2. LAND DEGRADATION

2.1 TYPES

Agricultural lands diminish in crop production potential or suitability for crop production through various types of land degradation*. All types are not equally important based on areal coverage, intensity or rate of degradation, and impact on soil productivity. Recognizing the relative importance of the various types of land degradation, Rauschkolb (1971) proposed three categories as a guide for use of resources to solve the problems. Included in Category I are erosion and sedimentation, salts and alkali, organic wastes, and infectious organisms (weeds, diseases and insects). Rauschkolb (1971) considered these types of greatest importance and indicated that immediate action is required to apply available technology or develop new technology to prevent land degradation from these causes from reaching a state of emergency.

Category II included industrial inorganic wastes, pesticides, radioactive substances and heavy metals. These causes were considered of lesser importance than those in Category I because of their lesser extent, intensity, or rate of increase. Fertilizers and detergents were included in Category III, which was considered to be of lowest priority for remedial action because they constituted no widespread hazard to soils and occurred only in isolated areas.

Although not included in the above categories, Rauschkolb (1971) discussed land subsidence caused by extraction of water, oil, or gas, and by mining activities as a form of land degradation. Another form, at least from an agricultural viewpoint, is the conversion of agricultural lands into urban areas, industrial sites, roads and highways, airports and recreational areas. While these may be “signs of progress”, wise long-range planning could minimize the adverse effects of these activities on present and future production.

All types of land degradation in Categories I, II and III are affected by tillage systems and related practices. In this report, however, the emphasis will be on those in Category I, and most explicitly on erosion (including sedimentation, desertification and dune creep) and on salinization and alkalization. Management of organic wastes, especially crop residues, and infectious organisms are integral parts of tillage systems, and will, therefore, be discussed as appropriate.

2.1.1 Erosion

i. Types

Soil erosion and concomitant sedimentation in ages past and at present are responsible for some of the major agricultural areas of the world. Paradoxically, past and present day erosion is also a major form of land degradation that has rendered or is rendering vast areas of land useless with respect to crop production (Rauschkolb 1971)

Plaisance and Cailleux (1981) listed classifications of erosion based on mode of action as chemical, running water, en masse movement, wind and biological. All these have been involved in geological erosion (as opposed to accelerated erosion caused by man), which has resulted in wearing down of mountains, cutting of canyons and wearing away of landscapes. Many and probably all of the world’s great agricultural areas have resulted from geological erosion.

Wind and water erosion are of major importance with respect to tillage systems, and the main emphasis in this report will be on these types. Tillage erosion (Papendick and Miller 1977; Wright 1977), a type of en masse movement, is of considerable importance under some conditions, and will be discussed to a limited extent. Chemical and biological erosion have little relevance with respect to tillage systems and, therefore, will not be further discussed.

Soil erosion by wind and water was the subject of two FAO Agricultural Development papers reprinted in 1978 (FAO 1978a, 1978b). Numerous other reports are contained in the literature. In this report, therefore, the basic principles of erosion processes and control will be discussed only briefly. Likewise, the magnitude and consequences of erosion will also be discussed only briefly.

a. Wind erosion

Soil erosion by wind is a potential problem wherever certain soil, vegetation and climatic conditions prevail. The conditions are (1) a dry, loose soil that is reasonably finely divided; (2) a smooth soil surface on which little or no vegetative cover is present; (3) a large enough field; and (4) wind that is strong enough to move soil (Skidmore and Siddoway 1978).

A generalized equation expressing the relative quantity of wind erosion from a field was first published by Chepil (1959). As new data have become available, the equation has been modified and is now generally given as

$$E = f(ICKLV) \qquad [1]$$

where E is the potential annual quantity of erosion per unit area and is a function, f, of I, soil erodibility; C, local wind erosion climatic factor; K, soil surface roughness; L, equivalent width of field (maximum unsheltered distance across the field along the prevailing wind erosion direction); and V, equivalent quantity of vegetative cover (Chepil and Woodruff 1963). The mathematical relationships among the components of the equation are complicated. The relationships, however, have been computed and developed into tables or plotted on graphs, and are useful for estimating annual soil losses by wind erosion and for determining alternate land treatments for wind erosion control. A guide containing this information for the Great Plains states (USA) is available (Craig and Turelle 1964). Tillage has a direct bearing on factors I, K and V through its effect on soil cloddiness, soil roughness and equivalent quantity of vegetative cover.

Sandy soils are extremely susceptible to erosion by wind because of little or no coherence between particles, small particle sizes and rapid drying (Figs. 14, 15). Severe erosion, however, may also occur on other soils when they are dry and loose, and when the particles have been finely divided by raindrop impact, freezing and thawing, or tillage. Particles greater than 0.84 mm in diameter are usually considered non-erodible by wind.

Provided other conditions are met, soils having smooth surfaces are highly susceptible to wind erosion. Smooth surfaces result from (1) tillage operations that break up surface clods and eliminate or incorporate surface residues (Fig. 16), (2) raindrop impact, (3) freezing and thawing, and (4) erosion itself. Tillage methods that provide a roughened soil surface by producing and maintaining clods and ridges on the surface and that retain adequate residues on the surface are desirable for controlling erosion by wind (Fig. 17).

Fig. 14 Sand dunes in Pakistan (FAO photo)

Fig. 15 Sand dunes of the Namib desert, Namibia (photo by James Brandenburg, copyrighted by National Geographic Society, June 1982)

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