Improving Plowing Efficiency

Elchanan Shochat – Mechanization Director, Extension Services, Ministry of Agricultural and Rural Development

(For more information, please visit http://www.agrosif.com.)

Cost efficient operation of tractors and ploughs reduces wear & tear of the equipment and inhibits the process of soil resistance.

This article is written against the backdrop of an old-new outlook on agriculture that pertains to all aspects of the field and that stands for minimal cultivation of the soil. Plowing is an activity where much energy and resources are invested relative to other agricultural activities. Every farmer knows that not plowing a field reduces costs. Fields that withstand erosion will be preserved much better. These advantages, however, must be weighed against the other side of the coin. In unplowed fields, long lasting weeds invade the field. Lack of plowing, which turns over and breaks up clods of dirt, enables destructive agents and pathogens to thrive from year to year. The question of how to deal with unplowed soil in the long term is a tough one indeed.

One must take into account a wide array of perspectives on the issue in the short and long term. Most farmers still choose to plow their fields based on rules abiding by which will yield the most from their crops. To clarify the issue, we use a term called a vector, a mathematical construct which can represent certain physical phenomena, such as force, velocity, and acceleration. The vector is symbolized as an arrow, whose length represents the magnitude of the vector and whose direction represents the direction in which the given physical phenomenon is acting.

Preventing soil from sticking to the plough arm affects the energy efficiency of the plough. It is important to note that ploughs with mouldboards have not been investigated enough in Israel. To turn over soil with a plough arm requires sidereal forces; these forces, however, are kept in check by the cross shaft. Braking the sidereal forces creates frictional forces in the direction opposite to motion which damage the soil and waste energy. The rubbing and adhesive motion of the long beam with the soil creates clods of dirt that inhibits crumbling of the soil, taking up additional energy during plowing. Clods which are not crumbled will remain during crop growth. Where the product itself is underground (e.g. potatoes), the plough might uproot it together with the clods, consuming even more energy and resources brought upon by the need to sort the product from the soil.

The most effective operation of the tractor occurs when the pulling force on the plow lies on a line not coincident with the direction of work but rather directed slightly toward the plowing area. The more this line is directed toward the plowing area, the more rubbing forces will develop (rubbing forces are the result of the long beam moving against the furrow will adhering to it with lateral forces.) All of this holds true until the plough starts to slide and lose stability (the varies according to the kind of soil.) One must therefore ensure that detractive forces are minimalized at all times to improve the plough's efficiency and preserve the quality of the soil.

We have dealt until now with purely theoretical aspects. To actually implement ploughs in an optimal fashion, one should use strong and narrow tractors. While working within the furrows is a step in the right direction with regard to improving plowing efficiency, it is problematic and inconvenient in
other respects, such as damage to the tires and exposure to increased lateral forces on the steering and other systems. For this reason, tractors in Israel do not plow within furrows. Tractors which induce large drag forces relative to their width are known as track-type tractors. To estimate what the real gain is in using a tractor with respect to its costs and how much is actually saved, the proper tests must be carried out.

The improvement in efficiency can be accurately measured in an experiment carried out with the right kind of equipment. Conducting tests and experiments on various types of soil will, in the future, enable optimal use of tractors with ploughs. These experiments can also shed light on the qualitative properties for cost saving.

Most tractors attached to ploughs that are used in Israel have the pulling force work in the direction opposite to the desired inclination. As most tractors are wide relative to the width of the furrowed area, they lean the draft line toward the fallow area. Working outside of the furrows leans the drag force line toward the fallow area. Although most tractors, being rather wide, work outside of the furrows, the prospects do not look good and so we need to improve the plowing efficiency.

The fact that the tractor moves on unplowed land outside of the furrows increases the detractive forces; moving on plowed land or within the furrows decreases them. Leaning the pull line toward the plowed area is possible up to a certain point, namely, the direction of the Rh force. Leaning it beyond that will cause instability to the tractor. Theoretically, pulling the plow in the direction of the Rh force should result in zero detractive forces; this is not advisable, however, due to the loss of stability thereof.

Summary: It is indeed possible to improve plowing efficiency. Leaning the pull line toward the plowed area reduces the detractive forces and energy spent, in addition to preserving the soil's quality. One should thoroughly investigate which type of mouldboard available is best suited for the adhesive type of soil found in Israel. Plowing within the furrows, as opposed to outside of them, reduces the energy necessary for operation by about 5%. Plowing with the second to last mouldboard within the furrow further reduces the energy input by about 5%, resulting in a total of 10% of the energy saved, which represents a significant increase in profit. Economical use of the tractor and plough decreases wear & tear and inhibits the ground's resistance to cultivation.

According to initial estimates, 3 liters of fuel are needed to power the plowing of one dunam. This means that to plow 300,000 dunams, 900,000 liters of fuel are necessary. Saving 10% would therefore save 90,000 liters of fuel. While the savings in itself might not be that significant, the return in terms of soil preservation and environmental conservation is much more significant. Reduction of spent energy, preservation of soil quality, decreasing the amount of clods, and protecting the environment are the real improvements of plowing efficiency.