CROP WATER USE and YIELD

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INTRODUCTION

A question that often arises in discussions of dryland cropping systems is, "How much water will a given crop use?" The answer to that question is not a single number, for crop water use is a variable number influenced by a number of environmental and plant factors.

FACTORS AFFECTING CROP WATER USE

Water Availability

Water availability in dryland cropping systems is comprised of 1) water stored in the soil that exists at planting time and 2) growing season precipitation. Not all of the water stored in the soil is available to a given plant species, for different species have different rooting depths, rooting densities, and water extracting capacities. Fig. 1 shows the lower limit of soil water extraction for several crops and clearly shows the ability of sunflower to extract water to a lower volumetric water content than wheat, corn, and millet at lower soil depths. Additionally, the amount of water stored in the soil at planting time is a consequence of how much precipitation has fallen during the preceding non-crop period, and the crop residue characteristics, weed control, and tillage frequency and method used. The better the weed control and the less aggressive tillage employed, the better the residues will be maintained, resulting in more stored soil water for the crop to use. Crop water use increases with more available soil water at planting. Likewise, crop water use increases with more growing season precipitation. So in general, crops use more water in wet years than in dry years.

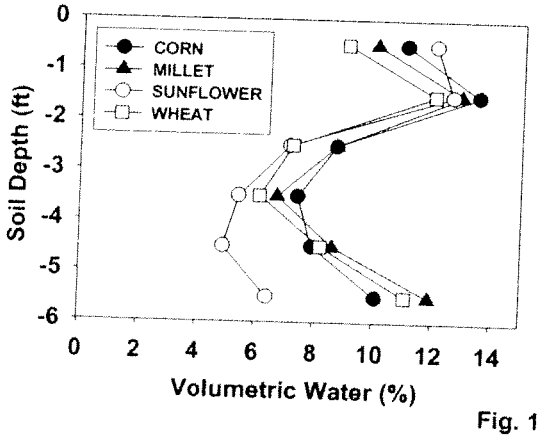

Fig. 1

Length of Growing Season and Time of Year

Fig. 2 shows typical growing seasons for wheat, corn, sunflower, and proso millet superimposed on the graph of average monthly temperature at Akron, CO.

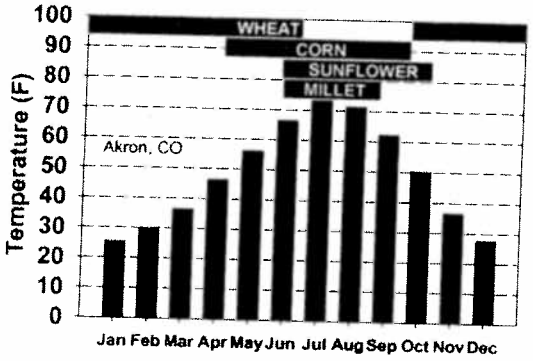

Fig. 2

Winter wheat does much of its growth during months with much cooler temperatures, lower solar radiation, and higher humidity than the growth periods of the other three crops, but grows for many more months. On the other hand, millet grows for a much shorter time period than the other three crops, which shortens the amount of time during which the crop can use water. Additionally, weather conditions vary from year to year. Years with above average temperature, solar radiation, and wind, and below normal humidity will have higher than average crop water use.

Eight-year average dryland crop water use values at Akron, CO are shown in Fig. 3. Highest water use was seen for winter wheat in the wheat-corn-fallow rotation. Wheat water use in the wheat-fallow (conventional till) and wheat-corn-millet systems was lower because less water was available in those two systems at planting time. Pea water use was lowest because of its short growing season, shallow rooting depth, and cooler temperatures in which it is grown. Sunflower water use is lower than might be expected because of the intensity of the rotation in which it was grown (sunflower-fallow-wheat-millet). There is very little opportunity in this system for soil water recharge in the lower soil profile (below three feet) following the wheat and millet crops. Consequently, soil water that would normally be available to sunflower at those lower depths generally does not exist.

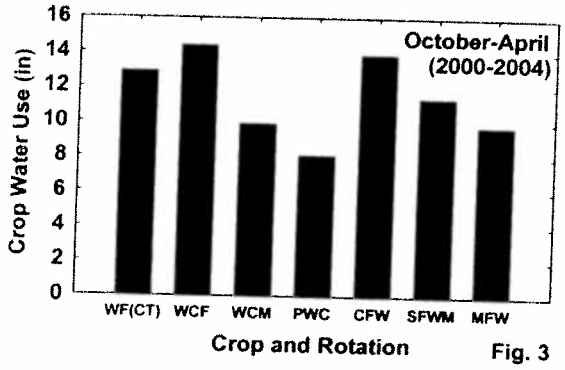

Fig. 3

It should be remembered that the water use values shown in Fig. 3 are averages and that water use varies widely from year to year due to weather, growing season precipitation, and stored soil water. For example, wheat water use ranged from 7 to 17 inches and corn water use ranged from 6 to 18 inches.

Relationship Between Crop Yield and Water Use

Fig. 4 and Table 1 show the linear relationships existing between dryland crop yields and water use, and that those relationships differ with crop species. Corn is the most responsive species to water, with yield increasing at a rate of 582 lb/a per inch of water use. Yields of seed legumes such as chickpea, black bean, and pea respond at a lower rate, while oilseeds such as canola, crambe, and sunflower have the lowest seed yield response to water use. These differences are a result of differences in carboxylation pathways (C3 vs C4), and differences in energy requirements to produce starch, protein, and oil.

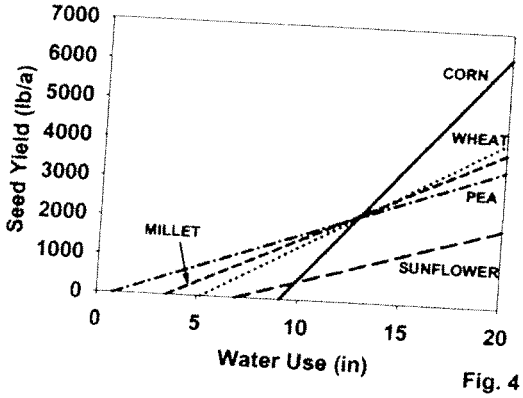

Fig. 4

Water Use Yield Relationships		
Crop	**Slope (lb/a per in)**	**Water Use Offset (in)**
Corn	582	9.1
Wheat	283	5.2
Millet	237	3.5
Chickpea	240	5.8
Black bean	193	5.5
Field pea	181	0.8
Soybean	179	3.7
Canola	176	6.2
Crambe	171	3.4
Sunflower	151	6.9