Horticultural Responses to a Wet Season:

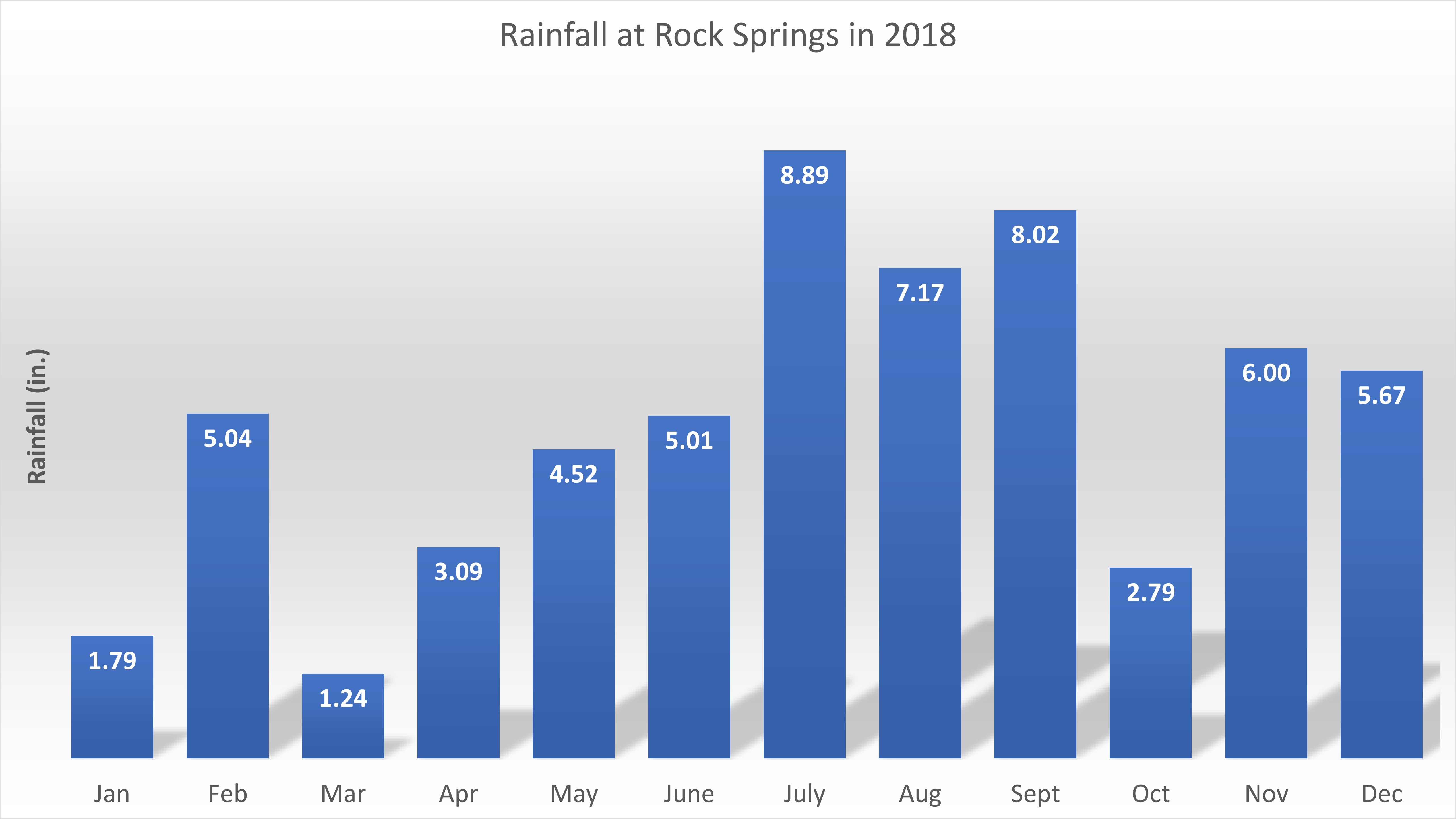
Herbicide, Nutrient & Tree Management Strategies

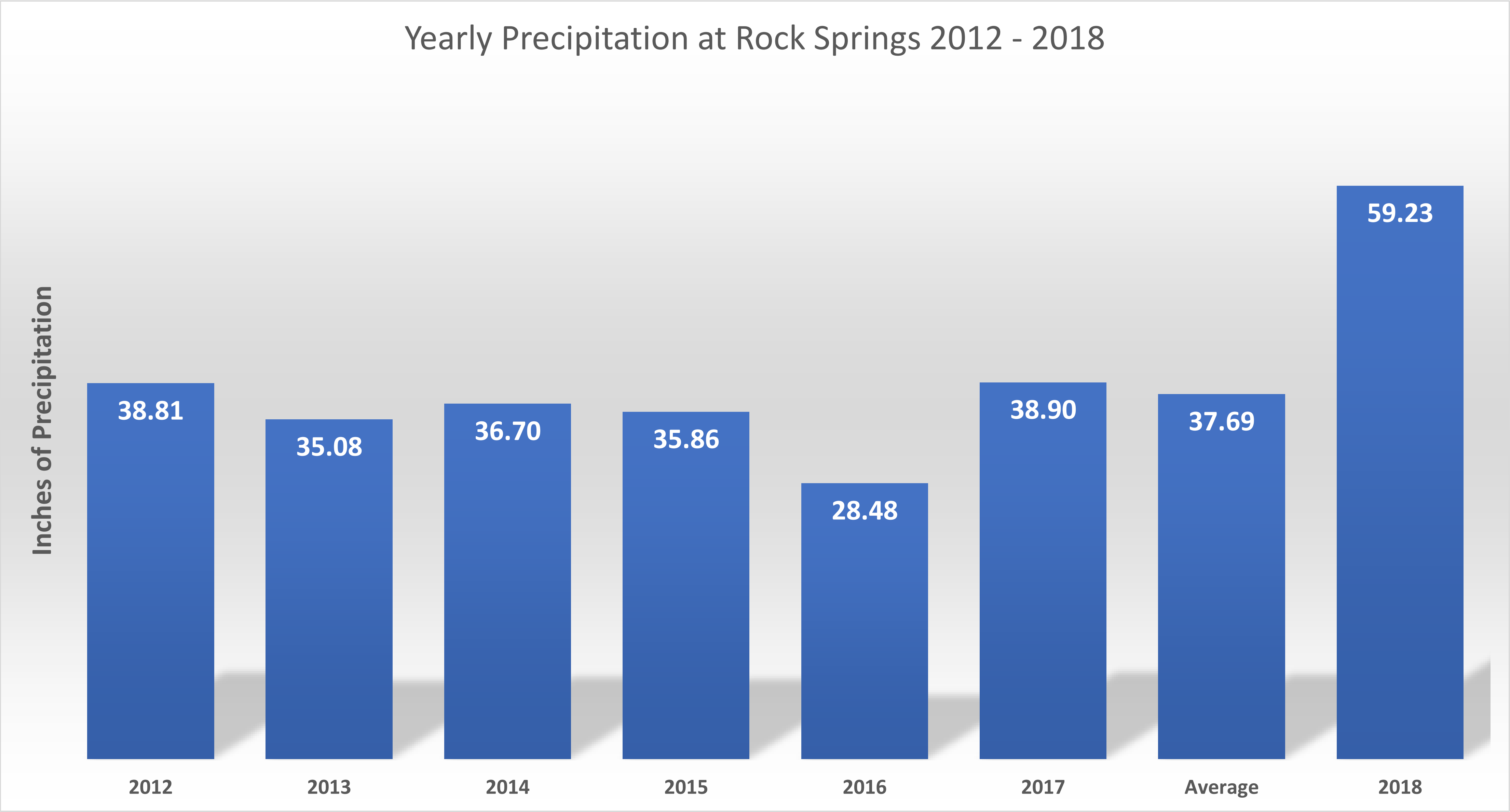
2018 Monthly Precipitation Across PA NEWA Stations

Month	Biglerville	Piney Mountain	York Springs	Rock Springs	Lewisburg	Middletow n	New Paris	Allentown	Reading	Erie	Scott Twnshp	Pittsburgh
Jan	4.48	3.11	3.55	1.79	2.30	4.00	1.44	4.91	3.20	2.28	2.35	3.60
Feb	4.20	4.88	5.02	5.04	3.79	5.44	5.59	5.50	5.53	3.26	3.34	7.10
March	0.94	1.85	2.12	1.24	1.78	2.97	2.28	3.23	2.34	3.75	1.20	2.74
April	4.68	4.84	4.22	3.09	3.48	3.98	3.92	3.69	3.70	3.43	3.65	4.17
May	5.11	5.26	5.49	4.52	4.88	5.71	4.33	4.89	4.18	3.35	5.74	2.83
June	3.86	5.13	4.49	5.01	3.57	3.99	7.21	2.58	4.28	3.98	4.16	5.11
July	7.64	10.78	11.42	8.89	9.31	12.09	3.97	5.80	6.13	2.46	6.59	3.96
Aug.	5.86	5.03	6.35	7.17	6.32	5.28	3.44	12.21	14.81	4.87	9.03	4.53
Sept.	9.73	10.13	10.20	8.02	8.70	6.81	9.69	6.65	8.03	4.37	7.59	8.50
Oct.	4.06	2.69	2.80	2.79	3.30	2.39	4.71	3.25	2.01	6.48	4.36	3.59
Nov.	6.73	7.56	7.87	6.00	4.85	8.46	4.53	9.58	7.83	5.12	5.19	4.40
Dec	6.21	6.95	6.42	5.67	5.03	5.70	5.06	6.24	4.51	3.35	3.05	4.97

Total Precipitation in 2018 from PA NEWA Weather Stations

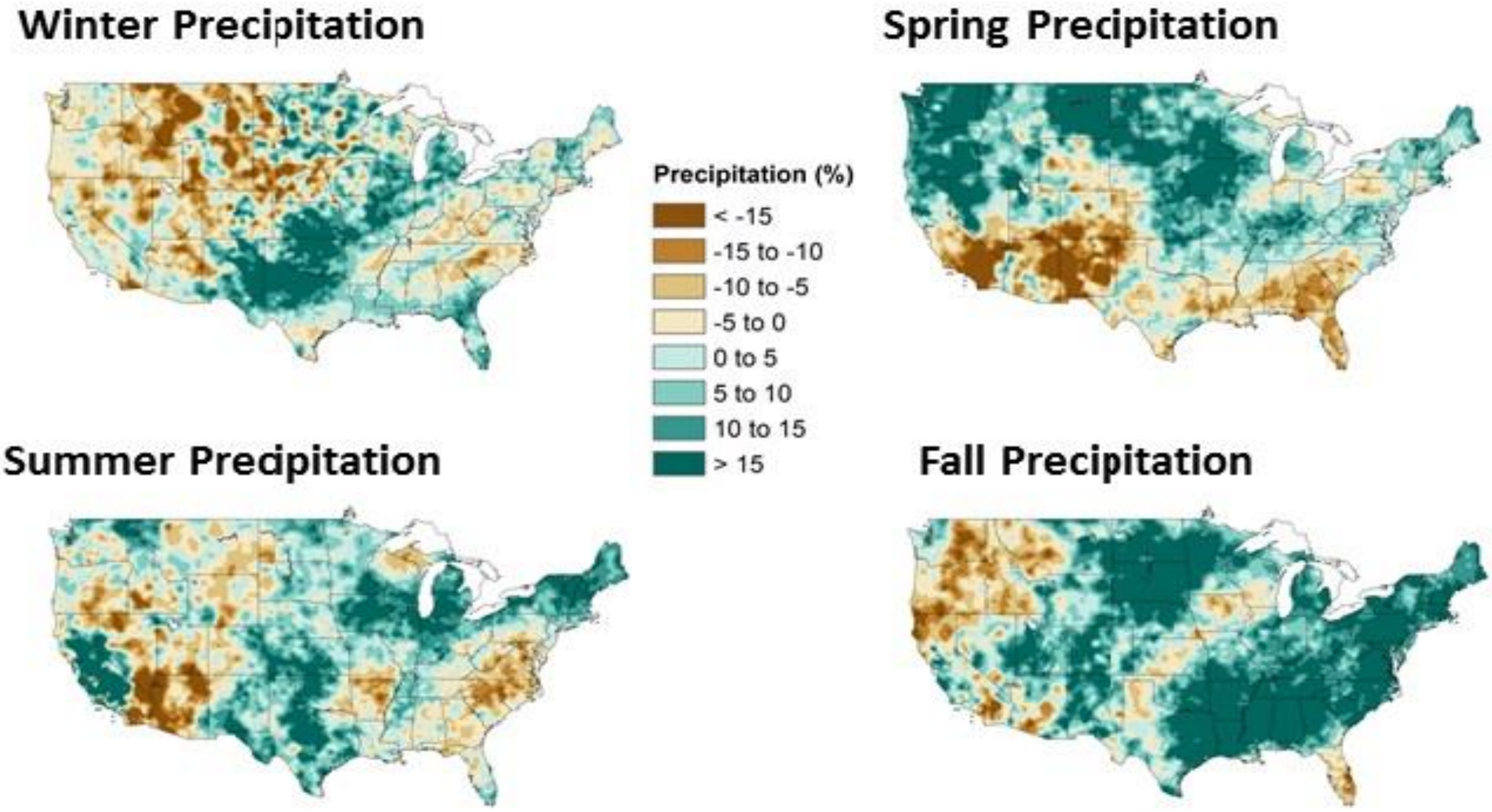
	Biglerville	Piney Mountain	York Springs	Rock Springs	Lewisburg	Middletwn	New Paris	Allentwn	Reading	Erie	Scott Twnshp	Pittsburgh
Total	63.50	68.21	69.95	59.23	57.31	66.82	56.17	68.53	66.55	46.70	56.25	55.50


Rainfall at Rock Springs in 2018
Rainfall (in.)
1.79
5.04
1.24
3.09
4.52
5.01
8.89
7.17
8.02
2.79
6.00
5.67
Jan
Feb
Mar
Apr
May
June
July
Aug
Sept
Oct
Nov
Dec


Yearly Precipitation at Rock Springs 2012 - 2018
Inches of Precipitation
38.81
35.08
36.70
35.86
28.48
38.90
37.69
59.23
2012
2013
2014
2015
2016
2017
Average
2018

Wet Season Issues

- Leaching
  - Herbicides
  - Nutrients
- Fruit Growth & Quality
  - Carbohydrates and Thinning
  - Fruit sugar levels
- Future Plantings



from 2017 Climate Science Report

https://science2017.globalchange.gov/chapter/7/

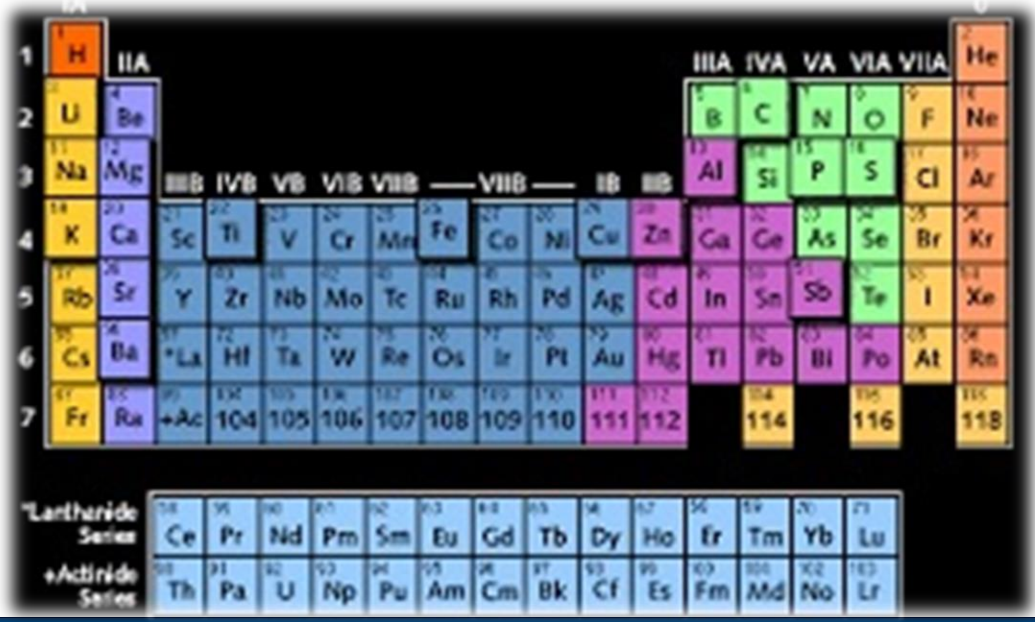
Leaching

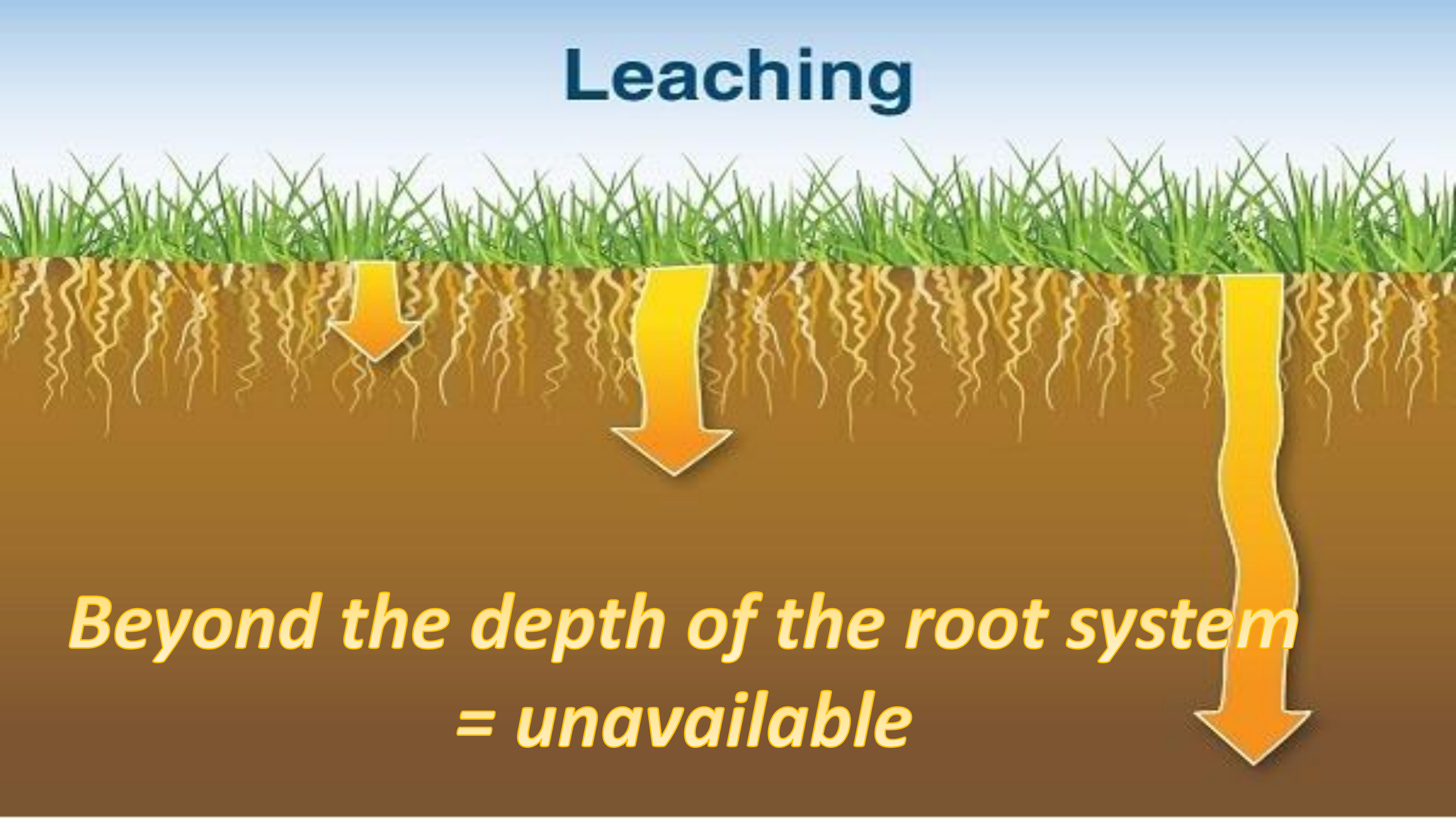
- The downward movement of dissolved nutrients/herbicides in the soil profile with percolating water

[Image from: https://criticalzone.org/national/blogs/post/what-is-leaching/](https://criticalzone.org/national/blogs/post/what-is-leaching/)

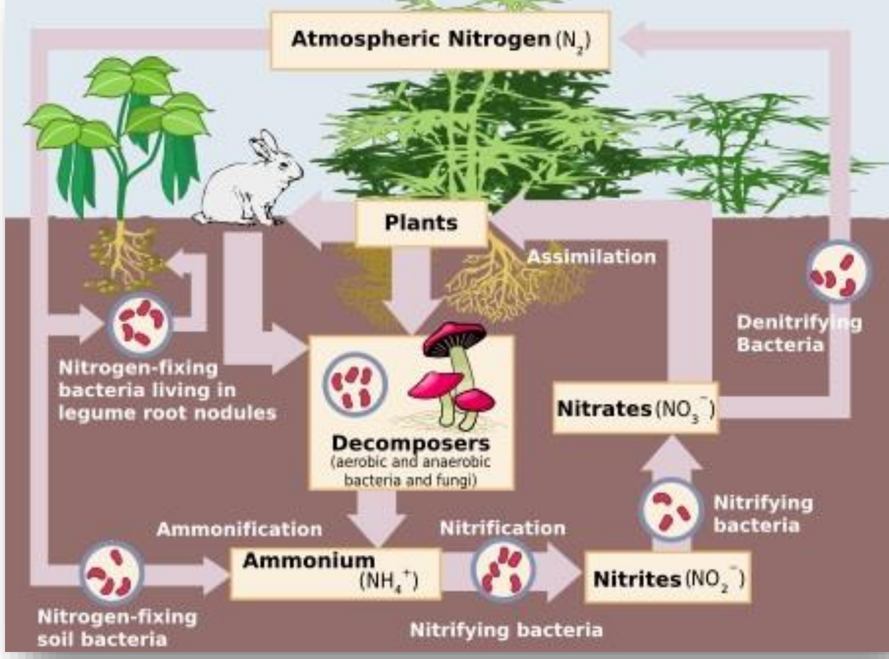
Susceptibility of Nutrients to Leaching

- Anions
  - Nitrate (NO_3^-)
  - Sulfur (SO_4^{-2})
- Cations in sandy or coarse soils
  - Calcium (Ca^{+2})
  - Magnesium (Mg^{+2})
- Micronutrients
  - Boron
  - Manganese




Leaching
Beyond the depth of the root system
= unavailable

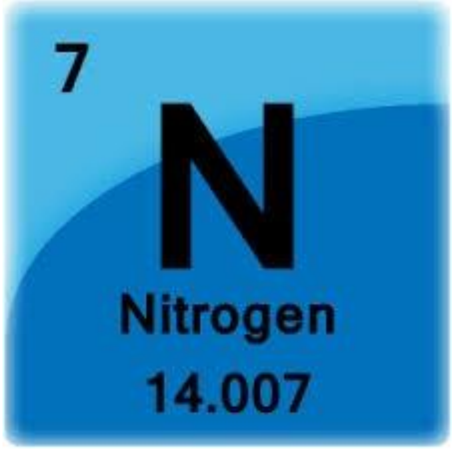
Saturated Soils



N Cycle

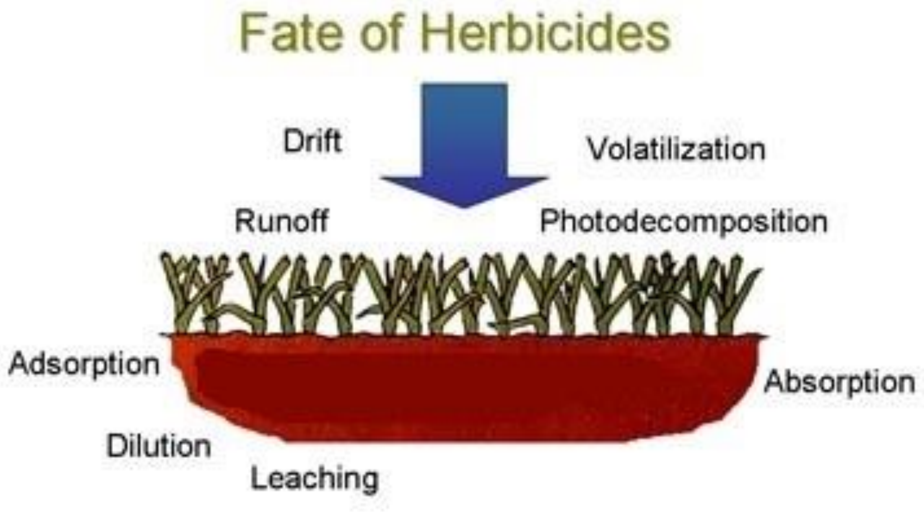
- Reduction in nitrification in waterlogged soils
- Nitrogen losses from soil can occur when rainfall exceeds transpiration
  - Occurs more often under high intensity rains
- Nitrogen is more often lost due to subsurface leaching than to runoff
- Nitrogen leaching losses account for ~30% of mineral N fertilizer
- Mulching/Sod strips can reduce N loss through greater recycling

Considerations for Nutrient Leaching



- % Organic matter in soil (Orchards often <3%)
- Ground Management System (GMS)
  - Impact on soil microbiology
- Splitting fertilizer applications
  - One before flowering and one after fruit set (especially with stone fruits)
  - 1/3 before bloom, 1/3 after fruit set, 1/3 postharvest
- Micronutrient foliar sprays
  - Annual applications of B & Zn
  - Postharvest or early spring

Fate of Herbicides



- Chemical degradation and photodecomposition
  - Hydrolysis, oxidation, reduction, photodecomposition
- Living rhizosphere – microbial decomposition
  - Bacteria, fungi, algae, invertebrates other microorganisms
- Volatilization and evaporation
  - Increases with temperature, vapor pressure and wind movement
- Plant uptake and metabolism
  - By roots shoots or leaves
  - *Majority of weed seedlings germinate in top 2-3 inches of soil*

Characteristics of Herbicides Impacting leaching

- Solubility – high solubility - > more leaching
- A**d**sorbency – stronger binding to soil - > less leaching/loss
- Persistence – quick degradation by sunlight or microbes
  - Moist soils favor high microbial populations - > greater breakdown
- Formulation – granular materials more susceptible
  - e. g. Casoron

Moisture Levels to Move Herbicide into Soil to Achieve Optimum Level of Control

Relative Moisture to Activate	Solubility of Herbicide (ppm)	Estimated Water to Activate (inches)
Low	> 500 ppm (very soluble)	0.33
Medium	250 – 500	0.33 – 0.5
High	100 – 250	0.5 – 0.75
Very High	< 100	> 0.75

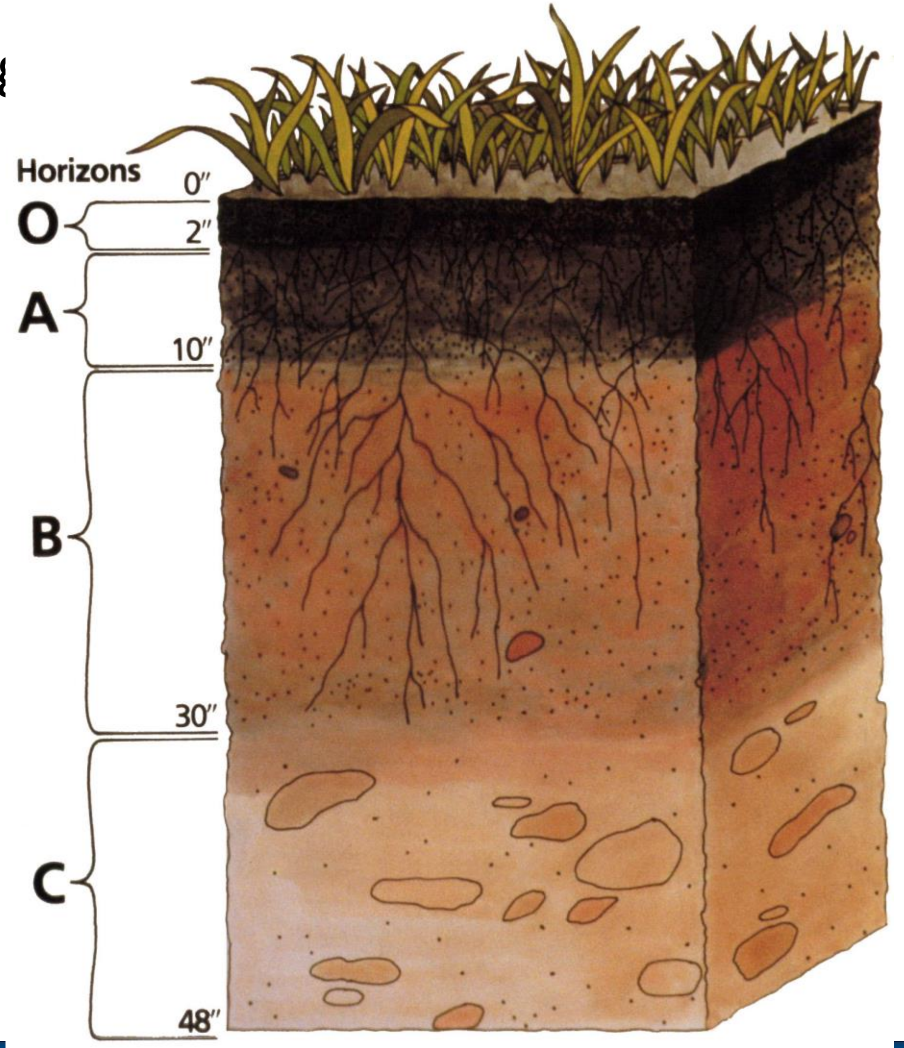
Soil factors affecting herbicide ***persistence***

- Soil Composition
  - High in clay, %OM or both favor retention and less leaching
  - May also be less effective
- Soil pH impact chemical & microbial breakdown;
  - rimsulfuron, halosulfuron-methyl
    - ≥ 7.0; may persist longer
    - ≤ 6.0; may degrade faster
- Soil microbial population
  - Warm, moist, well-aerated fertile soil favors soil microbes

Solicam runoff in orchard

Characteristics of soil that impact runoff

- Organic matter
  - High OM – less runoff, more surface area for bindin
- Slope
- Soil texture
  - Coarse texture –> more runoff
  - Clays – less runoff
- Structure
  - Compacted soil –> more runoff
- Water content
  - Saturate soils - > more runoff



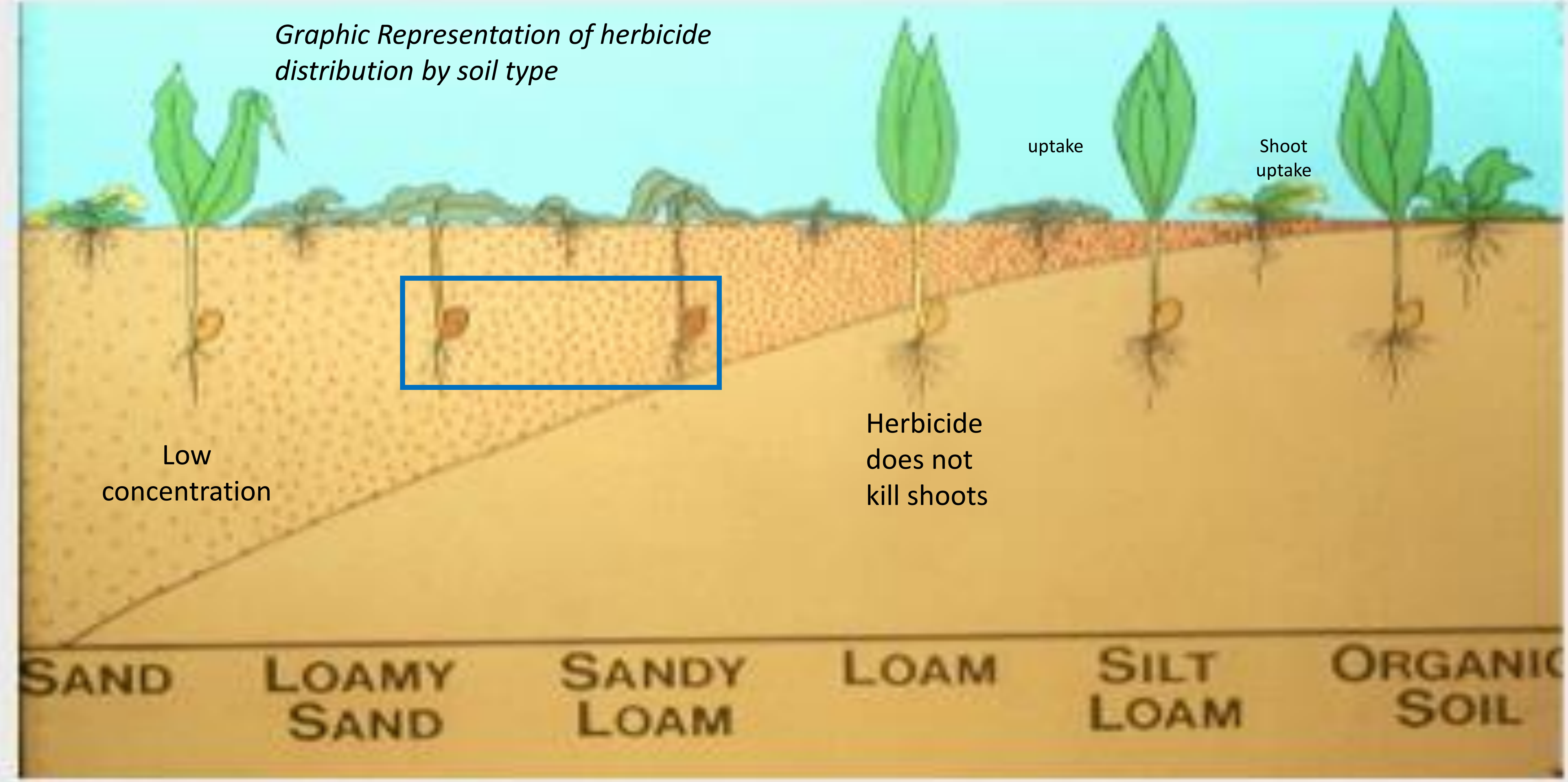


Figure 3. Schematic drawing of herbicide movement in soil (red dots) based on soil texture. Herbicide movement is greater in sand compared to silt loam or high organic matter soils. (Image source: Steve Dewey, retired, Utah State University)

https://www.techlinenews.com/herbicides/2015/environmental-factors

Chemical	Product	Solubility (ppm)	K_{oc} Sorption Index	WSSA Group	Leaching Potential	Soil half life (days)
2,4-D	Formula 40, etc.	900	61.7	4	Some	10
carfentrazone-ethyl	Aim	12000	3.36	14	None	0
clopyralid	Stinger, Spur, etc	1000	6 to 60	4	Moderate	40
clethodim	Select, Arrow, etc.	NA		1	NA	3
diclobenil	Casaron	20.5	400		Low	60
diuron	Karmex, Diuron, etc.	42		7	Moderate except in low OM & clay soils	90
fluazifop-P	Fusilade	1.1		1	Low	15
flumioxazin	Chateau, Tuscany, etc.	2		14	Low	20
fluroxypyr	Starane Ultra	4000		4	Low	36
glufosinate	Rely, etc.	$>10^6$		10	High	7
glyphosate	RoundUp, etc	15000		9	V. Low	47
halosulfuron-methyl	Sandea	15		2	low to moderate	30
indaziflam	Alion	2040	>1000	29	NA	1500
isoxaben	Gallery, Trellis, etc	1.04	190-1270		High	60
mesotrione	Broadworks	2200	14-390	27	Low	21
norflurazon	Solicam	28	12	12	%OM & Clay, runoff	45
oryzalin	Surflan	3		3	Moderate	20
oxyflurofen	Goal, Goal Tender, etc.	0.1	100,000	14	Sands	35
paraquat	various	10^6 est.	10^6 est.		not	NA
pelargonic acid	Scythe	10		26	NA	NA
pendimethalin	Prowl H2O, Prowl, etc.	0.3	5000	3	not	44
penoxsulam	Pindar, etc.	410	104		High	5 to 16
pronamide	Kerb	15		3	low to moderate	60
pyraflufen-ethyl	Venue	<1		14	NA	60
rimsulfuron	Matrix, Pruvin, Solida, etc.	7300		2	Low	3
saflufenacil	Treeix	0.21	9 to 56	14	Very	17
sethoydim	Poast	4400	100	1	NA	7
simazine	Princep, Caliber 90	2	130	5	Moderate	60
sulfentrazone + carfentrazone	Zeus Prime XC	780 + 12,000	9.8 + 3.36	14	Moderate	120 + 0
terbacil	Sinbar	710	55	5	Moderate	120
trifluralin	Treflan	0.3	8765	3	Low	45

Solubility: Amount of herbicide that will dissolve in a specified amount of water. The higher the number the more herbicide in the soil solution and available to plant but can also be leached from effective zone of weed germination. The lower the number the more tightly the herbicide is bound to soil particles

Sorption Index (K_{oc}): Ratio of amount of herbicide adsorbed by soil to aamount in the soil solution. Low sorption index means greater amount of herbicide is in soil solution and less is held onto soil particles, i.e. greater likelihood of leaching

Half-life: Period of time it takes for 50% of a herbicide in soil to degrade by sunlight, microbial action or plant absorption

Go to: Handout on Herbicide Characteristics

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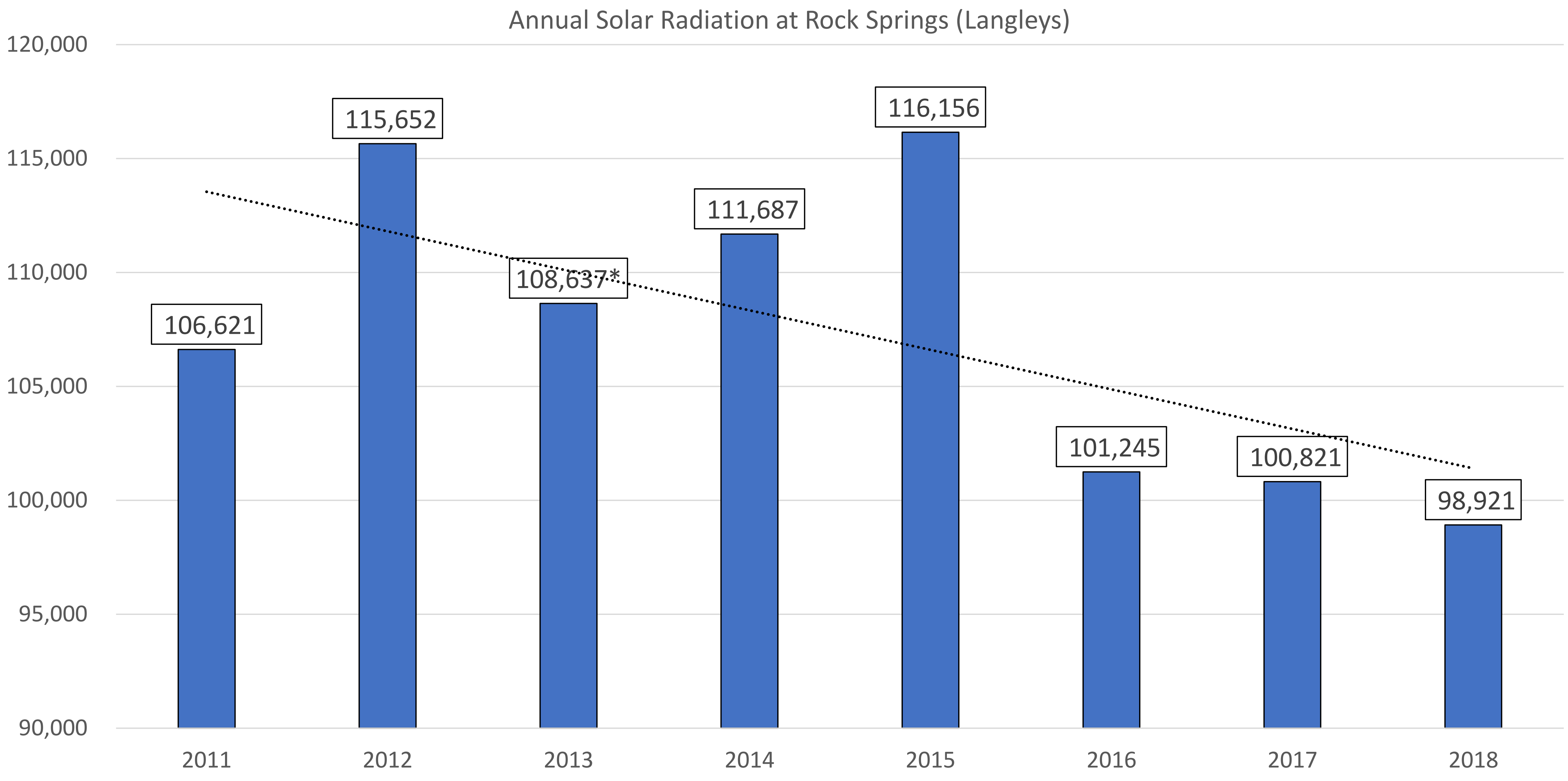
Predicted future impacts

- **Increased herbicide degradation due to higher temperatures along with increased leaching of materials into the ground water due to higher rainfall**
  - ***from: Science of the Total Environment 514:239***

  - **How many made herbicide application this past fall?**
  - ***2018 Fall applied herbicides may not be as effective due to late season rain fall***

- Fruit Growth & Quality
  - Carbohydrates and Thinning
  - Fruit sugar levels



*Jan & Feb 2013 estimated

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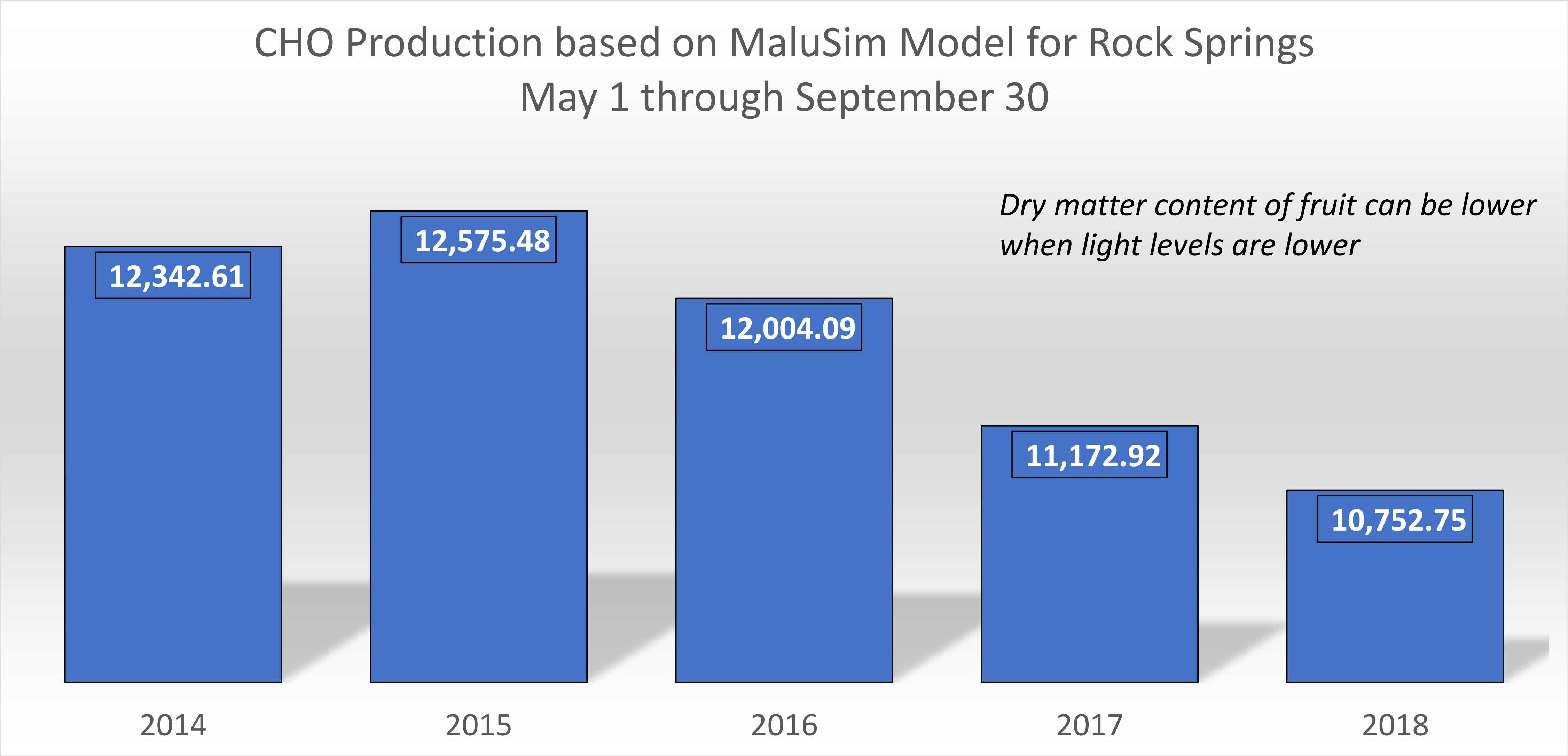
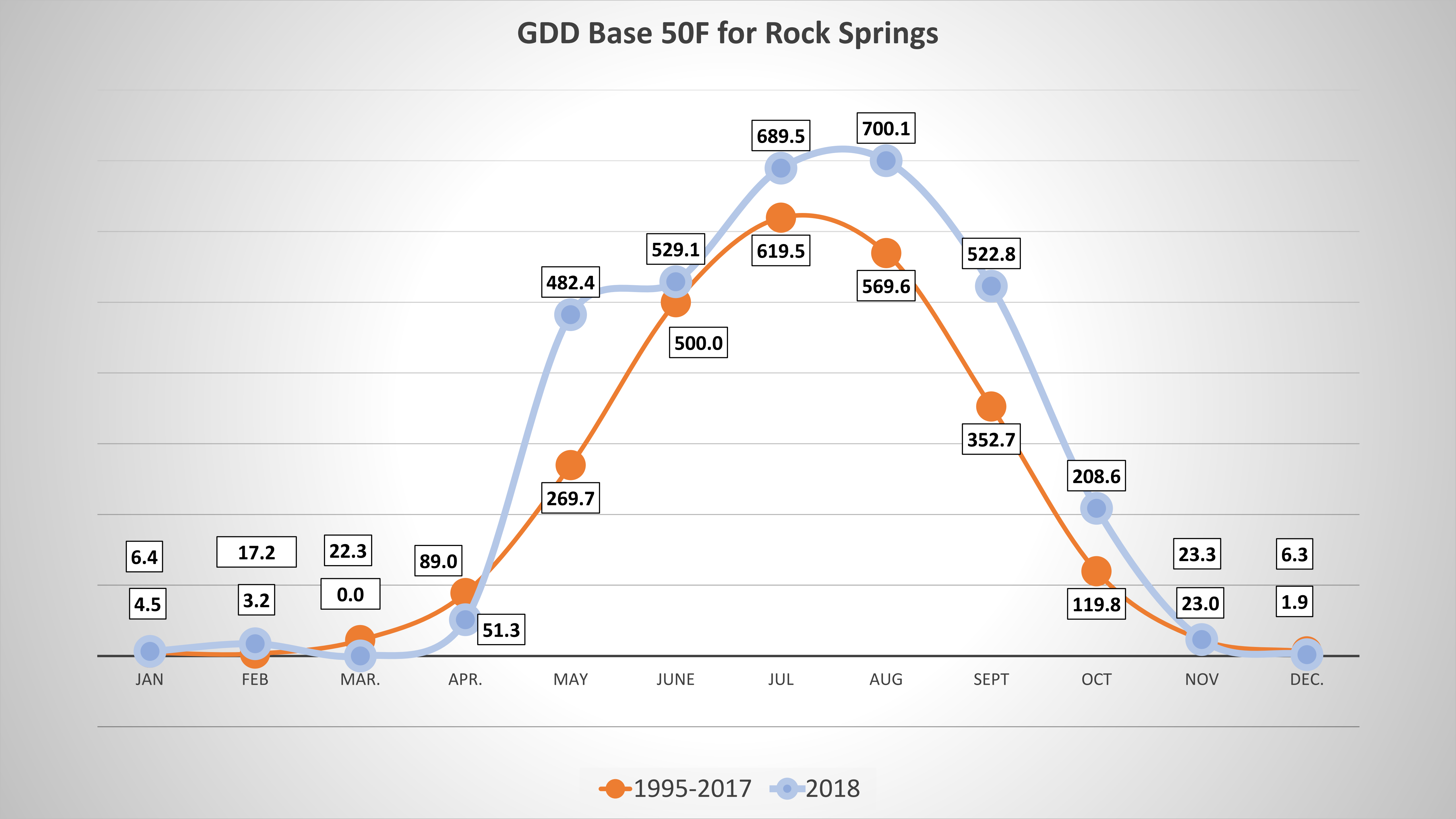
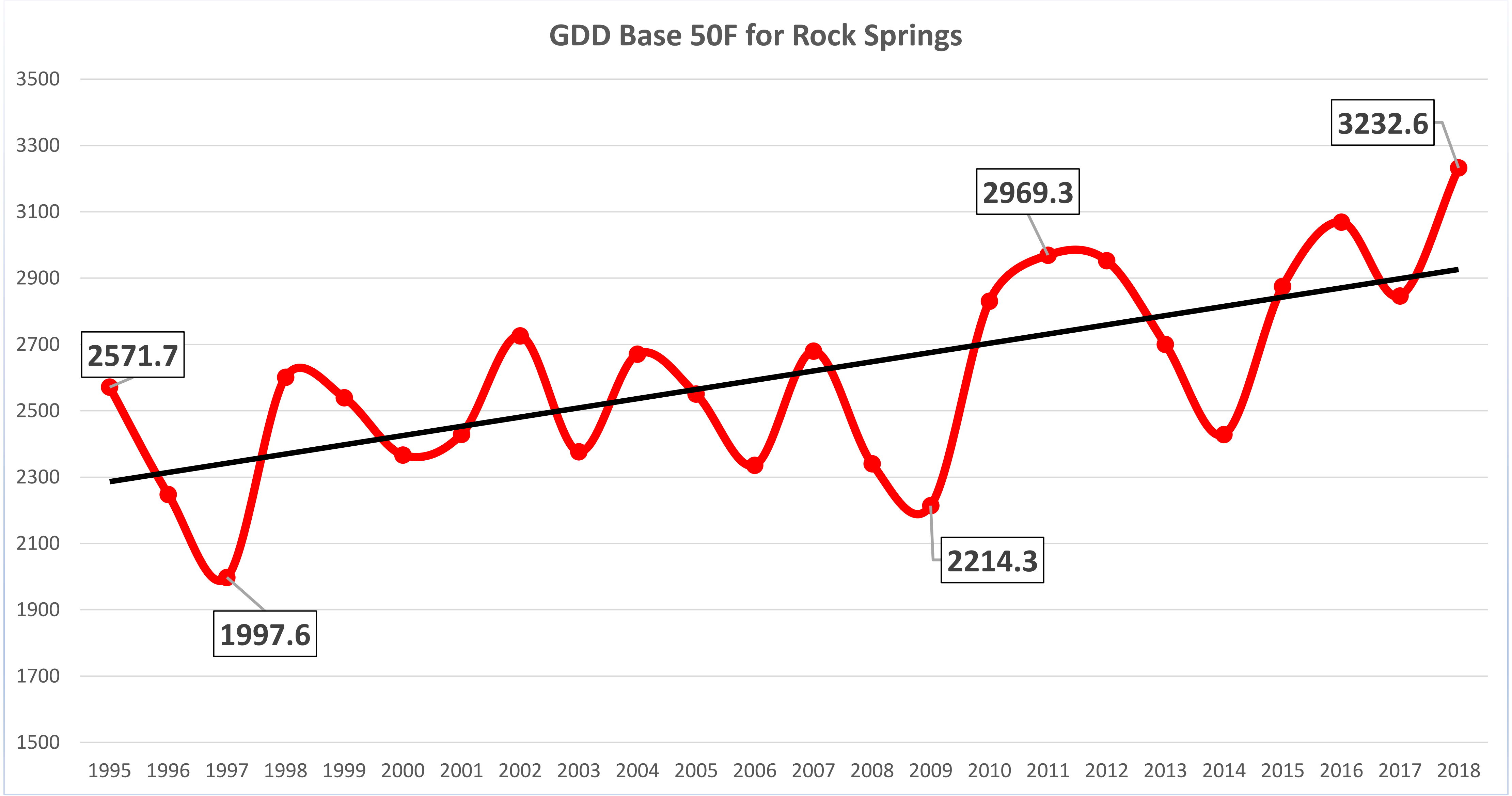


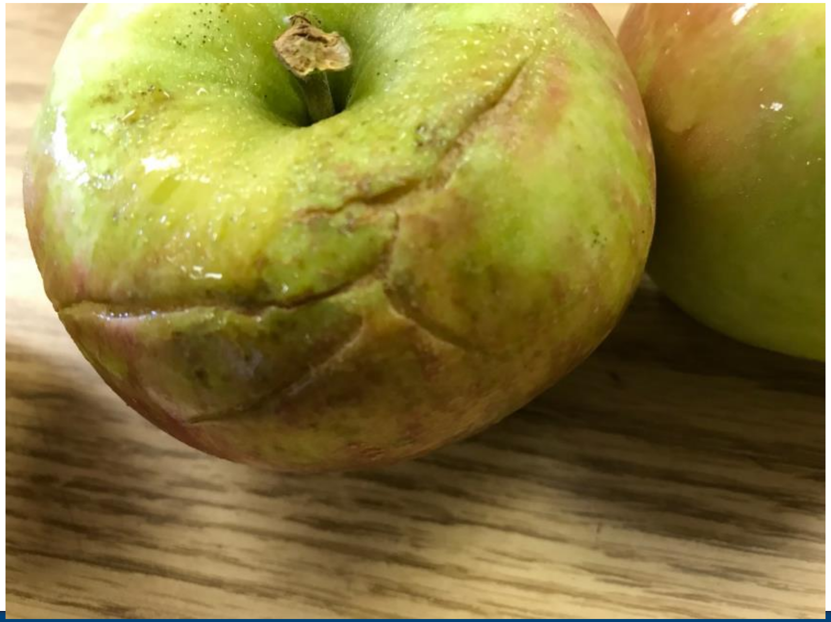
CHO Production based on MaluSim Model for Rock Springs
May 1 through September 30
Dry matter content of fruit can be lower when light levels are lower
12,342.61
12,575.48
12,004.09
11,172.92
10,752.75
2014
2015
2016
2017
2018


GDD Base 50F for Rock Springs
6.4
4.5
17.2
3.2
22.3
0.0
89.0
51.3
482.4
269.7
529.1
500.0
689.5
619.5
700.1
569.6
522.8
352.7
208.6
119.8
23.3
23.0
6.3
1.9
JAN
FEB
MAR.
APR.
MAY
JUNE
JUL
AUG
SEPT
OCT
NOV
DEC.
1995-2017
2018


GDD Base 50F for Rock Springs
3500
3300
3100
2900
2700
2500
2300
2100
1900
1700
1500
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
2571.7
1997.6
2214.3
2969.3
3232.6

2018 Season Comments on Fruit

- Fruit disorders such as bitter pit and splitting was greater
  - Calcium uptake may have been reduced due to low light & transpiration
  - Excess soil moisture can lead to premature fruit ripening



Study of Stem – End Splitting in Apples

Factor or Mgmt. Practice	Level Associated with Increase	Degree of Association
Irrigation/Rain fall	**Frequent/Heavy**	**Definite**
Fruit Thinning	Low Crop Load	Slight
N Fertilizer	No Effect	None
Exposure to Sunlight	**High Exposure (sudden change?)**	**Definite**
Fruit Size	**Large Fruit**	**Definite**
Soluble Solids Content	High	Indefinite
Flesh Textural Strength	Low	Definite
Maturity Stage	**Over Mature**	**Definite**
Mineral Deficiency	No Effect	None

From T. Kon as adapted from Opara, U. L. 1993. A study of stem-end splitting in apples. Ph.D. Dissertation. Massey Univ. 293 pgs.

2018 Season Comments on Fruit

- Starch Index abnormalities
  - “Fuji samples continued to hang on the trees despite being devoid of starch”
  - Starch levels were lower and did not develop due to lower photosynthesis
- Cloudy weather
  - Reduces % soluble solids and starch levels in fruit
  - Starch Index tests may not be as reliable under current weather patterns
  - Best to use 3 tests: firmness, %SS and starch index

Good News from 2018 Season

- Learned where the potential for wet spots exist in your orchard
- In the future consider the need for installing drainage tile.

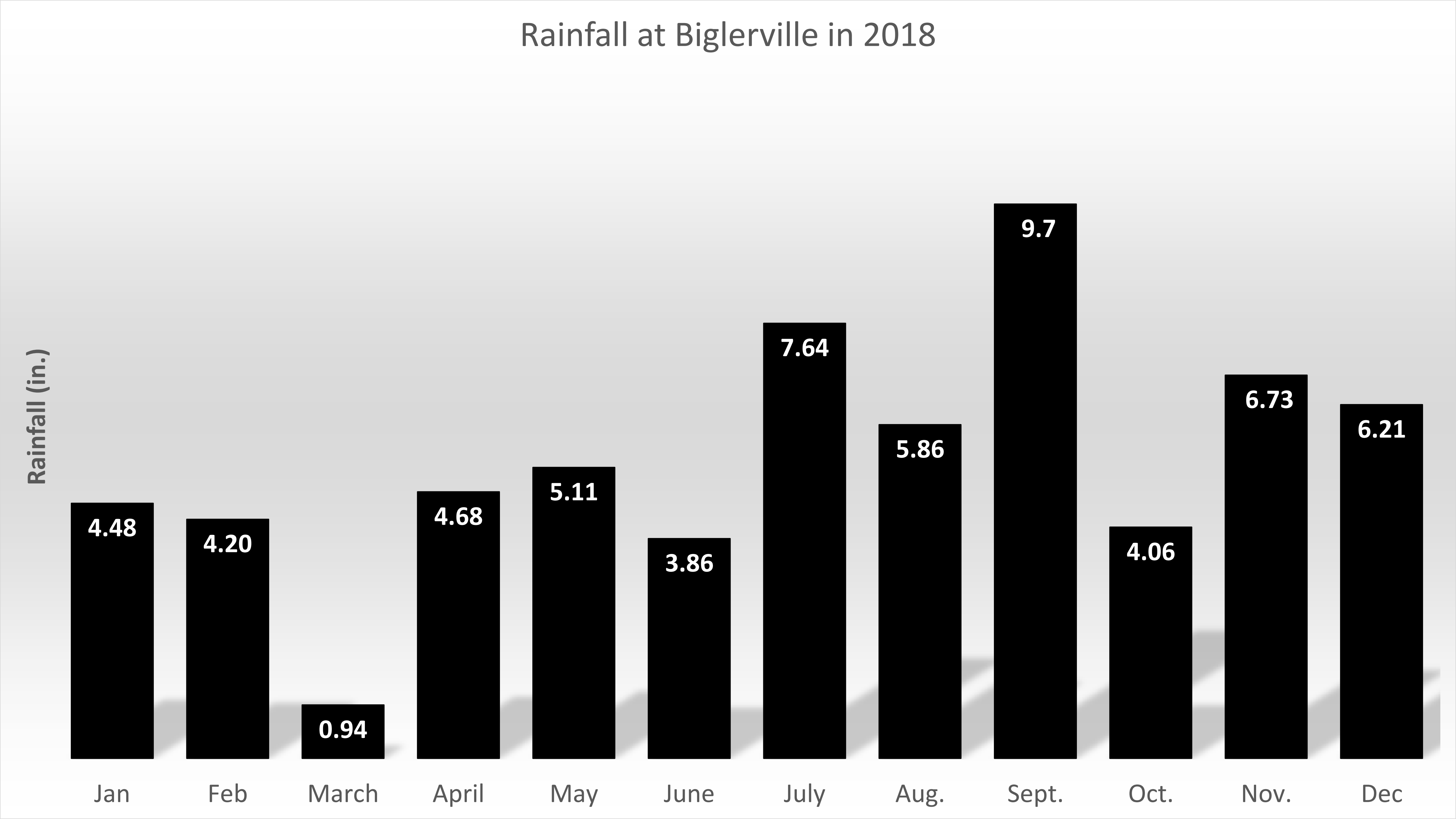
Rootstock sensitivity to wet soils

- Peach rootstocks – very low tolerance (12- 36 hours?)
- Mahaleb, Mazzard – very to extremely sensitive
- Pears are more tolerant to wet soils than most fruit crops
- Apple rootstocks may survive wet soils depending upon time of season, tree size, and soil pathogens
  - M.27 & M.9 are moderately tolerant to wet soils
  - MM.106 & MM.104 are not tolerant at all to wet soils

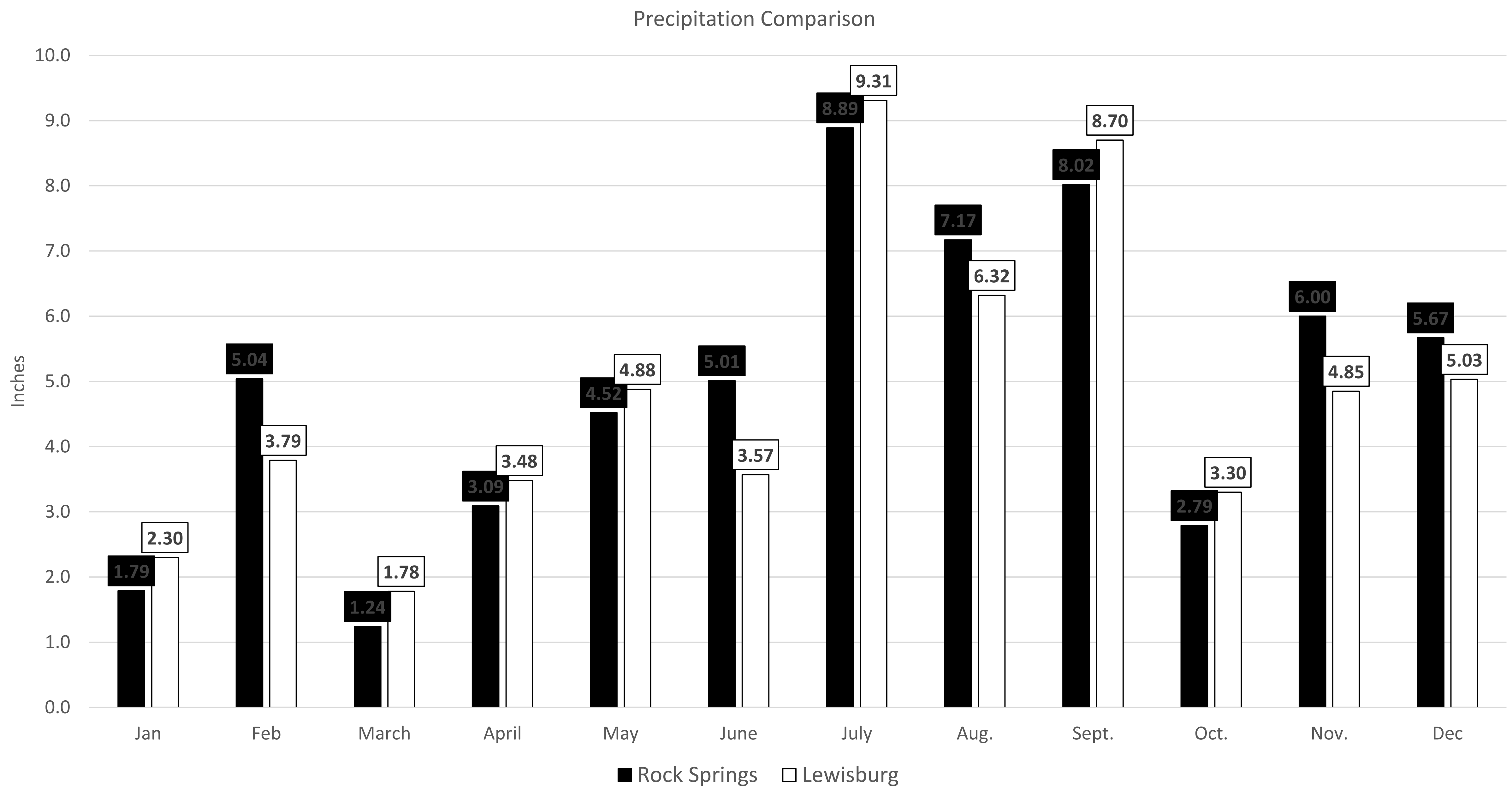
Geneva Rootstocks?

- Symptoms of water logging
  - Leaf wilting & browning (scorching)
  - Fruit drop & leaf chlorosis and leaf abscission
  - Stem dieback, limb dieback
  - Reduced nutrient uptake and visual deficiency signs
  - Decreased photosynthesis, transpiration

Questions
Comments



Rainfall at Biglerville in 2018
Rainfall (in.)
4.48
4.20
0.94
4.68
5.11
3.86
7.64
5.86
9.7
4.06
6.73
6.21
Jan
Feb
March
April
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec



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