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COMPARISON STUDY BETWEEN CONVENTIONAL AND CONSERVATION TILLAGE SYSTEMS WITH RESPECT TO GREENHOUSE GASSES, SAVING ENERGY AND MAIZE PRODUCTION

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Abstract
Conventional tillage (CT) consumes a lot of energy and causes problems for soil and environment. Strip tillage (ST) is an alternative method to save environment and soil structure. A complete randomized experimental design was conducted. Two treatments with three replicates each were applied. They were T1 polwed conventionally and T2 plowed by ST. A strip tillage prototype was fabricated. Results indicated that there was a significant difference between T1 and T2 on SOC% and total soil N after harvest. SOC% and total soil nitrogen increased by 19.38 and 8.5% for T2 compared to T1. Fuel consumption was less in T2 by 46.7% compared to T1. There was a significant difference between grain yield of T1 and T2. Grain yield of T1 increased by 8.04% compared to T2. Also, there was a difference between T1 and T2 in water consumption. T2 saved about 5.75% of water compared to T1. Applying ST per one million feddan planted by maize crop allover Egypt saves 5.76 million tons of CO_2 and 18.316 million kg of N_2O which contributed into greenhouse gases. Also, T2 saves about 15.75 milion liters of fuel and 2.32 billion m^3 of water per one million feddan.

Keywords: strip tillage, biological fertilizers, new planting system, fuel consumption, water saving.

1. Introduction

Environment becomes increasingly degraded by agricultural practices as tillage which provides both a source and a sink of greenhouse gases (GHG) [1] The emissions of GHG are the main contributor to increase global warming because of its radiative [2]. The most abundant GHG in increasing order of importance are carbon dioxide (CO_2) and nitrous oxides (N_2O). Surprisingly, 24% of direct CO_2 emission comes from agriculture, forestry and other land use [3]. It is important to reduce CO_2 and N_2O emissions into the environment because in 2010, CO_2 and N_2O accounted for 66.5% and 17.2% of greenhouse gases, respectively, worldwide [4]. N2O is one of the greenhouse gases which causes global warming the atmosphere 290-310 times than CO_2 [5].

On the other hand, tillage consumes around 30% of field energy [6]. There are two types of tillage systems, conventional tillage and conservation tillage. Conventional tillage is the most common practise in Egypt. Strip tillage is one type of conservation tillage and it is the most approperaite type for furrow crops as maize. By using ST only 30% of the soil area is plowed [7]. There is no established design of strip tillage equipment and its working parts worldwide. Therefore, there are different designs appropriate in different countries depending on the plants to be cultivated or the prevailing soil properties [8].

Maize is of one of the most important cereal crops. Anual cultivated area in Egypt is around 2 million feddan with an average production of 3.26 tons/feddan [9]. In general, Egyptian farmers still using manual planting for maize. Seeding is in furrows 70 cm apart and 20 cm between each seed and other on the same furrow. [10] developed a new planting system (NPS). The distance between furrows in NPS becomes 140 cm apart and 10 cm between each seed and other on the same furrow keeping the same plant population per feddan as recomended i.e. 28000 plant/feddan. The results of his research saved water by 53.22% and increased productivity by 8.74%.

Therefore, the objective of this work is to compare conventional and conservation tillage with respect to greenhouse gasses, saving energy and maize production.

2. MATERIALS AND METHODS

Location:

Field experiment was conducted in Ezbet Alqshere-Namol- AlQalyubia Governorate -Egypt (latitude 30°17`N and 31°13`E) during the perioud of 23th may to 29th septemper, 2021.

Experimental design:

A complete randomized experimental design was conducted. Two treatments with three replicates each were applied :-

T1: NPS was plowed by CT

T2: NPS was plowed by ST

Where:- NPS: new planting system, ST: strip tillage and CT: conventional tillage

Area of each plot was 42 m^2 (4.2 m * 10 m). One meter border left between each two plots.

Tillage

The first treatment was plowed conventionally (Fig.1) using chisel plow which consisted of seven sweep shares with working width 1.75 m.

Fig. (1) Conventional tillage

In the second treatment, a strip tillage prototype was fabricated in the Faculty of Agriculture, Benha University based on [11]. Prototype main frame (Fig. 2) has three bars.

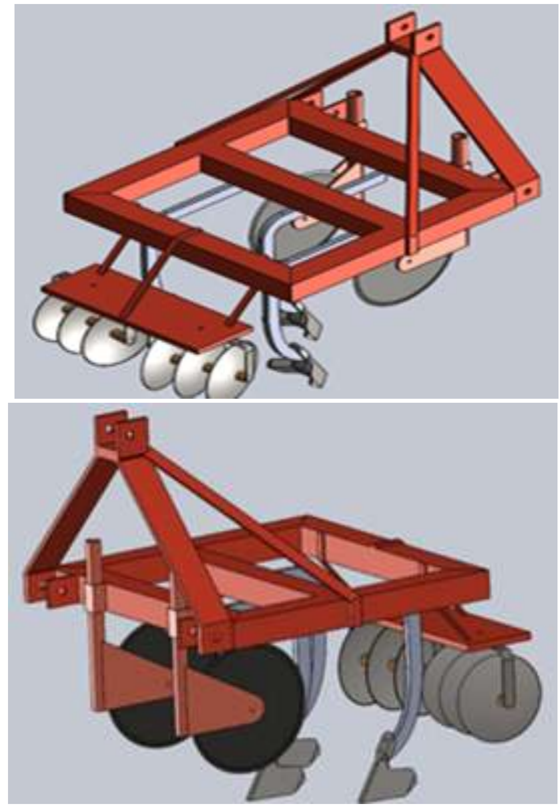

Fig. (2) strip tillage prototype

Distance between each two bars is 35cm. The first bar has a pair of rolling coulters, 46 cm diameter to limit the plowed area cultivation in a strip. Distance between these coulters is 42 cm. The second bar has three sweep chisel shares to till soil strip. One of them is in the middel and ahead of the other two. This means only 30% of the soil is plowed using this prototype (Fig. 3). The third bar has a disk harrow with six concave disks 12.7 cm diameter to break up the surface of the soil.

Fig. (3) Strip tillage

Planting:

Maize hybrid namely SC P3444 was planted mechanically. Each plot was divided into three furrows. Seeding distance between furrows was 140 cm apart and 10 cm between each seed and other on the same furrow (Fig. 4).

Fertilization:

Treatments were biologically fertilized by a liquid biofertilizer namely Nova Plus which recommended by [12]. It was added three times during the growth stages of the crop at a rate of 20 liters per feddan.

Fig. (4) New planting system

Measurements:

1- Physical and chemical properties of soil were measured (Table.1)

Table (1) Physical and chemical properties of soil

Bulk Density (g cm^{-3})	PH	SOC%	Total N (mg kg^{-1})	Physical analysis %		
1.39	8.4	1.125	1.6	**sand**	**silt**	**Clay**
				28.9	22.9	48.2

The soil was clay in texture. Soil texture was determined based on Soil texture triangle.

2- Soil organic carbon (SOC%) and total soil nitrogen (total N) were determined as an average of five samples per each plot. They were measured in the central laboratory of Faculty of Agriculture at Moshtohor, Benha University.

The stored Co_2 and N_2O sequestrated in the soil are calculated as follow:-

CO_2 sequestrated = 44/12 * SOC%

N_2O sequestrated = 44/28 * total nitrogen * 298 [13]

In strip tillage plots, only 30% of soil was plowed. Soil organic carbon and total soil nitrogen of this area was calculated as follows:-

Soil organic carbon or total soil nitrogen of ST treatment = (0.3 × soil organic carbon or total soil nitrogen from the tilled zones) + (0.70 × Soil organic carbon or total soil nitrogen from no-tillage treatment with residue) [14].

3- Water consumption (m3) was measured by weir.

4- Leaf surface area (m2) was calculated by :-

$$LA = L * W * a$$

where LA, L, W, and a are leaf area, leaf length, leaf maximum width and a constant, respectively. The value of the constant (a) is 0.75 [15].

5- Plant measurements were determined as an average of ten sequence plants from the second furrow of each plot. Measurements were plant height (cm), stem diameter (mm), photosynthetic photon flux (µmol m^{-2} s^{-1}) and chlorophyll content. Photosynthetic photon flux and chlorophyll content were measured by lux meter and chlorophyll meter respectively.

6- Yield components including cob length (cm), cob diameter (mm), cob grain weight (g), weight of 100 grains (g) and grain yield (kg) were measured. Grain yield (kg) was adjusted to 14% grain moisture content.

Statistical analysis:

Statistical analysis was carried out using SPSS v. 23.0. 2015 software package. Mean comparisons were done by least significant difference (LSD) test at the 0.05 level of significance.

3. RESULTS AND DISCUSSION

Greenhouse gasses:

Soil organic carbon and soil total nitrogen weare measured

Soil organic carbon:

SOC% was measured after seedbed preparation and after harvest for T1 and T2. SOC% after seedbed preparation and after harvest is shown in table (3) and figure (5) for the two tillage systems.

Table (3) SOC% after seedbed preparation and after harvest for T1 and T2

	SOC%	
Treatments	After seedbed preparation	after harvest
T1	1.125	1.65
T2	1.125	1.97
LSD at 5%	NS	0.0347

NS=No significance

Statistically, there was no significant difference on SOC% between T1 and T2 after seedbed praparation as expected. After harvest, there was a significant difference of SOC% between T1 and T2. SOC% of T2 increased by 19.39% after harvest compared to T1. This increase was because of the limited disturbance of soil structure and the accumulation of crop residue above the ground. CO_2 emissions into the environment are greater in areas where no plant residues exist on the soil surface. This agrees with [16] and [17].

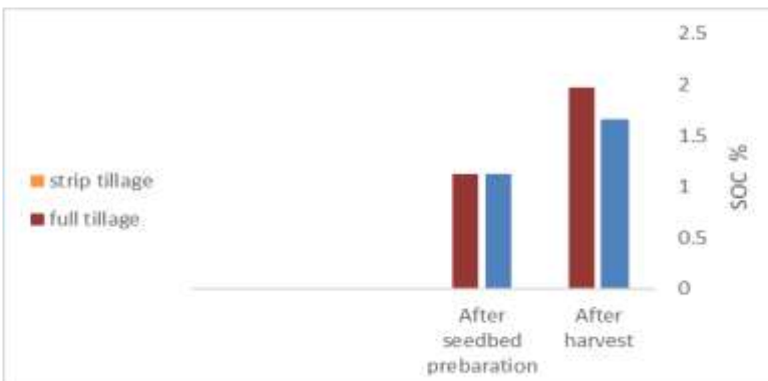

Fig (5) SOC% after seedbed preparation and after harvest for T1 and T2

Total soil nitrogen:

Total soil N (g/kg) was measured after seedbed preparation and after harvest for T1 and T2 in Table (4), Figure (6).

Table (4) Total soil N after seedbed preparation and after harvest for T1 and T2.

	Total N (g/kg)	
Treatments	After seedbed preparation	After harvest
T1	1.21	0.935
T2	1.22	1.015
LSD at 5%	NS	0.0383

NS=No significance

Statistically, there was no significant difference of total N after seedbed preparation between T1 and T2 as expected. There was a significant difference in total N after harvest between T1 and T2. Results shows that total soil N of T2 increased after harvest by 8.5% compared to T1. The high value of total soil N on strip tillage is because of the limited disturbance of soil structure. This agrees with studies of [18]. Decreasing in total nitrogen after harvest compared to after seedbed preparation is due to consumption of nitrogen from the soil by plants.

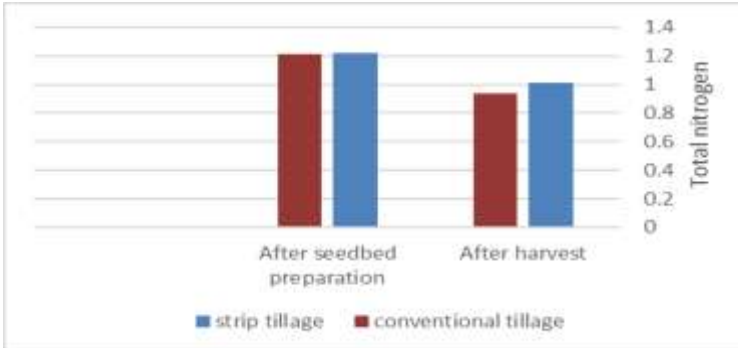

Fig (6) Total soil N after seedbed preparation and after harvest for T1 and T2

Saving energy:

Fuel consumption was measured per treatment. It was 337.5 and 180 ml/treatment of T1 and T2 respectively. This means that it saved around 46.7% of fuel consumption compared to conventional tillage. This agrees with [19] who stated that strip tillage system used less fuel compared to conventional tillage by up to 50-70% because only 30% of the soil area was plowed. Also, this agrees with [20] who stated that conventional tillage system consumed about 59.3 l ha^{-1} of diesel fuel compared to conservation tillage which consumed about 29.7 l ha−1 i.e. 50% of fuel consumption was saved. Burned fuel also contribute to air pollution.

Water consumption:

Water consumption (m^3) was measured for T1 and T2 in Table (4) Figure(7)

Table (5) Water consumption of T1 and T2

	T1	T2
water consumption (m^3)	12.254	11.553
LSD at 5%	0.644	

There was a difference between T1 and T2. T2 saved around 5.75% of water compared to T1. T2 consumes less water because of decreasing soil water evaporation. It occurs by plant residues which reflect sunlight, thereby cooling the soil and slowing air movement over the soil surface. This agrees with [21] .

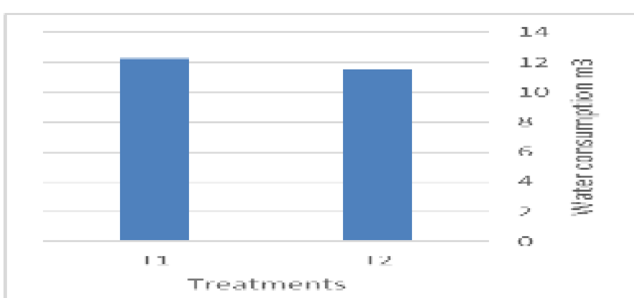

Fig (7) Water consumption of T1 and T2

Chlorophyll content:

Chlorophyll content was 49.016 for T1 and 47.472 for T2. Statistically, there was no signficant difference between them in chlorophyll content. This agrees with [22] who stated that tillage systems had no significant effect on chlorophyll content of maize.

Plant components:

Plant components (leaf surface area (m^2), Length of plants (m) and diameter of stem (mm) were measured for T1 and T2. Average of leaf surface area was 0.053, 0.055 m2 for T1 and T2 respectively. Statistically, there was no signficant difference between them. This agrees with [23]. Length of plants and diameter of stem was 2.027 m and 2.394 mm for T1 and 2.005 m and 2.31mm for T2 respectively. Statistically, there was no significant difference between T1 and T2 on length of plants and diameter of stem. This agrees with [23].

Yield and yield components:

Yield components (cob diameter, cob length, cob grain weight and 100-kernel weight) were measured as shown in Table (5) for T1 and T2.

Table (5) Yield components for T1 and T2

	T1	T2	LSD at 5%
Cob diameter (cm)	4.9495	4.81	0.0765
Cob length (cm)	24.922	24.609	0.2938
Cob grain weight (g)	251.21	232.502	3.5954
100-kernel weight (g)	35.714	33.55	0.6463

There was a significant difference between T1 and T2. Cob diameter, cob length, cob grain weight and 100-kernel weight for T1 increased by 2.9, 1.27, 8.1, 6.4 % respectively compared to T2. This agrees with [10, 24, 25].

Grain yield of maize crop was measured for T1 and T2 in Table (6) and Fig (8).

Table (6) Grain yield for T1 and T2

	T1	T2
Grain yield (kg)	70.338	65.101
LSD at 5%	3.545	

Statistically, there was a significant difference between T1 and T2. Grain yield of T1 increased by 8.04% compared to T2. This agrees with [10, 24, 25].

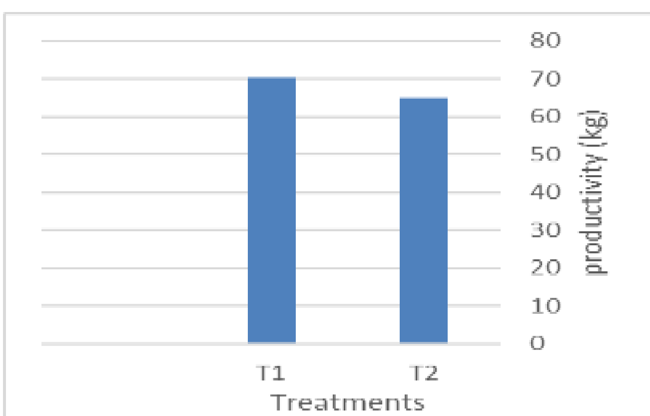

Fig (8) Grain yield for T1 and T2

Implications of applying the results of this study all over Egypt

By applying T2, the sequestrated soil organic carbon was 97.7 kg/treatment compared to 81.97 kg for T1. Sequestrated CO_2 was 300.56 kg for T1 compared to 358.2 kg for T2. This means soil of T2 sequestrated about 57.64 Kg of CO_2 more than soil of T1. Applying these results per feddan sequestrates about 5.764 tons of CO_2 per feddan i.e. 5.764 million tons of CO_2 per one million feddan all over Egypt planted by maize crop. The difference in CO_2 between T1 and T2 emissions into air and contributed into greenhouse gases.

By applying T2, soil sequestrated around 5.04 g and 2.36 kg of total soil nitrogen and N_2O/treatment compared to 4.65 g and 2.177 kg/treatment for T1. This means soil of T2 sequestrated about 183.16g of N_2O more than T1 which emissions to air and contributed into greenhouse gases i.e. 18.316 million kg of N_2O/one million feddan all over Egypt.

On the other hand, T2 saved around 157.5 ml of fuel per treatment i.e. 15.75 milion liters of fuel per one million feddan. Applying T2 saves around 2.32 billion m^3 of water per one million feddan. Applying T1 increases grain yield to 7 million tons per one million feddan all over Egypt.

4. CONCLUSI ON

A comparison study between conventional and conservation tillage systems (strip tillage) was conducted and measured its influence on greenhouse gasses, saving energy and maize production. Results of this study indicated that applying ST per one million feddan planted by maize crop allover Egypt saves 5.76 million tons of CO_2 and 18.316 million kg of N_2O which emissions to air and contributed into greenhouse gases. On the other hand, applying strip tillage saved about 5.75% and 46.7% of water and fuel consumption respectively compared to conventional tillage. However, grain yield of conventional tillage increased by 8.04% compared to grain yield of strip tillage.

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