SUMMARY AND CONCLUSIONS

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I have been asked to prepare a summary of material presented at this Short Course. The lecturers, however, have already reduced a large, complex body of material into concise presentations encompassing such diverse fields as horticulture, engineering, economics, plant physiology, soil chemistry, soil physics and regulatory matters resulting from water shortages and urbanization. It would be presumptuous of me to attempt further reduction. Thus, this summation only highlights the most pertinent material or material with the most immediate interest.

Citrus does not have morphological features that adapt it to arid or desert regions but much of the world's citrus is grown in subtropical, arid regions such as California and the Mediterranean countries. All such citrus must be irrigated systematically.

In contrast, Florida, which produces about 20% of the world's citrus, is humid and has fairly well distributed rainfall. Citrus production is economically increased with supplemental irrigation and it is a necessity in the flatwood areas.

Brazil is the only major producer with very little irrigation and, during the year of this course, a severe drought has resulted in an estimated 20% reduction of the crop in that country.

Most of the world's citrus is irrigated in a fashion, but much of it is irrigated rather crudely.

The need to remove excess water is not as widespread as the need for irrigation but it is highly important in some regions. Moreover, considerable damage is often caused by the application of excessive water. Such management problems, the growing scarcity of water and the increasing costs of labor and equipment are popularizing the term "water management" which takes into account all facets of water problems.

The technology of citrus production and its costs in countries with advanced technologies portends an era in which irrigation must be placed on an economic basis with inputs from horticulturists, engineers and others. The use of models and computers will play an increasing role.

Technological problems of water management are very complex. The soil itself is complex and the study of water movement involves physical, chemical and biological factors, many of which are still incompletely understood. Moreover, the soil cannot be separated from the plant itself and the grower is faced with problems involving soil texture, depth of the rooting zone, chemical factors, microbiology, rootstocks and climate. The terminology alone poses a problem to growers but there is no alternative to obtaining at least a gross understanding of the scientific principles and terminology involved if water is to be managed with the greatest efficiency.

Determining when to irrigate is obviously not a simple matter. Sophisticated instrumentation is used in California, where water is expensive, to monitor the water content of the soil. Timing of applications and the amount of water to be applied are carefully determined. The same instrumentation reportedly does not work in Texas, suggesting that it must be calibrated for specific soils and possibly modified before it can be utilized in some areas. Only meager efforts have been made to use and modify such instrumentation where water is cheap. California's experience, however, and warnings that even such areas as Florida face water shortages and water quality problems, suggests that growers will soon need better means to estimate when and how much water to apply.

Discussions regarding methods of irrigation invoked much interest. Several lecturers stated that surface or flood irrigation not only constitutes a major means or irrigation but will continue to be an important method under certain conditions. Some of the surface irrigation systems, of course, are highly refined and constructed so as to require a minimum of labor. Land in Texas, for example, is precisely leveled with large land planes and long basins with permanent borders are constructed. Water is brought to these basins by underground pipe and is distributed by

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valve-controlled outlets in each basin; which results in a very low labor requirement.

Surface irrigation is not adapted to the deep sands of central Florida but it has long been used on the shallow soils of the coastal and flatwood areas. Water is introduced in these cases via ditches between the beds on which the trees are grown. This method has fallen out of favor because of inadequately constructed systems but refined systems, such as were seen by those who participated in the field trip have overcome some of the previous problems and are very effective.

Florida uses perhaps the most extensive array of systems for applying water and there is considerable information on their characteristics and costs. The traveling gun is one of the newer systems that is becoming increasingly popular because of its flexibility, relatively low labor requirements and relatively moderate initial cost. All irrigation systems, however, are expensive and each has distinctive characteristics. The high costs of establishing and maintaining irrigation systems suggests that the services of an engineer or engineering firm should be employed from the outset in planning and installing them.

The system in which there is the most widespread, immediate interest is the drip or trickler type and the closely related microjet type. Data were presented showing a large increase in the number of installations of such systems in many parts of the world during the past several years. There are many variations of these systems, based on the same principles, and they have a number of advantages in common. Among the primary advantages of drip irrigation are relatively low initial cost and low volume of water. They are not cheap even so.

There was a concensus that the basic principles of drip irrigation are sound and that trees can be effectively watered in this manner. The point was made, however, that drip irrigation is not a panacea. It has problems as well as advantages. There is still uncertainty as to the long-term response of trees to drip irrigation because the method is relatively new. There are problems related to the number of emitters needed for a specific soil and crop. Perhaps the most vexing problem is the need for simple, easy methods to prevent or overcome the clogging or fouling of emitters by slimes, algae and silt. These problems are not insurmountable but research and further modification of these systems will be needed before they reach full potential.

There was a concensus that the key to successful use of drip irrigation is management. Such systems cannot be left virtually untended. They require much more attention and maintenance than was initially envisioned.

Drip systems will face certain problems if current methods of mechanical harvesting are ever widely used because these systems shake fruit onto the ground and employ windrowing and collecting equipment that might damage emitters and lines under the trees. Moreover, current harvesting systems in sandy soil generally work best when the ground has been firmed by recent rains or the use of overhead irrigation.

The lectures made one point rather apparent, *i.e.*, a tremendous amount of information has been developed by research and extension workers and by commercial concerns on the various facets of water management. California, with its high water cost, has led the way in developing techniques for monitoring soil water and its use and determining when to irrigate. Research in Florida and elsewhere has been extensive in determining when to irrigate, physiological problems related to poor timing and excessive use of water, the responses of various varieties of citrus to irrigation and the characteristics and relative costs of various systems.

There has never been, however, a greater need for additional information and for better use of existing information. Urbanization, water shortages and governmental regulations make it imperative that we use water as effectively as possible, learn the fate of pesticides and fertilizers carried in irrigation water, ascertain the usefulness of antitranspirants in preventing moisture loss, refine our current systems and develop new ones not yet conceived.

Last, as I see it, water management has become and will remain a major part of citrus production technology. Rules and regulations regarding water use will increase, not decrease, in the forseeable future. The best cooperative efforts of research, commercial suppliers and citrus growers will be needed to keep citrus producers competitive through proper water management. This group has worked well together before and there is no reason to assume they cannot continue to do so. In addition, however, we must now concern ourselves with urban problems and gain the understanding and support of our urban population. This is a relatively new problem and solutions are not yet clear.