

Theme V: Interaction Between Water Delivery and Irrigation Scheduling  
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Irrigation Scheduling: From Theory to Practice

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**Guidelines for Establishing Irrigation Scheduling Policies**

by

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**Summary**

Successful on-farm irrigation scheduling requires that water delivery projects adopt a service concept, and that water deliveries be made with a high degree of reliability. An arranged delivery schedule and seasonal volumetric allocations are additional requirements. Until these conditions are met, attempts to implement modern on-farm irrigation scheduling techniques to maximize water use efficiency, and to maximize yields will be only partially successful.

**Introduction**

The agronomic concept of irrigation scheduling is to apply water to the crop in the correct amounts and at the proper times to maximize crop production and/or profit, while maintaining a reasonably high irrigation efficiency. The water delivery engineer concept of irrigation scheduling is to develop and implement a schedule of water deliveries which is compatible with the water delivery system capabilities and constraints, with the least amount of hassle. It is desirable for an irrigation project to combine the two concepts by developing an irrigation scheduling policy which extracts the most flexible and reliable performance available from the water delivery system to meet the agronomic goals.

Various theoretical computer models have been developed which examine the complex hydraulics of water delivery systems together with the evapotranspiration/soil water balance concepts in the field. This author believes that the most beneficial uses of such models are associated with training or examining general patterns of water use. They generally have little or no practical use in terms of implementing a desirable schedule of water deliveries on a real time basis, if the goal is to maximize personal farmer initiative and crop yields. Farmer initiative is very important, as it will impact many on-farm decisions, the willingness to pay for water, and the desire to maintain (or not destroy) project facilities.

Successful irrigation scheduling must be simple to implement and easy to understand, from both the farmer and project management personnel standpoints. Practical irrigation scheduling policies must also recognize that hydraulic, weather, crop, and soil conditions are variable and dynamic. Irrigation scheduling programs must be robust enough to withstand physical and human uncertainties.

This paper points out a number of factors which the author feels are very important for implementing a viable irrigation water management scheme which includes irrigation scheduling as one component.

### **Flexibility**

A discussion of irrigation scheduling must consider the degree of flexibility which is to be offered to the farmer (or to a group of farmers). Flexibility has three components: (i) frequency, (ii) flow rate, and (iii) duration. There are numerous variations of these three components, and many authors have developed terminology to describe various types of delivery schedules, such as "rotation", "arranged", and "limited rate demand".

In theory, it would be nice if farmers had water available on complete demand. In practice, areas with very advanced on-farm irrigation systems, such as California, do well with an arranged schedule. The following conditions are generally required in California for an arranged schedule if optimum on-farm irrigation efficiency and crop yields are to be obtained:

1. The flow rate must be large enough to minimize labor requirements.
2. The farmer should be able to open and close his own turnout (offtake) without needing a project employee present.
3. The water can be ordered within 24 hours advance notice. If a farmer has a known weekly schedule, the water supplier can provide that schedule without being re-notified.
4. The water is available on a volumetric basis, which allows both the farmer and district to understand that there is an upper limit to the amount of water available for a season/year. Furthermore, the flow rate and volume delivered per irrigation is controllable and is known to the farmer in advance.

5. The water delivery can be shut-off at any time by the farmer with minimal or no advance notice.
6. The flow rate and duration of irrigation can be changed from one irrigation event to another.

Additional water management flexibility is sometimes obtained downstream of the offtake with reservoirs, or with conjunctive use of well water.

It must be acknowledged that in many countries, this degree of flexibility cannot be given to individual farmers because the fields are too small. However, this degree of flexibility may be given to a larger farmer unit area of 50 ha.

Certainly, all farms in California do not receive water with as much flexibility as described above. However, as water management becomes more important most California water districts are rapidly moving toward providing such flexibility.

### **Who's the Boss?**

A key idea abides within the flexibility criteria outlined above -- the government does not dictate the schedule of irrigations on a farm. Government agencies rarely have the expertise, manpower, or ability to determine the optimum schedule of irrigations on individual fields, much less implement that schedule. How many engineers have seen the well-defined rotation schedules displayed prominently on boards in irrigation projects, and to realize that they exist only on the board? We should recognize the failure of such attempts and move on to other options.

Water delivery agencies should be cognizant of the fact that their responsibility is to provide service, not to dictate schedules. The only way this concept of "service" can possibly work is if the water delivery system is broken into "levels of service". The main canals provide service to the secondary canals, which in turn serve the distributaries, which serve the offtakes, etc. Obviously, all canals and levels cannot provide service of the same flexibility or reliability. For example, run-of-the-river schemes have inherent limitations that reservoir-supplied projects do not. Nevertheless, when the concept of service is wholeheartedly adopted by project staff, amazing agronomic and social improvements can be made.

Of course, providing service means a shift in power and attitudes. It requires a shift from pride in power to pride in service. The prospect of relinquishing power may also bring up the following question: How can project managers prevent anarchy if the project management is not able to dictate water delivery schedules?

This question often ignores reality. In many projects one should ask: Is the present state of water delivery anarchy due, at least in part, to the impossible water delivery schedules which are theoretically imposed on the water users (at any level in the delivery system) by project management?

### **Risk, Volumetric Deliveries, and Details**

We must remember that farming is risky business, and the farmer is the one and only person that truly takes a risk. Therefore, the farmer should be given water with as much flexibility as possible so that the farmer can manage his water well and minimize his risk. The water agency, however, only has a certain amount of water available, and there are system design constraints (which can often be overcome) that put limitations on flexibility. The water agency, once it buys into the service concept, will do its best to provide the maximum flexibility possible.

How is water wastage minimized if flexibility is provided? Quite simply -- farmers must be allocated a known and reasonable volume of water. When that volume is used up, there is no more water forthcoming unless the farmer can purchase water from other farmers. Does this mean that modern on-farm irrigation scheduling is impractical on most existing projects until volumetric deliveries are established? This author believes that the answer is yes.

There is another point to consider -- there is no justification for project authorities to concern themselves with the details of developing on-farm irrigation schedules. Those details are too complicated for central authorities to tackle. Instead, the burden should be placed on the farmer, who will willingly pick up that burden -- if the volume of water is known and guaranteed.

This does not say that project authorities should not assist farmers with demonstrations and technical assistance regarding irrigation scheduling. If the demonstrations and technical assistance are simple and worthwhile, the farmers will adopt the recommended practices. If "modern" irrigation scheduling schemes have not been adopted by farmers, those schemes must not have provided substantial, identifiable benefits.

This discussion highlights several key points:

1. Good water management and irrigation scheduling require volumetric allocations and volumetric deliveries. How can farmers begin to think in terms of proper depths of irrigation (i.e., irrigation scheduling) unless this is so?
2. There must be an ability to withhold water from farmers once they use up their allotment.

3. The water volume must be provided in a fashion that it is usable and beneficial. If a volume is allocated, but that volume is only available in an unreliable or untimely manner, the program will fail.

Such a volumetric delivery program requires extensive programs to make farmers aware of the concepts of water depths and volumes, basic crop water use, and soil water holding capacity. These programs do not depend upon sophisticated soil moisture monitoring equipment, remote sensing, or other such elaborate devices/tactics.

### **Reliability**

Irrigation scheduling discussions often concentrate upon crop water requirement computations and the degree of flexibility needed for water deliveries, just as was done in the previous paragraphs.

We must not lose sight of the fact that unless the water deliveries are reliable, confidence in a new program will be immediately lost and irrigation scheduling programs will be disasters. Given a choice between a program having high flexibility but unreliable deliveries (due to operator errors, technical difficulties, politics, etc.) versus a less flexible but very reliable system; the latter is preferred.

### **What About Those Computer Programs?**

FAO has been a leader in publishing information about weather-based evapotranspiration predictions. Numerous conferences, including this one, provide additional insight to the mathematics and details of computerized on-farm irrigation scheduling. Irrigation scheduling computer programs have been available through government programs and commercial irrigation scheduling companies in the U.S. since the early 1970's. Noting that there are always exceptions to any rule, the author believes that the two major benefits of these computer programs have been:

1. They have provided education for many farmers. If, however, the major benefit has been education rather than real-time decision support, one must ask if there is an easier way to transfer the information to farmers.
2. They provide a data base, or accounting of irrigation for farmers with multiple crops and fields. Although this may be important for many U.S. farmers with diversified crops, it is not a typical need of small farmers in most countries.

In California, well under 5% of the farmers personally own and use such computer programs for real-time information, even though they are readily available. Government assistance programs in California have largely moved away from providing real-time scheduling and soil monitoring of individual fields.

Rather, the computer programs are often used by water districts or the California Dept. of Water Resources (the CIMIS program) to provide an estimate of ETo, and perhaps an estimate of daily or weekly ET for the most popular crops in an area.

The author does not want to make light of these programs - but wants to put things in perspective. In California and other locations in the U.S., there are many farmers who do hire commercial irrigation scheduling services just as they hire soil fertility specialists. Those irrigation scheduling services provide information which, when combined with other information such as the need for tillage and spraying, allows the farmer to make a more informed decision.

A small farmer with only a few hectares of land will not suffer from a lack of computerized irrigation scheduling information. That farmer also does not require sophisticated soil moisture sensing equipment. In general, the most limiting factors for his excellent on-farm water management are the lack of flexible and reliable water deliveries, and poor land grading.

### **What Can Irrigation Project Authorities Do?**

The following steps must be followed in order to take improved water management off the books and into the field:

1. Recognize that "irrigation scheduling" tools are just that -- tools. Irrigation scheduling programs, whether they are computer programs or one-on-one demonstrations of how to estimate soil moisture "by feel", are means to an end, not the end. The goal should be improved water management - not the implementation of a specific irrigation scheduling program.
2. The service concept must be adopted by the water delivery agency so that water can be delivered with the highest possible degree of reliability and flexibility. This requires that decisions to be decentralized, so that the management becomes responsive rather than dictatorial.
3. Water must be allocated and delivered volumetrically, and in a manner (i.e., flow rate, duration) that is compatible with good farming and irrigation practices.
4. Only after points 1-3 are adequately addressed will on-farm demonstrations and discussions of on-farm irrigation scheduling be meaningful to most farmers.