5 Drainage and Subsurface Water Management

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5.1 Introduction

Drainage of water from the soil profile is an important hydrologic process in most agricultural soils. Natural drainage processes include groundwater flow to streams or other surface outlets, vertical seepage to underlying aquifers, and lateral flow (interflow) which may reappear at the surface at some other point in the landscape. In many soils the natural drainage processes are sufficient for the growth and production of agricultural crops. In other soils artificial drainage is needed for efficient agricultural production.

Soils may have poor natural drainage because they have low surface elevations, they are far removed from a drainage outlet, they receive seepage from upslope areas, or they are in depressional areas. Water drains slowly from soils with tight subsurface layers, regardless of where they are on the landscape; so soils may have poor natural drainage due to restricted permeability or hydraulic conductivity of the profile. Climate is another important factor affecting the need for artificial drainage. A natural drainage rate that is sufficient for agriculture at a location in Iowa where annual rainfall is 800 mm may be inadequate in southern Louisiana where the annual rainfall is 1500 mm. Nowhere is this factor more evident than in irrigated arid and semi-arid areas. Lands that have been farmed for centuries under dryland cultures often develop high water tables and become waterlogged after irrigation is established. By contrast, natural drainage may be adequate in other arid region soils and the several-fold increase in the amount of water applied to the surface due to irrigation will not result in poorly drained conditions. Seepage from unlined irrigation canals or from man-made reservoirs may also result in poorly drained soils in areas where they did not previously exist.

In summary, most soils require drainage for efficient agricultural production; many need improved or artificial drainage. In most cases improved drainage practices can be used to satisfy agricultural requirements. Drainage requirements and methods used to design systems to satisfy those requirements are discussed in the following sections. Drainage, either natural or artificial, may be excessive, resulting in loss of water that could be used by

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the crop and increased movement of pollutants to receiving streams. Thus, drainage should be considered as one component of an agricultural water management system. Controlled drainage and sub-irrigation are being used in some areas to provide both irrigation and drainage needs for crop production. Methods for analyzing and designing drainage and subirrigation systems are discussed in this chapter. Examples are presented to demonstrate the effects of drainage and subirrigation on yields and profits, and to illustrate the use of simulation models to optimize the design of agricultural water management systems. This chapter concludes with a discussion of the off-site impacts of agricultural drainage and the need to consider those impacts in design and management of drainage and related water table control practices.

5.2 Drainage Requirements

There are basically three reasons for the installation of agricultural drainage systems: (1) for trafficability so that seedbed preparation, planting, harvesting and other field operations can be conducted in a timely manner; (2) for protection of the crop from excessive soil water conditions; and (3) for salinity control.

5.2.1 Trafficability

The effect of good drainage on timeliness of farming operations is discussed in detail by Reeve and Fausey (1974). Soils with inadequate drainage may experience frequent yield losses because essential farming operations cannot be conducted in a timely fashion. The result may range from complete crop failure if planting is delayed too long to reduced yields if tillage, spraying, harvesting or other operations are not performed on time.

5.2.2 Protection from Excessive Soil Water Conditions

It is well recognized that one of the major effects of excessive soil water on crop production is the reduction in exchange of air between the atmosphere and the soil root zone. Wet soil conditions may result in a deficiency of O_2 required for root respiration, an increase in CO_2, and the formation of toxic compounds in the soil and plants. Under field conditions, both soil water and plant conditions vary continuously. Evaluating the effects of water content and aeration status on plant growth requires integration of these conditions over time during the entire growing season. One of the parameters that gives a certain integration of these factors in soils requiring artificial drainage is the water table depth (Wesseling 1974). Although the