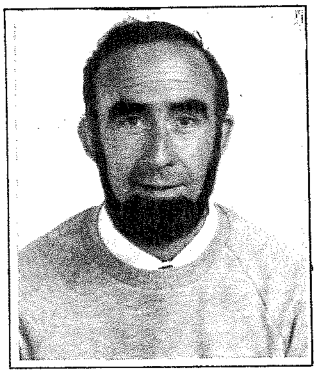
More irrigation with less water

Although the area which can be irrigated in New Zealand has been increasing at about 10,000 hectares annually in the 1980s, surface and groundwater availability is becoming increasingly constrained in some areas by natural shortage and competing interests. Volumetric efficiency of water use is therefore increasing in importance.



By David Painter

Irrigation is the managed supply of water to crops. It must satisfy water requirements of the crops a farmer or grower waters during a season, given certain management constraints. Some constraints are subtle, like the effect of irrigation devices on crop pests and diseases. Those constraints which are common and important are:

- Water availability
- Labour availability
- Irrigation equipment availability
- Financial resources and subsidies
- Management ability.

The "best" irrigation system for a particular situation is that which most closely meets the management objectives while staying inside the management constraints.

Coping with change

Weather changes daily, while crop growth stages and perhaps water availability change not much more slowly. These effects have traditionally been coped with in sprinkler and trickle irrigation by basing irrigation system capacity (eg maximum design flow rates) on expected extremely high values of some parameters, such as crop ground cover and evapotranspiration, and expected extremely low values of others, such as rainfall or well water levels. At the same time, irrigation system management has been based on the actual, time-varying values of other parameters, including soil moisture and stage of growth. Thus short-term changes have been coped with by having irrigation systems with built-in flexibility of operation.

Some irrigation systems of all application types have had inflexible operation and built-in over-capacity to deal with these short-term changes. Such systems should be changed if water is to be efficiently used to meet irrigation objectives.

Markets and crops change longer-term, say annually; so do costs, equipment available and perhaps water availability again, as it also depends on climate, competing uses and legislation.

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Current systems

Natural market forces and monitoring methods typical of a managed economy ensure that most current irrigation systems are contributing effectively to incomes — the farmer's and the nation's. It is also clear that there are unrealised potential benefits from building more irrigation systems, similar to those already in place. Large irrigation schemes are not immune to the cost increases which strike other major projects, but net benefits continue to be shown.

These positive statements do not mean that there is nothing wrong with current systems. Motivation for change in both current systems and those yet to be installed comes in two ways: from realising that a system in place is not the "best" irrigation system for its situation, or from realising that the constraints in place have changed since it was the "best". Even systems which are technically good sometimes have a poor "image". Their operation and benefits are not well understood, particularly by those who advocate competing uses, or no use at all, for their water supply resources.

Although it is almost impossible to define what it would be, it is clear that primary industry is entitled to a fair share of water, in regional and national interests. As no over-riding priority has been given to primary industry a fair share of limited water resources implies a comparison of objectives, requirements and benefits of water use with competing interests.

Because more irrigation in New Zealand is possible and has potential benefits, it is desirable. Because increasingly severe constraints on water availability are becoming apparent it is necessary to increase the degree to which the irrigation objective is met without using extra water, to maintain this degree using less water — and bring in more area irrigated — or do both. (Hence the ambiguous title of this paper: it is "more irrigation-with-less-water" rather than "more irrigation, with less water")

These necessary changes are technically feasible. The concept which must be emphasised is that of volumetric efficiency of water use in meeting reasonable demands.

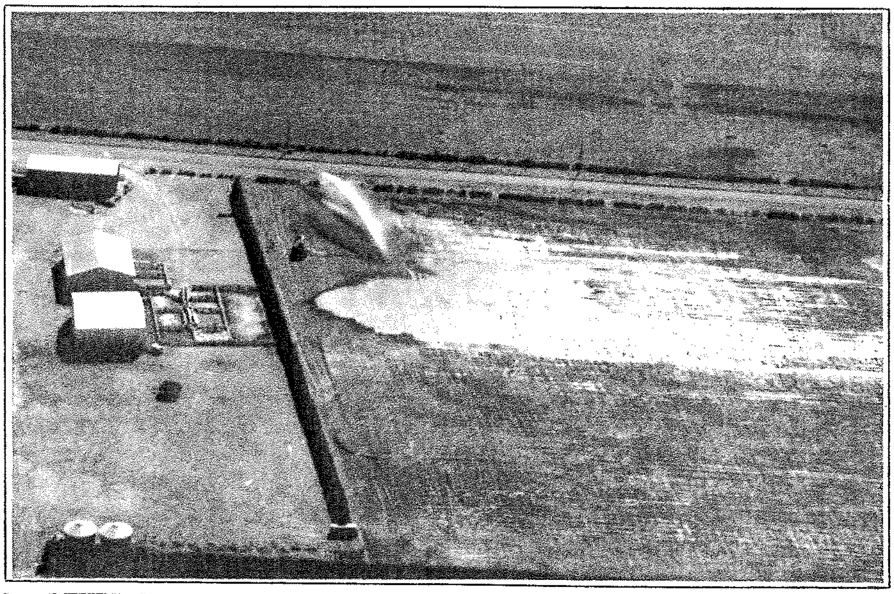
Reducing demand

Some crops, fruits especially, benefit from a restricted water supply at certain growth stages. But much greater water savings can come from reducing water losses. These occur all the way between extracting water from a supply and delivering it to the roots of plants. Losses during extraction, delivery and application are often obvious. (See "What is irrigation efficiency?" *Soil and Water* 14(5) 1978.) They include relief valve and filter flushing bypasses, leakage from pipes or channels, wind effects and evaporation. Losses during storage in the root zone are less obvious and have sometimes been overlooked.

To avoid losses during storage in the root zone it is necessary to ensure that more of the applied water passes by transpiration through the crop, less is evaporated from the soil or weed plants and less is lost by movement away from active roots, notably by deep drainage. The more obvious problems are: over-watering the top ends of strips in border-dyke irrigation; non-uniform, wind-affected sprinkler patterns requiring over-watering in some parts to ensure a minimum desired amount in others; deep percolation in porous soils during trickle irrigation.

The recent popularity of large self-propelled spray or sprinkler booms has led to research (at the NZ Agricultural Engineeirng Institute) on the losses likely to occur due to very high level local intensity of application. Spatial variability of soil properties, the details of field microrelief and macropore development due to soil fauna or soil-cracking behaviour can combine with the high intensities to produce underwatering of high spots and over-watering of low spots. In some circumstances, the non-uniformity can be much greater than that previously estimated from above-ground water distributions and losses can be severe. When watering patterns are much larger than individual plant root distributions, as in sprinkler irrigation of peas for example, then uniformity of water application and soil water-holding properties are very important.

If the reverse is true, as in trickle or micro-irrigation of orchard trees, then the application sites and plant root behaviour are very important. Designers then need information on the newer micro-irrigation equipment, which is becoming available, and on irrigated root behaviour, which is not yet so readily available.



A travelling "big-gun" irrigator near the end of its run. An application rate greater than the soil infiltration rate has led to surface ponding and overland flow to low spots. (Photo, KWC Nicolle).

A final example of reducing water demand by reducing waste of water is making better use of rainfall. Because rainfall is not certain in amount or arrival time it is often simplest to manage irrigation ignoring all but large amounts of rainfall of opportune timing. But if irrigation water has been applied to "field capacity" and is followed by addition of appreciable rainwater, then waste occurs. In over-simplified terms, if reserve soil water storage is always left for rainwater, irrigation might be required more frequently, but less water will be required. A whole-system approach to design, incorporating local rainfall statistics, can reduce overall water demand.

Enhancing supply

Major water storage projects for irrigation, or for multiple objectives, have been suggested (at the National Water Conference 1982) as the next phase of scheme development. Water harvesting schemes for irrigation have been investigated and the Glenmark Scheme in North Canterbury is being completed during 1984 and 1985. Media reports in the last two years have referred to enhancing groundwater storage by deliberate recharge in many parts of New Zealand, including Hawkes Bay, Marlborough and Canterbury.

Apart from these technological aspects for enhanced water supply, there are two further possibilities which should be remembered. Better understanding of competing demands for water, such as wildlife habitat and recreational needs, could in some cases lead to more water (instead of less) becoming available for irrigation without detriment to the other needs. Better proposals, integrated with other uses and planned with full participation of people with other interests and points of view, could lead to greater acceptability of the irrigation parts of such proposals.

Conclusions:

1. Short-term changes in parameters affecting irrigation system performance (such as weather) can be catered for in design by considering system capacity and system management separately, arriving at a system with built-in flexibility of operation up to a maximum capacity. This is already conventional in New Zealand for demand-operated sprinkler, trickle and micro-irrigation, and partly incorporated in some recent, surface irrigation schemes.

2. Some irrigation schemes of all ap-

plication types have inflexible operation and built-in over-capacity. These need to be changed to more closely meet irrigation objectives within tighter water constraints.

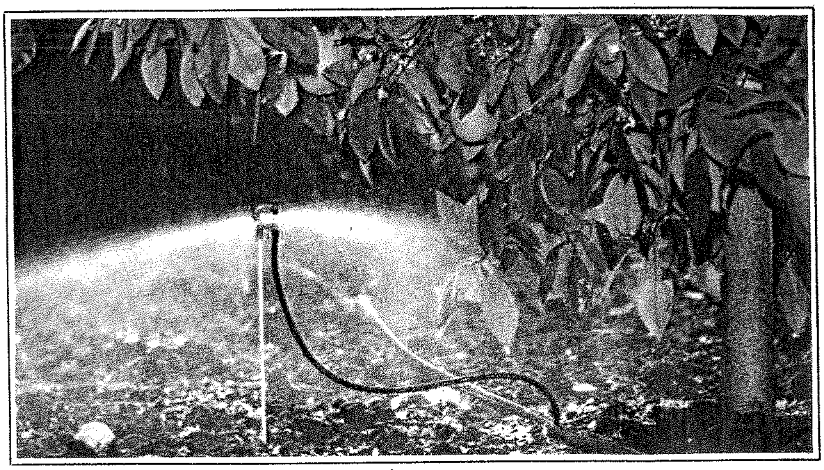
3. Longer-term changes in parameters affecting irrigation system performance (such as constraints on water availability) must be catered for by management willingness to change or adapt the system itself. Such adaptability has rarely been built in to New Zealand systems.

4. Two possible adaptations of irrigation systems are reducing specific water demands and enhancing specific water supplies. To make best use of primary industry's fair share of limited water resources it is necessary to understand and act upon the concept of volumetric efficiency of water use in meeting reasonable demands.

5. Irrigation demand can be lowered by reducing losses during extraction, delivery, application and root zone storage of the water.

6. Losses during storage in the root zone are most important, and least well-recognised. Recent research in New Zealand has provided information relevant to irrigation design and management.

7. Means are available to enhance water supplies for irrigation. They deserve attention for possible implementation by irrigation planners, designers and managers. □



One of the new micro-sprinkler devices, of the plastic spinner type, used for undertree watering covering less than the total root zone of the citrus tree. (Photo, Educational Services Unit, Lincoln College).