# IRRIGATION EFFICIENCY AND MOSQUITO PRODUCTION [1]

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The association of mosquito problems with agricultural irrigation is not new. George E. Waring, Jr., in his book "Sewerage and Land Drainage," published in 1889, referred as follows to a paper written in 1870 by the French worker Leon Colin: "Colin also states that irrigation causes an increase of intermittent fever (malaria)." Waring goes on to say, "Similar observations are made in California and in our dry Western plains, many portions of which are malarious under all conditions, with a sudden and great aggravation on the introduction of irrigation." At the time Waring wrote his book the cause of malaria was not known. We now know that he and Colin were actually reporting an increase in mosquito populations caused by the practice of irrigation. Recent studies have shown that faulty agricultural practices are the primary cause of mosquito problems in many areas.

Irrigated acreage, and therefore the potential for irrigation-caused mosquito problems is continually increasing throughout the United States. Prior to 1950 most of the irrigated acreage in the United States was in the 17 Western States. The 1950 Census of Agriculture reported a total of 25,787,455 acres of irrigated land. About 94 percent of this was in the 17 Western States, 5.3 percent in Arkansas, Louisiana and Florida, and only 0.6 of one percent in the other 28 States. If present trends continue, about 4,600,000 additional acres of land in arid and semi-arid areas will be irrigated by 1975. Supplemental irrigation is rapidly gaining favor in humid and semi-humid areas. Although the largest acreage increases in irrigated land occurred in Texas and California during the ten-year period from 1939 to 1949, the largest proportionate or percentage increases occurred in the humid area states of Massachusetts, Oklahoma, and Michigan. Several millions of acres of land have been placed under supplemental irrigation since the 1950 census. If present trends continue, a minimum of 8,700,000 additional acres of land may receive supplemental irrigation by 1975. A major portion of the increase will occur in States which have previously reported small totals of irrigated acreage. Although mosquito problems associated with supplemental irrigation may sometimes not be as severe as those associated with full irrigation, they are always important to a mosquito control program. It appears, therefore, that the factors associated with irrigation—caused mosquito problems may soon be of concern to public health and mosquito control agencies throughout all of these United States.

Efficient use of water resources is a matter of national concern. Good irrigation and water management practices, which aim toward efficient use of irrigation water, drastically reduce or eliminate many irrigation-caused mosquito problems by reducing the extent and duration of ponded water areas suitable for mosquito production. The best attack on a majority of irrigation-caused mosquito problems appears to be the promotion of practices which increase efficiency in the use of irrigation water. It behooves us, then, to be familiar with irrigation efficiency and to know what it is.

The efficiency of any given operation can be generally defined as the percentage ratio between results actually achieved and the theoretical maximum results obtainable. Efficiencies commonly referred to in irrigation practice relate to quantitative measurements of water and soil moisture. The quantitative efficiencies we are most interested in are conveyance and delivery

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efficiency, farmstead irrigation efficiency, and field application efficiency.

Conveyance and delivery efficiency can be defined as the percentage ratio between the quantity of water actually delivered to the individual farms and the quantity of water turned into the upper end of the conveyance system from the original water source. Factors which reduce this efficiency are seepage losses from the canals and structures, evaporation, transpiration from weeds growing in the canals, water wasted due to the diversion of more water than the farmers use, and water wasted due to accidents.

Farmstead irrigation efficiency can be defined as the percentage ratio between the quantity of water stored in the soil in the plant root zone and the quantity of water delivered to the farm. Factors which reduce this efficiency are seepage losses from farmstead ditches and structures, evaporation, transpiration by non-beneficial plants, accidents, and poor field application practices.

Field application efficiency can be defined as the percentage ratio between the quantity of water stored in the soil in the plant root zone and the quantity of water applied to the field. Factors which reduce this efficiency are deep percolation losses due to the application of excess water which percolates downward through the soil to a position below the plant root zone, evaporation from water standing on the soil surface, and waste water which runs off the lower end of the irrigated field.

Quantitative irrigation efficiencies, as defined above, affect both off-field mosquito production, or mosquito production outside the irrigated fields, and production on the field. Off-field production occurs through such situations as flooded roadside ditches, canal borrow pits containing water seeping from the canals, water standing in poorly constructed or poorly maintained farmstead ditches, and the development of seepage areas on the lower lands of an irrigation project. These problems can be attacked from an agricultural standpoint on the basis of saving water, preventing the development of high water table and effluent seepage drainage problems, or saving time and labor through the use of well designed and properly maintained irrigation facilities.

On-field mosquito production, or mosquito production within the irrigated fields occurs through ponding of water in the field, poor leveling with low spots, lack of surface outlets or excessive and prolonged applications of water. Practices which increase field application efficiencies also decrease mosquito production. This has been shown for intermittent irrigation by a cooperative investigation in California by the California State Bureau of Vector Control, the California Mosquito Control Association, and the Agricultural Research Service. (Davis and Husbands, 1955, and MacGillivray and Husbands, 1956). There are some exceptions to this rule, however, because application efficiencies are based on average measurements for the fields concerned and do not consider the time factor. We need to do much more work to permit us to explain and to predict these exceptions. We need to initiate studies to define the relationship between mosquito production and water application efficiencies for continuously flooded crops such as rice.

Although irrigation efficiencies generally do not consider the time factor, agricultural technicians are concerned with the length of time water is applied to the surface of the soil in intermittently irrigated fields. Intake opportunity measurements are often made in connection with application efficiency measurements. Intake opportunity represents the length of time water stands on, or is applied to, the various areas of an irrigated field and indicates the opportunity for water to soak into those areas. The purpose of such measurements is to determine the equality of distribution of irrigation water within the field. It should be mentioned that no method of irrigation provides perfect distribution of irrigation water, and that ponding of water on the soil surface can, and frequently does, occur even when sprinkling methods are used. Although, to my knowledge, intake opportunity measurements have not been so expressed, they could be converted to a "distribution efficiency" which would compare distribution actually obtained to the perfect distribution which is theoretically possible. Such a distribution efficiency would relate directly to the length of time water stands upon the soil surface in intermittently irrigated fields and so could be related to the opportunity for mosquito production within those fields. We have a serious need for the development of expressions, such as distribution efficiency, which will permit us to make direct comparisons between mosquito production and the efficiency of irrigation and water use practices. Such terms must obviously be accepted by, and useful to, irrigation and water use technicians.

Human nature being what it is, the correction of some irrigation-caused mosquito problems will have to be obtained through the enforcement of laws pertaining to public health, public safety, and public nuisances. Law enforcement is not ordinarily a popular way of doing business and is usually quite difficult. Some irrigation-caused mosquito problems can be corrected through the desire of some agencies, such as irrigation districts or county road departments, for good public relations. This approach does not always work, however, as we all know. The easiest and best approach, in the long run, will be to prove that efficient irrigation and water use practices not only reduce mosquito production but save water and increase crop production. We will then be in the excellent position of being able to show that the practices which should be adopted for mosquito control are the same practices which should be adopted for improved water use and crop production. A good start in that direction has been made through a project now under way in Montana. In 1955, co-operative field studies were initiated in the Milk River Valley, Montana by the U. S. Public Health Service and the Agricultural Research Service. The objective is to determine whether or not improved fertilization and irrigation practices can be developed which will increase bluejoint (*Agropyron smithii*) yields on heavy Bowdoin clay soils and at the same time decrease mosquito production. Preliminary results indicate that a five-fold increase in bluejoint yields is possible by using nitrogen fertilizer and allowing 60 percent of the available moisture within the root zone to deplete prior to irrigation. Mosquito production under these conditions was eliminated, whereas adjacent flooded border strips representing former irrigation practices in the area produced an abundance of *Aedes* and *Culex tarsalis* mosquitoes.

We should remember that when we work to correct irrigation practices which cause mosquito problems we are dealing with the bread and butter operations of the irrigation farmer. Our corrective programs must be based on facts, not deductive reasoning. The research we do to collect the needed facts must be based on sound scientific principles and must consider all aspects of the problems we are investigating. Physiological and ecological investigations of the mosquitoes concerned should be correlated with investigations of the plants involved, the associated soil and water phenomena, and the associated management practices. Good correlation will in many cases require concurrent measurements on the same study sites. Measurements should be made by qualified personnel whose competence will not be questioned. Entomological aspects of the problems should be investigated by qualified entomologists. Agronomic aspects should be investigated by qualified agronomists. Soil and water aspects should be investigated by qualified soil scientists and irrigation engineers. Since most individual research groups do not have personnel qualified to conduct investigations in all the fields of entomology, agronomy, and soil and water management, the best hope for reasonable progress appears to be a co-operative pooling of knowledge, resources and personnel in joint research projects. We have made a good start in this direction, but we have only scratched the surface of the potential progress which can be made through an expanded program of co-operative effort.

Mosquito control and public health agencies are most certainly not alone in their desire to promote more efficient irrigation and water use practices. Agricultural agencies, such as State Extension Services and the Federal Soil Conservation Service, have for many years been conducting programs aimed at improved irrigation and water use practices, but agricultural benefits alone have frequently not provided arguments strong enough to obtain immediate adoption of such practices. Mosquito control benefits, including improved public health and comfort and economic gains from improved farm animal health and comfort, can be of great assistance to such programs. As technical information is developed to prove the existence of these benefits the agricultural agencies will welcome it and will use it. The day will come when it will be common practice for agricultural and water use agencies to use mosquitoes as symptoms of improper or inefficient water management and irrigation practices. How soon that day arrives depends upon our progress in obtaining the information those agencies need.

The relationship between mosquito production and the efficiency of irrigation and water use practices offers us the opportunity to develop a powerful weapon for use in combatting irrigation-caused mosquito problems. This opportunity is not in itself, however, an answer to our problems. We will obtain the answers we need only through intelligent planning, wholehearted cooperation, and hard work.

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