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Review

Influence of different tillage systems on yield of Corn (*Zea mays l.*); An Overview

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Corn (Zea mays L.) is the world's most important crops after wheat, barley and rice. Among the factors that influence corn productivity is tillage practices. Tillage operation affects the physical properties of soil structure and will change specific gravity of soil, apparent tolerance and thermal conductivity. Also reports showed that tillage effects had advantages on water distribution, porosity, root distribution and crop yield. Change in soil porosity leads to the change in soil aeration or air transfer and water soluble into the soil which may reform the crop production. Researchers reported that no tillage causes the decrease of soil porosity space which can have reverse effect on the rain fed crop yield. Between 1970 and 1980 there appeared considerable changes in the concept of tillage requirement for produce of products. These changes were energy consumption reduction and use of minimum tillage methods which often lead to reduction of soil erosion, and also no tillage for seed bed preparation. The rotary cultivator method which has been the common practice for corn has some disadvantages and it would be worthwhile to compare it with other tillage methods. The shallow depth of ploughing and degradation of the soil because of intensive impact of the rotary blade with the soil has been identified as problems of this tillage method. Knowledge of soil physical properties of the areas with annual rain fall of above 1000 mm is necessary and important since the use of an unsuitable tillage method can lead to soil erosion.

Keywords: Tillage systems, Soil properties, Corn, Energy

INTRODUCTION

Corn plant is nutritionally superior to other cereals in many ways, except in protein value. Considering the limitation of production resources and the increasing world population, efforts should be made to increase productivity of crop.

Depending on the type of tillage implements, soil structure can exist as one of the three classes of fine, medium and coarse (Miller and Dunahue, 1990). Granular and single-grain, fine and smooth soil structure which has rapid water infiltration rate and with no soil surface roughness can be created by RC and or rotary plough, particularly when ground speed is low and rotor speed is high, and also in the soils with low plant coverage or residues. Otherwise, there could be following disadvantages such as soil erosion, create crust layer on soil surface which appear with the first irrigation or rainfall, washing and movement of the smaller soil particles and

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Figure 1. The Corn plant members

some chemical elements from top layer to downwards which can help or speed-up the making of hard pan layer or soil compaction and finally, yield reduction. The second type of soil structure is blocky and prismatic soils (semi-massive) which have moderate water infiltration rate and medium roughness of soil surface; and third type of soil structure, platy and massive soils which have slow infiltration rate and high roughness of soil surface.

The main objective of this study was to find out the best tillage system or method in terms of soil physical characteristics, and then determining the crop yield of sweet corn as affected by different planting densities. In addition, the most economical tillage system in the field, optimum energy on drawbar power and engine fuel consumption for three tillage methods were also calculated.

Crop adaptation and distribution

Corn (*Zea mays* L.) also commonly referred to maize, has been considered a unique plant since the time that the indigenous people of the Americas developed it to be their staple food. It is central to many sacred mythologies and creation stories which are still honored today (Fussell, 1992; Barreiro and Cornell, 1989). Figure 2.2 shows various parts and members of the corn plant. Duration of growth period is different for different varieties and type of use (fresh and grain) between 70-100 days.

Corn was introduced from the New World to the Old World in the 1400's, and it was planted as a summer crop between the harvesting of spring and winter crops, in countries where there are four seasons differently (Barreiro and Cornell, 1989).

The USA is the world's largest producer and exporter of maize (Meng and Ekboir, 2000), and it is the most important feed grain because of its efficient conversion of dry substance to meat, milk and eggs, compared to the other grains (Sprague *et al.,* 1988).

Corn (*Zea mays l*.) based cropping system under rain fed areas to optimize or maximize, selecting the correct variety.

Influence of tillage methods on soil properties

Short term effects of tillage include reduction in weeds, expansion of root depth and increasing soil moisture (Saral and Yavuzscan, 2000). The field experiments have shown that for tillage operation of one hectare land with mouldboard plough, more fuel was utilized as compared to chisel plough, and field capacity of chisel plough (in ha hr^{-1}) was about two-fold as much when compared to mouldboard plough (Khosravani *et al*., 1995).

Aykas and Onal (2004) showed that different tillage techniques did not reveal significant differences on seed cotton and leaf quality. They also determined that the proper tillage (new alternative system) reduced the tractor traffic on soil and make the plants grown in these plots emerged earlier.

The primary tillage operation is often for reducing the compression of the soil and increasing root growth. The compression of soil also causes reduction in the moisture penetration, soil oxygen capacity, root penetration and amount of organic materials, and also increasing energy consumption because of high adhesion force between the soil layers and or breaking the hard pan layer (Tebrugge, 2002). Many farmers have accomplished tillage operation without much awareness of its effects on soil and crop characteristics. More investigation is required to evaluate the choice of different production systems. For an instance, there are various minimum tillage systems. One of them is the different types of chisel plough. It must be investigated which one of them is proper for which crop production. When production costs might be reduced, cotton production might be lower. In this regards, Ahmad and Haffer (1993) and Ozpinar and Isik (2004) reported that there is the significant difference between the two types of afore-mentioned tillage on cotton yield.

Conventional tillage (CT) is utilized for seed bed preparation and or improving seed-soil contact. However, in long-term CT (comprising primary and secondary tillage operation) may have negative effects on the soil fertility, and it can vary at different depths of the ploughed layer (Josa *et al*., 2010). CT can decrease soil organic matter content and aggregate stability in upper layer horizon. It also create plough pan below the ploughed layer, consequently, resistance to penetration and bulk density in these depths increase (Micucci and Taboada, 2006). Changing soil porosity can be done by conventional tillage method (Sasal *et al*., 2006; Lipiec *et al*., 2005). Effective porosity improved by the stubble of cereals in the top 2.5 cm (Shaver *et al*., 2003). Soil moisture content (MC) was improved and increased by conservation tillage system (Angas *et al*., 2006). Farkas et al. (2009) studied on soil MC as affected by different tillage systems. They reported that MC was higher in no-tillage system in the top layer 0-20 cm as compared to CT system. In addition, other researcher (Gajda, 2008) demonstrated that CT and reduced tillage (RT) could alter some soil microbiological activity parameters. In this case the investigated parameter was better in RT as compared to CT. This result rely on that the CT created a more better environment and conditions for the growth and activity of soil micro-organisms. Under this condition the soil physical characteristics could be improved (Czyz and Dexter, 2008). Depending on the soil type, climate conditions and type of the crop (deep or shallow rooted plants), soil preparation method for seed bed can be different (Josa *et al*., 2010; Shamsabadi *et al*., 2006). It was revealed that the BD and aggregate stability of the silty loam soil were higher for reduced tillage as compared to CT, whilst MC increases in RT throughout the silty loam soil and top layer of the heavy loamy sand soil (Josa *et al*., 2010).

Tillage operation affects the physical properties of soil structure (Hamblin and Tennant, 1987) and will change specific gravity of soil, apparent tolerance and thermal conductivity. Lal et al. (1989) also reported that tillage effects had advantages on water distribution, porosity, root distribution and crop yield. Change in soil porosity leads to the change in soil aeration or air transfer and water soluble into the soil which may reform the crop production. Hill (1990) showed that no tillage causes the decrease of soil porosity space which can have reverse effect on the rain fed crop yield. Between 1970 and 1980 there appeared considerable changes in the concept of tillage requirement for produce of products. These changes were energy consumption reduction and use of minimum tillage methods which often lead to reduction of soil erosion, and also no tillage for seed bed preparation (Lal *et al*., 1994; Mahboobi *et al*., 1993).

The study by Raoufat and Matbooei (2007) showed that the two methods of tillage operation (discing followed by chisel tillage operation and discing ahead of planter) were successful in reducing tillage corn production system and reported environmental benefits and saving the time, fuel and labor were advantages of discing ahead of the planter.

Moupangwa et al. (2007), in their investigation on the effect of minimum tillage and mulching on corn yield and water content of clayey and sandy soils, showed that on two soil types, neither mulching nor tillage method had a significant effect on maize grain yield, but tillage methods had a significant effect on the giving the highest yield of biomass. In addition, the two tillage methods had no significant effect on soil water content, and mulching improved soil water content in both soil types with maximum benefits observed at 4 ton ha^{-1} of mulch. Therefore, they suggested, in the short term, minimum tillage in combination with mulching performs as well as the farmers' traditional practices of overall ploughing. Javadi et al. (2005) showed that the combined plough affected (broke) the plough pan and improved the soil physical properties. They also stated the combined plough increased the draft force about 15%, but due to the area of disturbed soil, the specific draft decreased to 6%.

Conservation tillage system, including no-till and reduced tillage practices, simultaneously conserved soil and water resources, reduced farm energy usage and increased stabilize crop production (Bescansa *et al*., 2006). These practices led to positive changes in the physical, chemical and biological properties of a soil. Some soil physical properties that are influenced by conservation tillage were such as bulk density, water infiltration and water retention (Osunbitan *et al*., 2004). Lipic et al. (2005) showed that improved infiltration of rain water into the soil potentially increased water availability to plants, reduced surface runoff and improved ground water recharge. Cultivation in reduced or minimum tillage decreases energy consumption and overall farming costs as less area has to be tilled (Monzon *et al*., 2006). In the study by Qin et al. (2006) indicated that up to 80% of corn roots were concentrated in the soil depth of 0-30 cm under no tillage systems. The sharp decline in soil water content in sandy soil could be attributed to drainage of water out of the sampling depth.

Humberto and Lal (2009) studied the influence of corn biomass on soil fertility indicators (chemical properties) and structural stability (physical properties) under no-till management. They concluded that complete stover removal reduced soil aggregates greater than 4.75 mm by 60% on the sloping soil, while stover removal at rates ≥25% reduced soil aggregates > 4.75 mm by 40%. Based on the data related to soil organic carbon (SOC) from this and previous studies, they determined that only about 25%

of stover might be available for removal, and that stover removal has the most adverse impacts on sloping and erosion-prone soils.

Influence of the two tillage systems and traffic (planters and tractors) investigated by Botta et al. (2010) on soil compaction and soybean yields in Argentinean Pampas. They reported that soil compaction was caused by the high traffic intensity and weight of tractor and machineries from land preparation to harvesting operations, especially when these operations are carried out on wet soil or with high ground pressure. They found that soil compaction created by the afore-mentioned operations led to decrease in soybean yield. Additionally, they reported that for three growing seasons the heavy equipment traffic in soil under direct seeding (no-till) reduced soybean grain yields to 460 kg ha^{-1}, while for the light equipment traffic, soybean grain yields reduced to 250 kg ha^{-1}. When the traffic was made with the light equipment on sub soiled soil, there was an effective increase for soybean grain yields which was 330 kg ha^{-1}.

Energy inputs to corn production

Fossil energy is essential to agriculture, where the following items are the major energy inputs for corn production:

a) Fossil fuels: gas oil, gasoline, liquified petroleum gas (LPG) and natural gas (NG);
b) Nitrogen fertilizers and Phosphate, Potash and Lime (mostly fossil energy);
c) Herbicides, pesticides and Insecticides;
d) Transportation (often gas oil, all fossil energy);
e) Machinery, roads, silos, plants;
f) Electricity;
g) Corn Seeds and Irrigation;
h) Labor;
i) Pure ethanol (bio fuel).

To produce the agricultural productions is often carried out the various operations. Each of them consumes energy and fuel. The best condition is optimum energy and fuel consumption (input) with higher yield (output). However, need to be investigated. So that it may with spending a little more energy on drawbar of tractor and engine fuel consumption, the yield increases considerably. Therefore, depending on production cost for selling, firstly it should be investigated and then decided the optimum condition from the view of all factors in agricultural production. As mentioned before, the first practice in agricultural production process is usually soil tillage and it consumes more energy and fuel, proportion to other operations in production process of agriculture. There are several soil tillage methods or systems in agriculture land preparation. Each one needs energy on drawbar of the tractor and engine fuel consumption and creates different soil disturbance, pulverization and aeration. Depending on the climate, soil texture and structure, access to water for irrigation, methods of soil preparation can be different and should be used with proper implements; otherwise, it can lead to soil erosion, degradation, more energy and fuel consumption, depreciation of spare parts and machineries, and finally can lead to reduction in yield of crop production. Therefore, study on power and energy demands for various agricultural field practices is necessary in terms of economical management of input resources for agricultural production in Malaysia and also other countries. When an implement, such as a mouldboard plough is pulled by a tractor for soil tillage operation, draught force and fuel are used. Draught force is the function of forward speed of tractor, depth of tillage operation and working width of implement. So, based on draught force and forward speed, power and energy can be calculated. Each implement has its operational costs. To minimize the cost for each implement, three parameters, namely, travel speed, width of working and depth of tillage operation are controllable and must be optimized until soil condition becomes ideal for seedbed in terms of disturbance, pulverization and aeration. Some implements or practices would be useful for shallow or deep rooted plants. It must be adapted; otherwise, it may not to be economical. Meaning that if a farmer wanted to have the shallow rooted plant, he should utilize the implements in a shallow depth, and vice versa, to have the deep rooted plants, he should utilize the implements in deep depths. Each of them consumes energy and fuel. If there are ways to obtain higher yield production with lower energy and fuel consumption one should follow them. Although there are some information related to power and energy requirements in agricultural machineries in the ASABE standard D497.3 (ASABE standards, 1997a), they are inadequate because those information do not have details on the power and energy demands of machinery utilized in the local area. Measurement of draught and energy requirement or demand can be obtained either by an instrumented tractor equipped with data logger for recording the data or using the equations achieved from the modeling and regression analysis. In agriculture, it is common for the farmers to utilize energy and fuel (input) in the farm for all operations and they expect to gain higher yield (output) for selling. Therefore, it is necessary and important to conserve physical properties of soil with lower energy and fuel consumption and higher yield. Otherwise, not only will it not be economical, but also it follows uncompensated losses from standpoint of degradation of soil or perhaps soil erosion.

Future Line of Research

Vegetative and reproductive growths of plants can greatly be function of soil properties. To find out the best tillage system or method in terms of soil physical characteristics, and then determining the most economical tillage system in the field, a streamlined research programmed for Corn should be focused on the below-mentioned points; texture, particle density, dry bulk density, total porosity; volumetric moisture content, mean weight diameter, dry and wet basis, and also water infiltration and resistance to penetration.

CONCLUSION

The no tillage system recommended in tropical countries, because of the mechanization costs and saving the time, as compared to other tillage systems (minimum, conventional and conservation tillage). However, to reach the desired conditions of the crop, it should be carried out the mechanical operations on the land. In the study on tillage systems revealed that minimum tillage leads to increase of brittleness of Australian tough soils. some studies reported less tensile strength for the soil of minimum tillage compared with the soil which is filled with common method. They stated that the reason of increase soil tensile strength is soil compaction resulting from running of tillage machines which is the indirect effect of tillage. However, the other study showed that energy of tillage operation may increase of tensile tolerance with strength of tillage. A few studies investigated the permanence of tillage effect on the tensile tolerance and soil brittleness. In the other experiment prove negative effect of tillage strength and running of agricultural machineries on the ease of breaking of sandy loam soils.

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