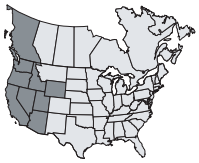
IPNI INSIGHTS
INTERNATIONAL PLANT NUTRITION INSTITUTE



September 2012

What About the Water?

Agriculture is the largest user of fresh water in the world and as demand grows for more food production, conflicts regarding water use are inevitable. In some areas, additional investment in irrigation and water supplies may provide room for further expansion of irrigated cropland. However in most areas of western North America, water is no longer in abundant supply and ferocious arguments erupt over water allocation. Since new supplies of irrigation water appear unlikely, there is significant incentive to improve water use efficiency. The pressure on the agricultural industry to carefully conserve water resources will certainly intensify.

Water uptake and plant nutrient absorption are closely related. When plant roots take up water, dissolved nutrients are carried to the root surface. When water uptake is restricted, the delivery of nutrients to the root also slows down. As the soil dries and the films of water between the particles shrink, the processes of mass flow and diffusion that bathe the roots with nutrients eventually come to a halt **(Figure 1)**.

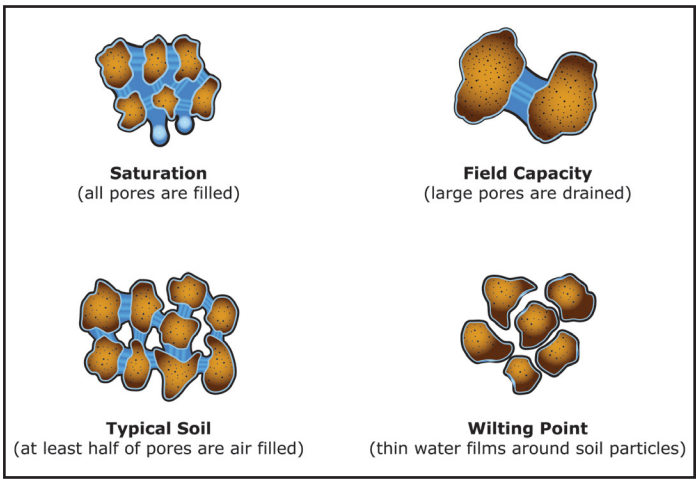
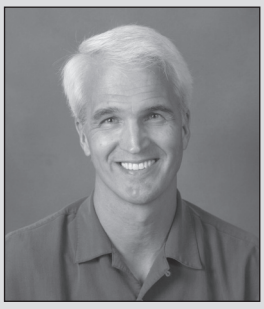


Figure 1. As soil dries, water films become thin and nutrient movement and uptake are reduced.



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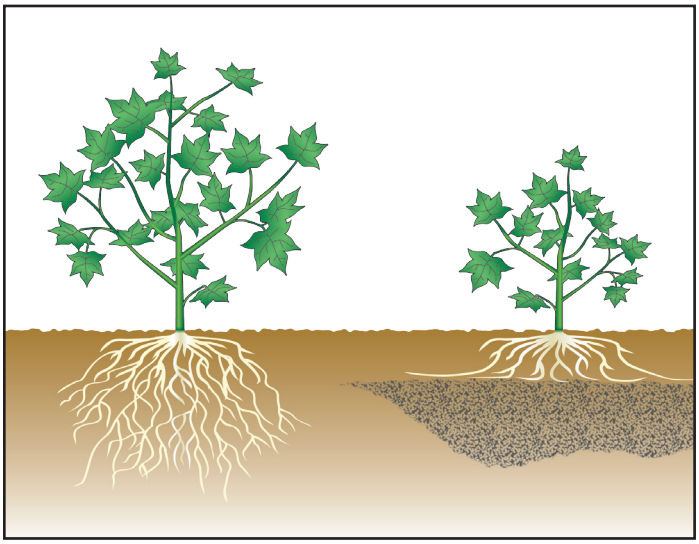

Figure 2. Soil factors that limit root growth will reduce water and nutrient uptake. These limitations become particularly severe during period of stress. These root restrictions may include hard pans, compacted soil, or acid subsoil.

Water use efficiency has several definitions. The most common usage is the ratio of the amount of water required to grow a crop compared with the amount of water actually applied by farmers (or supplied in rainfall). Sometimes it refers to economic efficiency (related to the economic benefits and costs of water use). The economic considerations include the cost of water delivery, the opportunity costs of irrigation and drainage, and any third party benefits or costs.

Healthy roots and water use

An important step towards improving water use efficiency is to encourage healthy plant roots. Maintaining proper soil conditions will enhance the volume of soil that roots explore. For example, a soil that has a compacted zone or a hard pan will present a barrier to plant roots and restrict their use of moisture deeper in the soil profile. Similarly, when subsoil acidity is not addressed, plant growth is stunted and roots cannot grow deep into the soil to utilize water and nutrients **(Figure 2)**.

Notes and Abbreviations: K = potassium; Ca = calcium; Mg = magnesium; Na = sodium; H = hydrogen; Al = aluminum; Cu = copper; Fe = iron; Mn = manganese; Ni = nickel; Zn = zinc; NH_4^+ = ammonium

How much water?

Plant species differ widely in their water requirements. One measure that is sometimes used is the "transpiration ratio", or the amount of water used to produce one pound of harvested product. While this number will vary depending on local conditions, some approximate figures are given in **Table 1**.

Table 1. Approximate amount of water required by various crops to grow one pound of harvested product (transpiration ratio).

Crop	Gallons of water/lb of dry matter
Alfalfa	100
Soybean	80
Oat, Potato	70
Wheat	66
Sugar beet	45
Corn	42
Sorghum	36

From Chrispeels, M.J. and D.E. Sadava (eds). 2002. Plants, Genes, and Crop Biotechnology. 2nd Ed. Jones and Bartlett, Sudbury, MA.

Plants grown with adequate nutrition typically have larger tops and root systems compared with crops grown with an inadequate nutrient supply. These well-fertilized plants are generally larger and may have greater water loss (transpiration), but a lower transpiration ratio. In other words, the healthy plant may use more water, but will generally produce larger yields. This translates into more yield per gallon of water extracted from the soil. Another way to say this is that greater water use efficiency results from proper plant nutrition.

How much water is in our food?

It seems like there is rarely enough water in western North America to meet everybody's needs. Especially after several years of prolonged drought in many areas, farmers are stressed to learn that there may be insufficient water to grow their crops.

A common cry from the urban areas is that agriculture uses more than its "fair share" of water. Some estimates have been made that more than 80% of developed water is going to agriculture in many areas. Attention is drawn to the fact that agriculture loses too much water through cracks, seepage, and evaporation from the miles of canals and pipelines. These losses should be addressed when financing is available.

Most consumers do not appreciate the large amount of water required to grow plants. A poorly understood concept is that a huge amount of water is indirectly delivered to cities in the form of food. A report by the Water Education Foundation documented the amount of water required to produce various foods in the western U.S. Their basic approach was to divide average water use (evapotranspiration) by average yields to determine the gallons of water per pound of food produced. Since some of the water delivered to a farm is unavoidably lost as deep percolation, runoff, or soil moisture storage, the irrigation efficiency was assumed to be 70%.

Using a typical 2,300-calorie menu proposed by the U.S. Department of Agriculture, the following meal was constructed and the gallons of water required to produce that particular food item are shown.

Breakfast	**Gallons of water per day**
One medium orange	14
Two eggs	126
Two slices of toast	22
Two pats of butter	92
One cup of milk	48
One quarter cantaloupe	40
	342 gallons
Lunch	
Taco salad (tomato, lettuce, hamburger, chips, and cheese)	806
One-quarter cantaloupe	40
	846 gallons
Snack	
One-quarter cup of almonds	160
One cup of yogurt	88
One cup of orange juice	49
	297 gallons
Dinner	
Chicken broccoli stir-fry	180
One cup of rice	50
Two slices of bread	22
Two pats of butter	92
Fruit cup	35
One cup of milk	48
	427 gallons
Total	**1,912 gallons**

Do farmers use a lot of water?

Yes… and we all benefit tremendously from their productivity. The water may not only come from our faucets, but it also comes to us in every bite we take.

Proper plant nutrition is a vital key to achieving efficient use of water. Nitrogen deficiencies have an impact on the ability of a crop to convert available water into yield. **Phosphorus** is important in stimulating seedling root development. This helps the plant explore more soil, increasing the recovery of nutrients and water. **Potassium** is often referred to as the regulator nutrient, influencing the water dynamics in plants. **Nutrients play an essential role in allowing plants to convert water and sunshine into food.**