Tillage is the largest single cost item entering into the production of many crops. The annual power consumption of American Agriculture is about sixteen billion horsepower hours \(6^3\); one horsepower hour represents nearly two million foot-pounds of work. The cost of farm power is extremely variable, but probably averages at least ten cents per horsepower hour. Thirty per cent of the total power used by agriculture is expended in the mechanical manipulation of the soil. The basic tillage operations, plowing and listing alone, require two and one-half billion horsepower hours and cost our farmers about one quarter of a billion dollars each year. However, soil tillage, as practiced today, can be described by calling it an art rather than a science.

Both tillage practices and tillage implement design have developed and progressed through the use of trial and error methods. The few attempts to apply the principles of soil science to the solution of certain tillage problems have met with reasonable success \(5, 8, 9, 10, 15, \) and \(16\). For the most part, however, soil science has not kept pace with practice in the field of tillage. While an enormous amount of energy is repeatedly expended in seed-bed preparation, the basic fact remains that no one can describe in definite, clean-cut terms what soil conditions one should attempt to produce in a given soil in order to obtain a desirable state of tilth.

Concepts of Tilth

Experience indicates that a certain amount of tillage is required on most soils to promote the growth of crop plants. Likewise, there is evidence that crop plants differ in sensitivity in their response to seed-bed preparation. The fact that tillage operations, for the purpose of seed-bed preparation, are repeated year after year is the best evidence that tilth is an unstable soil condition.

Tilth, a Problem of Soil Structure. The following soil conditions, according to Russell \(12\), profoundly affect the growth of plants: water supply, air supply, nutrient supply, temperature, injurious substances, and the depth of soil.

It takes little imagination to arrive at the conclusion that the structure of cultivated soils is the one soil property which may be rapidly altered by both tillage operations and changes in natural environmental factors such as rainfall and temperature. Likewise, it is easy to find evidence to show that soil structure affects the above-mentioned soil factors which influence plant growth.

Tilth is a blanket term which describes all those soil conditions that determine the degree of fitness of a soil environment for the growth and development of a crop plant. We may conclude then, that tilth is essentially a soil problem in which structure occupies a key position.

Characteristics of the Ideal Structure. What soil conditions must the ideal state of tilth provide? Slipher \(14\) has enumerated several important requirements of soil structure to which perhaps others should be added. It would seem that tilth structure should (a) offer minimum resistance to root penetration, (b) permit free intake and moderate retention of rainfall, (c) provide an optimum soil-air supply with moderate gaseous exchange between soil and atmosphere, (d) hold to a minimum the competition between air and water for occupancy of the pore space volume, (e) provide a maximum resistance to erosion, (f) facilitate placement and coverage of organic residues, (g) promote micro-biological activity, and, (h) provide stable traction for farm implements. Thus, the requirements of tilth structure are not