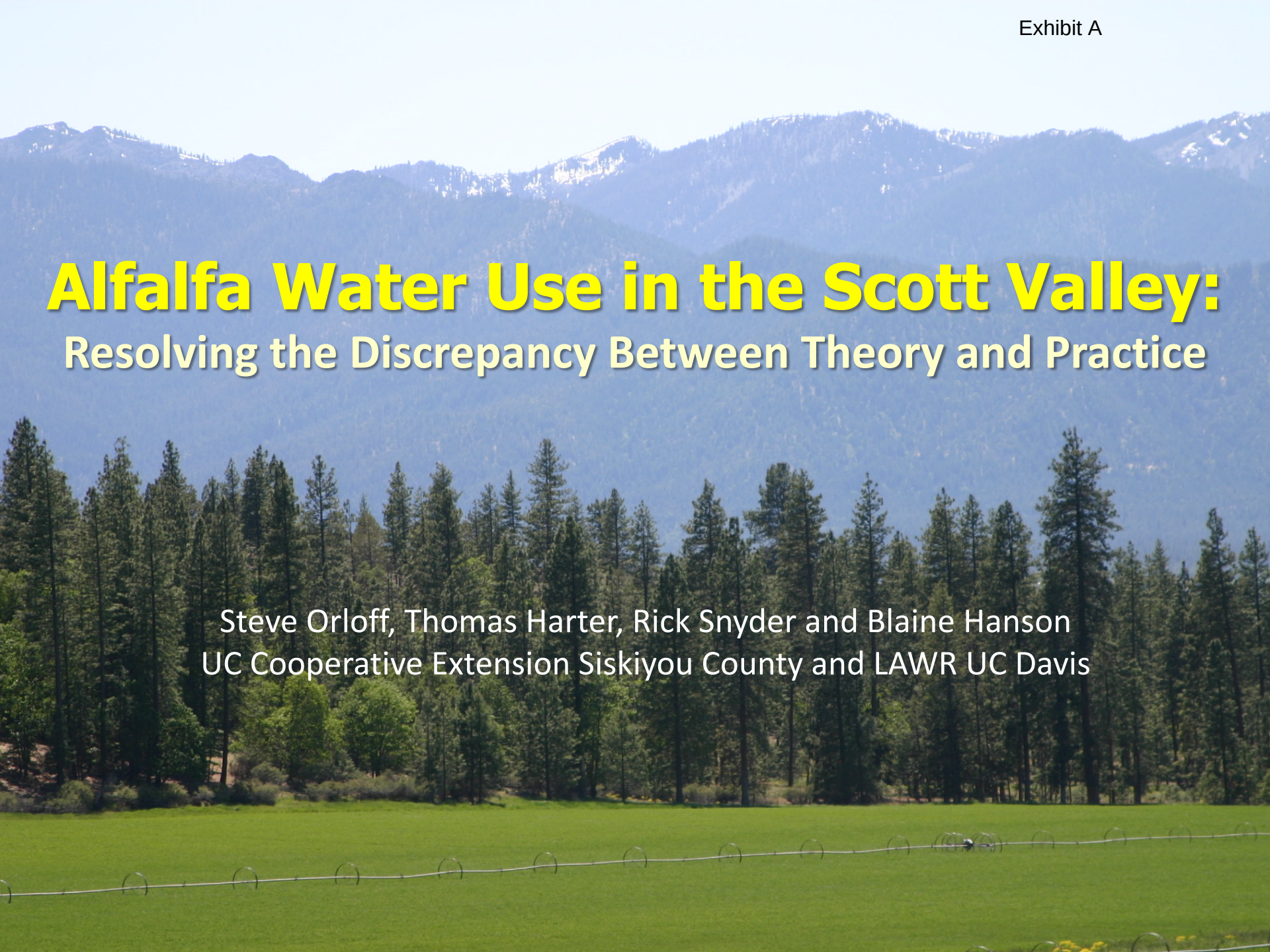
Exhibit A



Alfalfa Water Use in the Scott Valley:
Resolving the Discrepancy Between Theory and Practice

Steve Orloff, Thomas Harter, Rick Snyder and Blaine Hanson
UC Cooperative Extension Siskiyou County and LAWR UC Davis


Groundwater Dependent Ecosystems
And the GW – SW Interface
Etna, California

Accurate crop water use and applied irrigation water data critical for an accurate model.

What is ET?

Evapotranspiration: sum of evaporation and plant transpiration

Crop Water Use

$$ET_c = K_c \times ET_o$$

Crop Evapotranspiration (ET_c) is calculated by multiplying the reference crop evapotranspiration, ET_o, by a crop coefficient, K_c:

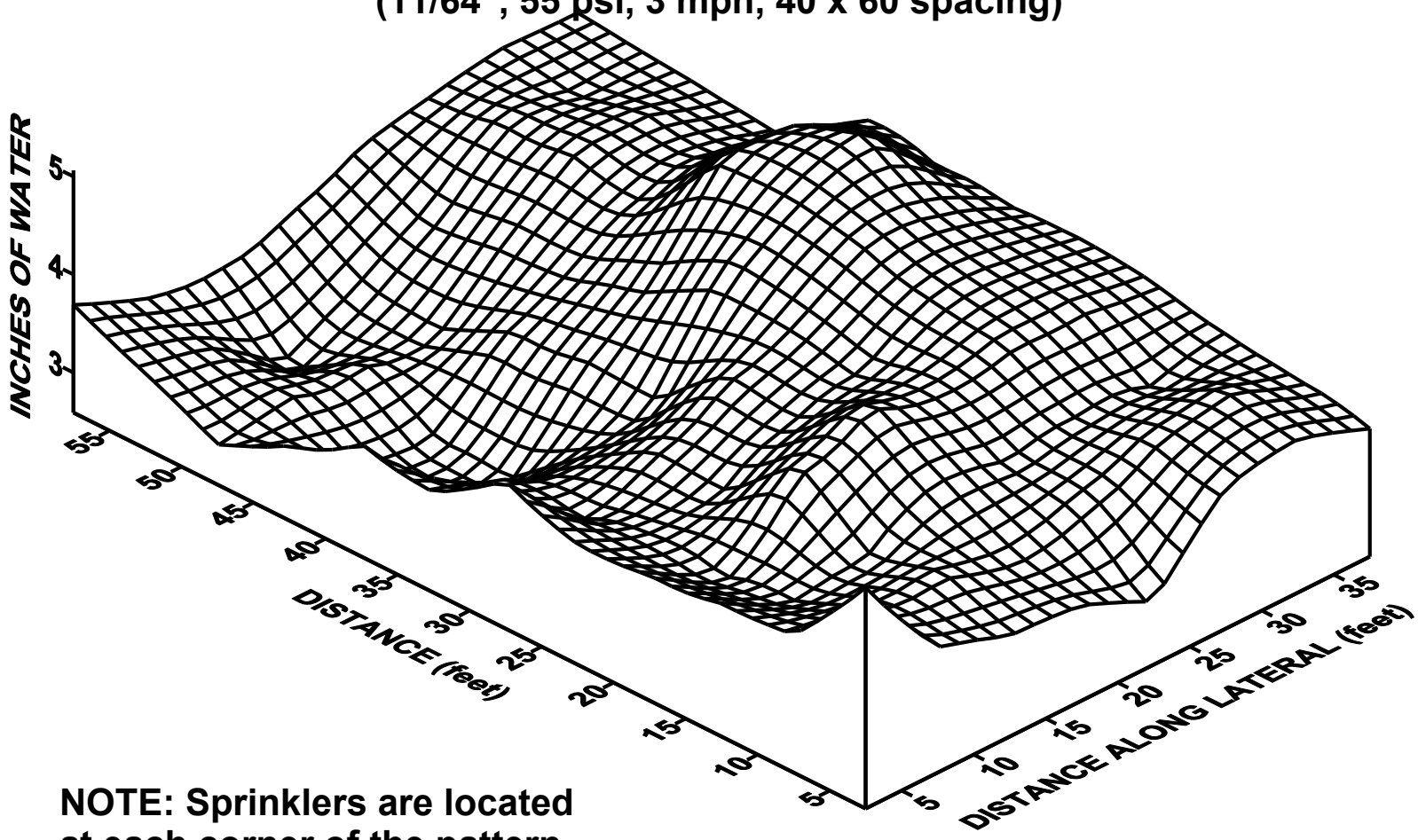
ET Estimation in the Field

- Field-wide alfalfa ET was determined in commercial fields using the surface renewal method (Paw U and Brunet, 1991; Paw U et al., 1995; Snyder et al., 1996; Spano et al., 1997).
- This is a micrometeorological technique that measures net radiation, air temperature, soil temperature, and soil heat flux (the amount of energy stored in the soil as a function of time) which are used in complex equations to calculate ET.

Region	Site	Year	Age Of alfalfa	Seasonal ET (inches)	Reference ET (inches)
Imperial Valley	LM1	2007	3	55.8	73.2
	LM2	2008	2	66.0	73.3
	LM2	2009	3	55.6	67.9
	GR	2010	2	63.5	73.2
	EL	2010	2	59.8	70.0
	WA	2010	2	65.8	70.0
San Joaquin Valley	KC	2007	2	56.6	57.0
	KC	2008	3	59.4	59.3
Sacramento Valley	CH1	2005	3	49.4	63.6
	CH2	2006	2	54.8	55.9
	CH2	2007	3	55.0	58.0
	CH2	2008	4	50.4	59.4
	EE	2010	3	46.3	48.8
	EW	2010	4	42.5	48.8
Scott Valley/Shasta Valley	EN	2007	2	39.6	44.0
	EN	2008	3	32.8	42.6
	EN	2009	4	33.8	40.4
	FI	2009	5	36.1	37.4
	SH	2009	4	38.8	40.4
	AP	2010	5	37.3	37.4
	FI	2010	2	34.7	37.4
	FA	2010	6	38.8	41.1
Tulelake	TU	2007	4	39.0	40.5
	TU	2008	5	34.3	36.5

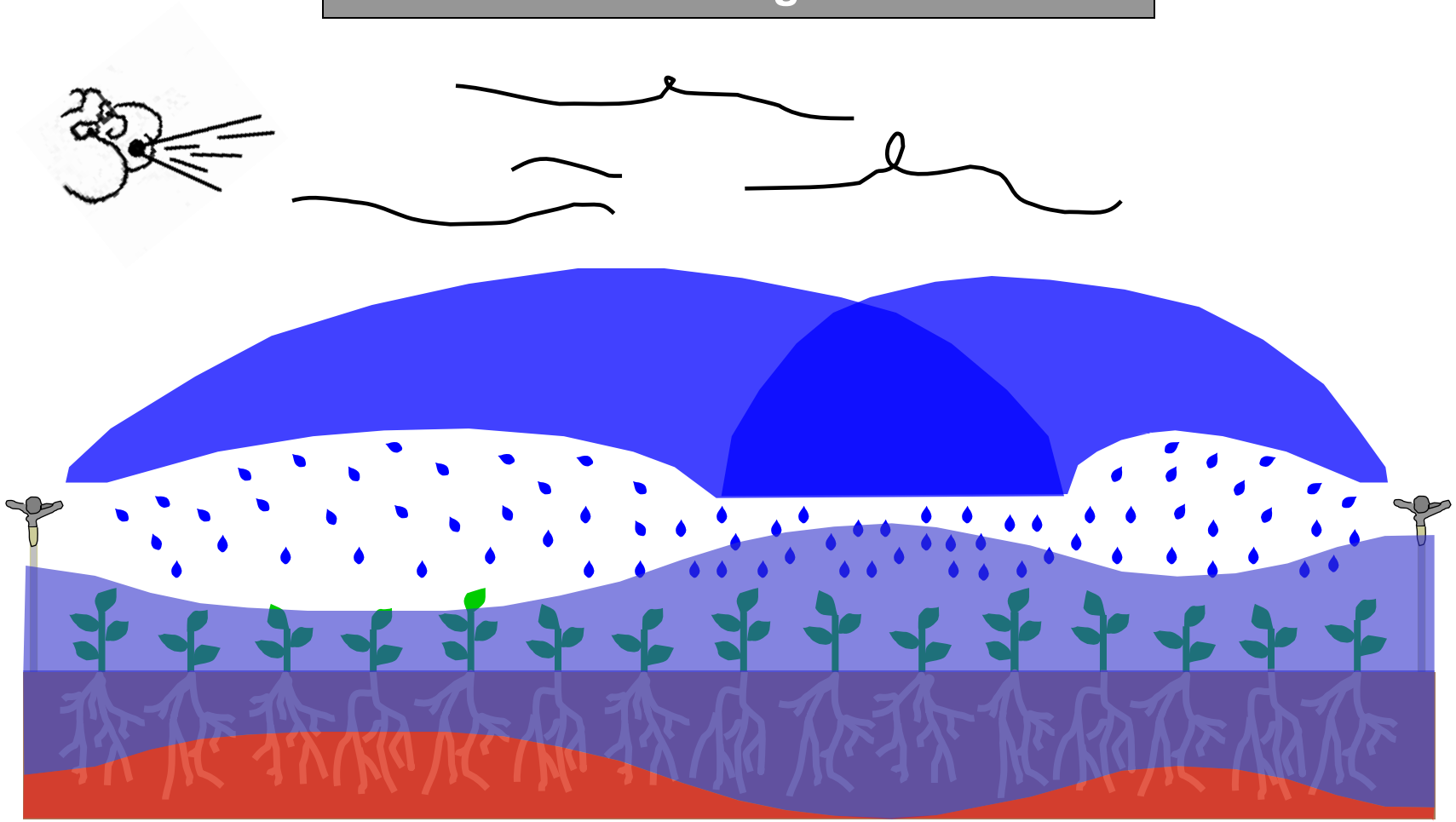
Ave. 37 in.

DISTRIBTUTION UNIFORMITY = 82%
(11/64", 55 psi, 3 mph, 40 x 60 spacing)

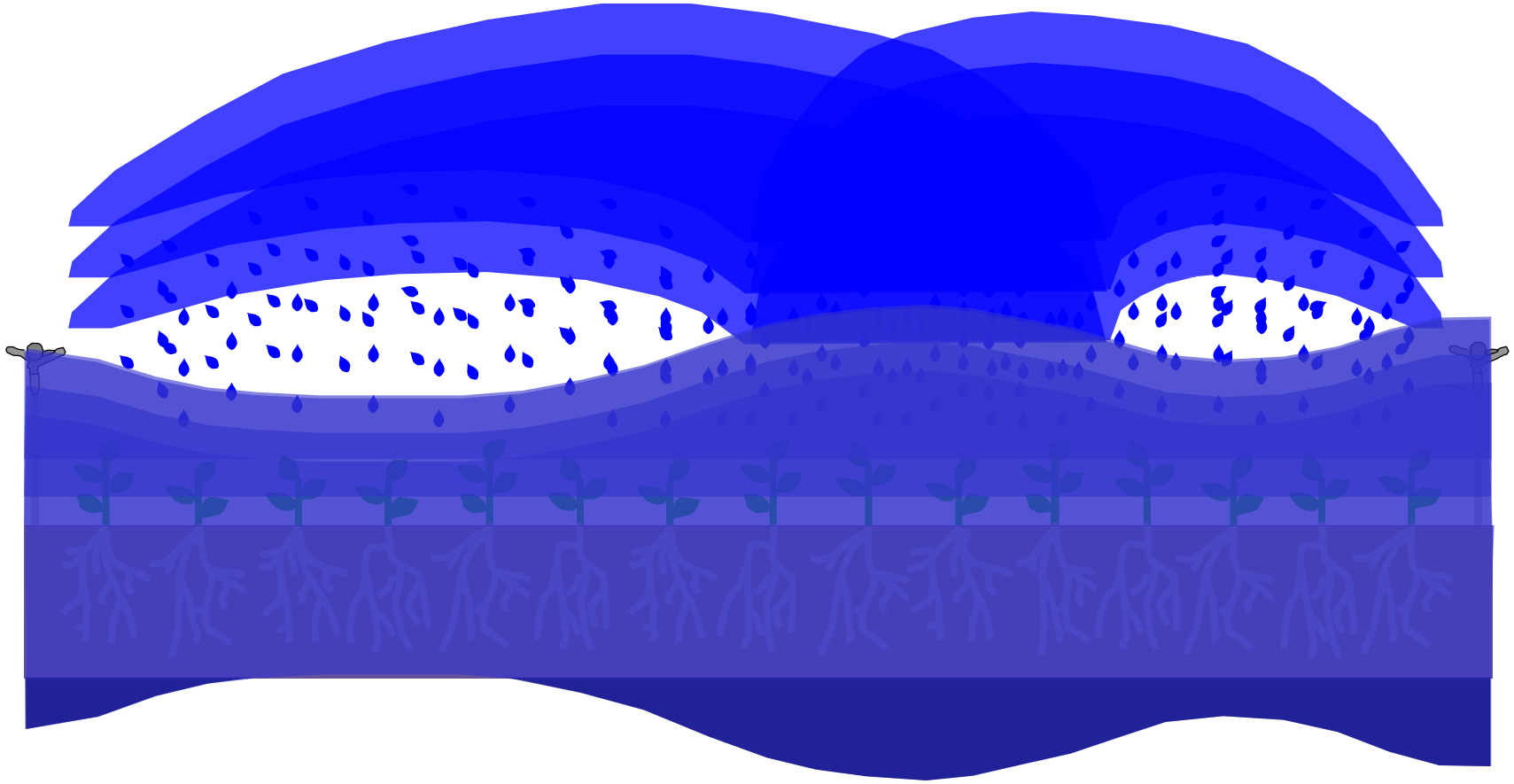


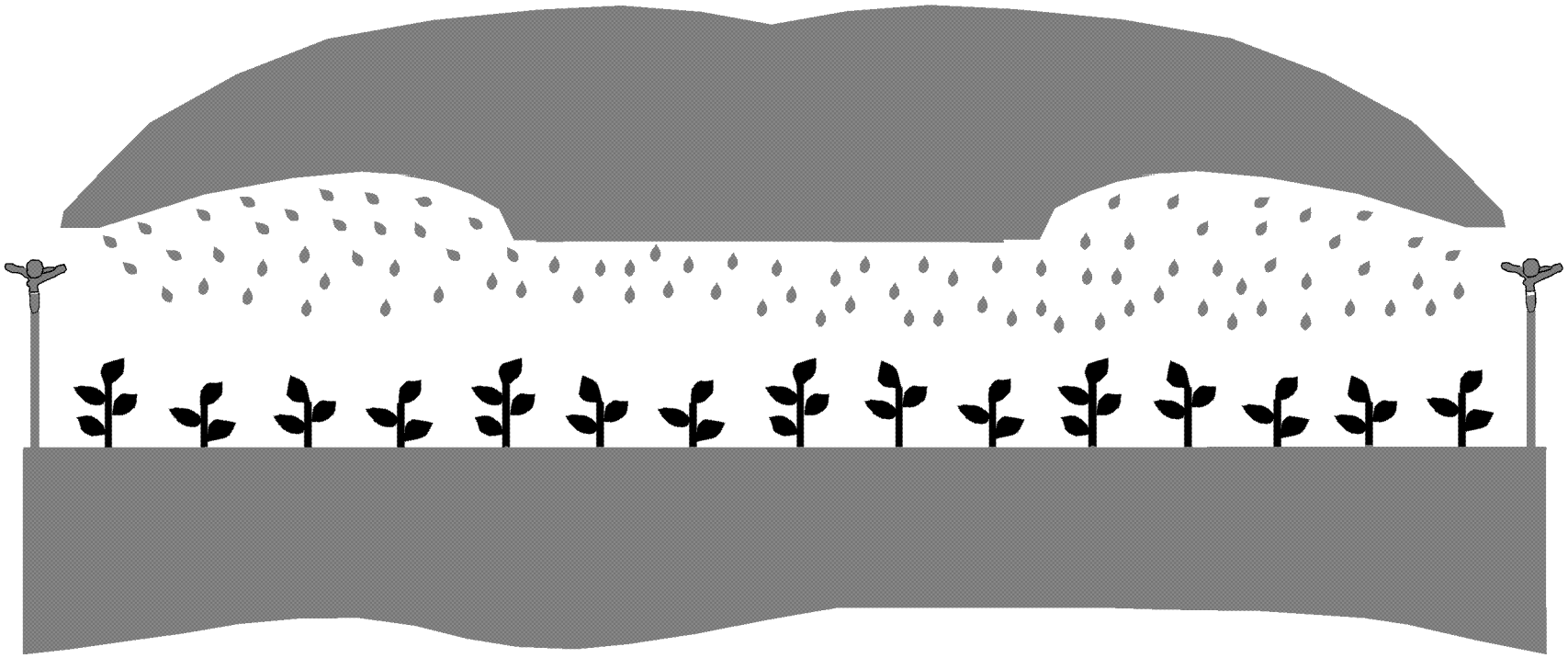
NOTE: Sprinklers are located at each corner of the pattern

Under Irrigation



Over Irrigation





So…How much water should growers apply to alfalfa (and what to assume in model) ?

Alfalfa ET		37 in.
Soil moisture storage	4 ft. rooting depth x 2 in. avail/ft.	8 in.
In-season rainfall	5.67 in. x 60% (effective rainfall)	3 in.
Net irrigation		26 in.
Gross irrigation	**26 in. ÷ 0.75 (irrig. effic.)**	**35 in**

How much are growers applying?

Flow meter data and sprinkler output calculation: 18 – 21 inches

So…What's happening?

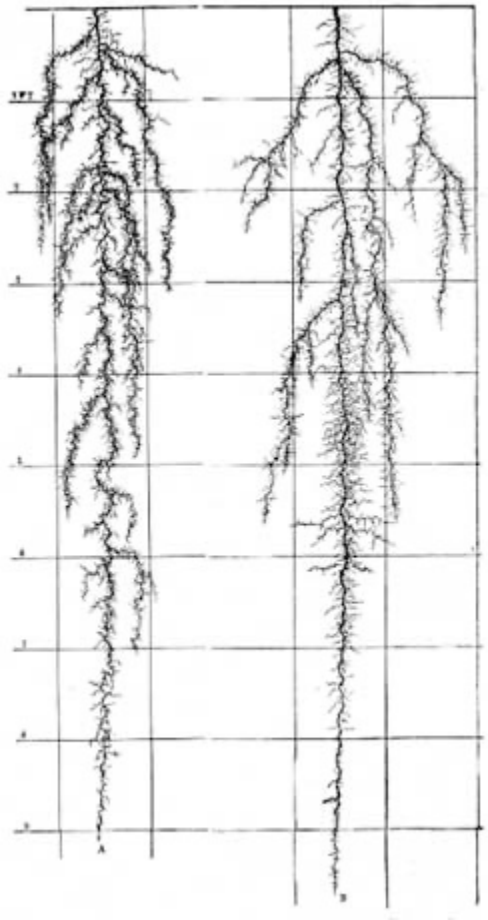
35 vs. 20 inches applied water

1. Alfalfa ET figures are in error and over-estimate the amount of water used
2. Soil moisture reserves are much greater than 8 inches
3. Growers underestimate the amount of water they are actually applying

Eight commercial alfalfa fields (4 center pivot & 4 wheel-line)

- Surface renewal instruments in 3 of the 8 fields
- Temporary CIMIS station in irrigated pasture
- Gravimetric soil moisture content determined April, August and late September down to 8 feet
- Watermark sensors at 1-foot increments down to 8 feet (2 locations per field)
- Permanently installed flow meters
- Doppler portable flow meter
- Nozzle output on wheel-line sprinklers
- Tipping rain gauge at each site
- Yield measurements at each cutting

Alfalfa Root System



- Alfalfa roots can go deeper than 4 feet
- However, more roots near surface
- 40, 30, 20, 10 rule of thumb


Do Not Stack Over
2 Pallets High
Wesson

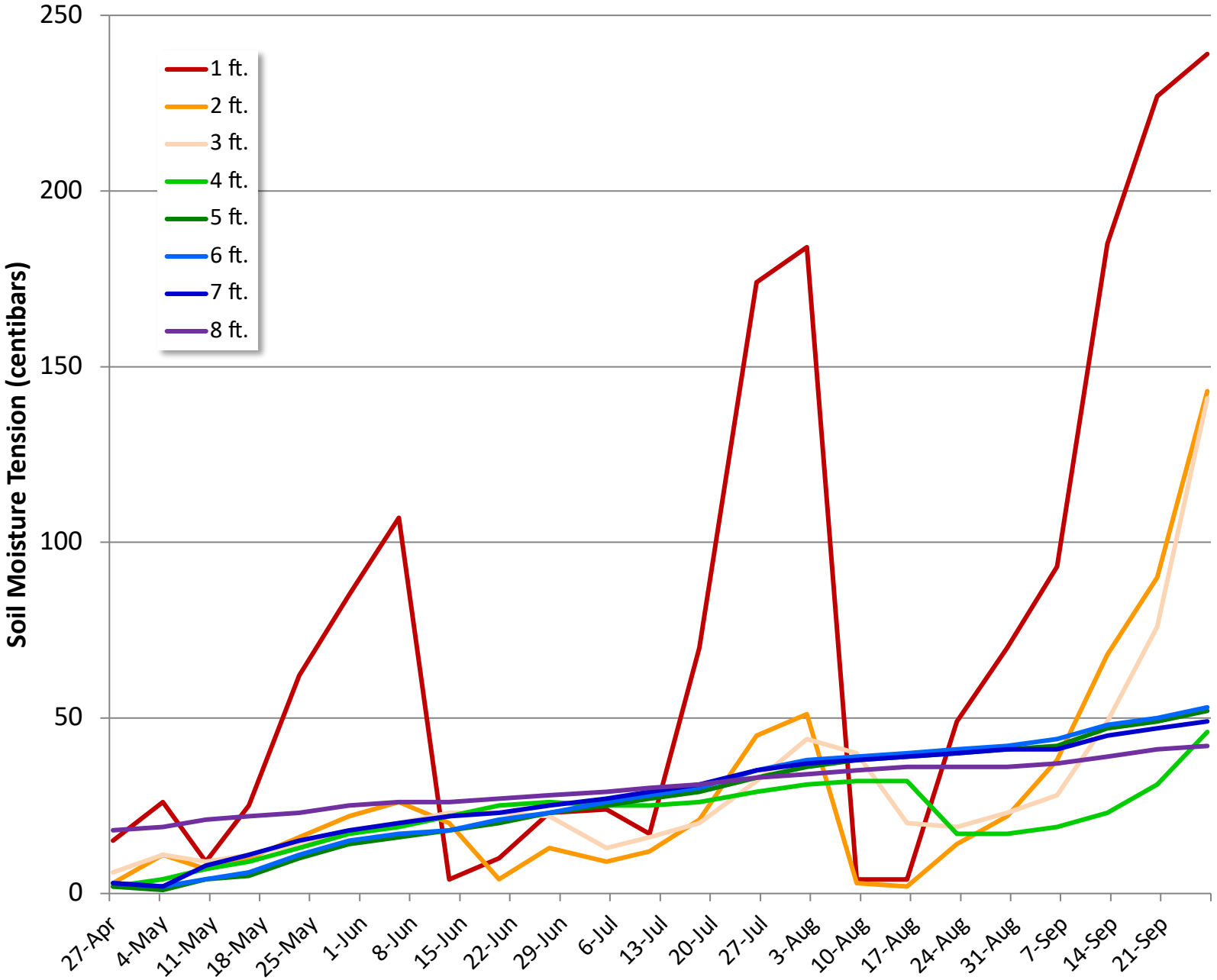
Flow per nozzle and nozzle size and pressure

Ultrasonic Doppler Flow Meter

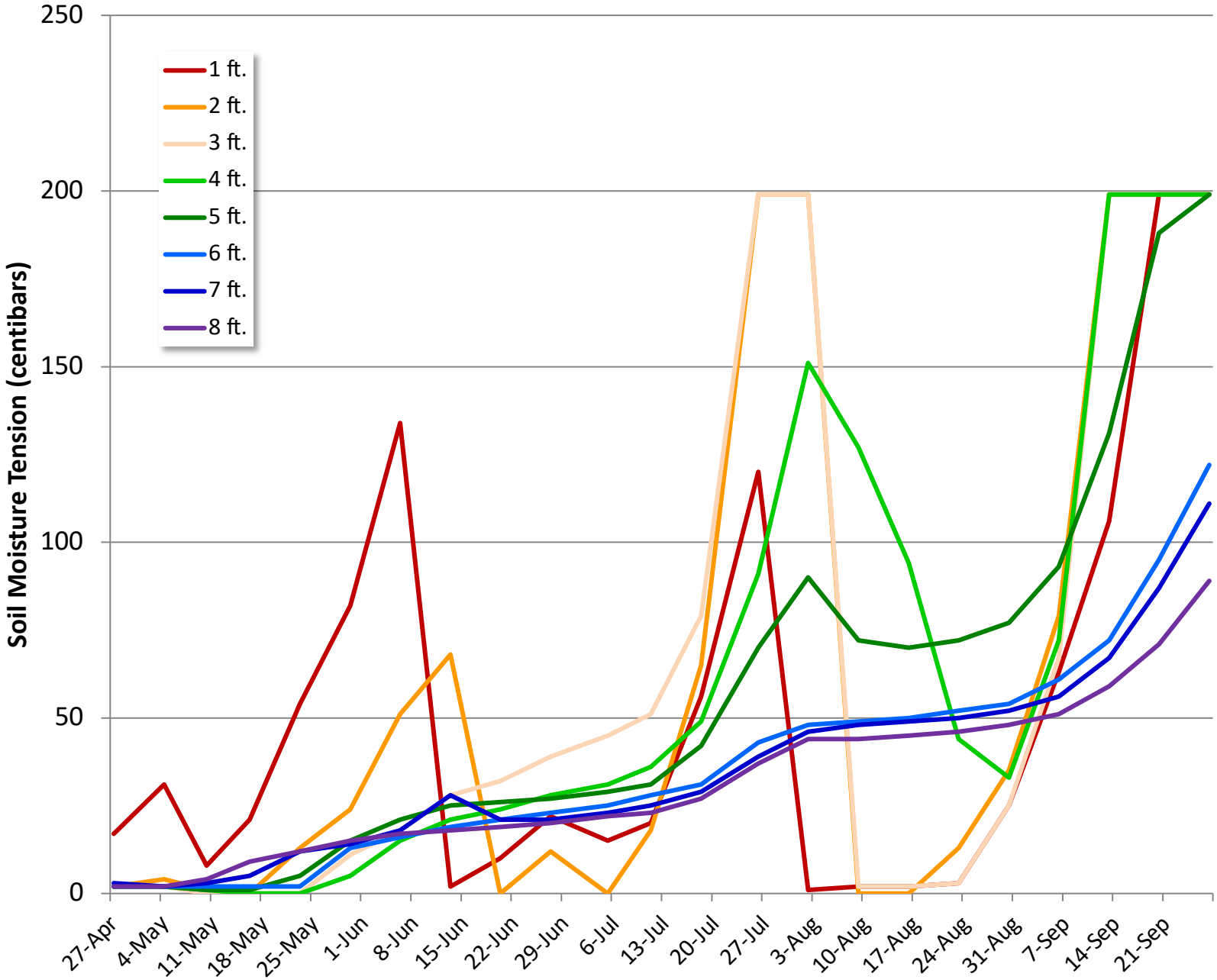
Requires particulates or bubbles in the flow

Electrical Resistance Blocks

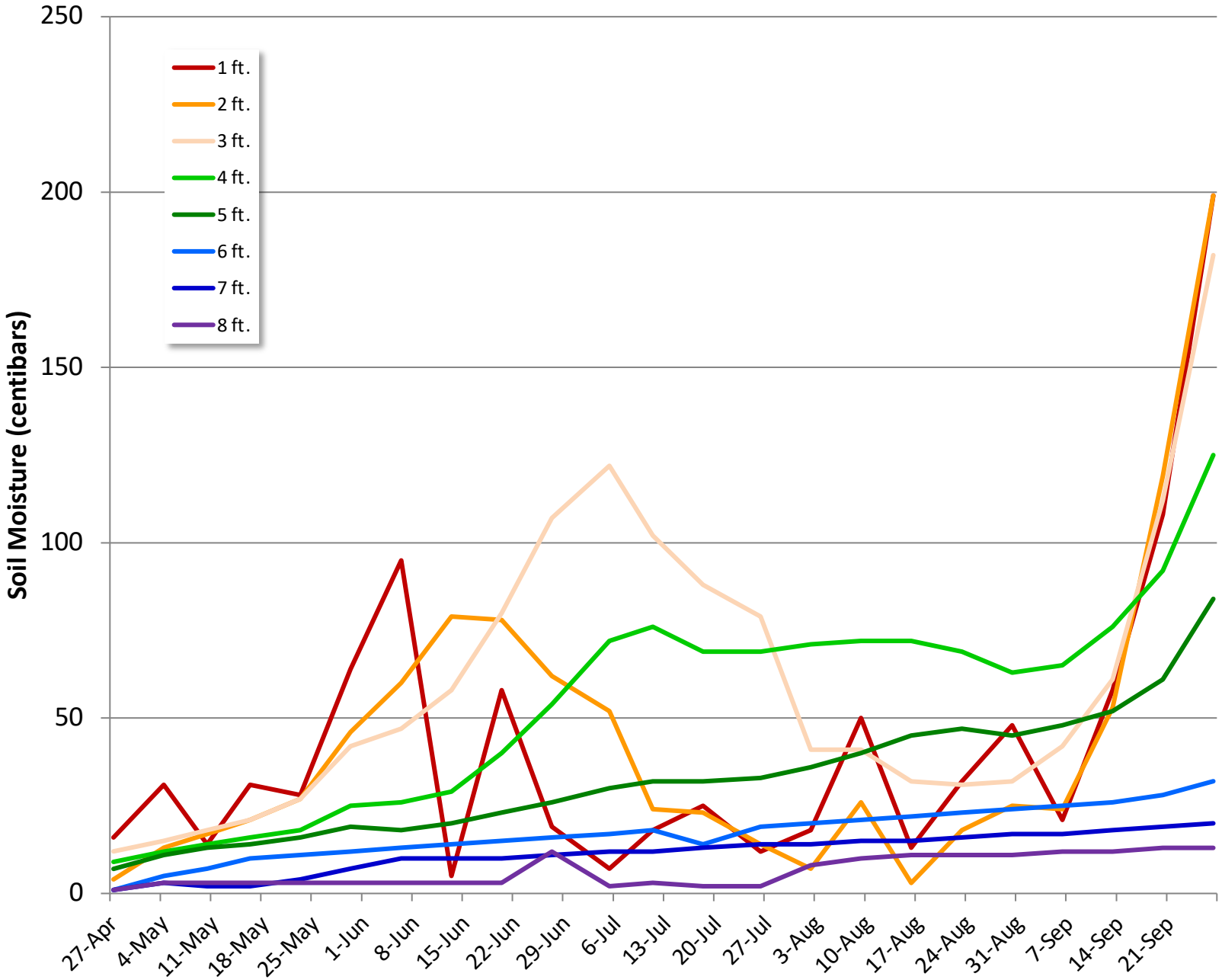
Grower 1 Location 1



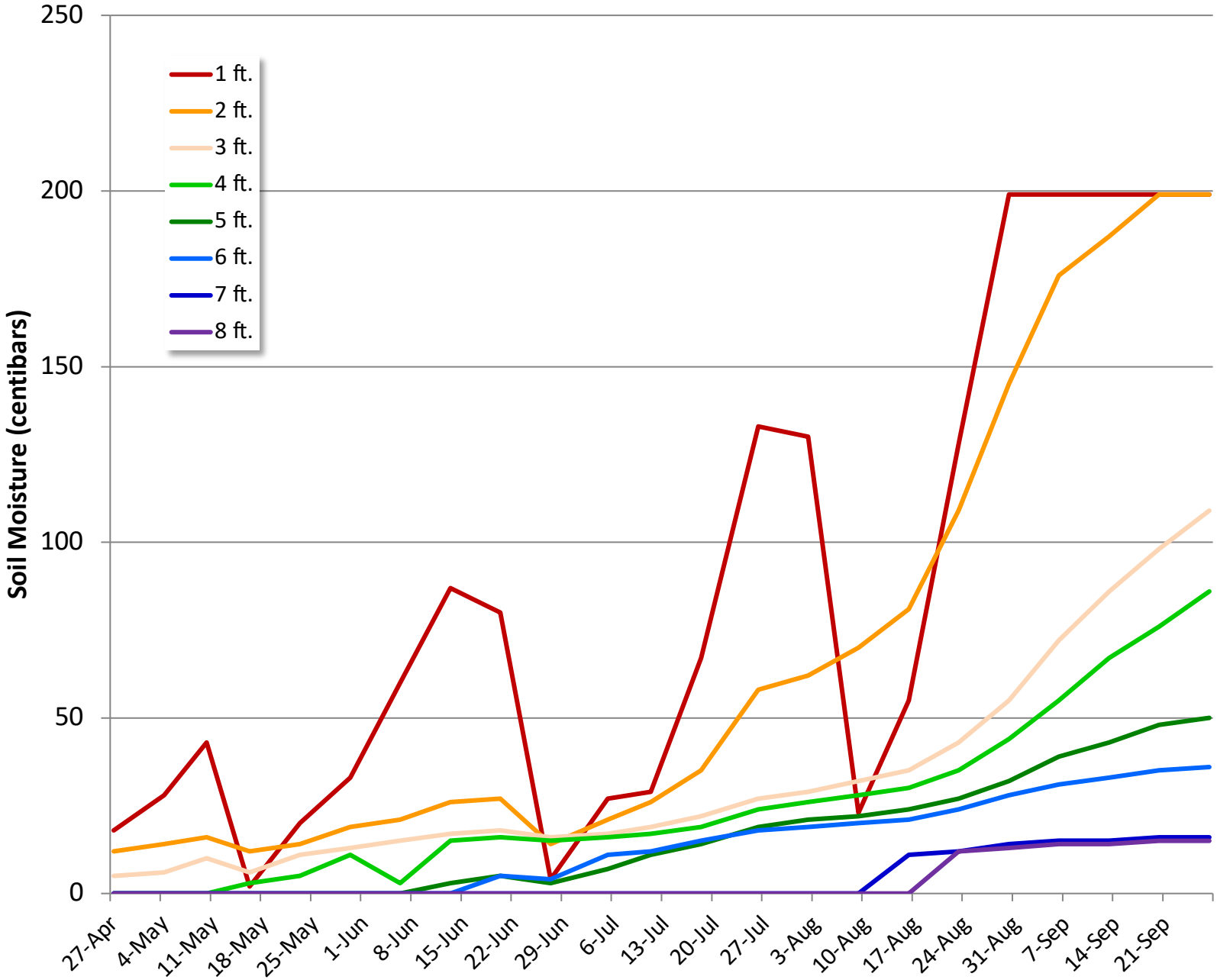
Grower 1 Location 2



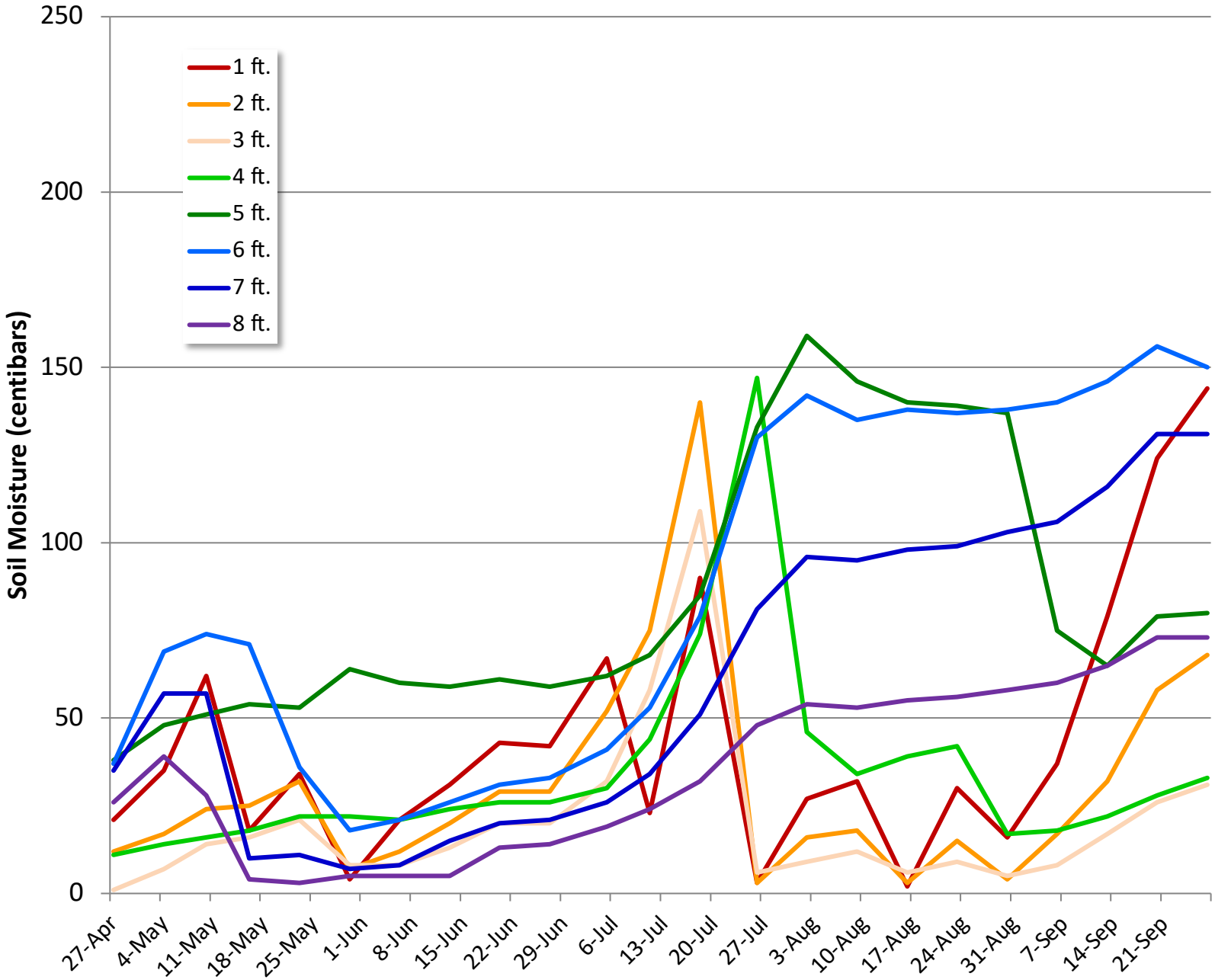
Grower 2 Location 1



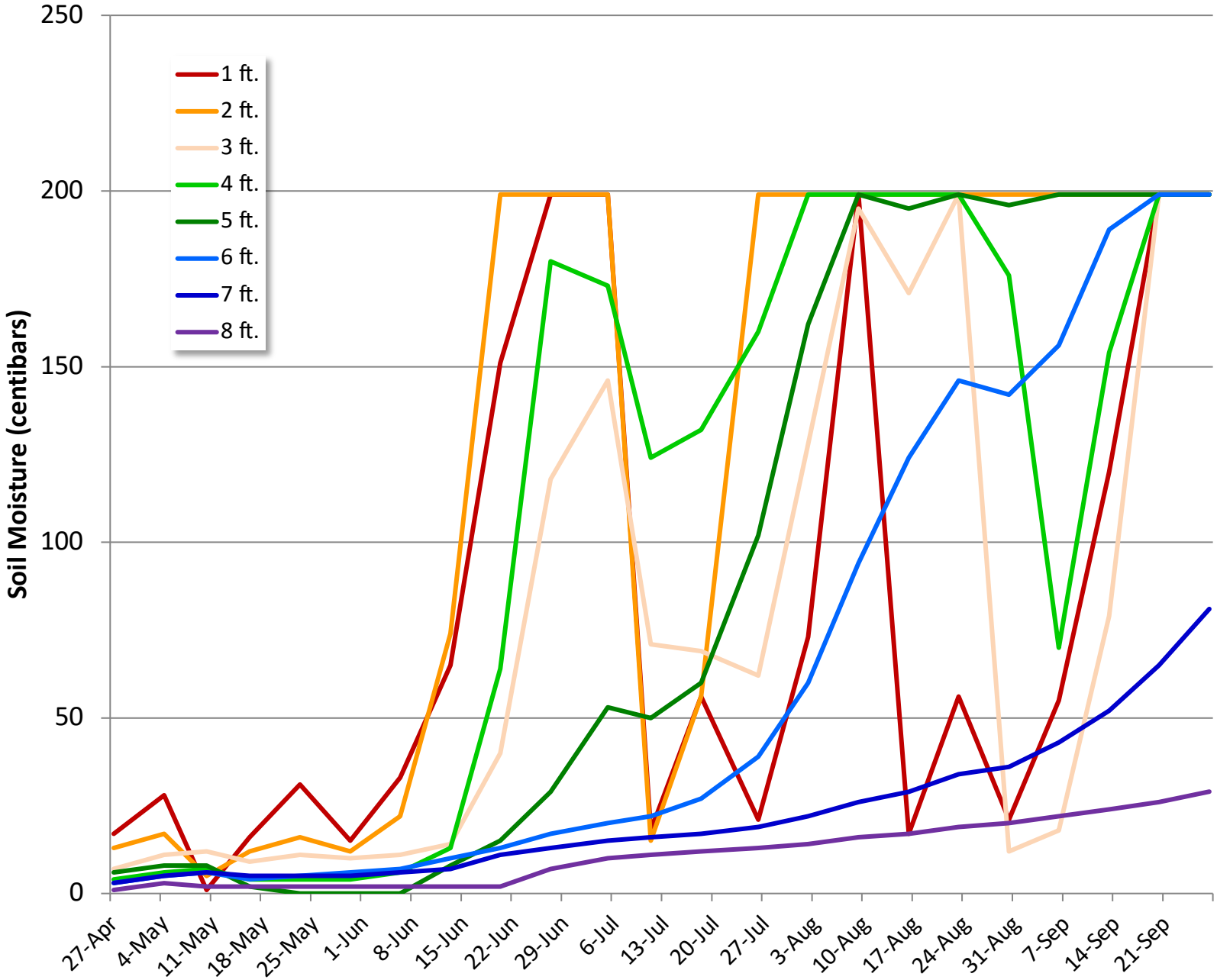
Grower 2 Location 2



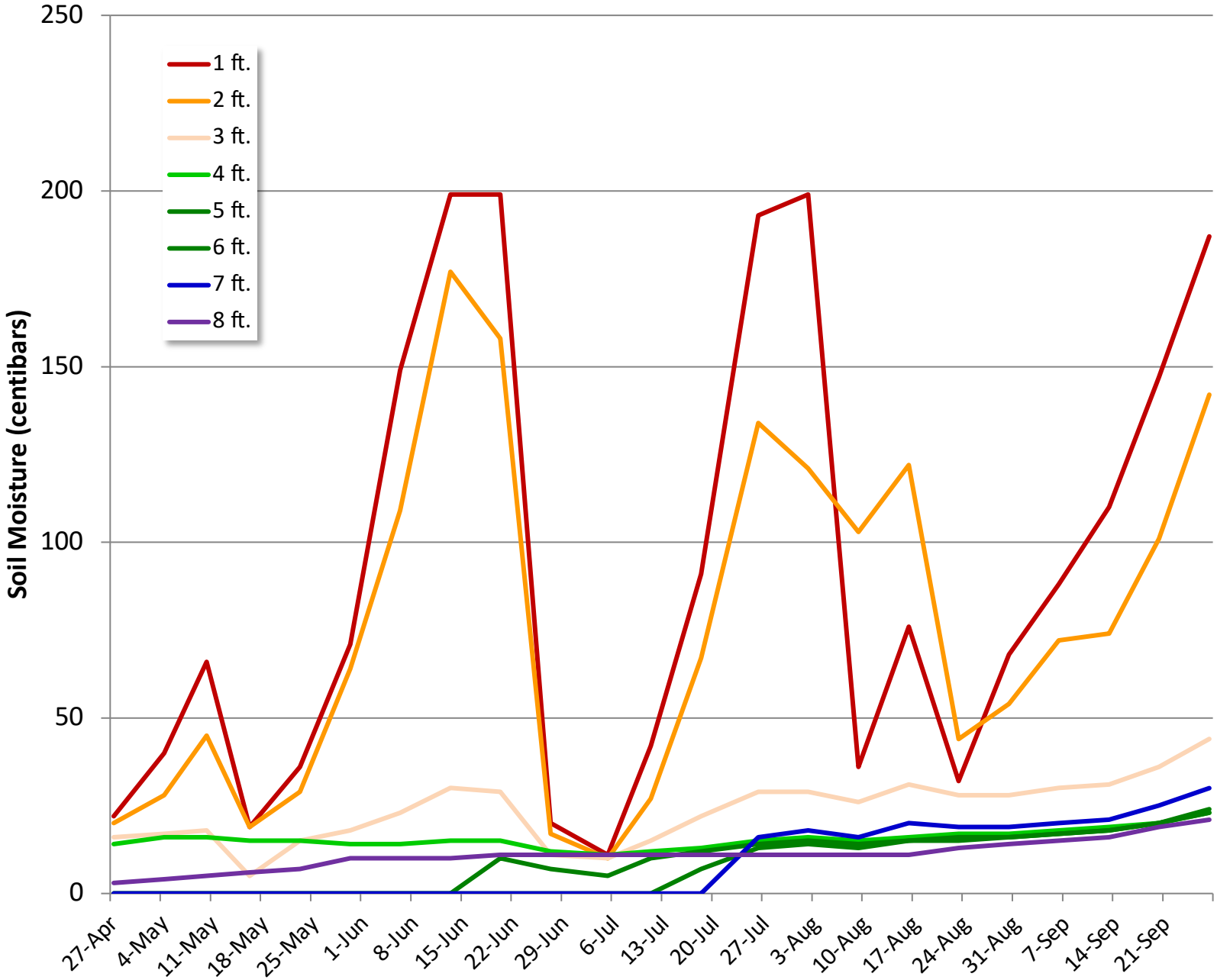
Grower 3 Location 1



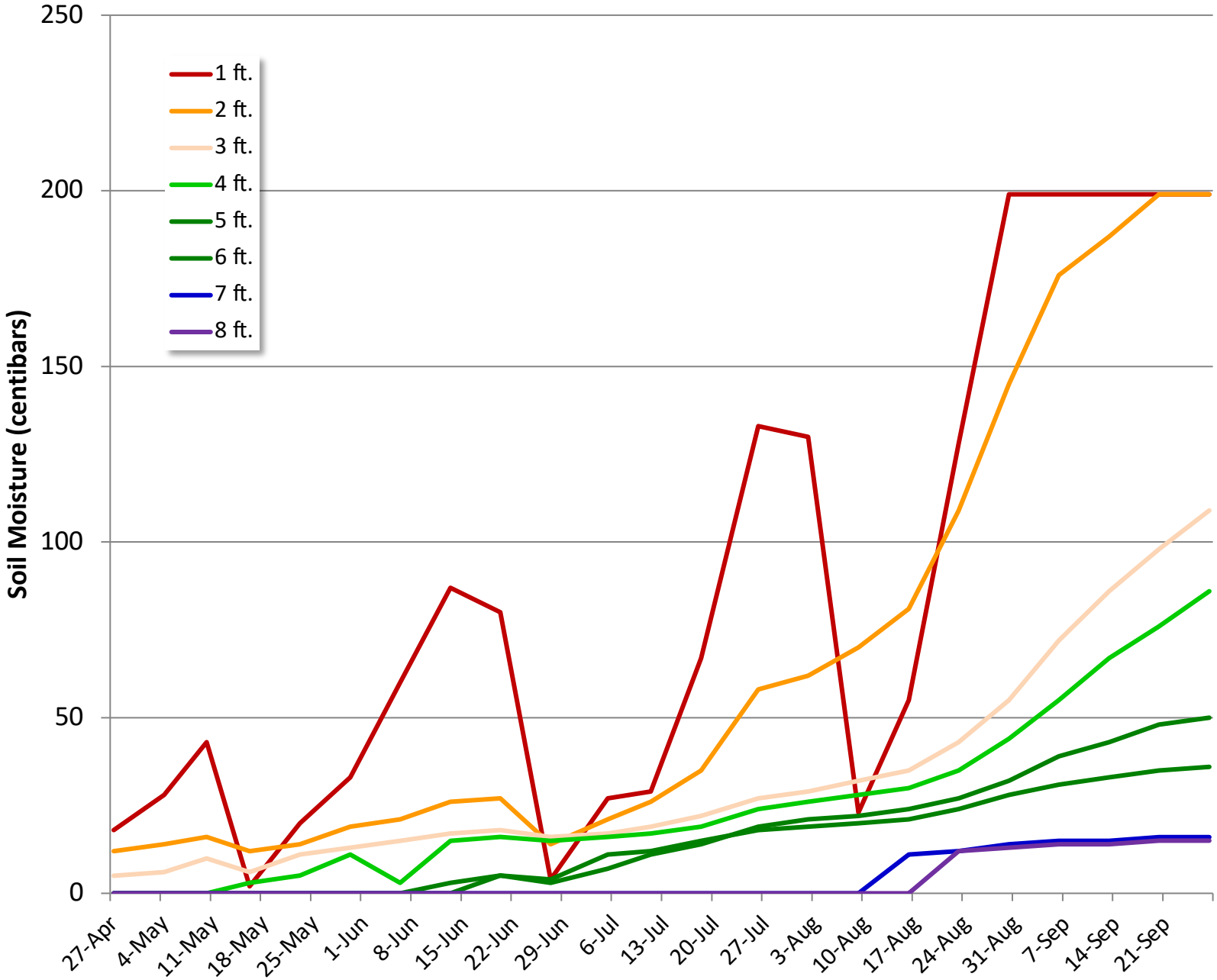
Grower 3 Location 2



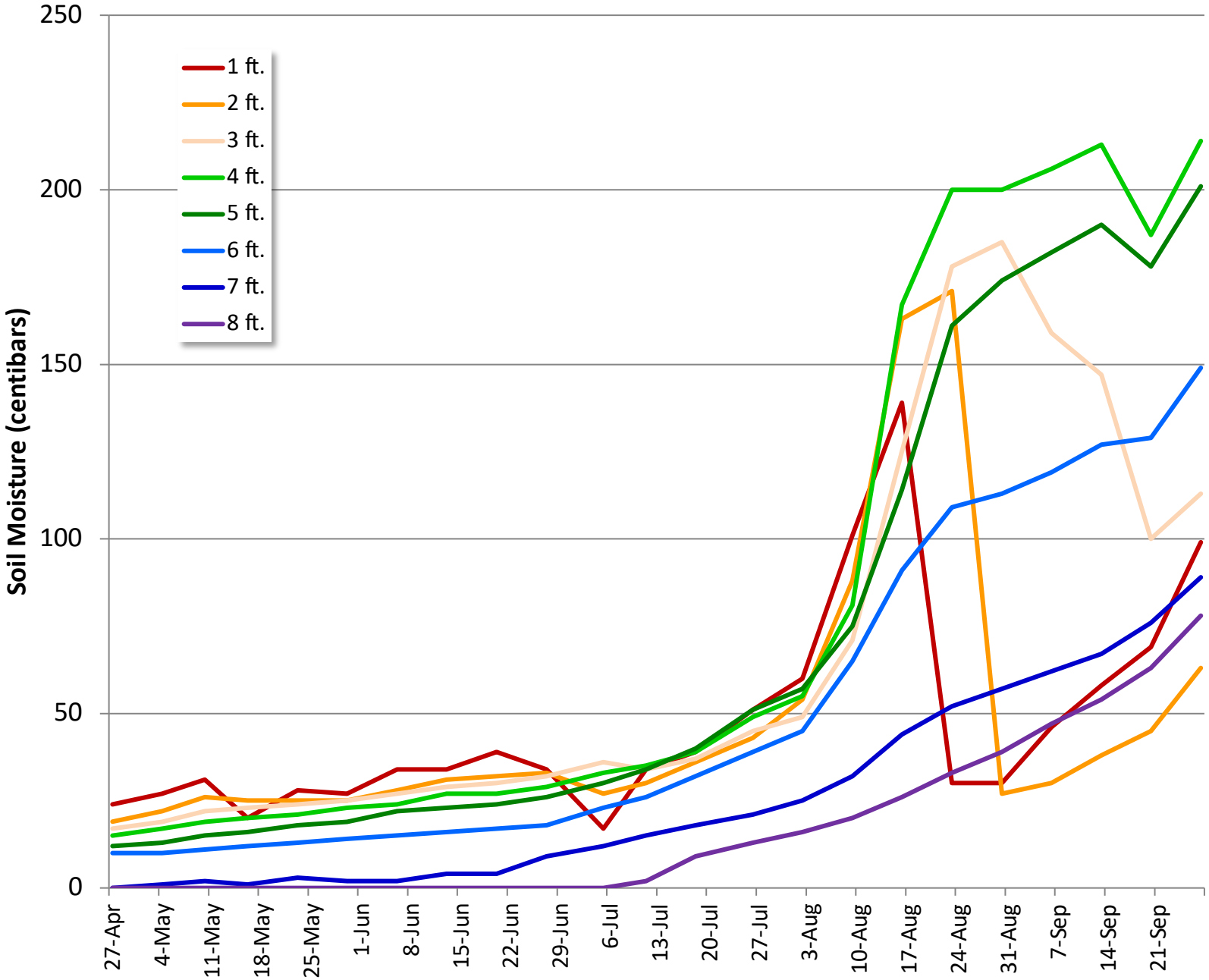
Grower 4 Location 1



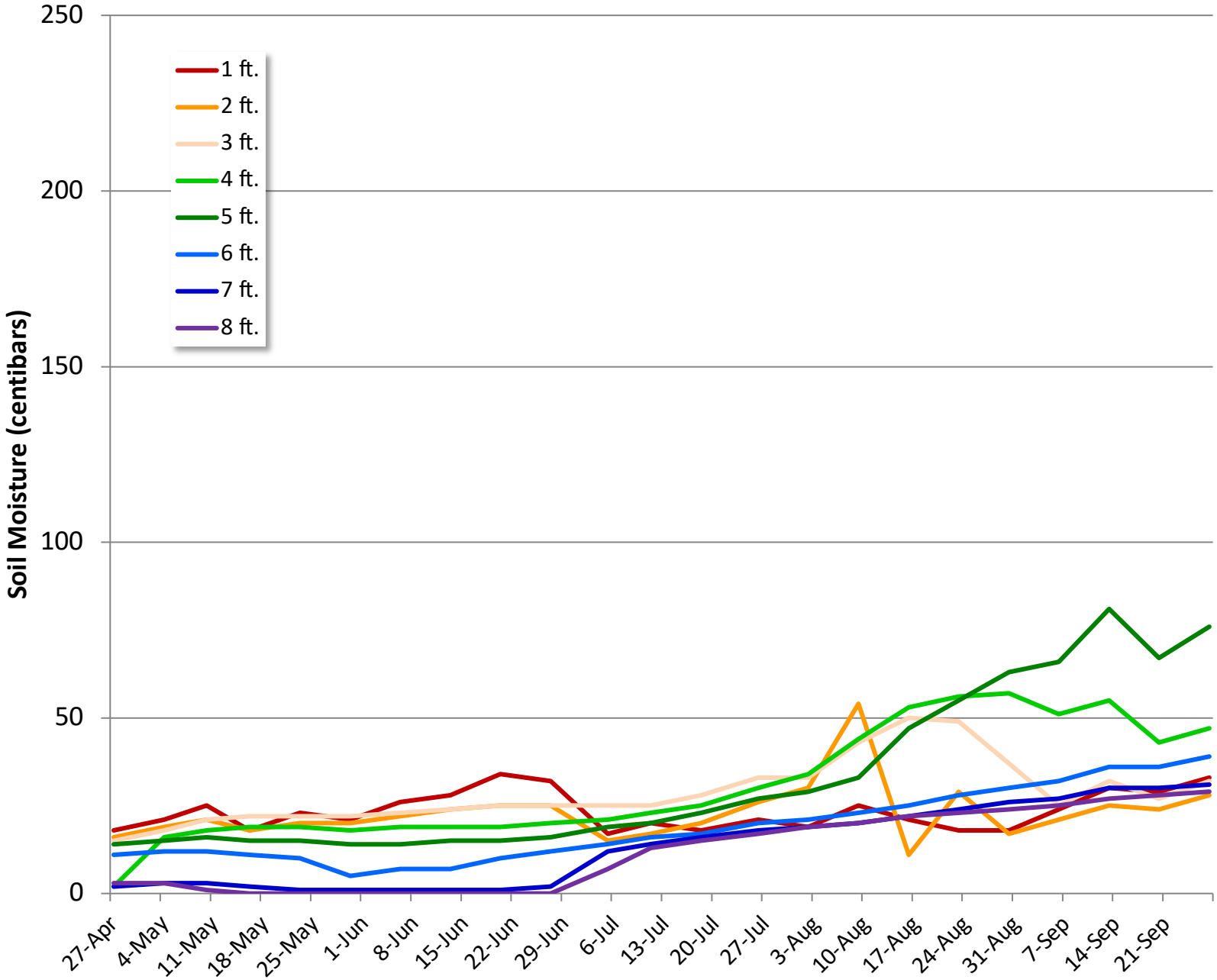
Grower 4 Location 2



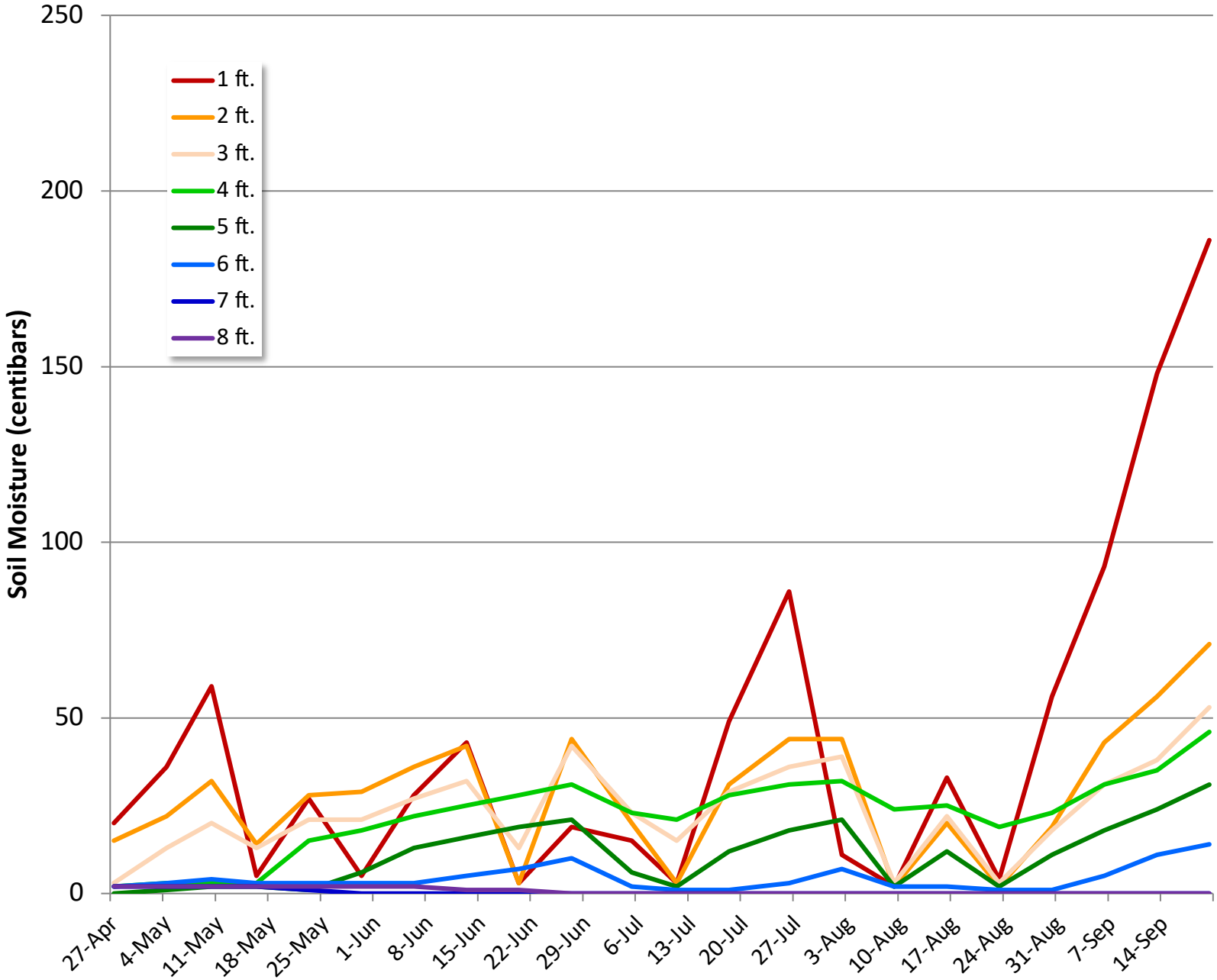
Grower 5 Location 1



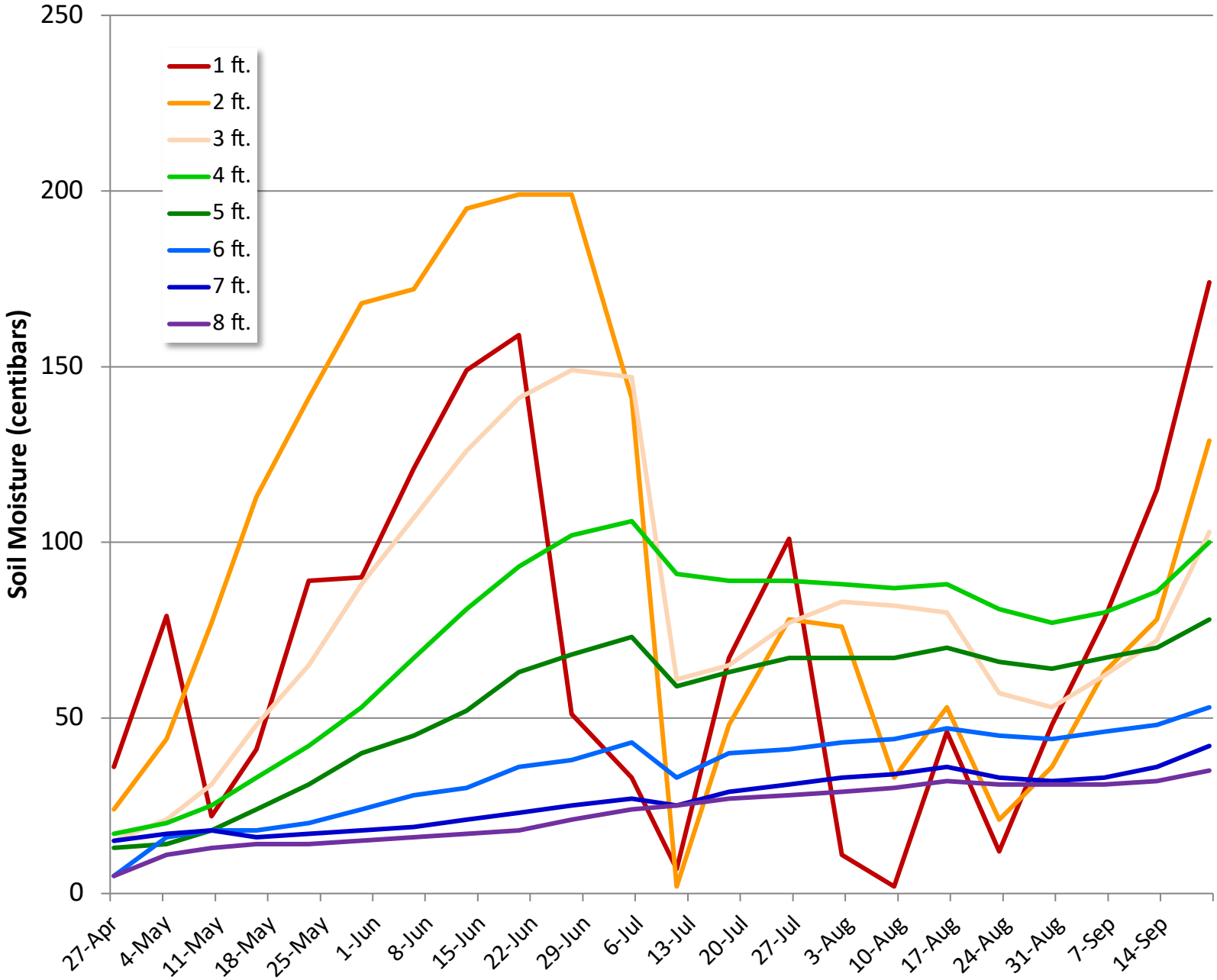
Grower 5 Location 2



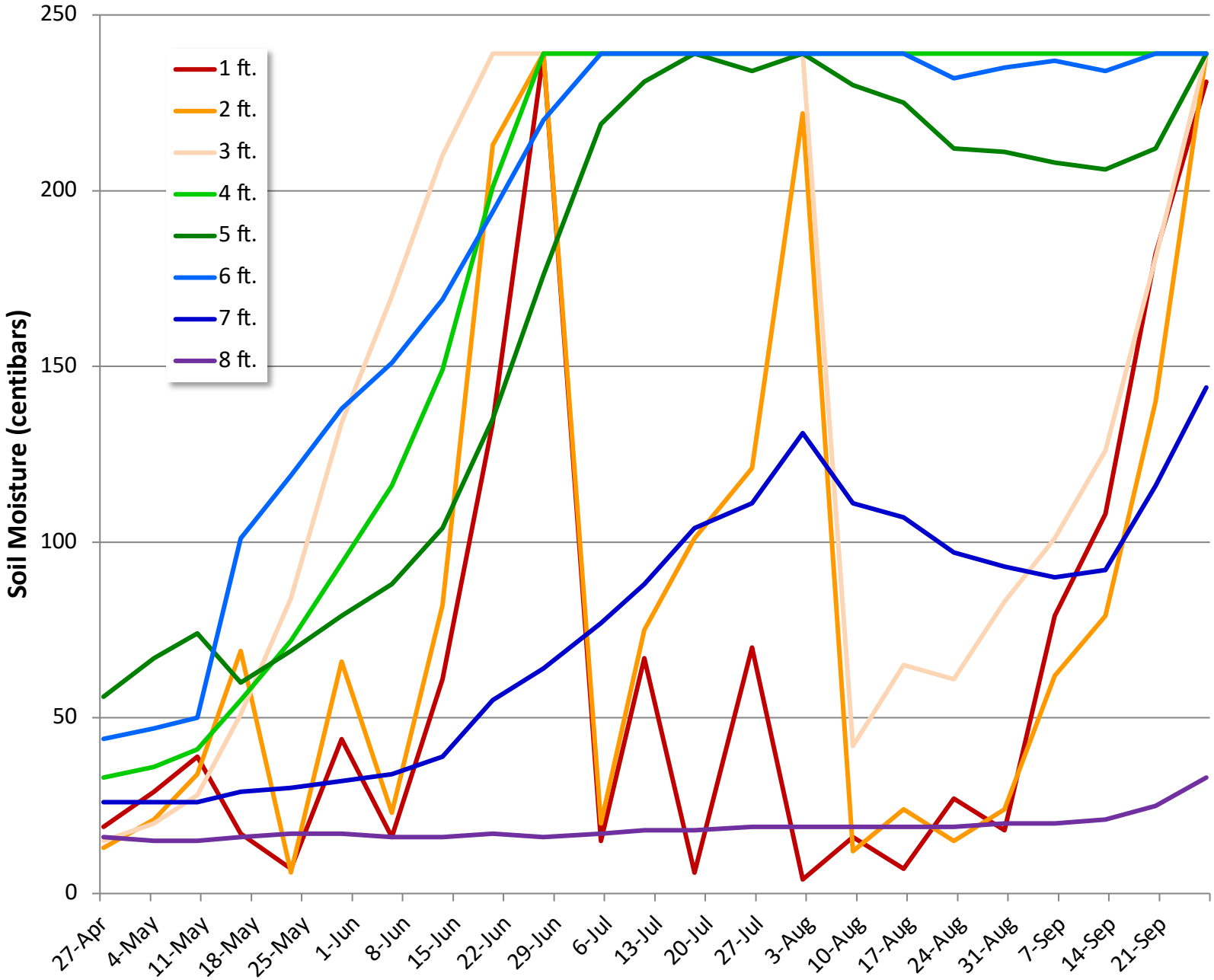
Grower 6 Location 1



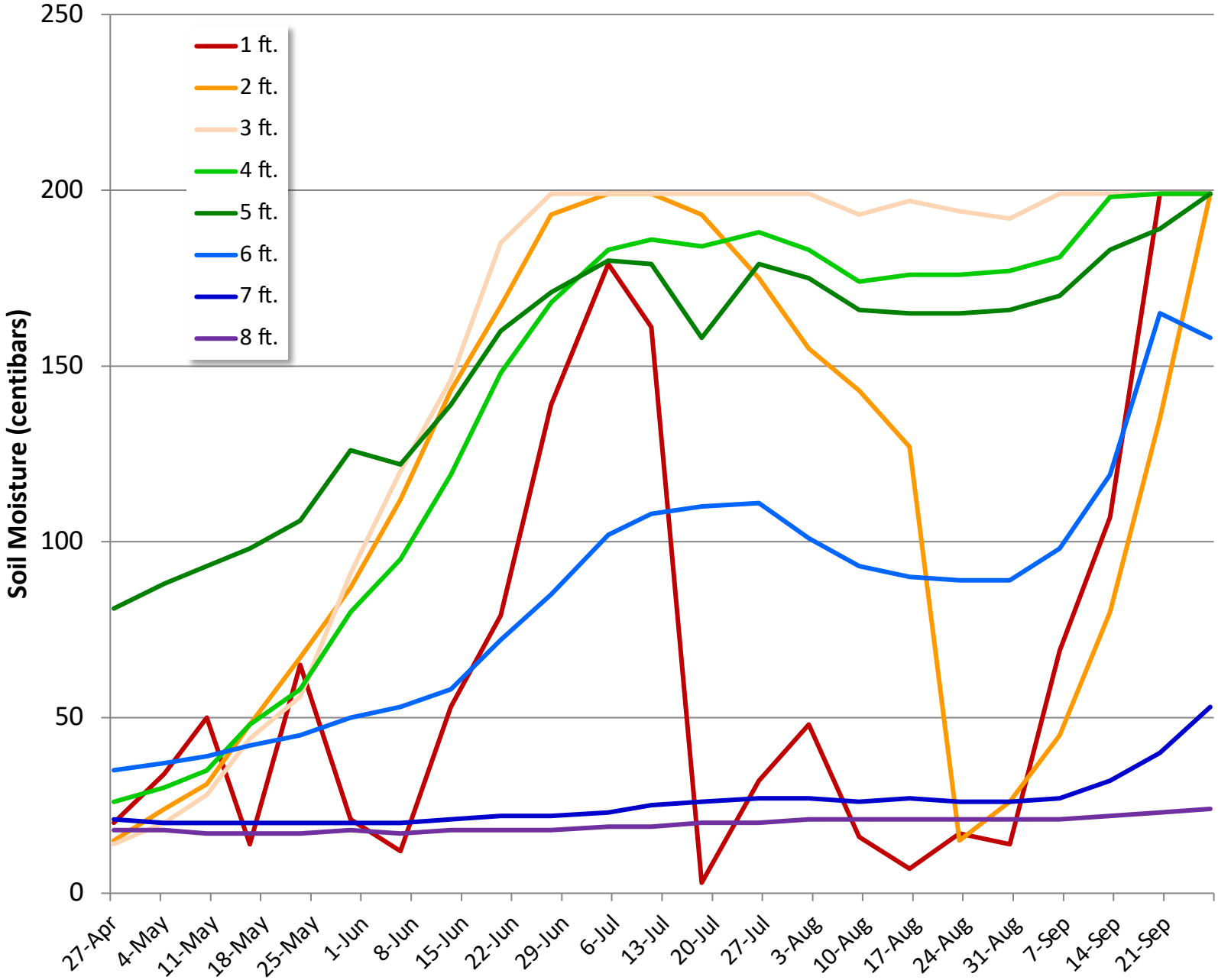
Grower 6 Location 2



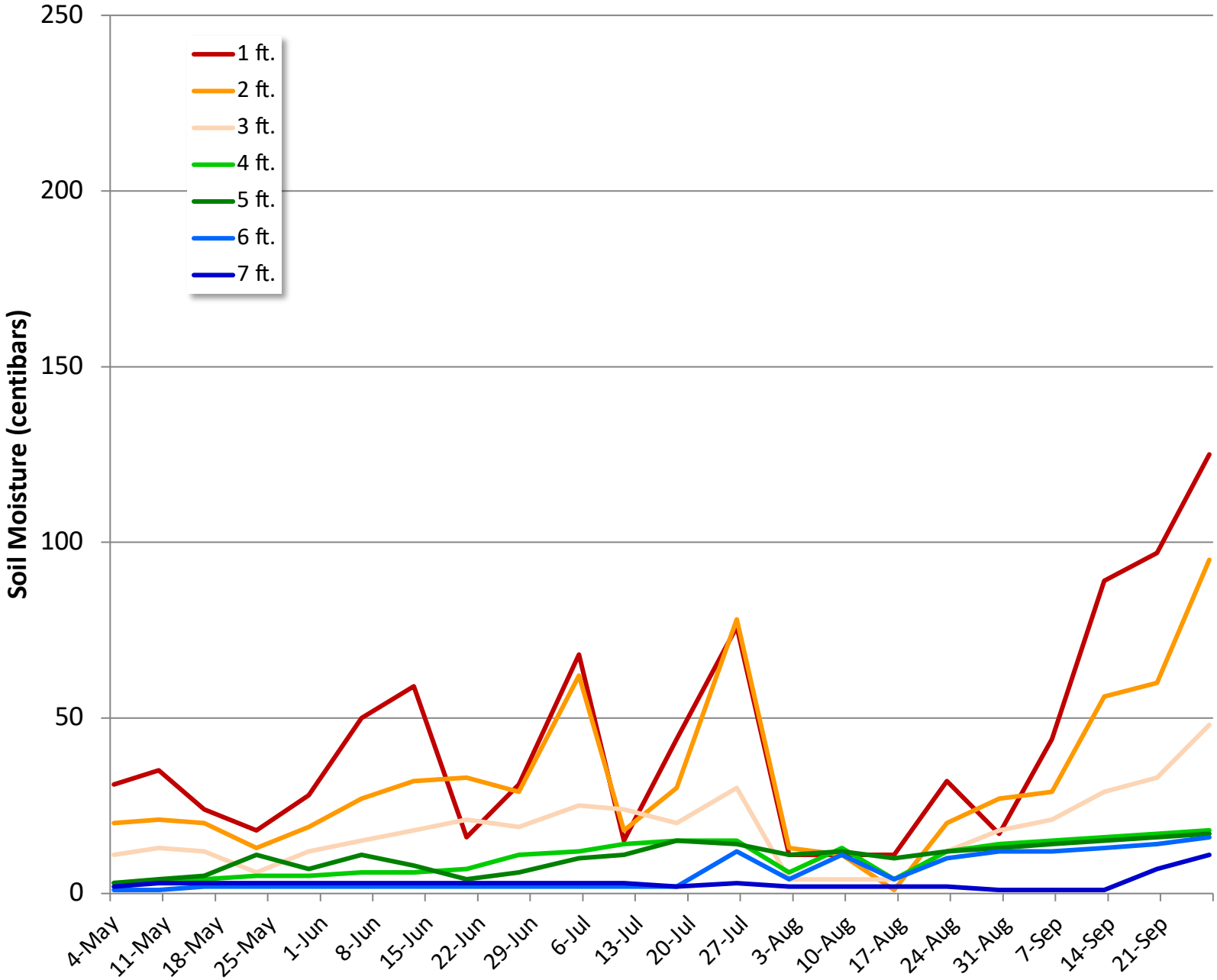
Grower 7 Location 1



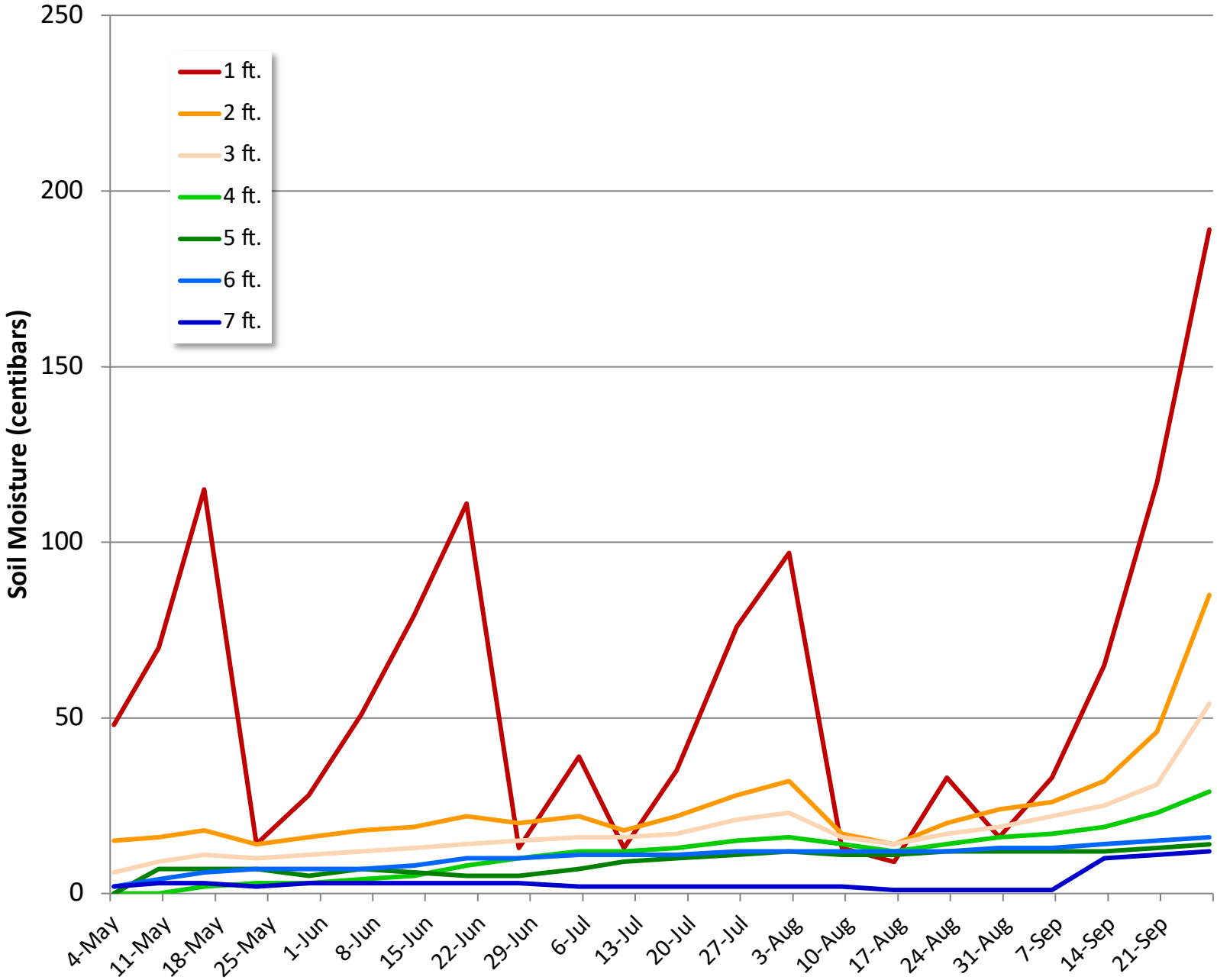
Grower 7 Location 2

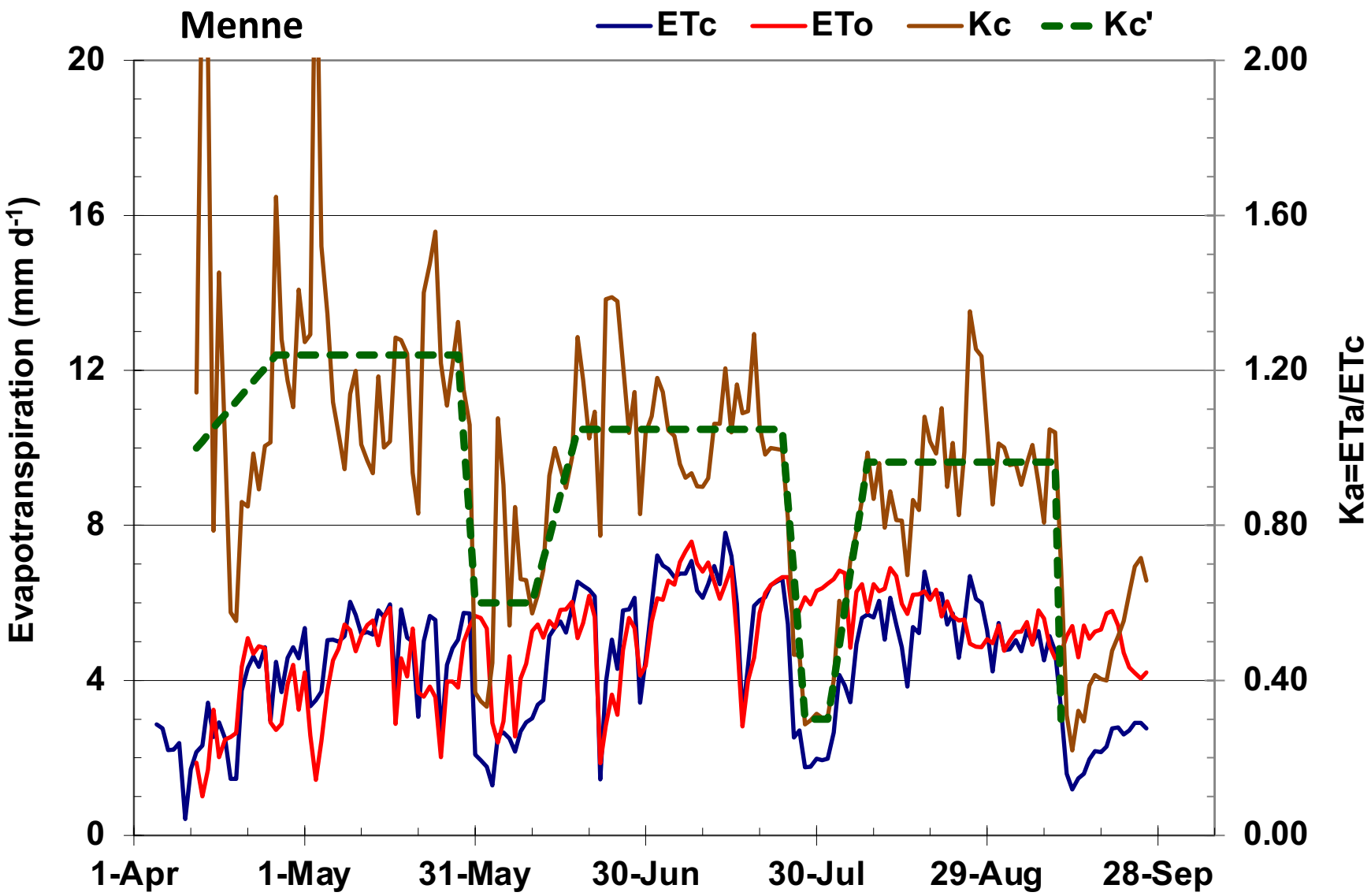


Grower 8 Location 1

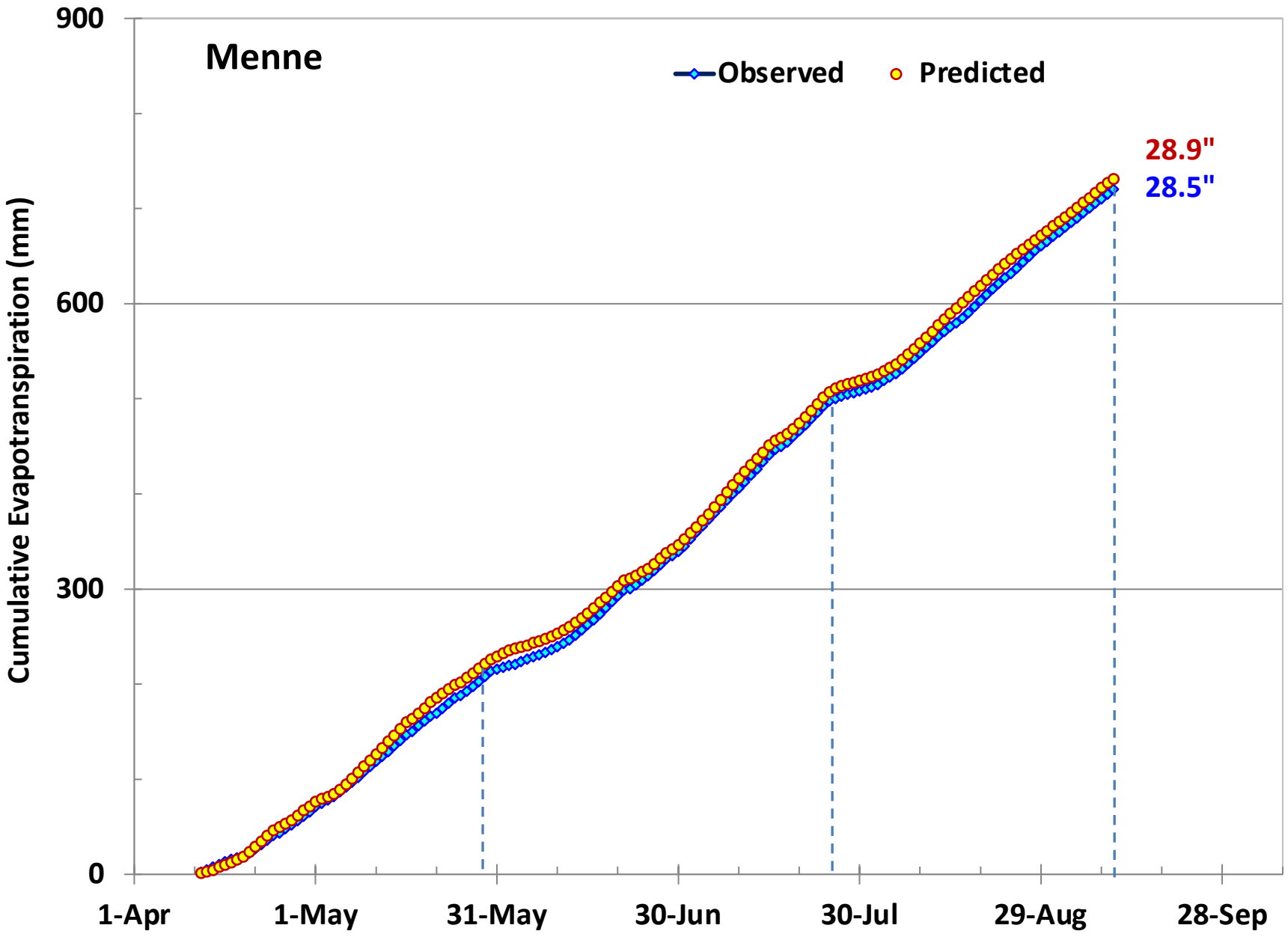


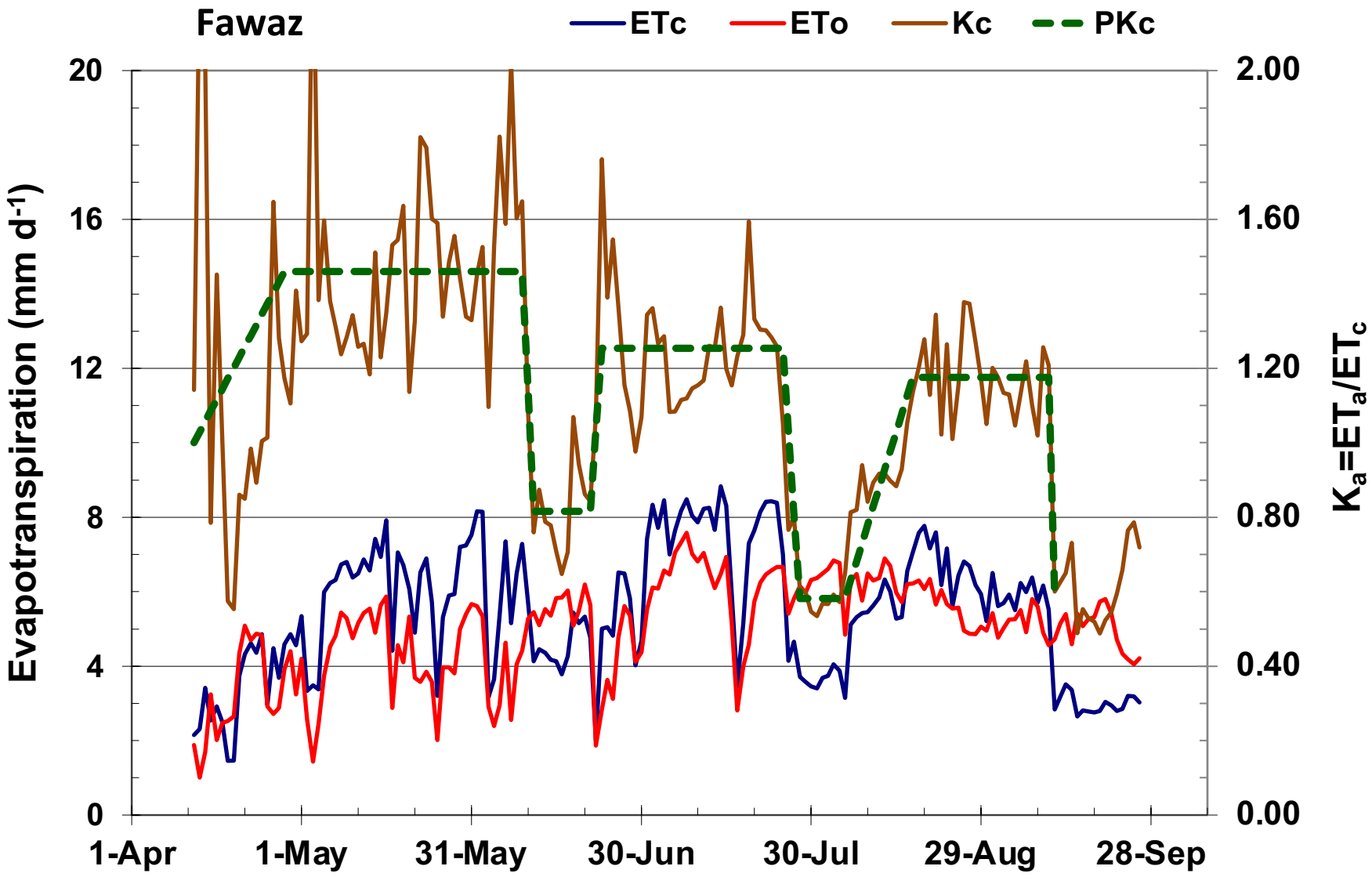
Grower 8 Location 2



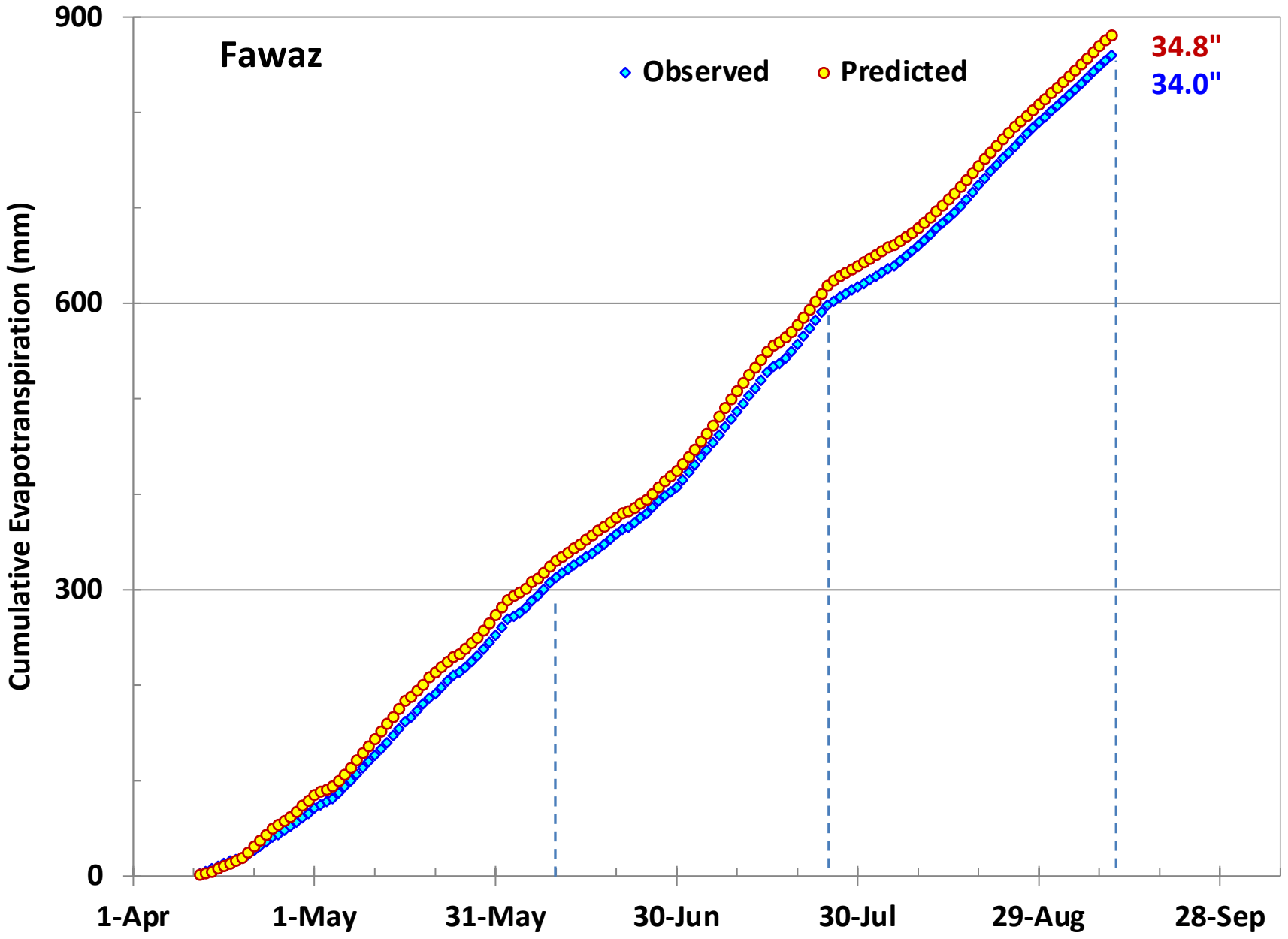

Menne
ETc
ETo
Kc
Kc'
Evapotranspiration (mm d-1)
Ka=ETa/ETc
20
16
12
8
4
0
2.00
1.60
1.20
0.80
0.40
0.00
1-Apr
1-May
31-May
30-Jun
30-Jul
29-Aug
28-Sep

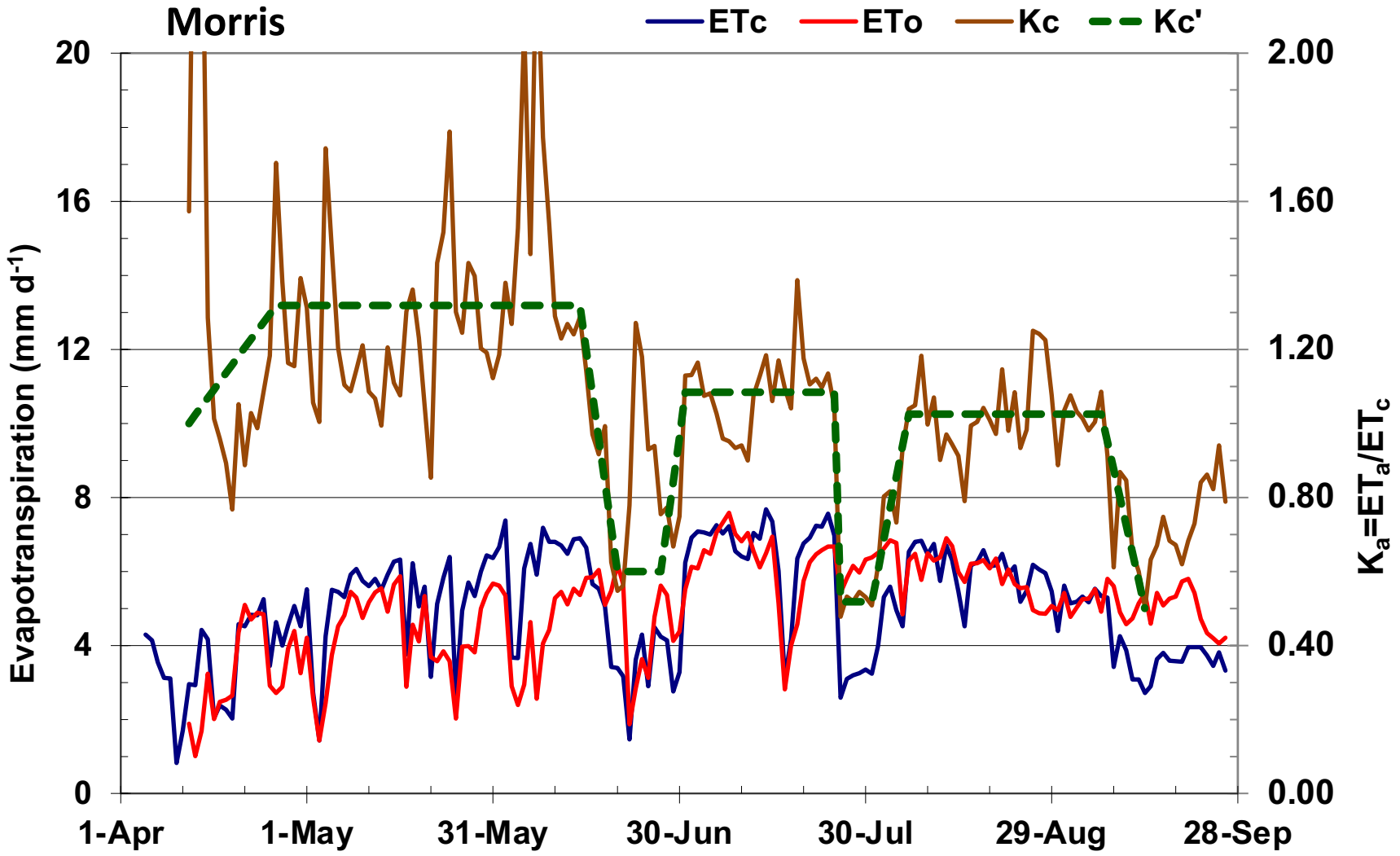
Cumulative Seasonal ET (Grower 1)



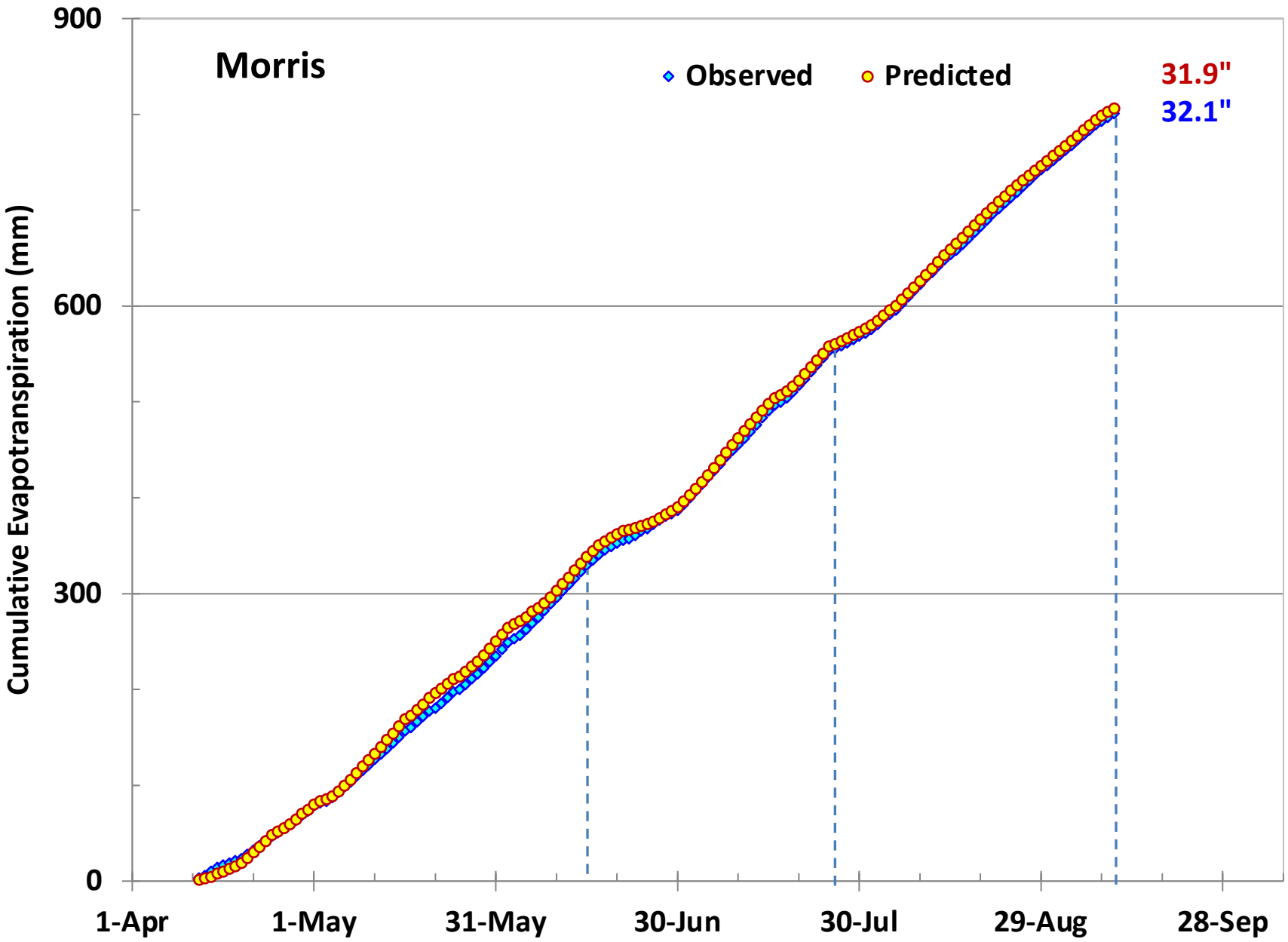

Fawaz
ETc
ETo
Kc
PKc
Evapotranspiration (mm d-1)
Ka=ETa/ETc
20
16
12
8
4
0
2.00
1.60
1.20
0.80
0.40
0.00
1-Apr
1-May
31-May
30-Jun
30-Jul
29-Aug
28-Sep

Cumulative Seasonal ET (Grower 5)

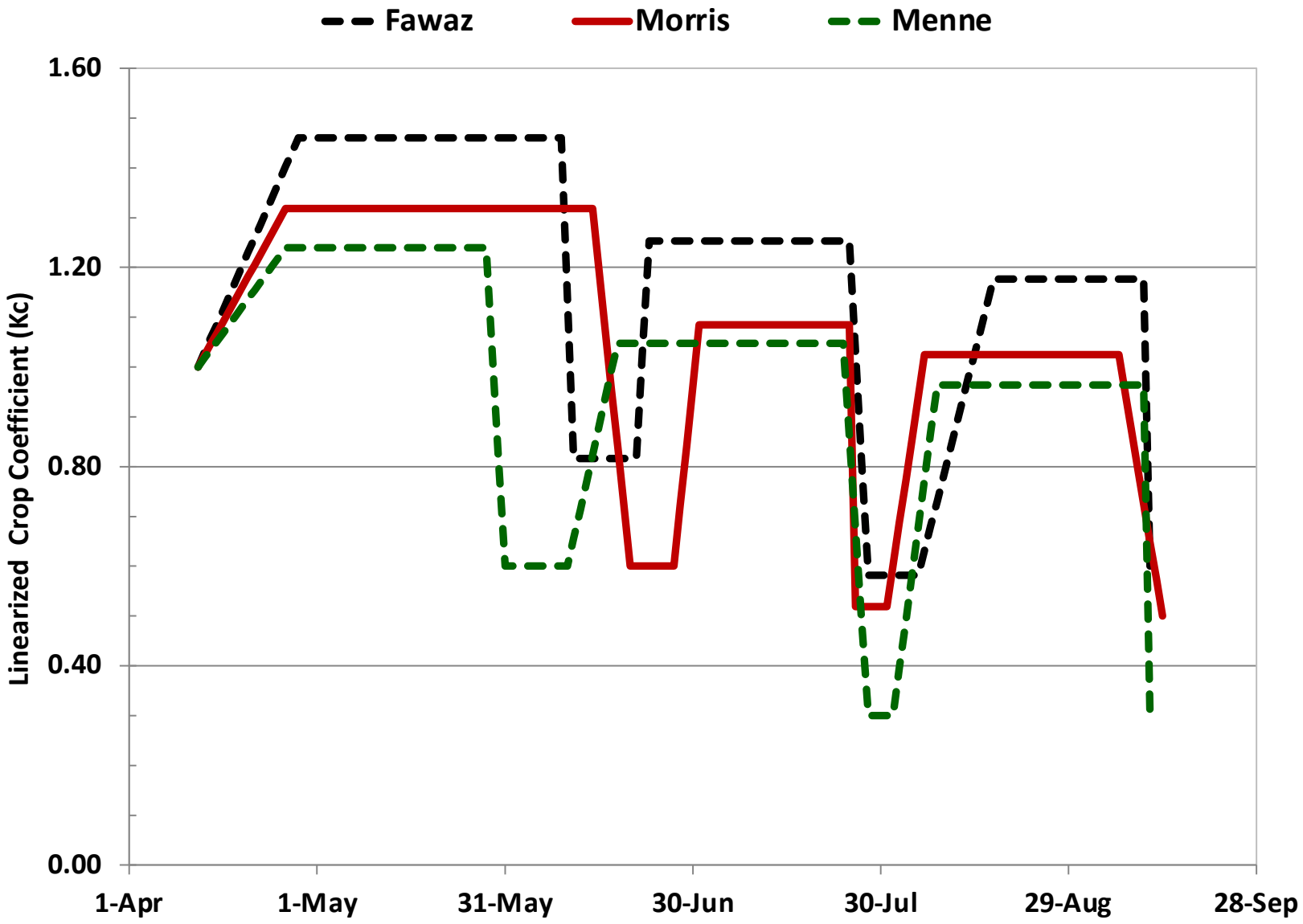



Morris
ETc
ETo
Kc
Kc'
Evapotranspiration (mm d-1)
Ka=ETa/ETc
20
16
12
8
4
0
2.00
1.60
1.20
0.80
0.40
0.00
1-Apr
1-May
31-May
30-Jun
30-Jul
29-Aug
28-Sep

Cumulative Seasonal ET (Grower 7)



Crop Coefficients for the Different Study Sites



Seasonal ET Data

	Measured		Plus One Month (4")	
	Observed Season Total ET (inches)	Kc Predicted Season Total ET (inches)	Observed Season Total ET (inches)	Kc Predicted Season Total ET (inches)
Fawaz	34.0	34.8	38.0	38.8
Morris	31.9	32.1	35.9	36.1
Menne	28.5	28.9	32.5	32.9

Seasonal ET Data

	Plus One Month (4")		
	Observed Season Total ET (inches)	Irrigation Required (inches)	Applied Water (inches)
Fawaz	38.0	35.3	37.41*
Morris	35.9	29.3	20.36
Menne	32.5	28.8	18.45

Assumed 0.85% irrigation efficiency
Assumed 3 inches of effective rainfall (need to look at actual)