Increasing Irrigation Efficiency

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All Arizona residents are aware that water is a very precious commodity in the state. The water used for agriculture and other purposes comes from three main sources: the Colorado River (36%), Arizona River (e.g. Salt, Gila, Verde, etc. 21%), and ground water (40%). Agriculture uses about 74% of the water, with municipal uses at 21% and industrial uses 5%. Crop production in Arizona is almost totally dependent on irrigation since precipitation where topography and soils are suitable for farming is not sufficient to raised crops without it. Irrigated farming is an important contributor to Arizona's economy, but because it also is a major user of water, it is important to implement practices that make irrigation as efficient as possible. Efficiency means to ensure that as much of the water as possible is used by the crops being raised and not lost to evaporation, seepage, weeds, or runoff. Increasing efficiency of irrigation use, as well as improved water conservation measures implemented in municipal and industrial uses, has resulted in an actual decline in the annual use of water in Arizona since 1980 despite a great increase in population http://www.arizonawaterfacts.com/water-your-facts.

On irrigated cropland there are a number of practices that can be used to improve the efficiency of water use. All of them have the objective of reducing water loss and maximizing the proportion of water actually used to grow the crops. Which practices, or combination of practices, are applied depends on the type of crop, the characteristics of the soil being cultivated, the quality of the water being applied, and the economic feasibility of implementing these practices.

The type of irrigation system used has a major effect on efficiency. There are three main types of irrigation used in agriculture: flooding, sprinklers, and drip. Flooding involves releasing a large volume of water onto a field periodically. For row crops (cotton, vegetables, etc.) the water may be released into furrows by siphon tubes coming from an irrigation ditch, where it runs by gravity down the furrow long enough to let the water soak the soil to a desired depth. This type of flooding often results in some water (tail water) being lost at the lower end of the furrow where it may run off into nearby drainage, or sometimes into a holding basin. In some cases, a "pump back" system can be used to return this tail water to the upper side of the field and use it again, thereby increasing efficiency but with an added cost of pumping.

Another method of flood irrigation, often used for forage crops, is called border irrigation. Here portions of the field are separated by small dikes, called borders, and the areas within the borders is flooded. If the land can be leveled so that the application of water is uniform across the area, then loss to tail water is eliminated. So, this method is usually more efficient than furrow irrigation, but requires a high rate of water delivery. Both furrow and border irrigation lose water to evaporation while the water is being applied and from the wet soil surface after irrigation. Some water may also seep below the level of plant roots and be lost to ground water, so efficiency can be increased by carefully applying only the amount of water that will remain in reach of the crop's roots.

Sprinkler systems of various types are generally more efficient than flooding systems because they apply water more uniformly over the land and also apply it at rates calculated to allow the water to soak into the soil as it is applied and not stand on the surface or runoff the field, thus reducing water lost to runoff, evaporation, and deep seepage. There are two main types of sprinkler systems: side roll and center pivot. Both are connected to hydrants fed by water pumped from a well or a reservoir through an underground pipe. The side roll is a series of connected pipe sections, each with wheels and a sprinkler head. The unit can be moved across the field and irrigate sections at each location. Center pivots are similar but are connected to a hydrant at the center of the field and move in a large circle like the hands on a clock. The sprinklers are calibrated to apply the same rate of water at each position on the pivot and the rate of movement calibrated to provide the desired rate of water delivery. Center pivots are generally more efficient than side rolls and require much less labor. Sprinklers have the advantage that the rate of water application can be uniformly controlled, thus reducing water loss by deep seepage or runoff. Evaporation losses can be reduced by irrigating at night and avoiding windy conditions.

The most efficient systems are various kinds of drip irrigation which are mainly used in orchards, some vegetable crops, etc. In this system plastic pipes are laid down the rows of plants with a small "emitter" at each plant. Water is applied directly to each plant at a slow rate. This reduces the amount of water needed because only the soil containing the plant roots is wet and thus loss to evaporation, deep seepage, and runoff is eliminated. By comparison, flood irrigation efficiency is often not much better than 50%, sometimes less. Sprinkler irrigation is usually around 75-80%, and drip irrigation is about 90-95% efficient.

Other ways to increase water use efficiency include reducing losses that occur in moving water from its source to the field. Water is often supplied in canals or ditches. Lining these ditches with concrete or other materials reduces seepage loss through the ditch banks. Reservoirs can also be lined or treated with bentonite to reduce seepage. Weeds may compete with crops for water, so keeping the field clear of weeds can save water for use by the crop. Using well-adapted, high producing strains of crops, as well as adequate fertilization and control of disease and insects, can also make water use more efficient. Applying plenty of water to healthy plants will result in more efficient use of that water in producing a crop than skimping on water, fertilizer, and pest control, or using inferior plant genetics. Sickly plants still use water, but don't produce much crop.

The foregoing discussion only dealt with efficiency of water use, but economic efficiency must also be considered. All of the practices described above cost money to implement and to operate. For example, switching from flood irrigation supplied by gravity flow to a center pivot system not only costs money to buy and install the center pivot, but also requires added expense in pumping water. To be economically feasible (efficient) the added cost must be offset by added value of the product produced or savings in other inputs. For example, in some areas of Arizona, fields that formerly produced cotton or grain sorghum using flood irrigation from ground water, are now planted to pecans and pistachios using drip irrigation. Pumping costs due to increased energy cost and increasing depth to groundwater made cotton and other crops uneconomic. Shifting to orchards with drip systems cost money to install, and a waiting period before a crop could be harvested, but the water use and pumping costs were reduced, and the crop produced has a higher value per acre than the previous crops.