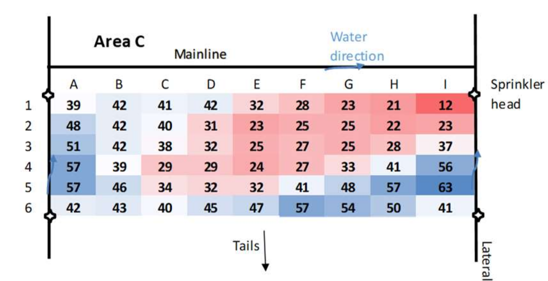
4/29/2021 4 GPM nozzles

Collection volume (ml)

	Area A			Area B			Area C		
	Col	Row		Col	Row		Col	Row	
obs 1	A	1	9	A	1	48	A	1	39
obs 2	B	1	23	B	1	64	B	1	42
obs 3	C	1	55	C	1	66	C	1	41
obs 4	D	1	68	D	1	62	D	1	42
obs 5	E	1	41	E	1	59	E	1	32
obs 6	F	1	35	F	1	62	F	1	28
obs 7	G	1	38	G	1	57	G	1	23
obs 8	H	1	35	H	1	40	H	1	21
obs 9	I	1	33	I	1	40	I	1	12
obs 10	A	2	33	A	2	43	A	2	48
obs 11	B	2	48	B	2	55	B	2	42
obs 12	C	2	44	C	2	50	C	2	40
obs 13	D	2	55	D	2	52	D	2	31
obs 14	E	2	39	E	2	52	E	2	23
obs 15	F	2	36	F	2	48	F	2	25
obs 16	G	2	30	G	2	43	G	2	25
obs 17	H	2	32	H	2	26	H	2	22
obs 18	I	2	32	I	2	27	I	2	23
obs 19	A	3	40	A	3	42	A	3	51
obs 20	B	3	53	B	3	50	B	3	42
obs 21	C	3	38	C	3	45	C	3	38
obs 22	D	3	28	D	3		D	3	32
obs 23	E	3	20	E	3		E	3	25
obs 24	F	3	29	F	3		F	3	27
obs 25	G	3	34	G	3	46	G	3	25
obs 26	H	3	37	H	3	40	H	3	28
obs 27	I	3	39	I	3	41	I	3	37
obs 28	A	4	54	A	4	40	A	4	57
obs 29	B	4	27	B	4	40	B	4	39
obs 30	C	4	29	C	4	50	C	4	29
obs 31	D	4	18	D	4		D	4	29
obs 32	E	4	16	E	4		E	4	24
obs 33	F	4	23	F	4		F	4	27
obs 34	G	4	27	G	4	45	G	4	33
obs 35	H	4	30	H	4	43	H	4	41
obs 36	I	4	30	I	4	52	I	4	56
obs 37	A	5	65	A	5	41	A	5	57
obs 38	B	5	63	B	5	40	B	5	46
obs 39	C	5	53	C	5	47	C	5	34
obs 40	D	5	43	D	5	41	D	5	32
obs 41	E	5	35	E	5	40	E	5	32
obs 42	F	5	33	F	5	48	F	5	41
obs 43	G	5	34	G	5	39	G	5	48
obs 44	H	5	43	H	5	48	H	5	57
obs 45	I	5	54	I	5	62	I	5	63
obs 46	A	6	66	A	6	40	A	6	42
obs 47	B	6	69	B	6	34	B	6	43
obs 48	C	6	75	C	6	40	C	6	40
obs 49	D	6	72	D	6	46	D	6	45
obs 50	E	6	57	E	6	52	E	6	47
obs 51	F	6	47	F	6	52	F	6	57
obs 52	G	6	52	G	6	64	G	6	54
obs 53	H	6	52	H	6	63	H	6	50
obs 54	I	6	49	I	6	49	I	6	41







5/5/2021 1.5 GPM nozzles

Collection volume (ml)

	Area A		
	Col	Row	
obs 1	A	1	69
obs 2	B	1	60
obs 3	C	1	37
obs 4	D	1	35
obs 5	E	1	35
obs 6	F	1	34
obs 7	G	1	39
obs 8	H	1	52
obs 9	I	1	89
obs 10	A	2	46
obs 11	B	2	37
obs 12	C	2	31
obs 13	D	2	32
obs 14	E	2	34
obs 15	F	2	34
obs 16	G	2	40
obs 17	H	2	37
obs 18	I	2	52
obs 19	A	3	42
obs 20	B	3	41
obs 21	C	3	31
obs 22	D	3	37
obs 23	E	3	34
obs 24	F	3	37
obs 25	G	3	32
obs 26	H	3	35
obs 27	I	3	40
obs 28	A	4	42
obs 29	B	4	37
obs 30	C	4	37
obs 31	D	4	43
obs 32	E	4	38
obs 33	F	4	38
obs 34	G	4	45
obs 35	H	4	38
obs 36	I	4	39
obs 37	A	5	40
obs 38	B	5	38
obs 39	C	5	47
obs 40	D	5	48
obs 41	E	5	50
obs 42	F	5	46
obs 43	G	5	44
obs 44	H	5	40
obs 45	I	5	39
obs 46	A	6	76
obs 47	B	6	58
obs 48	C	6	54
obs 49	D	6	47
obs 50	E	6	46
obs 51	F	6	
obs 52	G	6	48
obs 53	H	6	60
obs 54	I	6	76

Area A

Tails

	A	B	C	D	E	F	G	H	I
1	**69**	**60**	**37**	**35**	**35**	**34**	**39**	**52**	**89**
2	**46**	**37**	**31**	**32**	**34**	**34**	**40**	**37**	**52**
3	**42**	**41**	**31**	**37**	**34**	**37**	**32**	**35**	**40**
4	**42**	**37**	**37**	**43**	**38**	**38**	**45**	**38**	**39**
5	**40**	**38**	**47**	**48**	**50**	**46**	**44**	**40**	**39**
6	**76**	**58**	**54**	**47**	**46**		**48**	**60**	**76**

Sprinkler head

Mainline

Water direction

Lateral

Recommendation 5:

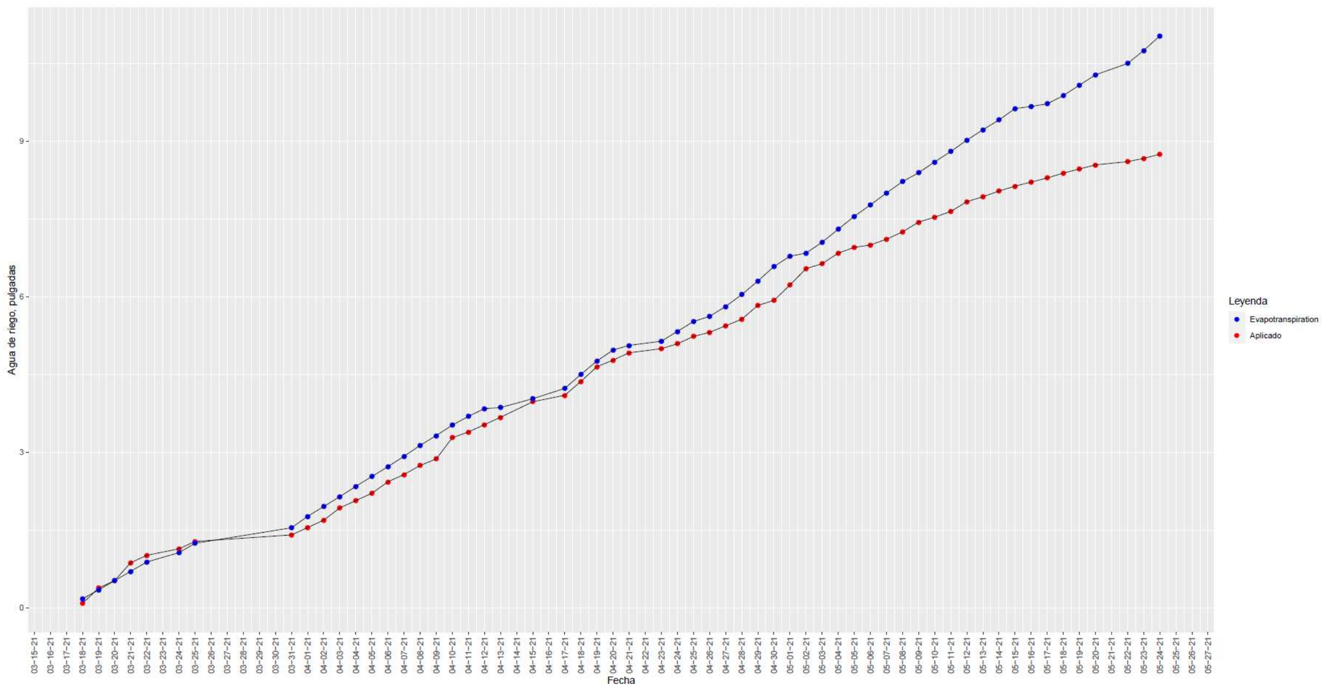


Figure 2. Water applied (red dot) measured by the flowmeter and reference evapotranspiration (blue dot) obtained from the Escondido CIMIS station.

The water volume measured by the flowmeter was divided by the block area to obtain the irrigation depth applied. This was compared with the reference evapotranspiration from the Escondido CIMIS station in the cumulative plot above. The two lines follow each other closely, until the end of the cycle when the applied starts lagging behind.

Typically, the applied irrigation is calculated from ETo with the following formula:

$$\text{Recommended irrigation water} = \frac{ETo\ Kc}{DU\ (1 - LF)}$$

Where ETo is reference ET, Kc is a crop-specific coefficient, DU is the distribution uniformity and LF is the leaching fraction. Some authors suggest a leaching fraction of at least 10-15% while it seems that in this case the leaching fraction was zero.

Load cell experiments:

We weighted two pots with a load cell (a scale that logs data continuously) to monitor plant weight. The graph is below:

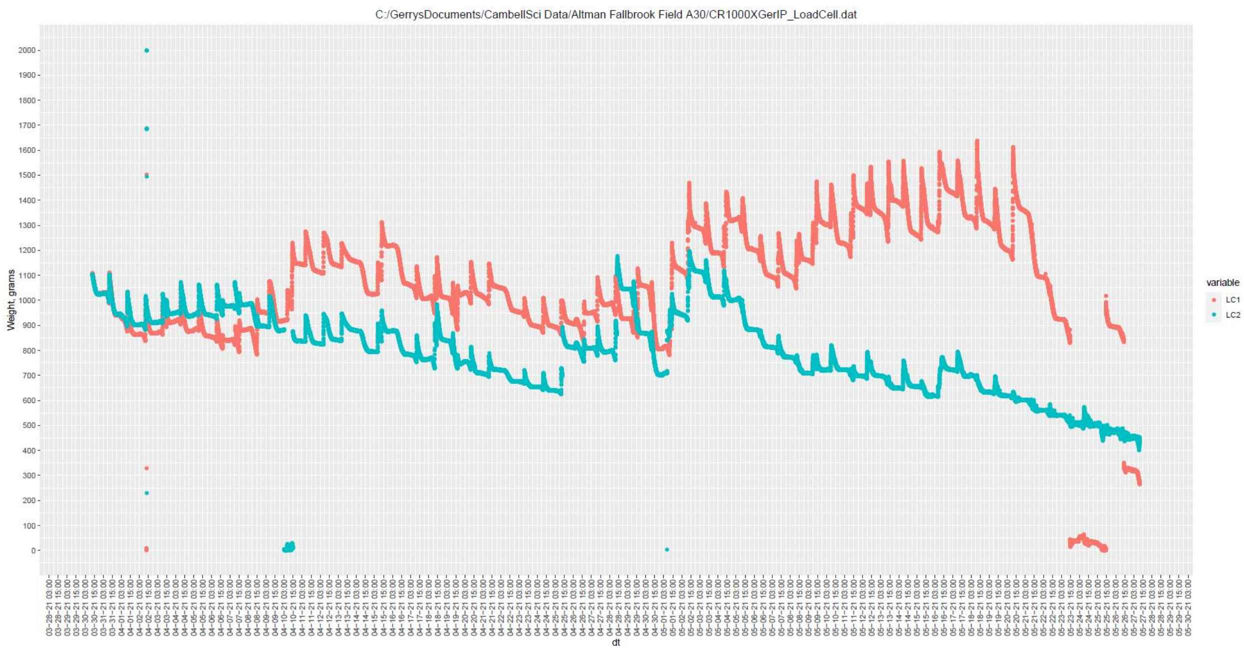


Figure 3. Weight of two 1-gal containers as recorded by the load cells

In an experiment, we saturated 5 containers with water, and we weighted the containers after no more leachate was coming out of the pots. This weight is called “container capacity” and it was on average 1520 grams. Only on a few occasions at the end of the cycle one load cell showed that the container weight was above container capacity, indicating that leachate was produced. We also let one plant dry out and the weight when visible wilting started was 720 grams (permanent wilting point). One load cell shows that around April 25 the plant approached wilting point. The available water of 1-gal was thus estimated as 1520-720 = 800 mL. The load cells recorded an average increase in container weight of 128 grams following a 20-minute irrigation. However, the two load cells showed very different patterns in time, suggesting that each container was receiving different amounts of water. This is probably due to the poor distribution uniformity mentioned above.

It could be a useful practice for growers or irrigators to weigh ten plants in a block to decide how long to irrigate for example in overcast days or during heat waves.

Recommendation 5:

Table 6.2. Growth characteristics of representative nursery crops grown in a nursery or greenhouse at the University of California, Davis (continued)

Species	Dry wt. (g)	Shoot nutrient concentrations N (%)	P (%)	K (%)	Water use (L)	Recommended liquid feed concentrations N (mg/L)	P (mg/L)	K (mg/L)
Ilex aquifolium 'San Gabriel'	25.06	1.73	0.21	2.18	14.1	26	4	33
Impatiens hawkeri 'Bonfire Orange'	6.70	2.81	0.60	3.38	1.6	93	16	79
Impatiens walleriana 'Double Ole Rose'	8.10	4.28	0.63	4.41	3.9	142	33	167
Imperata cylindrica 'Red Baron'	20.62	1.20	0.34	2.26	9.0	28	8	52
Juniperus scopulorum 'Moonglow'	11.60	2.12	0.15	1.45	11.8	13	—	—
Kniphofia 'Border Ballet'	15.20	3.21	0.42	4.41	3.3	119	9	143
Lagerstroemia indica 'Petite Orchid'	28.37	3.08	0.70	2.84	11.3	65	15	59
Lantana 'Pink Caprice'	29.70	2.04	0.17	1.89	18.6	34	—	—
Lavandula dentata	32.40	2.05	0.19	1.92	13.3	56	—	—
Lavendula angustifolia 'Munstead'	6.70	3.97	0.45	3.75	2.1	87	11	107
Ligustrum japonicum 'Texanum'	25.69	1.81	0.19	1.57	7.4	51	7	48
Miscanthus sinensis 'Purpurescens'	20.84	1.73	0.27	1.72	9.9	30	5	31

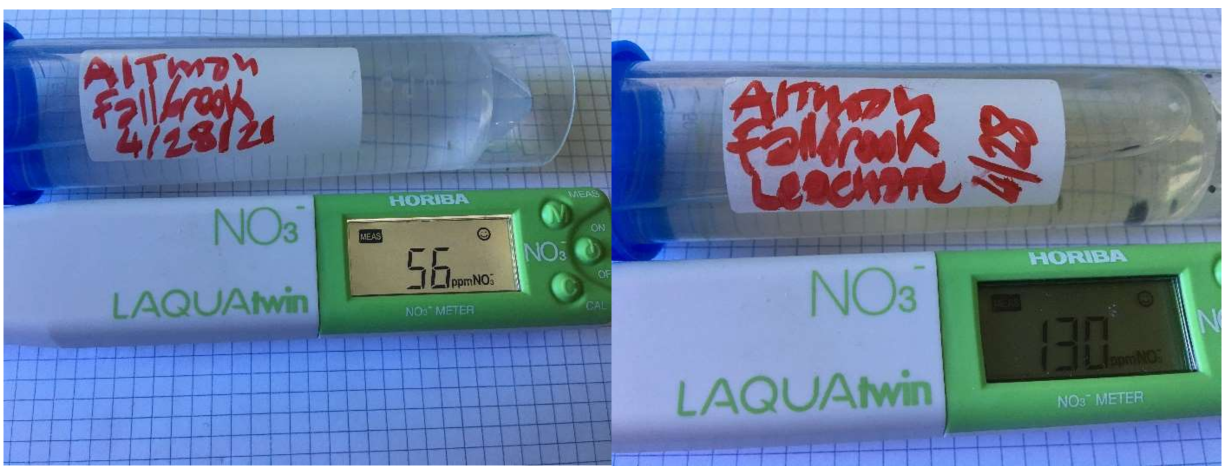


Figure 4. Nitrate concentrations in the irrigation water (left) and in the leachate (right). Recommended N concentration in Lavandula Angustifolia from Container Nursery Production and Business Management Manual.