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Effect of Partial Substitution of Mineral Nitrogen Fertilizer by Farm Compost on Soil Fertility and Productivity

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ABSTRACT

A field trial was conducted at Middle Egypt area (Sids Agric. Res. Station), Beni Suief Governorate (clay soils) for two successive summer seasons 2015/2016 using maize plant, variety (Th 310), to study the effect of partial substitution of mineral nitrogen fertilizer by farm composted (rice straw, corn stover and mixture of them) on soil fertility improvement, maize yields, its components and grains quality. Treatments comprised (100% mineral) recommended rates of N, P and K& (75% mineral-N + 25% rice straw) & (50% mineral-N + 50% rice straw) & (100% rice straw) & (75% mineral-N + 25% corn stover)& (50% mineral-N + 50% corn stover) & (100% corn stover) & 75% mineral-N + 25% (rice straw + corn stover) & 50% mineral-N + 50% (rice straw + corn stover) & 100 % (rice straw + corn stover). The obtained results (average of two seasons) indicated that: *A slight decrease in soil salinity EC_e (dS m^{-1}) and soil pH, in the rhizosphere of grown maize after harvesting. In the other hand, soil organic matter was increased with farm composted and mineral-N fertilizer application. *Residual available soil N, P and K were increased with farm composted and mineral –N fertilizer application.* A significant increase in maize grain yield due to farm- composted and /or mineral-N fertilizer application. The highest values were (8.58 and 8.52 Mg ha^{-1}) which achieved upon treating with (75% mineral-N + 25% corn stover) treatment, then 75% mineral-N + 25% (rice straw + corn stover) treatment, respectively. *A significant increase in proteins%, P% and K % in maize grains yield. The highest value which reached to 10.37, 0.42 and 0.72, for Proteins%, P% and K %, respectively which achieved upon treating with (75% mineral-N + 25% corn stover) treatments, then 10.34, 0.40 and 0.70, for Proteins%, P %and K %, respectively, which achieved upon treating with (75% mineral –N + 25 (rice straw + corn stover))*These data already reflected on the proteins yields, P and K uptake .The highest value reached to 887, 36.03 and 61.77 (kg ha^{-1}) for proteins yields, P and K uptake, respectively. This achieved upon treating with (75% mineral -N+ 25% corn stover) treatments, then 884, 34.08 and 59.64 (kg ha^{-1}) for proteins yields, P and K uptake, respectively. This achieved upon treating with ((75% mineral-N + 25% (rice straw + corn)).

Keywords: Farm composted (rice straw, corn stover) - mineral-N fertilizer- maize plant-clay soil.

INTRODUCTION

Continuous maintenance of soil fertility is very essential in achieving high crop yields all over the time. There is a need to apply fertilizers to maintain soil fertility. The use of mineral fertilizers has been found more convenient than the use of organic fertilizers. It however often leads to a decrease in soil organic matter content, an increase soil acidity level and soil nutrient imbalance and it also results in soil physical degradation. Therefore, a reduced dependence on chemical fertilizer has been advocated to avoid the problems arise from continuous and gushing applications of it. Composted organic materials enhanced more growth as compared to uncompensated materials (Badar *et al.,* 2015). Pane *et al*., (2015) recorded that compost characteristics affected plant development and productivity through increased nutrient uptake.

Rernolds *et al*., (2015) showed that compost addition increased bulk density relative to virgin soil by 46%, while organic carbon, air capacity and plant available water capacity had decreased relative to virgin soil by 60, 56 and 43%, respectively. Nweke (2014) showed that guinea grass compost significantly increased soil parameters studied enhanced growth and yield of maize, this study suggests that guinea grass compost is capable of improving the fertility status of soil; enhance the growth and yield of maize.

HuiLI *et al*., (2017) concluded that the increase in maize yield induced by NPK fertilizers alone declined greatly with increasing soil organic carbon (SOC), whereas the combination of NPK and manure resulted in high maize yield and a remarkable improvement in soil organic carbon (SOC) stock. Based on these results, it was suggested that NPK fertilizers could be at least partially replaced by manure to sustain high maize yield after SOC stock has reached 41.96 Mg C ha^{-1} in the Northeast China Plain and highly recommend the combined application of chemical fertilizers and manure (i.e., 60 Mg ha^{-1}). In these connection (Chuan Ning *et al*., 2017) recorded that 10-season field experiments showed that single chemical fertilizer reduction (CF80) had no significant effect on SOM, soil catalyses activity and soil heavy metal content, but slightly reduced soil available N, P, K, and soil urea's activity, and significantly reduced soil acid phosphates activity. Compared with complete chemical fertilizer application (CF100), chemical fertilizer reduction and supplementation of partial organic fertilizer (CF60+ OM20 and CF40+OM40), significantly increased SOM, soil catalyses activity and urea's activity, particularly in the last several seasons, but reduced soil available P, K, and soil acid phosphates activity.

Egyptian soils are known to be rather poor in organic matter. Thus, the application of organic manures to soils improving their physical, chemical and biological properties. The chemical improvements of these soils lead to increasing the other factors, such as increasing microbial activity. This depends mainly on soil type, soil reaction, temperature and moisture content, source of organic matter and microbial activity (Hoda *et al*., 2009).

Maize is one of the most important grain crops grown in Egypt. It plays a fundamental role in human and animal feeding. There is an ever increasing need to increase the agricultural production in Egypt to meet the continuously increasing demands of the growing population. To increase the maize production, it is fundamentally necessary to pay particular attention to the nutrient supply to this crop, since, maize proved very responsive to various nutrients. So the main target of the current investigation is to study the efficiency of on - farm composted (rice straw, corn stover and mixture of them) and mineral fertilizer on soil fertility improvement, maize yields, its components and grains quality.

MATERIALS AND METHODS

A field experiment was carried out at Sides Research Station, Beni Suief Governorate, for two successive summer seasons using maize plant (hybrid S.C

310). Some physical and chemical characteristics of the studied soil are presented in Table (1) which, were determined according to (Page *et al*., 1982 and Klute 1986). Some characteristics of on - farm composted are shown in Tables (2) .The experimental design was a randomized complete block with three replicates. The plot area was 10.5 m^2 (3 m width and 3.5 m length). On- farm composted was made where rice straw and corn stover were collected from the farms and ground to be preparation. One hundred kg from rice straw, corn stover and mixture of them (50% rice straw + 50% corn stover) were taken to make the composts.

Studied treatments were as follows:

- Control (100% mineral) recommended dose from mineral fertilized by N, P and K according to the general recommendations by Ministry of Agriculture.
- 75% mineral-N + 25% rice straw compost.
- 50% mineral-N + 50% rice straw compost.
- 100% rice straw, compost.
- 75% mineral-N + 25% corn stover compost.
- 50% mineral-N + 50% corn stover compost.
- 100% corn stover.
- 75% mineral-N + 25% (rice straw cmpost + corn stover copost).
- 50% mineral-N + 50% (rice straw compost + corn stover compost).
- 100% (rice straw compost + corn stover compost).

At harvest, plant samples were separated and grains were dried at 70 ºC, ground in a Willy mill and digested with H_2SO_4 and H_2O_2 according to Parkinson and Allen (1975). Grains were analyzes for N, P and K (Cottenie *et al*., 1982), proteins content calculated by multiplying N content with factor 6.25.

Representative soil samples of rhizosphere for grown maize were collected, at the depth of (0-30) cm from each plot after harvesting. Air-dried and analyzed for N, P, K, electrical conductivity ECe (dS m^{-1}) of soil paste and pH in (1: 2.5) soil: water suspension. The obtained data (average of two seasons), were statistically analyzed according to S.A.S (2001).

Table 1. Some physical and chemical properties of the studied soil before cultivation.

Characteristics	Value
Particle size distribution (%):	
Coarse sand	5.50
Fine sand	11.50
Silt	32.75
Clay	50.25
Texture class	clay
Chemical analysis:	
pH(1:2.5 soil suspension)	8.10
Total carbonates (%)	2.73
Organic matter (%)	1.63
EC_e dS m^{-1}, soil paste	0.67
Soluble cations (meq l^{-1})	
Ca^{++}	10.75
Mg^{++}	5.47
Na^{+}	8.52
K^{+}	0.77
Soluble anions (meq/l)	
$CO_3^{=}$	-
HCO_3^{-}	6.54
Cl^{-}	8.10
$SO4^{=}$	10.87
Available N (µg g^{-1})	13.97
Available P (µg g^{-1})	5.700
Available K (µg g^{-1})	174.00

Table 2. Chemical analysis of the compost.

Farm Composted	pH 1: 5	EC_e (dS m^{-1})	C/ N	OC %	O.M %	N %	P %	K
Rice straw	8.38	9.82	17.96	19.76	34.07	1.10	0.317	1.53
Corn Stover	8.20	11.19	20.98	31.27	53.91	1.49	0.372	1.78
Mixture of rice straw and corn stover (50%+50%)	8.25	10.02	18.19	26.20	45.17	1.44	0.362	1.58

RESULTS AND DISCUSSION

- **Soil properties after harvesting:**
- **Soil pH , ECe and organic matter**

The effect of on - farm composted (rice straw, corn stover and mixture of them) and / or mineral-N fertilizer application on soil organic matter, pH and ECe after maize harvest was recorded in Table (3). Concerning the effect of the treatments on soil salinity, in the rhizosphere of grown maize, data revealed that the value, of soil salinity EC_e (dS m^{-1}) and soil pH decreased by soil treatments. The lowest pH and EC_e values were recorded with the treatments (75% mineral-N + 25% rice straw)&(75% mineral-N + 25% corn stover) and/ or(75% mineral-N + 25% (rice straw + corn stover)).In the other hand, soil organic matter was increased with farm composted and mineral fertilizer application. The highest values were recorded with the treatments of (100% rice straw) & (100% corn stover) and/ or (100% (rice straw + corn stover)). These data are in harmony with those of (Rernolds *et al*., 2015 and Nweke 2014).

- **Residual soil fertility after maize harvesting**

The effect of on - farm composted (rice straw, corn stover and mixture of them) and / or mineral fertilizer application on residual available soil N, P and K (µg g^{-1}) after maize harvest was recorded in Table (4), data revealed that the value of residual available soil N, P and K was increased with farm composted and mineral fertilizer application. The highest values were 36, 14 and 109(µg g^{-1}) for N, P and K, respectively, which achieved upon treating with (75% mineral-N + 25% corn stover) treatment, and then 75% mineral-N + 25% (rice straw + corn stover) treatment, by values were 34, 12, and 101(µg g^{-1}) for N, P and K, respectively. The statistical analyses show that residual available soil N, P and K were significantly affected by all treatments. These are because organic composite as a source of NPK which seemed to promote rhizosphere activity and consequently increased the soil capacity for the available macronutrients. In these connections, Wang *et al*., (2006), Mohamed *et al*., (2009), Wenhui *et al*., (2010) and Taha *et al*., (2010) found that the soil application of organic manure greatly increased available NPK content. Teshome *et al*., (2014) indicated that except for pH value, all soil properties including ECe, organic carbon, total nitrogen, available P and available K were slightly increased due to compost application.

Table 3. Soil pH, ECe and organic matter after maize harvest.

Treatment	Organic matter %	pH (1:2.5 soil suspension)	EC_e dS m^{-1} soil paste
100% mineral	1.41	7.95	0.44
75% mineral-N+25%rice straw	1.65	7.79	0.41
50% mineral-N+50% rice straw	1.75	7.83	0.42
100% rice straw	2.09	7.74	0.43
75% mineral-N+25% corn stover	1.66	7.69	0.41
50% mineral-N+50% corn stover	1.77	7.84	0.42
100% corn stover	2.12	7.77	0.44
75% mineral-N + 25% (rice straw + corn stover)	1.65	7.73	0.42
50% mineral-N + 50% (rice straw + corn stover)	1.76	7.78	0.43
100% (rice straw+ corn stover)	2.05	7.73	0.44

Table 4. Residual available soil NPK after maize harvesting

Treatment	N	P	K
	($\mu g g^{-1}$)		
100% mineral	24	10	98
75% mineral-N + 25% rice straw	29	13	108
50% mineral-N + 50% rice straw	25	10	72
100% rice straw	21	12	90
75% mineral-N + 25% corn stover	36	14	109
50% mineral-N + 50% corn stover	23	12	89
100% corn stover	20	12	88
75% mineral-N+25% (rice straw+corn stover)	34	12	101
50% mineral-N+50% (rice straw+corn stover)	23	11	100
100% (rice straw + corn stover)	26	10	99
$L.S.D_{0.05}$	2.52	2.30	6.10

• **Maize grain yield**

The effect of on - farm composted (rice straw, corn stover and mixture of them) and / or mineral-N fertilizer application on maize grains yield was recorded in Table (5). Data show that a significant increase in maize grains yield due to farm- composted and /or mineral fertilizer application. The highest values were (8.58 and 8.52 Mg ha^{-1}) which achieved upon treating with (75% mineral-N + 25% corn stover) treatment, then 75% mineral-N + 25% (rice straw + corn stover) treatment, respectively, comparing to control (100 mineral) or 100% (rice straw + corn stover) which recorded (7.78 and 5.01 Mg ha^{-1}), respectively. This is could be explained by the general improvement in soil characteristics or at least maintains soil productivity. This is because mineral fertilizers and organic compost in the soil has a catalyzing effect; in general its application implies an increase in soil enzymatic activity as a consequence of increased metabolic activity of the soil microorganisms. This finding stands in well agreement with those of (Badar *et al*., 2015 and Pane *et al*., 2015). In these connections, (Pinitpaitoon *et al*., 2011) recorded that organic amendments have significant effects on soil physical properties and other nutrients besides N are a significant factor in the crop yield response.

Grain Quality

The effect of on - farm composted (rice straw, corn stover and mixture of them) and / or mineral-N fertilizer application on maize grains quality was recorded in Tables (6 and 7). Data in Table (6) revealed that soil application of on - farm composted (rice straw, corn stover and mixture of them) and / or mineral fertilizer led to a significant increase in proteins %, P % and K % the highest value which reached to 10.37, 0.42 and 0.72, for proteins %, P % and K %, respectively which achieved upon treating with (75% mineral-N + 25% corn stover) treatments , then 10.34, 0.40 and 0.70, for proteins %, P % and K %, respectively, which achieved upon treating with (75% mineral-N + 25% (rice straw + corn stover)). These data were already reflecting on the proteins yields, P and K uptake (Table 7). The highest value reached to 887, 36.03 and 61.77 (kg ha^{-1}) for proteins yields, P and K uptake, respectively. This achieved upon treating with (75% mineral-N + 25% corn stover) treatments, then 884, 34.08 and 59.64 (kg ha^{-1}) for proteins yields, P and K uptake, respectively. This are achieved upon treating with (75% mineral-N + 25% (rice straw + corn stover)). These data in harmony with (Pane *et al*., 2015 and Badar *et al*., 2015).

Table 5. Maize grain yield (Mg ha^{-1}) as affected by organic and mineral fertilizer application

Treatment	Grains yield (Mg ha^{-1})
100% mineral	7.78
75% mineral-N + 25% rice straw	8.43
50% mineral-N + 50% rice straw	7.88
100% rice straw	5.16
75% mineral-N + 25% corn stover	8.58
50% mineral-N + 50% corn stover	7.97
100% corn stover	5.18
75% mineral-N + 25% (rice straw + corn stover)	8.52
50% mineral-N + 50% (rice straw + corn stover)	8.18
100% (rice straw + corn stover)	5.01
$L.S.D_{0.05}$	0.10

Table 6. Effect of organic and mineral fertilizer application on protein, P and K % for maize grains

Treatment	Protein	P	K
		%	
100% mineral	9.50	0.33	0.64
75% mineral-N + 25% rice straw	10.12	0.39	0.69
50% mineral-N + 50% rice straw	9.74	0.32	0.65
100% rice straw	9.56	0.29	0.60
75% mineral-N + 25% corn stover	10.37	0.42	0.72
50% mineral-N + 50% corn stover	9.76	0.34	0.66
100% corn stover	9.44	0.30	0.61
75% mineral-N + 25% (rice straw + corn stover)	10.34	0.40	0.70
50% mineral-N + 50% (rice straw + corn stover)	9.93	0.38	0.68
100% (rice straw + corn stover)	9.18	0.28	0.60
$L.S.D_{0.05}$	0.076	0.002	0.065

Table 7. Effect of organic and mineral fertilizer application on protein yields, P and K (kg ha^{-1}) uptake for maize grains

Treatment	Protein yield	P uptake	K uptake
		(kg ha^{-1})	
100% mineral	739	25.67	49.79
75% mineral-N + 25% rice straw	853	32.87	58.16
50% mineral-N + 50% rice straw	768	25.21	51.22
100% rice straw	493	14.96	36.96
75% mineral-N + 25% corn stover	887	36.03	61.77
50% mineral-N + 50% corn stover	778	27.09	52.60
100% corn stover	489	15.54	31.59
75% mineral-N + 25% (rice straw + corn stover)	884	34.08	59.64
50% mineral-N + 50% (rice straw + corn stover)	812	31.08	55.62
100% (rice straw + corn stover)	460	14.02	30.06
$L.S.D_{0.05}$	65.04	13.01	15.50

CONCLUSION

From above, the mentioned discussion and under the current soil conditions, it can be concluded that, soil treating with (75% mineral-N + 25% corn stover), or 75% mineral-N + 25% (rice straw + corn stover) increased maize yield, and improved grain quality. Also, these treatments decreased soil pH and ECe in the rhizosphere, of grown maize, increased soil organic matter. This approach assist farmers to increase their income through reducing mineral-N fertilizer and at the same time reduce the potential hazardous contamination of surface and ground water.

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تأثير الإحلال الجزئي للأسمدة النيتروجينية المعدنية بكمبوست المزرعة علي خصوبة التربة وانتاجيتها

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أقيمت تجربه حقلية بمحطة بحوث سدس- محافظة بني سويف لموسمين زراعيين متتالين 2015 /2016م بزراعه نبات الذرة الشامية صنف (هجين ثلاثى 310) لدراسة تأثير الإحلال الجزئى لسماد النيتروجين المعدنى بمخلفات المزرعة (قش الأرز وحطب الذرة وخليط منهم) ودراسة تأثير المعاملات المختلفة لهذه المخلفات على تحسين خواص الأرض وانتاجيتها لمحصول الذرة الشامية وجودة البنور وكانت المعاملات كالاتى :- 100 ٪ معدنى (المعدل الموصى به من النيتروجين والفوسفور والبوتاسيوم) و (75٪ نيتروجين معدنى + 25٪ قش أرز) و (50٪ نيتروجين معدنى + 50٪ قش أرز) و (100٪ قش أرز) و (75٪ نيتروجين معدنى + 25٪ حطب ذرة) و (50٪ نيتروجين معدنى + 50٪ حطب ذرة) و (100٪ حطب ذرة) و ((75 ٪ نيتروجين معدنى + 25٪ (قش أرز+ حطب ذرة)) و ((50٪ نيتروجين معدنى + 50٪ (قش أرز+ حطب ذرة)) و 100 ٪ (قش أرز+ حطب ذرة). وقد أوضحت النتائج انخفاض طفيف فى ملوحة التربة ECe في منطقة إنتشار جذور نبات الذره وكذلك pH بعد الحصاد ومن ناحية أخرى زيادة المادة العضوية باضافة مخلفات المزرعة وسماد النيتروجين المعدنى. وقد زاد محتوى التربة بعد الحصاد من الأزوت والفوسفور والبوتاسيوم القابل للاستفادة بزيادة معدلات إضافة مخلفات المزرعة وسماد النيتروجين المعدنى. - أدت إضافة مخلفات المزرعة وسماد النيتروجين المعدنى إلى زيادة معنوية فى محصول الحبوب وكانت أعلى قيمة لمحصول الحبوب (8,52 و 8,58 ميجاجرام هكتار$^{-1}$) وذلك عند المعاملة (75٪ نيتروجين معدنى + 25٪ حطب ذرة) و 75٪ نيتروجين معدنى + 25٪ (قش أرز+ حطب ذرة) على التوالى. وكان هناك أيضا زيادة معنوية فى النسبه المئوية لمحتوى الحبوب من البروتين والفوسفور والبوتاسيوم وكانت أعلى نسبة (10,37 و 0,42 و 0,72٪) للبروتين والفوسفور والبوتاسيوم على التوالى وذلك عند المعاملة (75٪ نيتروجين معدنى + 25٪ حطب ذرة) و (10,34 و 0,40 و 0,70٪) للبروتين والفوسفور والبوتاسيوم على التوالى وذلك عند المعاملة 75٪ نيتروجين معدنى + 25٪ (قش أرز+ حطب ذرة). ووصل محتوى المحصول من البروتين والفوسفور والبوتاسيوم إلى ((887 و 36,03 و 61,77 (ميجاجرام هكتار$^{-1}$)) على التوالى وذلك عند المعاملة (75٪ نيتروجين معدنى + 25٪ حطب ذرة) و (884 و 34,08 و 59,64 (ميجاجرام هكتار$^{-1}$)) للبروتين والفوسفور والبوتاسيوم على التوالى وذلك عند المعاملة 75٪ نيتروجين معدنى + 25٪ (قش أرز+ حطب ذرة).