Chapter I

INTRODUCTION

Tillage is considered essential as it brings desirable changes in physical, biological and chemical nature of soil which promote seed germination and plant growth. It is affected by manipulation of the soil by a large variety of tillage tools. These tools in some form or the other apply mechanical forces to the soil. The soil in the path of these tools is subjected to complex stresses. When stresses developed in the soil exceed their ultimate values, the soil fails. This process requires considerable amount of energy. Any improvement in the mode of energy transfer to the soil by tillage tools will save energy, making tillage operation more economical.

A review of present tillage tools show that according to the manner of tool movement, following types of tillage tools exist in practice.

(i) Rigid type

(ii) Rotary type

(iii) Oscillating type

Rigid tools have no motion in implement reference system and apply compressive pressure to the soil. With these tools, the desired amount of soil break-up can not be controlled or achieved in a single pass. More number of operations are needed to get the desired soil break-up.

Rotary power tiller is the best example of rotary type of tillage tools. These tools, besides moving forward, have

rotary motion in implement reference system. The degree of soil break-up is controlled by changing the forward speed of the power tiller or rotary speed of the tines or both.

Oscillating tillage tools have linear or arc motion in implement reference system. These tools oscillate usually in a particular mode of oscillation with certain amplitude and frequency in addition to the forward motion of the implement. The mode of oscillation may be longitudinal or transverse. The plane of oscillation may be horizontal, vertical or at some inclination in three dimensional space. In comparison to these tools, rigid and rotary types of tools are in more common use. The main reason is that the known advantages of these tillage tools have not been fully explored. Also these tools require extra power transmission unit to transmit power from the p.t.o. shaft of a tractor to the tillage tools as in the case of rotary power tillers. Oscillating tillage tools have the following advantages over rigid (non-oscillating) tools.

1. Oscillating tillage tools require less draft as compared to rigid tools. This helps in reducing the compaction of soil due to tractor wheel loading as a result of decreased traction requirement. Higher traction requires higher wheel loading. This fact gives an opportunity to accomplish tasks such as deep and difficult subsoiling, which can not be done with available power because of excessive draft requirements of rigid tools.
2. These tools produce smaller soil aggregates. Soil fragmentation and intensity of tillage could be

altered at will by altering the ratio between the oscillating speed and the forward speed of the machine.

3. Force against the soil can be directed in such a manner that shear failure occurs with a minimum normal load against the shear plane. This in turn will reduce the force and energy necessary to cause failure or break-up of the soil.
4. According to some research workers, the total energy required to accomplish a tillage operation can be reduced.
5. The reduced drawbar pull and energy requirement of the vibratory implements could lead to the use of wider implements without necessary ballast on the tractor wheels, and would thus lead to a reduction in rolling resistance and the number of trips necessary to cover a certain area.
6. Better mixing of fertilizer could be expected from these implements.
7. A vibratory tillage tool may be more efficient from the standpoint of energy input to produce a final soil condition even if the total energy input is greater than that for other tools, since the efficiency of power transmission through traction members is low (about 50%) compared with p.t.o. method of power transmission (about 95%) (25).

After an analysis of kinematic and power requirement of oscillating tillage tools, Kofoed (26) states that with the

trend to increase horse power of agricultural tractors, it seems well justified to place more emphasis on oscillating equipment, as only a limited amount of the tractor engine power can be utilized as drawbar power under practical farming conditions.

Performance of a tillage tool is affected by three main factors namely soil factors, tool factors and manner of tool movement. It can be improved by suitably controlling these factors.

Manner of movement for an oscillating tool is specified by orientation of the tool; depth of cut; mode, frequency and amplitude of oscillations and forward speed of the tool. There is lack of information as to how these parameters affect the performance of tillage tools. Relationships for the prediction of draft and power requirements of oscillating tools as proposed by various research workers (7, 21, 26, 40, 41) appear to be inadequate as they do not take into account the elasticity and plasticity of the soil and related rate effects simultaneously. Effect of various parameters on soil break-up is also not fully understood.

Keeping in view the lack of information in the available literature on oscillating tillage tools, this project was taken up with the following objectives :

1. To study the dynamic behaviour of soil under sinusoidal oscillatory cutting and to develop a mechanical model of soil.
2. To predict theoretically with the help of the mechanical model of soil, the draft and power requirements

of an oscillating tillage tool and compare these values with the experimental results.

3. To determine the effect of amplitude and frequency of tool oscillations on soil break-up.
4. To determine optimum values of amplitude and frequency of oscillations corresponding to the maximum utilization of energy.

Laboratory facilities were developed to process the soil mechanically to achieve uniform soil condition in a soil bin. A small oscillating tillage tool was designed, fabricated and tested under laboratory conditions to achieve the objectives as stated above.

It is hoped that the results and analysis presented in this thesis will help the tillage tool designers and research workers engaged in agriculture to evolve better tools for tillage.