

# Predicting Environmental Causes of Tomato Yellow Shoulder Disorder

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# Yellow Shoulder: What is it?

- Discolored yellow or green sectors under the fruit peel
- YSD affects both the appearance and nutritional value of tomatoes.
- Processing efficiency is reduced.
- Physiological nature: Altered ripening not delayed ripening, green tissue fails to develop into red tissue. **Delaying harvest will not help!**
- Causes include:
  - genetics (10 - 20 %)
  - Environment ⇒ Soils (20 - 30 %)
  - Weather (5 -10 %)
  - Others ( 40 - 65 %)



## **Yellow Shoulder: Management**

- Weather cannot be managed
- Focus on Genetics and Environment
  - Genetics: choose the right variety, less susceptible to YSD
  - Environment: focus on soils with good quality and correct nutrient balance.

**Let's talk about soils and soil nutrients...**

## Soil nutrients and YSD

- Research in California has indicated that soils and plants with **high** levels of potassium presented a lower incidence of YSD (Hartz 1999).

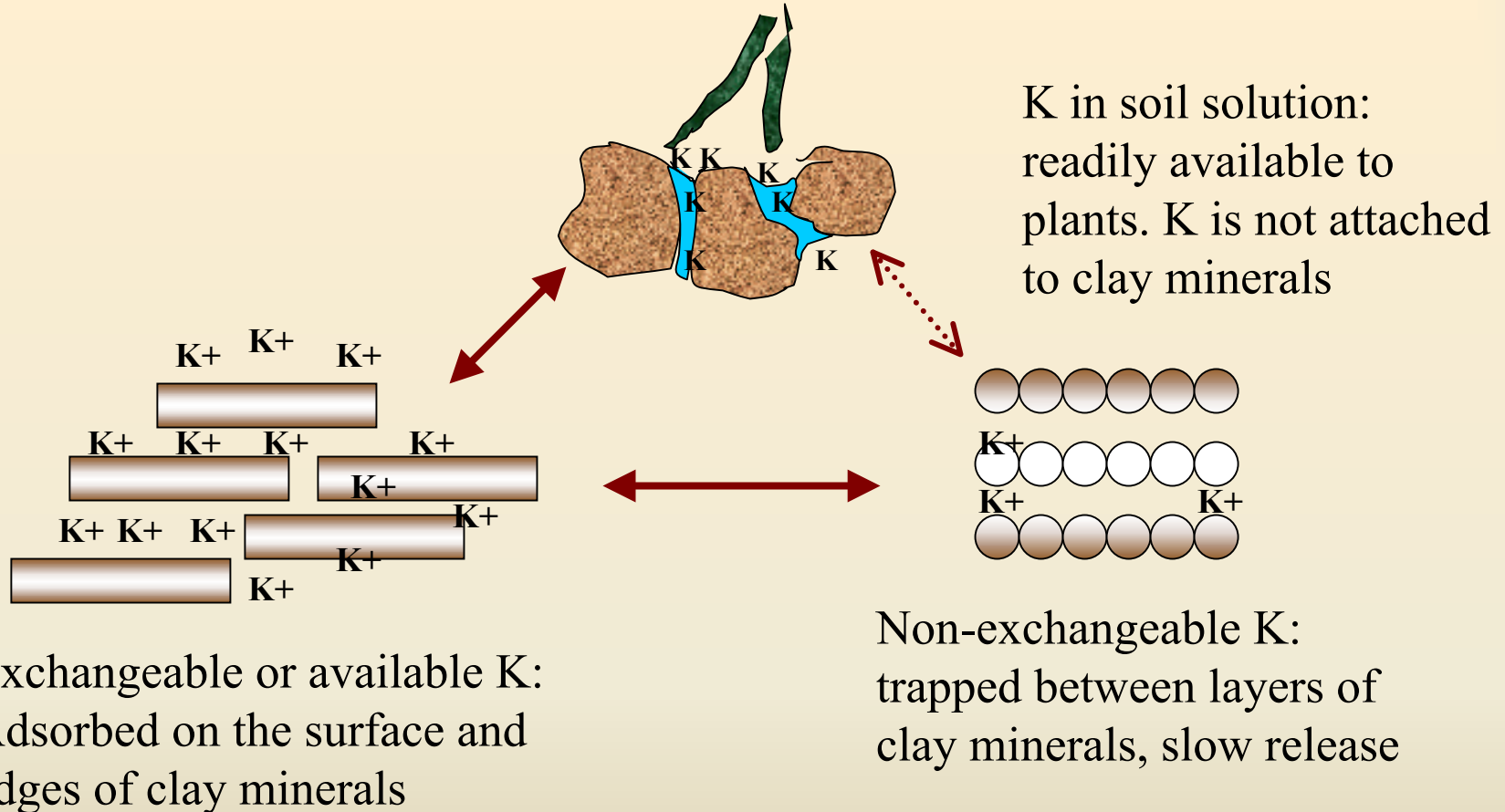
Thank goodness!.. Let's apply a lot of K and be done with it, right?



# YSD: Soil Nutrient Management

- Excess application of K fertilizer can cause nutrient imbalance inducing less Mg and Ca absorption by the plants;
- Heavy applications of K or Ca can lead to Mg deficiency
- Heavy application of gypsum can reduce Exchangeable K and Mg
- Not all K applied is directly available to plants.
- Loss of K by soil fixation and leaching

# Potassium in the Soil

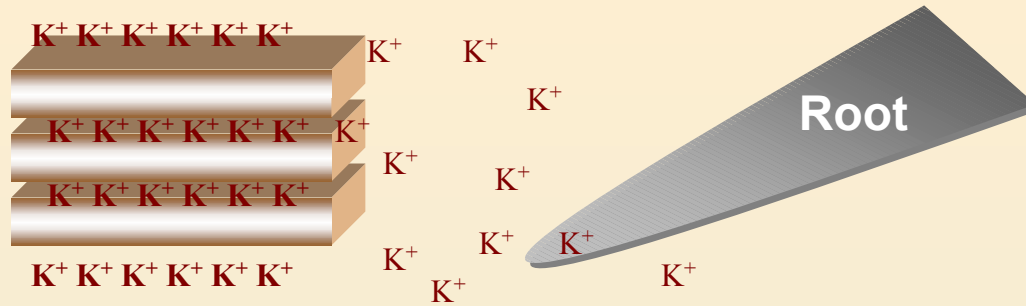


Exchangeable or available K:  
Adsorbed on the surface and edges of clay minerals

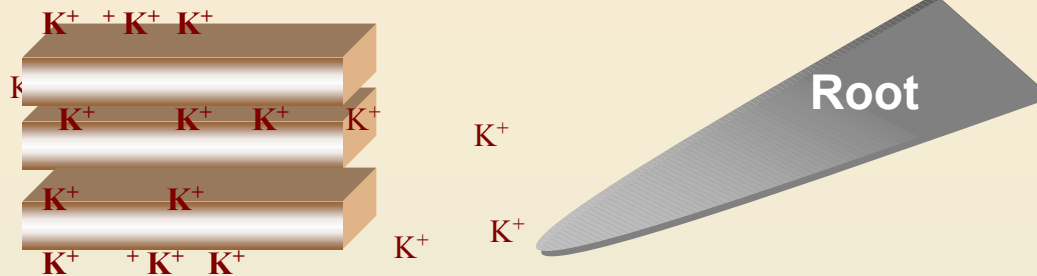
Non-exchangeable K:  
trapped between layers of clay minerals, slow release

**Total K in soil (20 cm): 2,700 to 90,000 lbs/ac but 98% is in mineral form, only 2% is in soil solution, exchangeable and non-exchangeable form.**

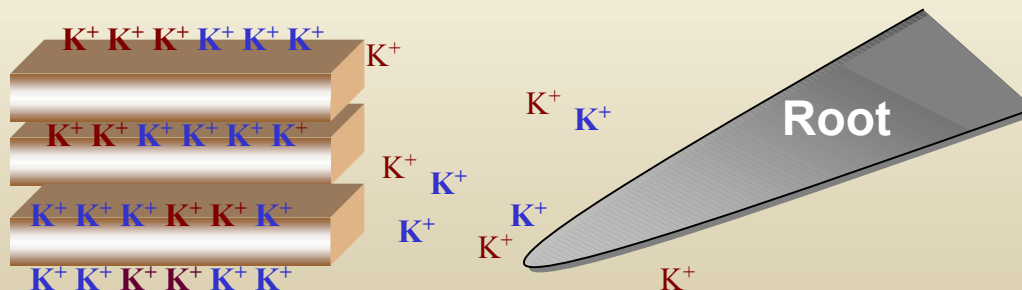
# Potassium Dynamics in the Soil



Exchangeable K and soil solution K are the first ones to be taken up by plants



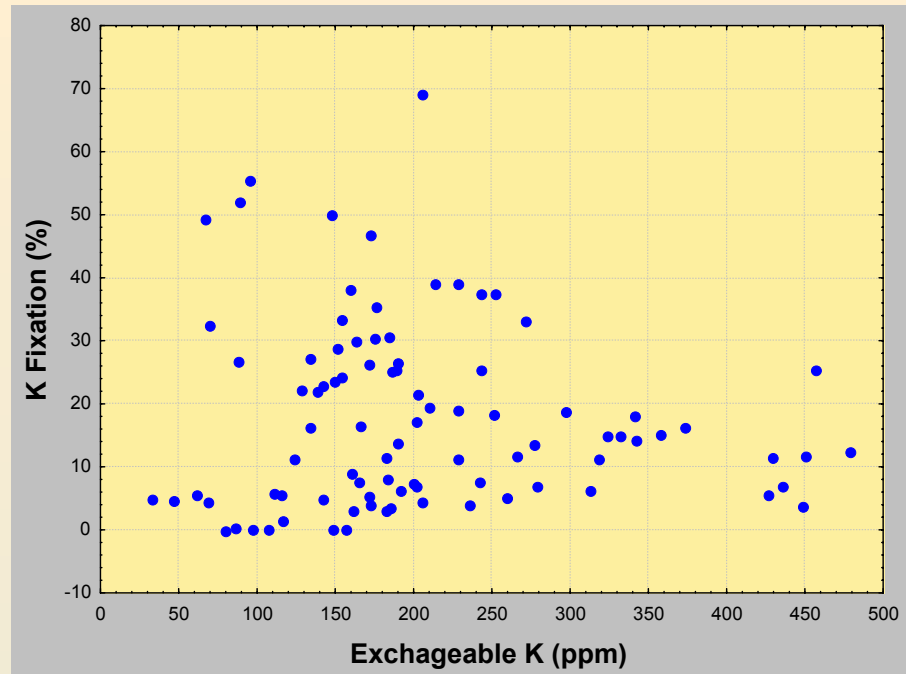
Intensive cropping causes exhaustion of the readily available K



When **K fertilizer** is applied, it will first be trapped inside the clay minerals. As those sites are satisfied, K will occupy external sites and reach an equilibrium with the soil solution.

# Soil Fixation: facts for our soils

Location	Samples	Exch. K ppm	K fix (%)
OH	38	199	15
IN	20	218	13
PA	7	148	1
CA	25	222	31
All Grps	90	206	18



OH, IN and MI have predominantly mixed-illitic mineralogy. By nature these soils fix less cations than California soils. CA fields are historically under fertilized (Hartz,2003).

# Tools to predict risk of YSD

- Work of Hartz & friends identified that soils in California are at greater risk of YSD if:
  - Extractable K is lower than 273 ppm or 546 lbs/ac ( 0.7 meq/100g)
  - $K/\sqrt{Mg}$  is smaller than 0.25
  - K is less than 2% of the CEC
  - Ca/Mg ratio (meq/100g) is less than 2:1

Do these tools work for Midwest soils?

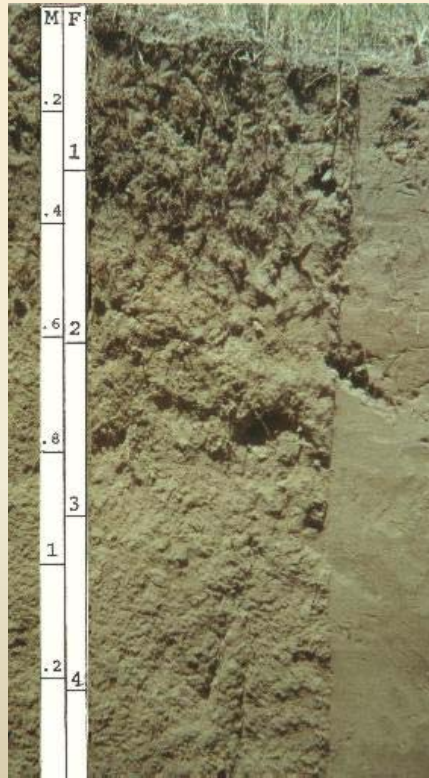
# Soils of the Midwest

- great variety of soils including natural fertility, mineralogy, texture:

Alfisols (IN, OH)



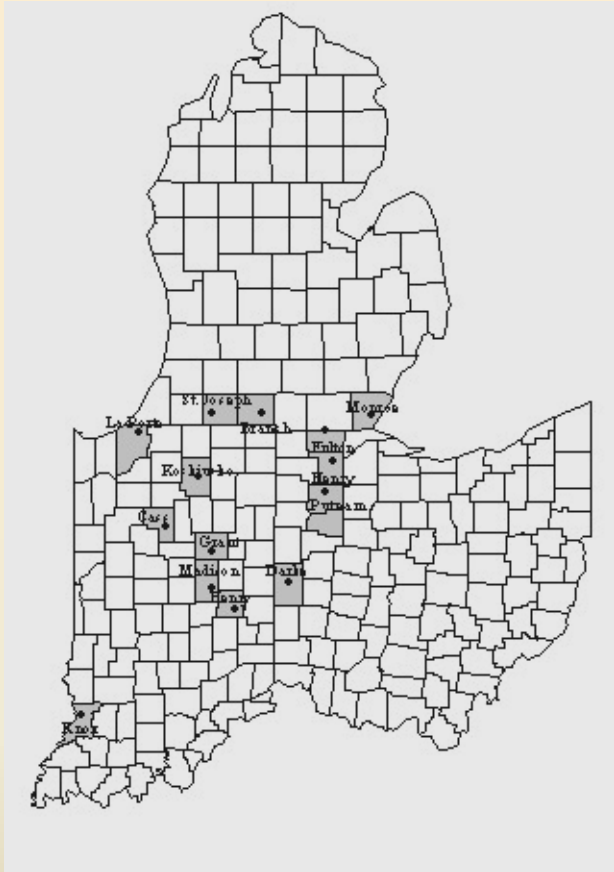
Entisols (IN, MI)



Mollisols (IN, OH)



# Searching for predictive tools for the Midwest....



- Fruit and soil samples from commercial fields were analyzed:
  - **Fruit color data**
    - Hue =color
    - L = light to dark
    - Hue difference = a uniformity measurement. Large values indicate YSD
    - L difference = a uniformity measurement. Large values indicate internal white tissue
  - **Soil fertility data**
    - Exchangeable K, Ca, Mg, %Organic Matter, pH, CEC.

# Results Years 2001- 2003

	Trait	K		Ca		Mg		K/sqrt(Mg)		pH		Org. Matter	
		Significance	r2	Significance	r2	Significance	r2	Significance	r2	Significance	r2	Significance	r2
2 0 0 1	L	0.565	0.008	0.448	0.013	0.332	0.021	0.320	0.023				
	a	0.556	0.008	0.370	0.018	<b>0.007</b>	<b>0.155</b>	0.106	0.058				
	b	<b>0.002</b>	<b>0.197</b>	<b>0.001</b>	<b>0.209</b>	<b>0.056</b>	<b>0.080</b>	<b>0.053</b>	<b>0.083</b>				
	Hue	<b>0.015</b>	<b>0.128</b>	0.292	0.025	0.285	0.026	<b>0.007</b>	<b>0.153</b>				
	Ldiff	0.163	0.044	0.363	0.019	0.252	0.030	<b>0.060</b>	<b>0.078</b>				
	adiff	<b>0.079</b>	<b>0.068</b>	0.606	0.006	0.122	0.054	<b>0.013</b>	<b>0.133</b>				
	bdiff	0.103	0.059	0.124	0.053	0.708	0.003	<b>0.085</b>	<b>0.066</b>				
	Huediff	0.198	0.037	0.331	0.022	0.346	0.020	<b>0.084</b>	<b>0.066</b>				
2 0 0 2	L	<b>0.000</b>	<b>0.100</b>	0.889	0.000	0.133	0.015	<b>0.029</b>	<b>0.032</b>	0.645	0.001	<b>0.001</b>	<b>0.077</b>
	a	<b>0.040</b>	<b>0.028</b>	0.976	0.000	0.759	0.001	<b>0.008</b>	<b>0.047</b>	0.595	0.002	0.260	0.009
	b	0.194	0.012	0.533	0.003	0.366	0.006	0.124	0.016	0.932	0.000	0.176	0.013
	Hue	<b>0.032</b>	<b>0.031</b>	0.774	0.001	0.511	0.003	<b>0.009</b>	<b>0.045</b>	0.779	0.001	0.125	0.016
	Ldiff	<b>0.002</b>	<b>0.061</b>	<b>0.073</b>	<b>0.022</b>	0.173	0.013	<b>0.042</b>	<b>0.028</b>	0.796	0.000	<b>0.077</b>	<b>0.021</b>
	adiff	0.173	0.013	0.806	0.000	0.726	0.001	0.098	0.019	0.663	0.001	0.480	0.003
	bdiff	0.158	0.014	0.130	0.016	0.805	0.000	<b>0.051</b>	<b>0.026</b>	0.574	0.002	0.836	0.000
	Huediff	0.126	0.016	0.777	0.001	0.722	0.001	0.084	0.020	0.485	0.003	0.360	0.006
2 0 0 3	L	<b>0.006</b>	<b>0.711</b>	0.493	0.000	0.570	0.000	0.190	0.033	<b>0.048</b>	<b>0.302</b>	0.392	0.001
	a	<b>0.011</b>	<b>0.622</b>	0.328	0.004	0.374	0.002	<b>0.077</b>	<b>0.191</b>	<b>0.001</b>	<b>0.868</b>	0.307	0.005
	b	0.129	0.084	0.093	0.147	0.118	0.100	<b>0.008</b>	<b>0.672</b>	0.155	0.057	<b>0.045</b>	<b>0.319</b>
	Hue	0.085	0.167	<b>0.070</b>	<b>0.212</b>	<b>0.077</b>	<b>0.190</b>	0.163	0.051	0.190	0.034	0.115	0.105
	Ldiff	0.194	0.031	<b>0.000</b>	<b>0.922</b>	<b>0.002</b>	<b>0.838</b>	<b>0.069</b>	<b>0.215</b>	0.204	0.027	<b>0.018</b>	<b>0.535</b>
	adiff	0.146	0.065	<b>0.026</b>	<b>0.451</b>	<b>0.009</b>	<b>0.659</b>	0.119	0.098	0.083	0.173	<b>0.055</b>	<b>0.271</b>
	bdiff	0.354	0.002	<b>0.033</b>	<b>0.395</b>	<b>0.016</b>	<b>0.560</b>	0.319	0.004	0.152	0.060	<b>0.064</b>	<b>0.233</b>
	Huediff	<b>0.024</b>	<b>0.475</b>	0.337	0.003	0.305	0.005	0.208	0.025	<b>0.000</b>	<b>0.998</b>	0.307	0.005

Numbers in red are significant

Numbers in blue are marginally non-significant

## What we have learned....

- Soil fertility (Ca, K and Mg) and  $K/\sqrt{Mg}$  can be applied as predictive tools to assess risk of YSD.
  - They explain 5%-60% of the observed variation in color.
- For soil in the Midwest pH and % OM are also important.
  - They explain 2%-50% of the observed variation in color.

Set soil fertility guidelines to reduce the risk of YSD

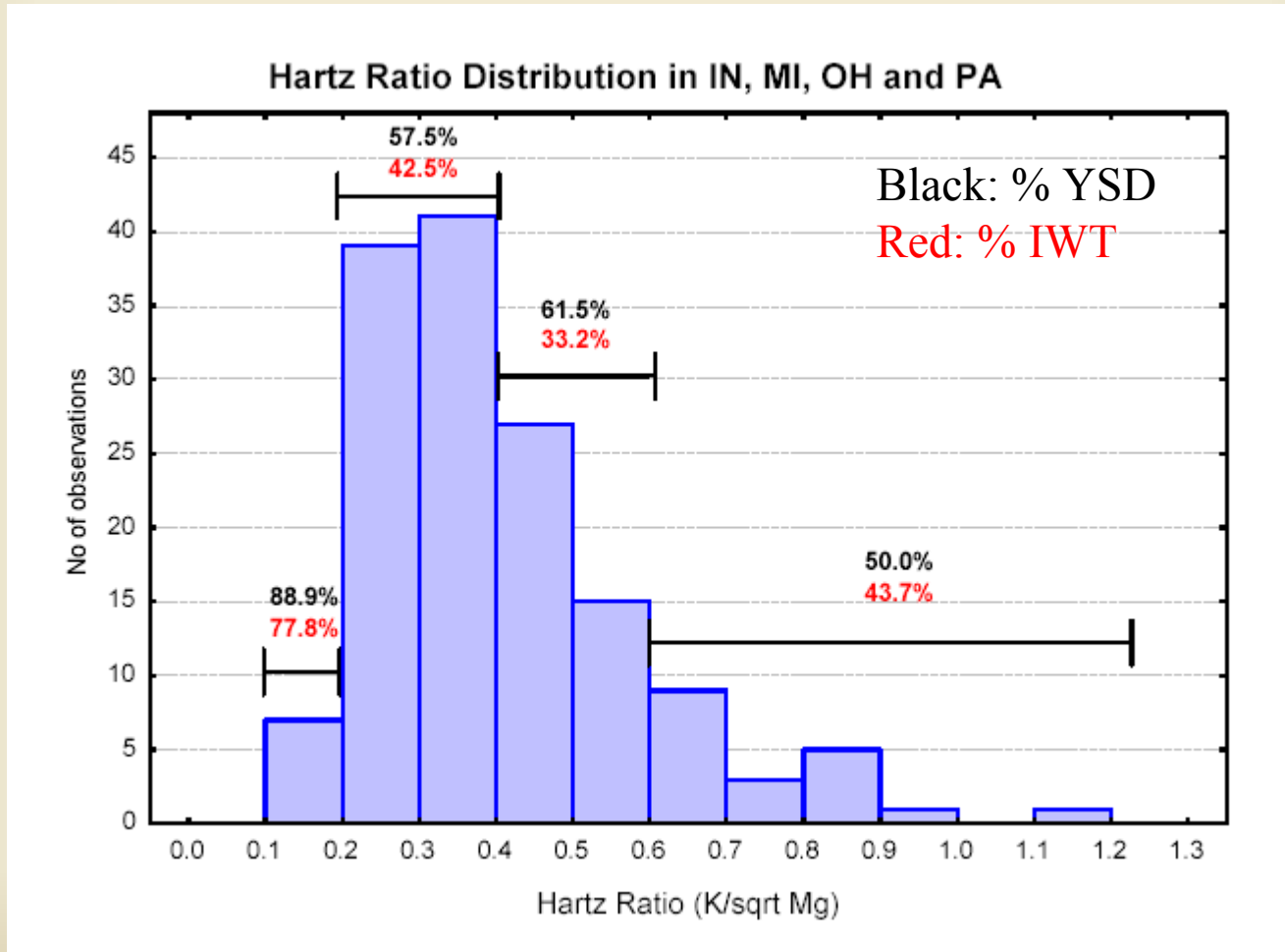
Where to find this information:

[www.oardc.ohio-state.edu/tomato](http://www.oardc.ohio-state.edu/tomato)

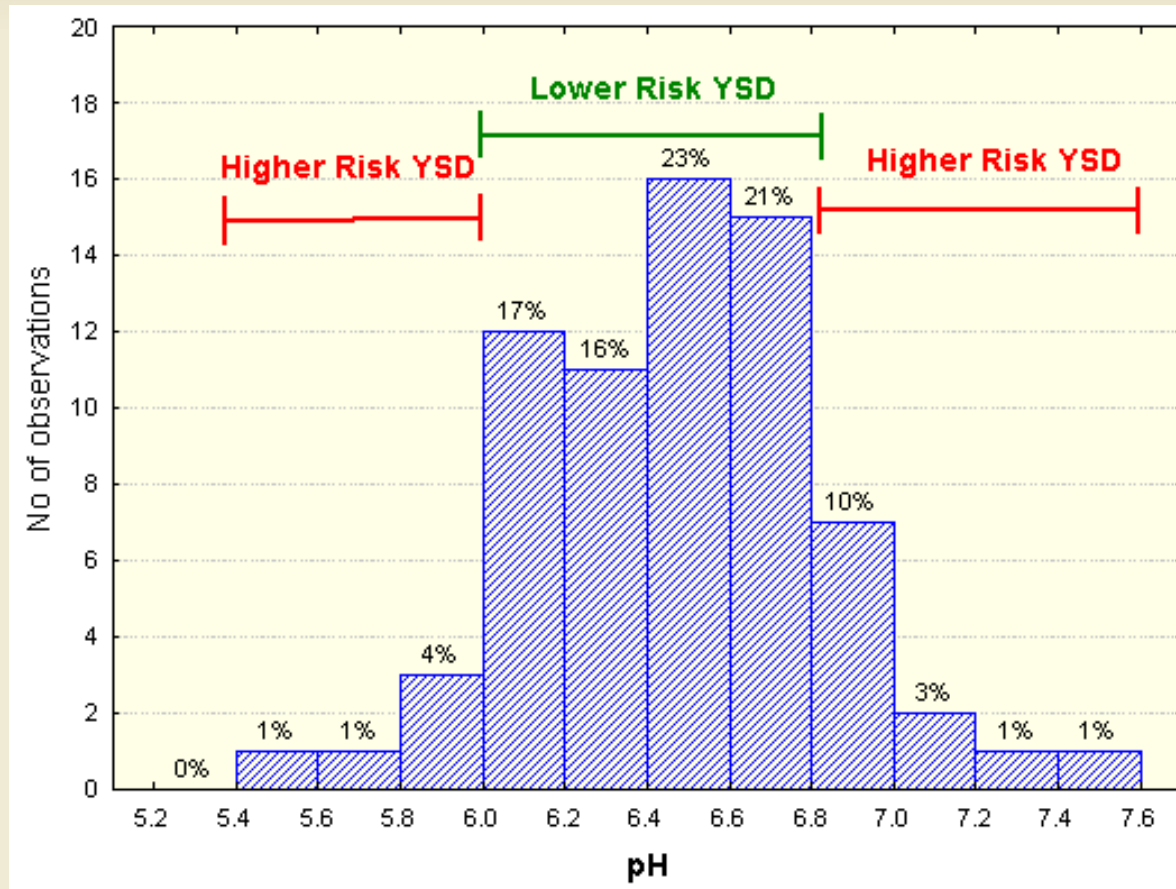
OH Vegetable Production Guide 2004 edition

# To set the guidelines...

perform a risk assessment for % of fruits with YSD or IWT



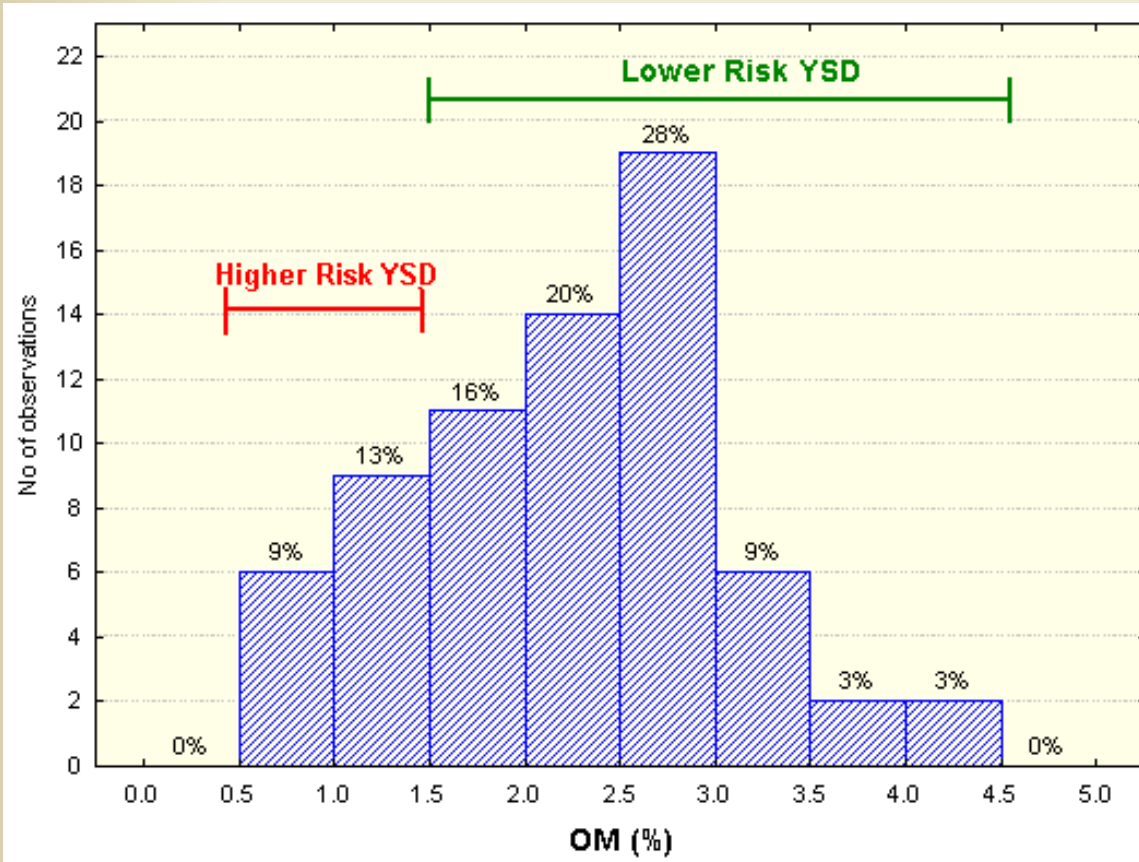
# Guidelines for pH



The availability of K, Ca and Mg to the plant is reduced.

The fixation of K tends to increase

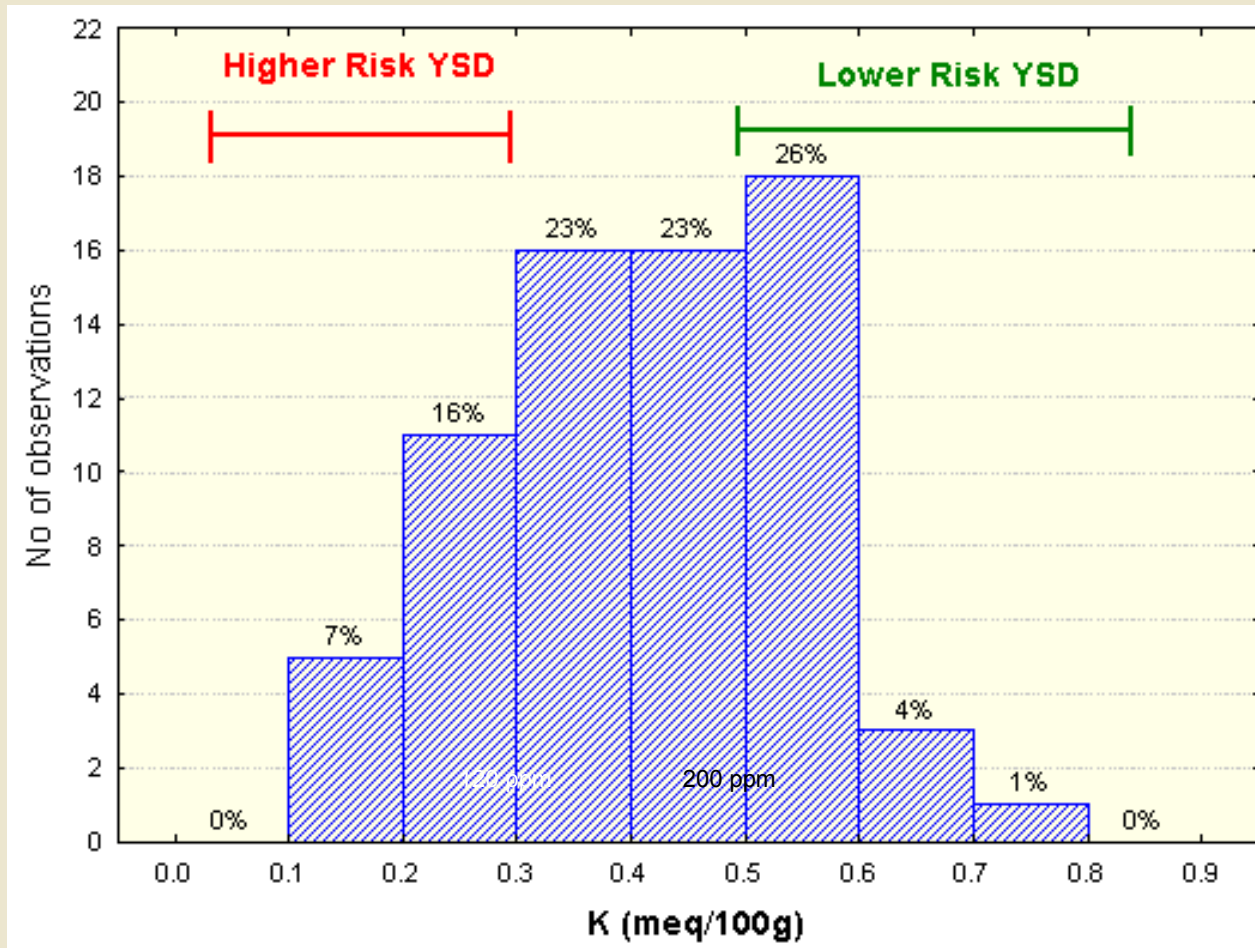
# Guidelines for % Organic Matter



OM increases

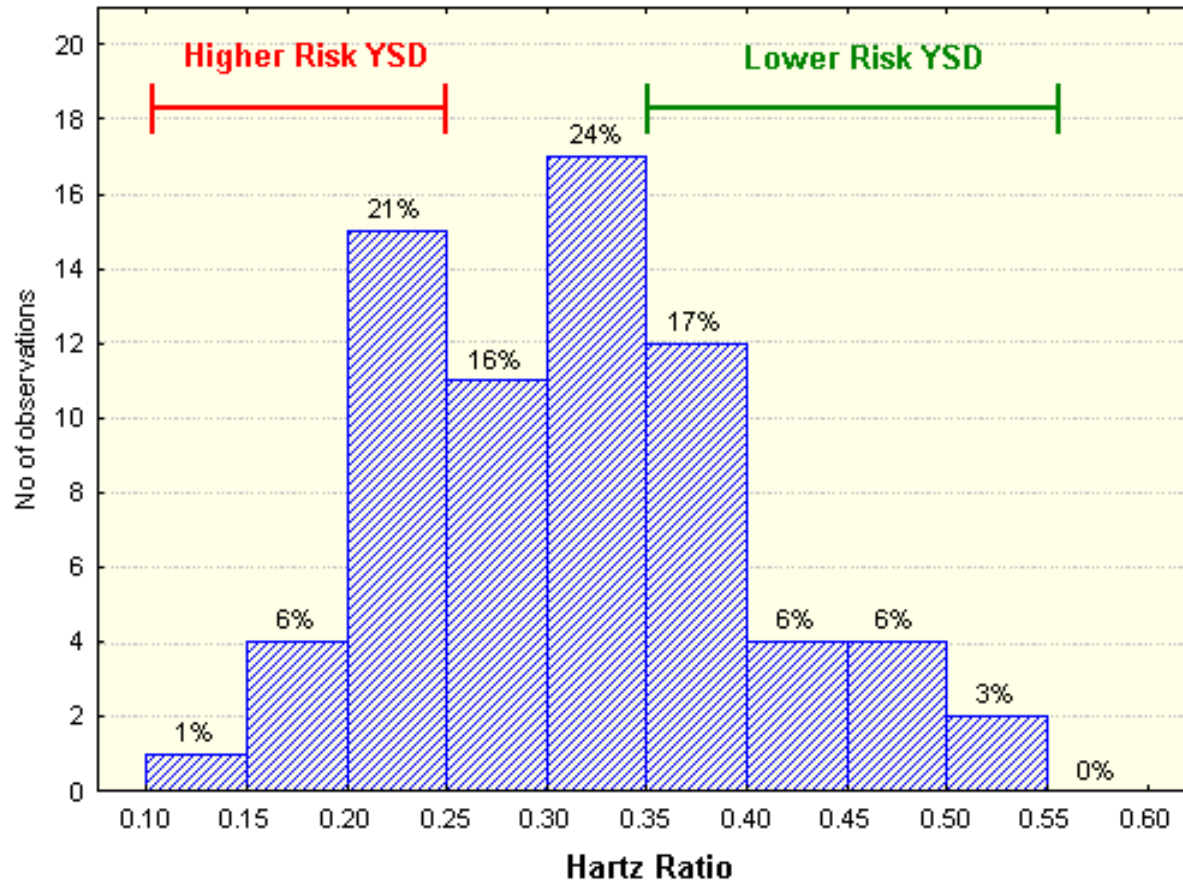
- the pool of nutrients available to the plant,
- the water holding capacity of the soil.

# Guidelines for Exchangeable K



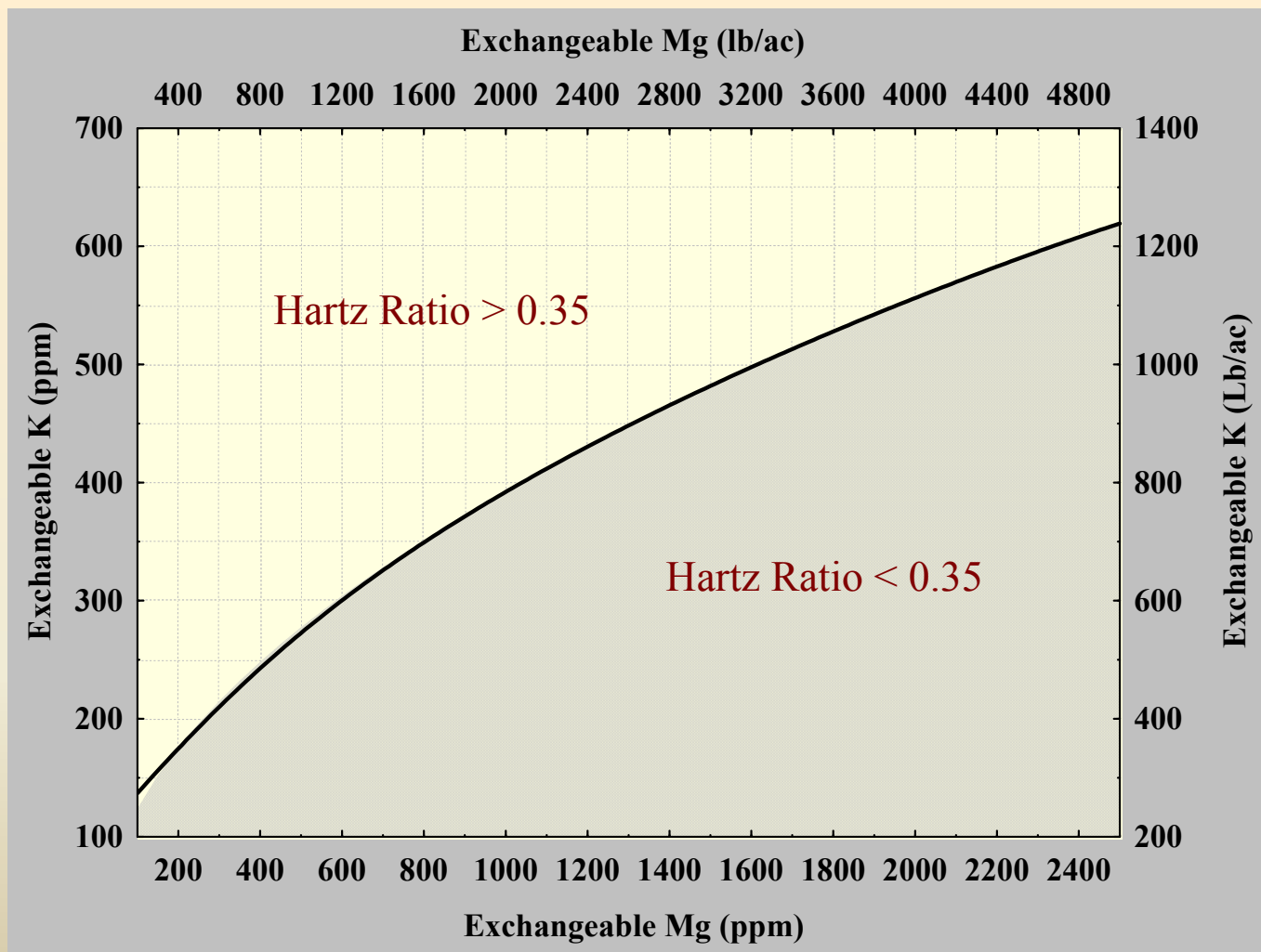
Be aware of the units: soil test units are ppm or lbs/ac  
1 meq/100g K = 391 ppm

# Guidelines for $K/\sqrt{Mg}$



# How to estimate the Hartz ratio?

[www.oardc.ohio-state.edu/tomato](http://www.oardc.ohio-state.edu/tomato) click on “managing color disorder”



# Fields at a lower risk of producing fruit with YSD have the following soil properties

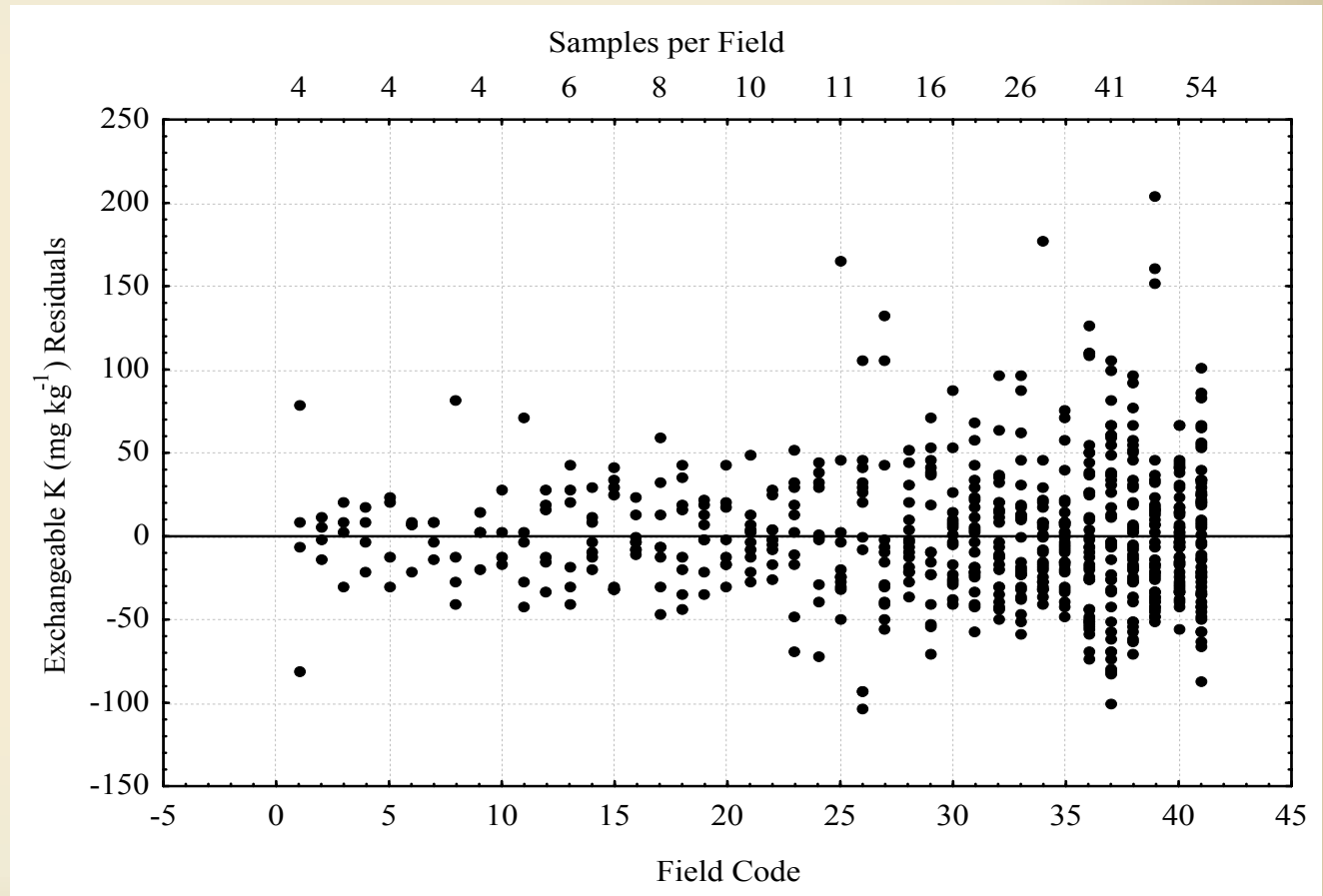
- pH between 6.0 and 6.8;
- organic matter above 1.5 %;
- exchangeable potassium above 400 lbs/ac (or 200 ppm) and,
- ratio of  $K / \sqrt{Mg}$  above 0.35.

## Should you be worried about the fertility of your field?

	<b>N</b>	<b>Mean</b>	<b>Min</b>	<b>Max</b>	<b>Std.Dev.</b>	<b>Coef. Var. (%)</b>
<b>pH</b>	<b>643</b>	<b>6.47</b>	<b>5.20</b>	<b>7.80</b>	<b>0.48</b>	<b>7.44</b>
<b>% OM</b>	<b>643</b>	<b>2.04</b>	<b>0.20</b>	<b>14.30</b>	<b>1.07</b>	<b>52.64</b>
<b>P (ppm)</b>	<b>643</b>	<b>55.04</b>	<b>8.00</b>	<b>421.00</b>	<b>35.44</b>	<b>64.38</b>
<b>K(ppm)</b>	<b>643</b>	<b>149.13</b>	<b>34.00</b>	<b>366.00</b>	<b>58.42</b>	<b>39.17</b>
<b>Ca (ppm)</b>	<b>643</b>	<b>1128.31</b>	<b>200.00</b>	<b>3900.00</b>	<b>649.63</b>	<b>57.58</b>
<b>Mg(ppm)</b>	<b>643</b>	<b>181.34</b>	<b>35.00</b>	<b>526.50</b>	<b>96.63</b>	<b>53.29</b>

- Average fertility of soil in our region is good;
- There is opportunity for improvement. Approximately 28% of commercial fields are at risk of YSD due to fertility;
- Pay attention to variability within field.

Within-field variability can be high for certain fields. Be careful when sampling: follow the guidelines.



# Conclusion



- Nutrient cycling in the soil is a matter of balance;
- **Fertilize** wisely;
- **Soil tests** can be used as a **tool** to identify soils at risk of YSD;
- Up to 50% of the risk of YSD can be reduced by adopting a better soil management plan and selecting uniform varieties.



[www.oardc.ohio-state.edu/tomato](http://www.oardc.ohio-state.edu/tomato)  
Link “managing color disorders”

Thanks to...

- David Francis – OSU/OARDC
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- John Molyet
- Emma Jean Dinkins
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