"EFFICIENCY" OF WATER APPLICATION METHODS IN ALFALFA

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Irrigation is recognized to be one of the most important cultural practices required for the productional alfalfa in California. Soil moisture conditions are closely related with other production factors such as: weed control, nutrition, stand longevity and overall yield all of which effect economic returns and survivability of the farm unit.

Irrigation is considered a major economic input with total cost of $160-$275 per acre per year depending on type of system and water cost. Considering these costs, irrigation systems deserve constant reevaluation to assess overall efficiency to maximize returns.

Alfalfa is a long season crop requiring slightly less than 50 inches (consumptive use) in a growing season. Alfalfa must compete with other crops for available water and land resources. It accounts for 20 percent of the irrigated area in California and uses about 22 percent of California's irrigation water. Ever increasing water needs and competition for California's available water supply stimulate the need for more efficient use of this scarce but vitally important resource.

The term efficiency when applied to irrigation is often used indiscriminately. Efficiency in irrigation can have many meanings:

Distribution Efficiency. This is often the term used for the uniformity of distribution of an irrigation system. It indicates how uniform irrigation water is applied to the land not considering type of crop, extent of root system or salt tolerance of crop.

Irrigation Efficiency. This term relates to the ratio expressed as a percent of the crop consumptive use to water applied.

$$\text{Irrigation Efficiency} = \frac{\text{crop consumptive use}}{\text{water applied}} \quad \frac{5.0}{10.0} = 50\%\ \text{Ei}$$

Water not directly consumed by plants or evaporated from the soil surface can be lost through seepage and evaporation from delivery canals but are generally small in comparison to losses from surface runoff and deep percolation.

Over irrigation and lack of uniformity in slope and intake rate in addition to the use of a small irrigation stream can increase deep percolation losses. Theoretical efficiency is 100% although in an arid or semi arid climate which provides little winter leaching of salts from rainfall, a 100% efficiency is not possible since a leaching requirement is necessary which would decrease efficiency potential unless the leaching fraction is considered a beneficial use of water. Salts can concentrate in soils if water additional to consumptive use (leaching fraction) is not applied to leach salts from the root zone. In general 10%-15% of the consumptive use is needed as a leaching requirement. This water need not be applied in addition to the water passed through the root zone associated with system inefficiency. Thus, although the leaching requirement is a beneficial use of water, most systems have this amount of deep percolation.

a) On-farm or field irrigation efficiency considers all losses:

runoff
deep percolation
canal seepage
canal evaporation

Therefore field irrigation efficiencies are generally lower than basin efficiencies.

b) Basin irrigation efficiencies considers as losses only the water which is released from the basin thru surface drainage, evaporation from free water surface or deep percolation of water to a water table which substantially degrades its potential for future use or to a depth uneconomically recoverable. Basin efficiencies are generally higher than on-farm or field irrigation efficiencies.

Since alfalfa is a major crop in California, a major improvement in irrigation methods and efficiency could have a significant impact upon production,water conservation, energy conservation, water quality and in some cases more net profit.

Improved on-farm efficiencies would result in:

less leaching of nutrients below the root zone resulting in a possible savings of fertilizer,
less opportunity for standing water to decrease stand and support weed growth,
less water applied reducing costs of water and energy.

Economic Efficiency. Production of a top yielding crop with a minimum amount of irrigation inputs. This factor is primarily the motivation behind water decisions on the farm. It puts the bread and butter on the table. A water conservation practice which saves water but is wasteful of capital resources may be tried by growers but will not be widely adapted.

Irrigation methods should be selected on the basis of many soil and crop characteristics as well as on economic conditions. There are two basic methods of alfalfa irrigation, flood and sprinkler both having specific characteristics making them suitable for a wide range of conditions.

Key factors affecting the choice of an irrigation system are:

Soils

infiltration rate
water holding capacity
soil depth
non uniformity in intake rate on water holding capacity

Crop

evapotranspiration rate
salt tolerance
cultivation requirements
economic return

Topography

land slope

Climate

wind pattern

Economics

available capital
cost of water
cost of power
cost of labor

The type of irrigation systems used in California for the production of alfalfa along with their general characteristics are listed in Table 1. Sprinkler irrigation systems generally are higher in efficiency than flood systems. Although a properly designed system of the types listed can perform similarly in terms of efficiency. But it is important to note that the best designed system will not function efficiently without proper manage-

TABLE 1. Factors to Consider in Selecting an Irrigation System.
(Limitations of Systems)

FACTORS TO CONSIDER	SPRINKLER SYSTEMS					SURFACE FLOOD SYSTEMS		
	Portable	Wheel Roll	Solid Set	Center Pivot	Boom (Giant)	Graded Border	Level Border	Furrow
SLOPE LIMITATIONS:								
Direction of Irrigation	20%	15%	None	15%	5%	0.5-4.0%	Level	3%
Cross-Slope	20%	15%	None	15%	5%	0.2%	0.2%	6%
SOIL LIMITATIONS:								
Intake Rate (in./hr.) Minimum	0.10	0.10	0.05	0.30	0.30	0.30	0.1	0.1
Maximum	6.0	6.0	6.0	6.0	6.0	2.0	2.0	3.0
Water Holding Capacity in Root Zone	3.0	3.0	None	2.0	2.0	6.0	6.0	4.0
Depth	None	None	None	None	None	Soil should be deep enough to allow for grading required.		
Erosion Hazard	Slight	Slight	Slight	Moderate	Severe	Moderate	Slight	Severe
Saline-Alkali Soils	Slight	Slight	Slight	Slight	Slight	Moderate	Slight	Severe
WATER LIMITATIONS:								
Quality:								
Total Dissolved Solids (TDS)	Severe	Severe	Severe	Severe	Severe	Slight	Slight	Moderate
Suspended Solids	Moderate	Moderate	Moderate	Moderate	Moderate	None	None	None
Rate of Flow	Low	Low	Low	High	High	Moderate	Moderate	Moderate
CLIMATIC FACTORS:								
Temperature Control	No	No	Yes	No	No	Yes	Yes	Yes
Wind Affected	Yes	Yes	Yes	Yes	Yes	No	No	No
ADAPTABILITY TO ALL CROPS	Good	Good	Good	Fair	Limited	Very Good	Very Good	Very Good
SYSTEM COSTS: (1976 data)								
Capital Cost ($/acre)	400-600	400-600	700-1200	700-1000	600-700	500-600	500-600	400-500
Labor Cost 1/	High	Moderate	Low	Low	Moderate	Moderate	Moderate	High
Power Cost 2/	High	High	High	High	High	Low	Low	Low
Average Annual Cost 3/ ($/ac/yr)	100-200	100-200	200-300	200-300	200-300	100-200	100-200	200-300
APPLICATION EFFICIENCY 4/	70-85	70-85	75-90	70-85	65-80	70-85	75-90	70-85

1/ Low = Less than $70/ac/yr, Moderate = $20-50/ac/yr., High = over $50/ac/yr.
2/ Low = 0-$5/ac/yr., Moderate = $5-$15/ac/yr., High = over $15/ac/yr.
3/ Amortized capital cost plus operation and maintenance cost.
4/ Assuming good to excellent management.

ment.

An irrigation method and system should meet your requirements and function efficiently under your management conditions.

Conclusions. An irrigation method and system should be selected based on a variety of criteria including soil and water characteristics and economic factors.

Irrigation systems should be monitored and reevaluated using a variety of efficiency terms. Especially considering rapidly changing energy and labor costs.

Low "efficiency" irrigation systems can be improved many times through increased management rather than increased capital expenditures.