Effect of Conservation Agriculture on broad bean and maize productivity in Egypt

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***Abstract*—Three field experiments were performed in Gemmieza agricultural experimental research station, AL-Gharbia governorate during the three successive seasons of summer, winter 2013 and summer 2014 under clay soil condition to study the effect of three different tillage systems (conventional tillage (CT), conservation agriculture (CA) and semi-CA (SCA) and two fertilizers (recommended doses of NPK and 1/2 recommended doses of it) on yield and its components of broad bean (Egypt-1 variety) and maize (single cross-10) through (maize-broad bean-maize (M/B/M) cropping system. As for the tillage system effect, During the summer season of 2013: results of maize traits revealed that, all the tested tillage systems not had significant effect on maize plant height (cm),cone length(cm),cone weight(g), biological yield (kg/fad) and seed yield (kg/fad) but the conservation agriculture (CA) scored the significant higher values. Regarding, the winter season of 2013/2014): the results showed that, CA system increased significantly all studied broad bean traits as compared with the other tillage systems. Referring to, the summer season of 2014: CA system scored the significant high values for the studied maize traits. As for the effect of studied NPK fertilizer levels, results indicated that, the recommended doses of NPK significantly favored values of the studied maize and broad bean traits during the winter and summer season 2013/2014. As compared by 1/2 dose of recommended NPK fertilizers in the first season (summer, 2013) respectively, while, there are no-significance effect between the two fertilizer levels for maize traits in the second and third season (winter, 2013 & summer, 2014) respectively. Regarding to, the first order interaction effect between the tested factors, results of the three trial seasons revealed that, cultivating maize and broad bean under the condition of conservation agriculture (CA) and fed by the recommended dose of NPK or the half dose of NPK fertilizers scored the greatest values for above mentioned measurements, and differences between them not reach to the significant level with the exception of all maize traits during the summer of 2013 season. On contrast, the lowest values was resulted under the condition of conventional tillage (CT) and fed by the half recommended dose of NPK fertilizers.**

As for The recorded improvement of soil fertility: results indicated that, CA led to decrease the EC by 6.25 % and increased the organic matter (OM) by 276.08 % and available N by 160.71 %, P by 254.54 % and K by 163.18% under the condition of half recommended dose of NPK fertilizer as compared with the analysis before starting the project plan. It is worthy to mention, about the comparison between CT and CA system under the condition of half NPK dose fertilizer that, CA exposed its superiority to improve the soil content of OM by 15.33 %, available N by 21.67 %, and P by 11.42 % and K by 42.97 % as compared with CT system.

Keywords*— *CA, CT, SCA, NPK, Maize, Broad bean, Crop sequence, Yield

I. INTRODUCTION

Agricultural farming systems involving extensive tillage and removal or on site burning of crop residuals led to soil erosion and degradation [14]. This depletion of soil fertility has now been associated with low productivity and subsequent decline in food security in Africa [4]. Even with interventions such as the introduction of high yielding improved varieties, the poor management of the soil has still resulted in persistently low productivity [8]. In response to this challenge. Conservation agriculture is a farming system based on three principles: 1) minimum soil disturbance, 2) permanent soil cover with crop residuals and/ or cover crops; and 3) crop rotations with different plant species, which include legumes [3].The derived positive benefits of CA practices have, however, been linked to several factors including management, environmental and soil conditions prevailing in different agro ecological regions, type of crop grown and the length of period of practice [7].;[12].Conservation Agriculture (CA) is increasingly promoted in Africa as an alternative for coping with the need to increase food production based on more sustainable farming practices. CA is specifically seen as a way to address the problems of soil degradation resulting from agricultural practices that deplete the organic matter and nutrient content of the soil. It aims at higher crop yields and lower production costs. Yet, success with adopting CA on farms in Africa has been limited [9]. The effects of CA on crop productivity in CA farming systems have not yet been reported in Egypt. The study therefore, evaluated the effect of CA practices and fertilizer levels on crop productivity under some cropping system.

II. MATERIALS AND METHODS

Three field experiments were conducted under the condition of the exhausted clay soil of Gemmieza agricultural experimental research station, Egyptian agricultural research center (ARC), during three successful growing seasons of 2013 to 2014 (summer and winter 2013 and summer 2014) to study the effect of tillage systems and fertilizers through (maize-broad bean-maize) cropping system on crop performance and the changes on the soil fertility. Table (1) shows the chemical analysis of the experimental site before starting experiments. As following:

TABLE I. SOIL PROPERTIES BEFORE THE START OF EXPERIMENT (0-30 CM)

PH (1 : 2)	EC (1 : 5)	Organic Matter (OM) (%)	N mgkg^{-1}	P mgkg^{-1}	K mgkg^{-1}
7.9	0.272	0.46	28.0	0.44	20.1

A. The studied experimental treatments

The treatments of this experiment can be summarized as following:

1) Tillage systems treatments: (TS):

a) Conventional tillage (CT): Under the method the normal agricultural practises of growing crop were done, also, the soil was involved moldboard ploughing to 20 cm depth followed by single disking at 10 cm depth before planting each year and the above ground crop study and cover crop biomass was removed.

b) Conservation agriculture (CA): Under this method, the soil was left without any land preparation and left the previous crop residuals on soil surface before and after planting the next crop, seeds of soybean crop or wheat grains were sown in hills as well as hand drilled around hills was done.

c) Semi-conservation agriculture (SCA): This method as the same conservation agriculture method without hand drilled around hills.

2) Fertilizer treatment:

a) Complete recommended fertilizer (NPK): Half recommended fertilizer (1/2 NPK) For each crop as show in table (2).

TABLE II. SHOWS THE RECOMMENDED NITROGEN, PHOSPHOROUS, POTASSIUM FERTILIZER AND SEEDING RATES FOR STUDY CROPS

Fertilizer crops	Nitrogen (kg N/fad)	P_2O_5 15% (kg/fad) Before planting	K_2SO_4 (kg/fad)	Seeding rate (kg/fad)
Broad bean	15	150	50	60
maize	120	200	50	15

The recommended phosphorus fertilizer was applied as Single calcium super phosphate (15.5% P2O5) during soil preparation for two crops under study.

Regarding to, the recommended nitrogen fertilizer was applied in the form of urea (46%N) before water irrigation.

Referring to, maize was added in two equal portions as follow:

Before the first irrigation at plant ages of 20 days from sowing date

Before the second irrigation at plant age of 35 days from sowing date

In reference to, Broad bean its nitrogen seeds were inoculated by the R. leguminosarum bacteria and the nitrogen fertilization take place before Mohayah irrigation at the rate of 15 kg N /fed.

Referring to, single cross-10 maize was sown in hills; 2-3 grains were hand afire (wet sowing method) planted in each hill spaced at 20 cm apart, on the 2nd Jun in 2013 seasons and 3nd Jun in 2014 season.

In addition, Egypt-1 broad bean variety was sown on the 25th November 2013/2014 seasons. Broad bean seeds were sown in hills, 2-3 seeds were hand afire planted in each hill spaced at 20 cm apart.

B. Weed control

1) Mechanical control: The Hoeing process was done during three seasons as following: First and second hoeing was done after 30 and 60 day from planting date respectively for both of broad bean and maize..

2) Chemical control: Herbicide was done during three seasons as following.

For maize crop, Atrazine herbicide known commercially as Atrazex 80%WP was applied after grain planting and before sowing irrigation at the rate of 750 g/Fadden.

As for Broad bean crop, Stomp herbicide was applied after seeds planting and before sowing irrigation at the rate of 1, 7 liters/ Fadden.

C. Soil chemical analysis

To record the happen of the soil fertility after harvesting of each studied crop. Soil samples were collected at experiment site to depth of 30 cm. after removal of visible crop residuals from the soil surface for each treatment during the three seasons, and it was air dried for chemical analysis, which recorded in Tables 1 and 6

This chemical analysis was analyzed at Soil, Lab., Soil Dep., Fac. Agric., Khafr El-Sheikh Univ., Egypt, which determined according to [11].

D. Experimental design

Experimental field included six treatments, which were the combination of the three systems of tillage practice and two levels of fertilizer. A split-plot arrangement in a randomized complete block design with three replicates was used. The main plots were randomly devoted to the three systems of tillage practice (CT, SCA and CA). The sub-plots were randomly assigned to the two levels of fertilizer (NPK and half NPK), which were separated from each other by 1 m alleys.

The experiment consisted of 18 plots; each plot area was (16 m2) 4 m. length and 4 m. width. Every the plots were irrigated by surface irrigation system every 10 day for maize crop and 20 days intervals for broad bean crop according to region study weather conditions.

E. Statistical analysis

All data were exposed to the proper statistical analysis according to [5].The mean values were compared at 5% level of significance using least significant differences (L.S.D) test

F. Studied attributes

Yield and yield components:

At harvest time, the following measurements were recorded:

Broad bean crop:

Plant height (cm) which was determined from mean of ten random plants samples taken from each plot.

Seed yield (kg/fed) which determined from all plants in each plot and converted to kg/fad.

Harvest index (HI) was calculated according to the following formula:

HI = Seed yield (kg/fad.)/ Total biological yield (kg/fad.)

100-Seeds weight (g) was obtained from the weight of 100 seed taken at random sample from each plot.

Maize crop: Five plant samples were taken randomly from each plot to measure the following traits:

Plant height (cm) * Cone length (cm) * Weight of Cone (g)

Biological yield (kg/fed) which determined from all plants in each plot and converted to kg/fad.

Grain yield (kg/fed) which determined from all plants in each plot and converted to kg/fad

III. RESULTS

A. *Summer, 2013 season (Maize 2013)*

Results presented in Table (3) showed the effect of tillage systems, NPK fertilizer levels as well as the interaction between them on studied traits of soybean during summer 2013 season through (maize→ broad bean→ maize) crop sequence. It worthy to mention that, there are non-significant differences between conventional tillage (CT), semi-conservation agriculture (SCA) and conservation agriculture (CA) for previously mentioned traits.

Referring to, fertilizer levels, results in the same previous Table indicated that, the recommended doses of NPK significantly favored maize plant height (cm), cone length (cm), cone weight (cm), biological yield/fed and grain yield/fed as compared by 1/2 dose of recommended NPK fertilizers by11.01 %, 28.84 %, 10.98 %, 30.37 %, 27.35 % and 2.34 % respectively.

Concerning to the interaction between studied treatments, results recorded in the same previous Table cleared that, the application of conservation agriculture (CA) and fed by the recommended dose of NPK or half recommended dose of NPK fertilizers scored the greatest value for all maize traits as compared with the other treatments. On contrast, the lowest values for maize plant height, cone length (cm), cone weight (cm), biological yield/fed and grain yield/fed was resulted under the condition of conventional tillage (CT) and fed by the half recommended dose of NPK fertilizers (252cm),(18.33cm),(345g),(9761.79kg/fad),(2819.00 kg/fad) respectively.

TABLE III. EFFECT OF TILLAGE SYSTEM AND FERTILIZER LEVELS ON YIELD AND YIELD COMPONENT OF MAIZE THROUGH (MAIZE→ BROAD BEAN→ MAIZE) CROP SYSTEM IN SEASON, 2013

Treatments		plant height (cm)	Cone length (cm)	Weight of cone (g)	Biological yield (kg/fad)	Grain yield (kg/fad)
Tillage systems	**Fertilizer level**					
Conventional tillage (CT)	**NPK**	286.33	25.00	391.70	12959.14	4975.00
	1/2 NPK	252.00	18.33	350.33	9956.00	3918.00
Mean		**269.17**	**21.67**	**371.00**	**11457.57**	**4446.50**
Semi-conservation agriculture (SCA)	**NPK**	282.67	25.33	388.33	12724.27	4842.67
	1/2 NPK	258.33	20.33	345.00	9761.79	3783.33
Mean		**270.50**	**22.83**	**366.67**	**11243.03**	**4313.00**
Conservation agriculture (CA)	**NPK**	287.67	25.67	392.00	13061.33	5042.67
	1/2 NPK	261.33	20.33	360.67	10000.42	3966.67
Mean		**274.50**	**23.00**	**376.34**	**11530.88**	**4504.67**
G.M. TS		**271.39**	**22.50**	**371.33**	**11410.49**	**4421.39**
Over all TS x F						
NPK		**285.56**	**25.33**	**390.67**	**12914.91**	**4953.44**
1/2 NPK		**257.22**	**19.66**	**352.00**	**9906.07**	**3889.33**
LSD at 5%						
Tillage systems (TS) =		**NS**	**NS**	**NS**	**NS**	**NS**
Fertilizer (F) =		**9.39**	**2.10**	**15.08**	**841.02**	**399.72**
TS x F =		**6.32**	**1.92**	**12.09**	**563.03**	**270.86**

B. *Winter, 2013/2014 season (Broad bean 2013/2014)*

As shown in the Table (4) shows that, broad bean plant height (cm), seed yield/fed),100-seed weight (g) and harvest index as affected by tillage systems, fertilizer level and the interaction effect between them through (Maize→ broad bean) crop sequence in winter 2013/2014 season. As a matter of fact, results revealed that, conservation agriculture (CA) significantly pronounced its superiority reflected on increase broad bean plant height by 16.81%, seed yield/fed by 30.16 %, 100-seed weight (g) by 23.17 % and harvest index by 10 %, as compare by conventional tillage (CT) system.

In relation to, fertilizer levels, results in the previous Table showed that, there are no significance effect between the recommended doses and the half dose of NPK for all previous traits of broad bean.

In reference to, the interaction effect between studied treatments, results recorded in Table (4) indicated that, cultivating broad bean under the condition of conservation agriculture (CA) and fed by the recommended dose or half dose of NPK fertilizers scored the greatest value for plant height (135, 131.33cm), seed yield/fed (1516.67, 1403.33 kg), 100-seed weight (91.60, 88.24g) and harvest index (0.099, 0.099) and the differences between them not reach to the significant level.

On the contrary, the lowest value for above mentioned traits was resulted under the condition of conventional tillage (CT) and fed by the half recommended dose of NPK fertilizers (112.67 cm), (1061.67 kg/fad) and (72.72g) respectively, with the exception of harvest index.

TABLE IV. EFFECT OF TILLAGE SYSTEM AND FERTILIZER LEVELS ON YIELD AND YIELD COMPONENT OF WHEAT THROUGH (MAIZE→ BROAD BEAN→ MAIZE) CROP SYSTEM IN SEASON, 2013/2014

Treatments		plant height (cm)	Seed yield (kg/fad)	Harvest index	100- seed Weight(g)
Tillage systems	**Fertilizer level**				
Conventional tillage (CT)	**NPK**	115.33	1181.67	0.094	73.28
	1/2 NPK	112.67	1061.67	0.099	72.72
Mean		**114.00**	**1121.67**	**0.096**	**73.00**
Semi-conservation agriculture (SCA)	**NPK**	114.00	1194.33	0.093	74.73
	1/2 NPK	113.33	1171.67	0.092	74.61
Mean		**113.67**	**1183.00**	**0.093**	**74.67**
Conservation agriculture (CA)	**NPK**	135.00	1516.67	0.099	91.60
	1/2 NPK	131.33	1403.33	0.099	88.24
Mean		**133.17**	**1460.00**	**0.099**	**89.92**
G.M. TS		**120.28**	**1254.89**	**0.096**	**79.20**
Over all TS x F					
	NPK	**121.44**	**1297.56**	**0.095**	**79.87**
	1/2 NPK	**119.11**	**1212.22**	**0.097**	**78.52**
LSD at 5%					
Tillage systems (TS) =		**5.29**	**37.33**	**0.001**	**1.55**
Fertilizer (F) =		**NS**	**NS**	**NS**	**NS**
TS x F =		**6.24**	**52.79**	**0.004**	**3.20**

C. Summer, 2014 season (Maize 2014)

Results presented in Table (5) described, maize plant height (cm), cone length (cm), cone weight (g), biological yield (kg/fad) and grain yield (kg/fad) as affected by tillage systems, fertilizer level and the interaction effect between them through (maize→ broad bean→ maize) crop sequence in 2014 season. Results indicated that, conservation agriculture (CA) significantly pronounced its superiority reflected on increase maize plant height by (11.31%, 3.31%), cone length (cm) by (13.48%, 1.29%), cone weight (g) by (33.62%, 9.5%) and grain yield (kg/fad) by (60.75%, 9.73%) as compared with either of conventional tillage (CT) or semi-CA respectively.

Our previous results are in accordance with [10].who revealed that, maize yield when cropped under no-till system present higher productivity combined with crop rotation than under continuous cropping; lower productivity tends to occur under conventional tillage and the difference in productivity under no-till using crop rotation and continuous cropping is 1,000 kg/ha for maize. Moreover [13].showed that, higher yields for maize and groundnuts from their CA fields than from the fields that were tilled in the conventional way. The current study calculated average maize yields of 4.4 and 2.8 tons per hectare for the manual CA and the traction CA respectively. In addition, the same trend was obtained by [15]. Who founded that, CA practices were significantly higher in maize yield (7.5%) as compared with conventional tillage (CT).

As for, fertilizer levels, results in the Table (5) showed that, there are no significance effect between the recommended doses and the half dose of NPK for maize plant height (cm), cone length (cm), cone weight (g), biological yield (kg/fad) and grain yield (kg/fad).

These results agree with [2].who reported that, over a 17-year period, maize yield increased by 86 %, while fertilizer inputs for these crops fell by 30%.

In respect of, the effect of first order interaction between tillage system and fertilizer levels, results recorded in the same previous Table revealed that, cultivating maize under the condition of conservation agriculture (CA) and fed by the recommended dose or half dose of NPK fertilizers exposed its superiority over than the same level of treatments reflected on gave the greatest value for plant height (315-308.33 cm), cone length (27-26.33cm), cone weight (386.67-381.67g), biological yield/fed (18661.98-18600.20 kg), grain yield/fed (5981.67-5833.33kg).

On the opposite side, the lowest values for maize pervious traits were resulted under the condition of conventional tillage (CT) and fed by the half recommended dose of NPK fertilizers (268.33 cm), (22.67 cm), (258 g), (9993.33 kg/fad) and (3037.33 kg/fad) respectively.

TABLE V. EFFECT OF TILLAGE SYSTEM AND FERTILIZER LEVELS ON YIELD AND YIELD COMPONENT OF MAIZE UNDER SOME CROP SYSTEM (MAIZE→ BROAD BEAN→ MAIZE) IN SEASON, 2014

Treatments		plant height (cm)	Cone length (cm)	Cone weight (g)	Biological yield (kg/fad)	Grain yield (kg/fad)
Tillage systems	Fertilizer level					
Conventional tillage (CT)	NPK	291.67	24.33	316.67	12031.67	4312.33
	1/2 NPK	268.33	22.67	258.33	9993.33	3037.33
Mean		280.00	23.50	287.50	11012.50	3674.83
Semi-conservation agriculture (SCA)	NPK	306.67	27.67	385.00	16599.90	5566.67
	1/2 NPK	296.67	25.00	316.67	16046.67	5200.00
Mean		301.67	26.33	350.83	16323.28	5383.33
Conservation agriculture (CA)	NPK	315.00	27.00	386.67	18661.98	5981.67
	1/2 NPK	308.33	26.33	381.67	18600.20	5833.33
Mean		311.67	26.67	384.17	18631.09	5907.50
G.M. TS		297.78	25.50	340.83	15322.29	4988.56
Over all TS x F						
NPK		304.44	26.33	362.78	15764.52	5286.89
1/2 NPK		291.11	24.67	318.89	14880.07	4690.22
LSD at 5%						
Tillage systems (TS) =		31.46	3. 03	92.64	3705.48	1123.01
Fertilizer (F) =		55.50	6.18	174.04	8831.25	2745.88
TS x F =		44.49	4.96	139.49	4482.98	2002.39

TABLE VI. SOIL PROPERTIES AFTER THE FINISHED OF CROP SEQUENCE OF [MAIZE→ BROAD BEAN→ MAIZE] AFTER HARVEST OF MAIZE, 2014

Crop sequence	Tillage system	Fertilizer treatments	PH	EC	Organic Matter (OM)	N	P	K
			1: 2.	1:5	(%)	mgkg-1	mgkg-1	mg kg-1
(B-M-B-M)	Conventional tillage (CT)	NPK	8.00	0.232	1.50	60	1.40	38.8
		½ NPK	8.00	0.230	1.50	60	1.40	37.0
	Semi-conservation agriculture (SCA)	NPK	8.04	0.250	1.60	67	1.52	44.0
		½ NPK	8.05	0.250	1.60	68	1.52	44.0
	Conservation agriculture (CA)	NPK	8.08	0.258	1.75	75	1.58	53.7
		½ NPK	8.09	0.256	1.73	73	1.56	52.9

IV. DISCUSSION

As explained before, in Egypt our agricultural farming systems involving extensive tillage and removal or in site burning of crop residuals which led to soil erosion and degradation [1]. Confirmed that, which reflected on increasing the production coast through the intensive consumption of chemical fertilizer for improving the soil productivity to gain profit.

Conservation agriculture (CA) is approving approach to save food production and mix possible benefits to smallholder farmers, consumers and rural national economies spatially in dry regions like Egypt.

The innovation of conservation agriculture is to avoid plowing of the soil, which saves time, energy and labor while conserving water and nutrients in the soil to support crop production, as shown from the results of the researches that, conservation agriculture gives at least the same yield as conservational tillage, often more, with less time and energy input and beater environmental sustainability.

The results of our research confirmed almost the benefit of follow conservation agriculture as compared with the conventional tillage (CT).

The results revealed that, by applying the conservation agriculture instructions (1.minimum soil disturbance, 2-permanent soil cover with crop residuals or cover crops and 3. Crop rotation with different plant species which include legumes) starting from summer season 2013 with maize crop through winter season 2013/2014 with broad bean and summer season of 2014 with maize in the same cite, the results recorded gradually improvement started from non-significant differences between the three tested tillage systems on maize studied traits, that agree with [14] who found that, zero tillage with residue retention is characterized by slower initial maize growth, compensated for by an increased growth in the later stages, positively influencing final maize grain yield. They added that, zero tillage with retention of crop residue resulted in time efficient use of resources as opposed to conventional tillage. Also, that may be due to improved soil aggregate stability, soil health and quality, reduce erosion and improve water use under CA as reported by [6].Through winter 2013/2014 season with broad bean, started CA or SCA (semi-CA) pronounced their superiority reflecting an increase of almost broad bean traits

such as, plant height, No. branches/plant, No. of pods/plant, biological yield/fed, seed yield/fed, 100-seed weight (g) and harvest index, these results may be attributed to the accumulate effect of nutrients in the soil as appositive effect of CA or SCA compared by (CT) system.

After harvesting broad bean and by applying the three tillage systems and cultivate maize, also CA or SCA tillage system led to more positive effect on the studied maize traits, these results probably attributed to the role of the residual organic nitrogen as constructive element come from planting broad bean before.

As for, the results of first order interaction effect between tillage system and fertilizer NPK rate through the crop sequences maize→ broad bean→ maize for each crop. It is very interesting to mention that, CA or SCA led to save half dose of NPK fertilizer rate for each crop and that gained by the greatest values of studied traits for maize, broad bean and maize through 2013, 2013/2014 and 2014.

The recorded improvement of soil fertility and the end of crop sequence system: The comparing between the soil analyses recorded in Table (1) for the experimental site before starting the research and the soil analysis recorded in Table (6) which did at the end of crop sequence in summer, 2014 for their location of the tillage system, indicated that, CA led to decrease the EC by 6.25 % and increased the organic matter (OM) by 276.08 % and available N by 160.71 %, P by 254.54 % and K by 163.18% under the condition of half recommended dose of NPK fertilizer as compared with the analysis before starting the project plan. It is worthy to mention, about the comparison between CT and CA system under the condition of half NPK dose fertilizer that, CA exposed its superiority to improve the soil content of OM by 15.33 %, available N by 21.67 %, and P by 11.42 % and K by 42.97 % as compared with CT system.

ACKNOWLEDGMENT

Three field experiments were performed in Gemmieza agricultural experimental research station, AL-Gharbia governorate during the three successive seasons of summer, winter 2013 and summer 2014 under clay soil condition to study.

- The effect of three different tillage systems (conventional tillage (CT), conservation agriculture (CA) and semi-CA (SCA) and
- Two fertilizers (recommended doses of NPK and 1/2 recommended doses of it) on yield and its components of broad bean (Egypt-1 variety) and maize (single cross-10)
- Through (maize-broad bean-maize (M/B/M) cropping system.

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