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Carbon Sequestrate through Incorporate Rice Straw and Microorganisms into Soil for Eggplant Production

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ABSTRACT

Agricultural greenhouse gases (GHG) fluxes are complex and heterogeneous, the management of recycle agricultural residues offers promising possibilities for mitigation. Firing the rice straw presented a main source of CO_2 emission of agricultural activities in Egypt. The study aimed to investigate the effect of applying rice straw into soil with or without rice straw decomposing fungi (RSDF) and plant growth promoting rhizobacteria (PGPR) under 50 and 100% of recommended NPK on sequestrating CO_2 into soil and eggplant production. Field experiment was conducted at experimental Site of Central Laboratory for Agricultural Climate (CLAC), Agricultural Research Center, Giza, Egypt during 2013 and 2014 seasons. A randomized complete block design was used with three replications. RSDF were used as one fungal strain of *Trichoderma viride.* PGPR were used as mixture of *Azotobacter chroococcum, Azospirillium brasilense, Bacillus megaterium* and *Bacillus circulans*. The obtained results showed that growth characteristics, mineral composition and yield component of eggplant cultivar Black Balady were significantly improved by applying 100% mineral fertilizers with rice straw plus PGPR with or without RSDF. Using 50% mineral fertilizers with rice straw plus RSDF and PGPR gave good yield with no significant differences comparing with 100% mineral fertilizers without rice straw treatment (control). This work shows that incorporation of rice straw into soil with decomposing fungi and plant growth promoting rhizobacteria led to improve the production of eggplant, as well as reduced the amount of mineral fertilizers and avoided one of the most serious environmental air pollution (Black Cloud), caused by burning rice straw annually.

Key words: Sequestrate CO_2, Rice straw management, Microorganisms, *Trichoderma viride*, Plant growth promoting rizobacteria (PGPR), Eggplant.

Introduction

Agricultural lands occupy about 8.6 million faddans (faddan = 4200 m^2) in Egypt, GHG Emission/ Agricultural Sector producing about 52.18 million tons CO_2 (Nakhla *et al.,* 2013) while 1 – 1.5 million faddans or about 22% of the cultivated area in Egypt during the summer season take in place of rice cultivation. The average of rice straw biomass yearly is around 3-4 million tons (Ministry of Agriculture and Land Reclamation, 2013), more than 50% of the rice straw residues, which are produced annually by farmers, are burnt in the field as a practical means of disposal. This allows farmers to clear and cultivate land early (within some 1-2 weeks after harvest) for sowing clover, which is the following major crop. The opportunities available for the use of residues in increasing farm income and value added to the national income have not generally been appreciated. The rice straw burning has resulted in a considerable loss of value to farmers and created extensive air pollution (viz. "black cloud") that affects wide areas of the Nile delta and even Cairo.

Improved agricultural management can reduce net GHG emissions, often affecting more than one GHG. The effectiveness of these practices depends on factors such as climate, soil type, and farming system. Agriculture releases to the atmosphere significant amounts of CO_2, CH_4 and N_2O (Cole *et al.,* 1997; IPCC 2001; Paustian *et al.,* 2004). Carbon dioxide is released largely from microbial decay or burning of plant litter and soil organic matter (Janzen 2004; Smith 2004b).

Incorporating rice straw back into the soil is an alternative to burning, albeit an unpopular one with farmers. Its advantage is that it builds up organic matter in the soil as well as returning the nutrients contained in the rice straw back to the soil (Singh, 2001). However, it has been shown that the incorporation of rice straw contributes to significant levels of methane which enter the atmosphere and therefore contributes to greenhouse gas emissions (Wu *et al.,* 2012). Singh and Singh (2001) noted that burning causes a loss of nutrients and organic matter. Not only is rice straw the major organic material available to rice farmers but a considerable amount of the macro-nutrients, namely nitrogen, phosphorus and potassium as well as important micro-nutrients

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like sulfur and silicon are contained in the rice straw (Dobermann and Fairhurst, 2002). The problem of agricultural wastes in Egypt became very obvious especially after the harvest of summer crops. Egyptian farmers get rid of the most these wastes by burning. Burning not only is considered an economic loss but also has harmful effects on the environment, i.e. emission of gases to the air and reducing the microbial activities in the soil. Therefore, utilization of agriculture wastes in any other environmentally friendly way is very important (Abou Hussein and Sawan, 2010).

The decomposition of crop stalks biomass in the soil improved the soil fertility by supplying organic matter, plant nutrients and improving the soil texture (Yu and Song, 2003; Abdulla, 2007; Dai *et al.,* 2010). As well as soil microbial structure and population. (Glinwood *et al.,* 2011 and Hou *et al.,* 2012).

Decomposition of rice straw is responsibility of many type of microorganisms, i.e. bacteria and fungi (Sirisena and Manamendra 1995; Kausar *et al.,* 2010). Fungi, i.e. Aspergillus, Fusarium, Trichoderma, Chyptoga, Mucor sp. the main decomposer agents that can breakdown the rice straw (Nandi *et al.,* 2000). Fungal inoculate can accelerate the decomposition of rice straw. Trichoderma sp. is the best indigenous fungi in the decomposition process of rice straw (Irfan *et al.,* 2010).

Plant growth promoting rhizobacteria (PGPR) are naturally occurring soil bacteria that aggressively colonize plant roots and benefit plants by providing growth promotion. Inoculation of crop plants with certain strains of PGPR at an early stage of development can improve biomass production through direct effects on root and shoot growth. Inoculation of vegetables with PGPR may result in multiple effects as seen in the enhancement of seed germination, stand health, plant vigor, nutrients content of plant tissues, early bloom and chlorophyll content (Joseph *et al.,* 2007). PGPR influenced the growth, yield, and increase supply with different nutrients, such as nitrogen, phosphorus, potassium, sulphur, iron and copper, produce plant hormones, enhance other beneficial bacteria or fungi (Saharan and Nehra, 2011).

Eggplant (*Solanumm melongena var. esculenta* L) is one of the important vegetable crops grown in the summer season of Egypt. The total cultivated area in Egypt was about 108 thousand feddans, producing about 1193 thousand tons on annual basis with an average of 11.079 tons/feddan (Ministry of Agriculture and Land Reclamation, 2013). Eggplant fruits contain a considerable amount of carbohydrates(6.4%), protein (1.3%) and fat (0.3%).They are also a rich source of potassium, magnesium, calcium and iron (Zenia and Halina, 2008).

This work aimed mainly to offer a new strategy for management the rice straw for sequestrating CO_2 into soil through microorganisms as mitigation procedure of CO_2 emission and a good agriculture practices, to improve the production of eggplant, and avoid the serious of environmental air pollution (Black Cloud), caused by burning rice straw annually.

Materials and Methods

The field experiment was carried out during the two growing summer seasons of 2013 and 2014 at Central Laboratory for Agricultural Climate (CLAC), Agriculture Research Center, Egypt to investigate the effect of applying rice straw into soil with or without rice straw decomposing fungi and plant growth promoting rhizobacteria on eggplant production. Eggplant (*Solanumm melongena var. esculenta L*) seedlings (cultivar Black Balady) were planted in the field on 24 and 20 of February in the first and second seasons, respectively. The experimental trial was conducted in clay soil using drip irrigation system. Emitter discharge rate was 4 l/hr, the distance between emitters was 0.5 m. Physical and chemical properties of the experimental soil were analyzed before cultivation according to FAO (1980) in Table (1).

Table 1: Physical and chemical analyses of the experimental soil.

Clay %	Silt %	Sand %	Texture	pH	EC dS/m	Cations meq/l				Anions meq/l			
						Ca^{++}	Mg^{++}	K^+	Na^+	Co_3^-	HCO_3^-	Cl^-	$SO_4^=$
67.60	18.56	13.84	Clay	7.65	1.33	2.58	0.94	1.82	1.94	-	1.92	2.38	3.25

The soil of the experiment was ploughed and divided into ridges; each plot contained three ridges 0.80 m width and 5 m length. The space between plants was 0.50 m on one side of ridge. Two ton/feddan (0.5 kg/m^2) of chopped rice straw (2 – 10mm) were incorporated into experiment soil during soil preparation except control treatment. Two different types of machines were used for cutting rice straw into different sizes. The first machine designed to chop rice straw between (10-15 cm) and the machine capacity was one ton/h. The second machine equipped with hammer mill drum and fixed knife, the machine capacity was 250kg / h, chopped rice straw size after grinding between (2mm -10mm). The chopped rice straw was incorporated into soil on the depth 10 – 15 cm. The main chemical analyses of rice straw are shown in Table (2). Incorporation rice straw into soil was applied two weeks before transplanting.

The recommended dose of NPK as mineral fertilizers (MF) were applied according to Ministry of Agriculture and Land Reclamation (2009) as follows: 140kg N/fed as 680kg ammonium sulphate (20.5% N); 45kg P_2O_5/fed as 300kg calcium super phosphate (15.5%P_2O_5) and 48kg K_2O/fed as 100 kg potassium sulphate (48% K_2O). Calcium super phosphate was added as one dose during soil preparation, whereas ammonium sulphate and potassium sulphate were added at three equal portions, during soil preparation, after 21 and 45 days from transplanting. Half of the above mentioned quantities (70 kg N/ Fed., 22.5 P_2O_5/fed and 24 K_2O/fed) of mineral fertilizers were applied at the same times with 50% NPK treatments.

Table 2: Chemical composition of the rice straw

DM (%)	Ash (%)	O.C (%)	C/N Ratio	pH 1:5	N	P	K
					(%)		
92.42	17.56	31.16	67.73	6.46	0.48	0.056	1.53

All microorganisms (pure local strains) were kindly provided by the Microbiology Dept. Soil, Water and Environment Research Institute, Agricultural Research Center. *Trichoderma viride* as rice straw decomposing fungi (RSDF) was supplemented to the soil by using liquid culture at a rate of 10 L/feddan (1ml contains 10^7cell) after rice straw incorporation and irrigation directly.

Plant growth promoting rhizobacteria (PGPR) were used as mixture of *Azotobacter chroococcum, Azospirillium brasilense* (nitrogen fixing bacteria), *Bacillus megaterium* (phosphate dissolving bacteria) and *Bacillus circulans* (potassium releasing bacteria). PGPR were supplemented to the soil surface beside plants after 2 and 4 weeks from transplanting by using liquid cultures at a rate of 20 ml/plant (1ml contains 10^8cell) according to Mashhoor *et al.* (2002) after diluted by water without Chlorine at 1 : 20 rate.

No manure, organic fertilizers or compost were applied in the experimental soil to avoid any interrupted effects.

The Experimental Treatments

1) Recommended NPK as mineral fertilizers without rice straw (100% MF as a control treatment).
2) 100% MF + rice straw (100% MF + RS).
3) 100% MF + rice straw + rice straw decomposing fungi(100% MF + RS + RSDF).
4) 100% MF + rice straw + plant growth promoting rhizobacteria (100% MF + RS + PGPR).
5) 100% MF + rice straw + rice straw decomposing fungi + plant growth promoting rhizobacteria (100% MF + RS + RSDF + PGPR).
6) 50% MF + RS
7) 50% MF + RS + RSDF
8) 50% MF + RS + PGPR
9) 50% MF + RS + RSDF + PGPR

The experiment was arranged in a completely randomized block design, with three replicates for each treatment.

After 60 days from transplanting, three plants per replicate were randomly chosen to measure plant height, stem diameter (under the first bottom leaf directly), number of leaves/plant, chlorophyll reading in the fourth upper leaf by using Minolta Chlorophyll Meter Spad 501. Total nitrogen, phosphorous and potassium percentage were determined in the dry matter of fourth upper leaf according to Cottenie *et al.* (1982). Total nitrogen was determined by Kjeldahl method according to the procedure described by FAO (1980). Phosphorus percentage was determined using spectrophotometer according to Watanabe and Olsen (1965). Potassium percentage was determined spectrometrically using Phillips Unicum Atomic Absorption Spectrometer as described by Chapman and Pratt (1961). Fresh and dry shoot weight was measured at harvesting. Early yield (recorded during the first two harvests) and total yield for each plot were recorded after each harvesting accumulatively and were collected per meter square. The saved nutrient of rice straw is calculated as following:

Nutrient save Kg /tone rice straw = Nutrient content % x 10

Data of the two seasons were statistically analyzed by the analysis of variance using one way ANOVA according to Snedecor and Cochran (1980) using SAS software, version 2004. Comparison of treatment means was done for significance at 0.05 level using Tukey test.

Results and Discussion

The environmental impact assessment of rice straw and microorganisms incorporation

The obtained data of Table (3) presented that the saved nutrients through rice straw and microorganisms incorporation, the revealed data indicated that rice straw offer moderate amounts of K 15.3 Kg/ton of rice straw followed by N 4.8 Kg/tone and minority amount of P 0.56 Kg/ton while presented huge amounts of organic carbon 311 Kg per each ton of rice straw. The organic matter contents of experimental soil plots showed that all rice straw treatments increase of organic soil matter content slightly compared to control treatment. These results were true in both seasons. Otherwise, any advantage could be achieved through rice straw and microorganisms incorporation is better than losing the essential nutrients, organic matter and increasing CO_2 emission that resulted from rice straw burning.

The real advantage is storing organic carbon of rice straw into soil by huge amounts. Needless to mention that, each faddan under the treatments of rice straw application receive about 0.6 ton of organic carbon (2 tons of rice straw/fad.). Carbon sequestration in soils implies transferring atmospheric CO_2 into long-lived pools and storing it securely so it is not immediately reemitted. Thus, soil carbon sequestration means increasing soil organic carbon and soil inorganic carbon stocks through judicious land use and recommended management practices (Lal, 2004). Although soil carbon sequestration does not mean avoidance and reduction of the formation of greenhouse gases, it is considered as a significant mitigation strategy because of the soils' potential to store large amounts of CO_2 at a global scale. Carbon sequestration is a promising mitigation option, it has to be emphasized that it is difficult to quantify the corresponding mitigation potential, due to the difficulties in measurement, data uncertainties and gaps. The slight increasing of organic matter content in the applied soil from first to second season and also among the control and treated soils as presented in Table (3) gave a good indicator for increasing soil fertility and sustainable agriculture production as a result of rice straw incorporation. Increasing organic soil matter content played a vital role in crop production (Abul-Soud *et al.,* 2014). Otherwise, the use of lower dose of recommended NPK had positive environmental impacts through mitigating the agricultural soil and fertilizers processing emission, save the natural sources (soil, water and energy), decrease the pollution and reduce the cost.

Table 3: The environmental impact assessment of rice straw and microorganisms incorporation into soil.

Treatments	Nutrient save Kg / ton				Organic matter %	
	N	P	K	O.C	1st season	2nd season
100% MF (control)	0.00 b	0.00 b	0.00 b	0.00 b	1.236 b	1.238 b
100% MF + RS	4.80 a	0.56 a	15.30 a	311.60 a	1.349 a	1.362 a
100% MF + RS + RSDF	4.80 a	0.56 a	15.30 a	311.60 a	1.350 a	1.363 a
100% MF + RS + PGPR	4.80 a	0.56 a	15.30 a	311.60 a	1.352 a	1.364 a
100% MF + RS + RSDF + PGPR	4.80 a	0.56 a	15.30 a	311.60 a	1.351 a	1.363 a
50% MF + RS	4.80 a	0.56 a	15.30 a	311.60 a	1.351 a	1.363 a
50% MF + RS + RSDF	4.80 a	0.56 a	15.30 a	311.60 a	1.351 a	1.363 a
50% MF + RS + PGPR	4.80 a	0.56 a	15.30 a	311.60 a	1.350 a	1.365 a
50% MF + RS + RSDF + PGPR	4.80 a	0.56 a	15.30 a	311.60 a	1.349 a	1.361 a

Means followed in same column by similar letters are not statistically different at 0.05 level according to Tukey test.
MF = Mineral fertilizer RS = Rice straw
RSDF = Rice straw decomposing fungi PGPR = Plant growth promoting rhizobacteria

The effect of rice straw and microorganisms incorporation on eggplant vegetative growth

Vegetative characteristics of eggplant plants as affected by the different treatments are presented in Table (4 and 5). Data showed that the treatments of 100% MF plus rice straw plus plant growth promoting rhizobacteria (PGPR) with or without rice straw decomposing fungi (RSDF) significantly increased vegetative growth of eggplant plants, these treatments gave the highest values of vegetative characteristics expressed as fresh and dry shoot weight, leaves number, plant height, stem diameter and chlorophyll reading compared to the other tested treatments. The treatments of 100% MF plus rice straw with or without RSDF increased of fresh and dry shoot weight compared to 100% NPK without rice straw treatment, while there were no significant differences among these treatments in other vegetative characteristics. On the other hand, the treatments of 50% MF plus rice straw plus PGPR with or without RSDF decreased of fresh, dry shoot weight and plant height compared to 100% MF without rice straw treatment, while there were no significant differences among these treatments in other

Table 4: Effect of rice straw and microorganisms incorporation on fresh, dry weight and leaves number of eggplant plants during 2013 and 2014 seasons.

Treatments	Fresh weight g/plant		Dry weight g/plant		Leaves No/plant	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
100% MF (control)	950 d	958 d	266 c	270 c	32.33 c	33.33 bc
100% MF + RS	1033 c	1050 c	284 b	287 b	32.67 c	33.43 bc
100% MF + RS + RSDF	1087 c	1092 c	289 b	291 b	33.00 c	34.33 b
100% MF + RS + PGPR	1225 b	1247 b	320 a	326 a	37.67 b	39.33 a
100% MF + RS + RSDF + PGPR	1300 a	1310 a	333 a	336 a	40.67 a	41.67 a
50% MF + RS	710 f	717 f	193 f	194 f	25.67 d	26.33 d
50% MF + RS + RSDF	740 f	750 f	189 f	192 f	26.33 d	27.33 d
50% MF + RS + PGPR	830 e	853 e	214 e	220 e	30.33 c	30.67 c
50% MF + RS + RSDF + PGPR	883 e	897 e	236 d	240 d	30.67 c	31.33 bc

Means followed in same column by similar letters are not statistically different at 0.05 level according to Tukey test.
MF = Mineral fertilizer RS = Rice straw
RSDF = Rice straw decomposing fungi PGPR = Plant growth promoting rhizobacteria

vegetative characteristics. Whereas, 50% MF plus rice straw with or without RSDF gave the lowest vegetative characteristics during the two growing seasons. The positive effect of 100% MF plus rice straw plus PGPR with or without RSDF treatments might be due to the decomposition of rice straw in the soil, that improved the soil fertility by supplying organic matter and improving the soil texture (Yu and Song, 2003; Abdulla, 2007). This effect also might be due to the beneficial effects of PGPR, that help in increasing nitrogen fixation in rhizosphere, increase supply of other nutrients and produce plant hormones (Saharan and Nehra 2011). All these led to improve the plant growth. These results are in agreement with those obtained by Joseph *et al.* (2007) on chickpea, Glinwood *et al.* (2011), Hou *et al.* (2012) on hot pepper and Latha *et al.* (2014)on eggplant.

Table 5: Effect of rice straw and microorganisms incorporation on plant height, stem diameter and chlorophyll of eggplant plants during 2013 and 2014 seasons.

Treatments	Plant height cm		Stem diameter mm		Chlorophyll reading spad	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
100% MF (control)	77.00 b	79.33 cd	13.00 b	13.78 cd	41.30 bc	42.29 bc
100% MF + RS	76.67 b	79.67 cd	13.33 b	14.12 c	42.00 b	42.99 b
100% MF + RS + RSDF	78.67 b	82.33 bc	13.33 b	14.39 bc	42.23 b	43.22 b
100% MF + RS + PGPR	84.67 a	88.33 ab	16.00 a	16.54 ab	44.13 a	45.12 a
100% MF + RS + RSDF + PGPR	90.00 a	92.67 a	16.33 a	16.89 a	44.60 a	45.59 a
50% MF + RS	56.67 d	57.33 f	8.33 c	8.62 f	37.07 d	38.05 d
50% MF + RS + RSDF	59.33 d	61.33 f	8.67 c	9.98 ef	38.03 d	38.82 d
50% MF + RS + PGPR	68.67 c	72.00 e	11.50 b	11.89 de	40.13 c	40.62 c
50% MF + RS + RSDF + PGPR	70.67 c	74.00 de	11.67 b	12.32 cd	40.8 bc	41.287 c

Means followed in same column by similar letters are not statistically different at 0.05 level according to Tukey test.
MF = Mineral fertilizer RS = Rice straw
RSDF = Rice straw decomposing fungi PGPR = Plant growth promoting rhizobacteria

The effect of rice straw and microorganisms incorporation on the leaves N, P and K content of eggplant

The effect of treatments on the nutritional status in eggplant plants is shown in Table (6). The obtained results in both seasons revealed that application of 100% MF plus rice straw plus PGPR with or without RSDF treatments gave the highest concentrations of N, P and K in eggplant leaves. On the other hand, the lowest N, P and K percentage of eggplant leaves were obtained by 50% MF plus rice straw with or without RSDF treatments. While, the treatments of 50% MF plus rice straw plus PGPR with or without RSDF were moderated, as these treatments decreased concentration of N in leaves compared to 100% MF without rice straw treatment, whereas there were no significant differences among these treatments in concentrations of P and K in eggplant leaves. These findings may be due to addition of rice straw as organic residues, the decomposition of this organic material improves physical, chemical and biological properties of soil, it also improves the nutrient cycling and availability to the plants (Yu and Song, 2003; Abdulla, 2007; Dai *et al.,* 2010). In addition, the presence of PGPR can increase nitrogen fixation, phosphate dissolving and potassium releasing (Saharan and Nehra 2011). All these increases of nutrient uptake and promote the nutritional status of eggplant plants. These results are in harmony with those obtained by Shehata *et al.* (2010) and Shahein *et al.* (2013) working on celery and lettuce respectively they reported that the biofertilizer increased NPK content in the leaves.

Table 6: Effect of rice straw and microorganisms incorporation on NPK content of eggplant leaves during 2013 and 2014 seasons.

Treatments	N		P		K	
	%					
	1st season	2nd season	1st season	2nd season	1st season	2nd season
100% MF (control)	4.039 b	4.192 b	0.352 bc	0.358 bc	3.577 cd	3.623 d
100% MF + RS	4.087 b	4.219 b	0.370 bc	0.380 bc	3.690 bc	3.828 bc
100% MF + RS + RSDF	4.102 b	4.252 b	0.403 b	0.415 b	3.827 b	3.969 b
100% MF + RS + PGPR	4.557 a	4.736 a	0.577 a	0.599 a	4.630 a	4.840 a
100% MF + RS + RSDF + PGPR	4.667 a	4.851 a	0.607 a	0.628 a	4.747 a	4.962 a
50% MF + RS	2.677 d	2.713 e	0.230 d	0.236 d	2.350 f	2.438 f
50% MF + RS + RSDF	2.867 d	2.905 d	0.247 d	0.254 d	2.557 e	2.653 e
50% MF + RS + PGPR	3.660 c	3.877 c	0.327 c	0.342 c	3.380 d	3.592 d
50% MF + RS + RSDF + PGPR	3.807 c	4.004 c	0.343 c	0.360 bc	3.523 cd	3.710 cd

Means followed in same column by similar letters are not statistically different at 0.05 level according to Tukey test.
MF = mineral fertilizer RS = rice straw
RSDF = rice straw decomposing fungi PGPR = plant growth promoting rhizobacteria

The effect of rice straw and microorganisms incorporation on eggplant yield

Data in Table (7) show yield properties (early, total yield and fruits number) of eggplant as affected by the different treatments. In both seasons the results cleared that the highest early and total yield were obtained by 100% MF plus rice straw plus PGPR with or without RSDF treatments compared to the other tested treatments. In addition, the treatments of 100% MF plus rice straw with or without RSDF came in the second order with no significant differences in comparison with 100% MF without rice straw treatment, then the treatments of 50% MF plus rice straw plus PGPR with or without RSDF came in the third order. Finally, the treatments of 50% MF plus rice straw with or without RSDF gave the lowest early and total yield of eggplant. Similar trend was true with property of fruit number on plant. In general, the most favorable treatments were 100% MF plus rice straw plus PGPR with or without RSDF compared with the other treatments. The superiority of these treatments may be due to increased uptake of N, P and K by these plants as shown in table (6) which resulted in increased plant growth characteristics as shown in table (4 and 5). The improved plant growth led to better carbohydrate build up which increased the early and total yield of eggplant. In this concern, Suge *et al.* (2011) reported similar results and explained that addition of suitable organic matter in the soil improves the soil physical and chemical properties which encourage better root development, increased nutrient uptake and water holding capacity which leads to higher fruit yield and better fruit quality of eggplant. These results confirmed the study by Man *et al.* (2003), they indicated that rice straw after harvesting was incorporated into soil within a week by tilling the land with power tiller plus NPK fertilized; grain yield offered higher than treatment of fertilizer without addition of rice straw. These results also supported the finding in experiment by Man and Ha (2006), they mentioned that there was not significant different in rice yield between decomposed rice straw combined with 50% recommended rate of chemical fertilizer (NPK) and 100% recommended rate of chemical fertilizer treatments.

Table 7: Effect of rice straw and microorganisms incorporation on early, total yield and fruits number of eggplant during 2013 and 2014 seasons.

Treatments	Early yield Kg/m^2		Total yield Kg/m^2		Fruit No./plant	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
100% MF (control)	0.795 b	0.760 b	3.197 bc	3.230 bc	18.18 c	18.36 c
100% MF + RS	0.799 b	0.764 b	3.242 b	3.349 b	18.83 bc	18.91 bc
100% MF + RS + RSDF	0.805 b	0.770 b	3.269 b	3.351 b	19.04 b	19.45 b
100% MF + RS + PGPR	1.052 a	1.089 a	4.360 a	4.368 a	24.31 a	24.38 a
100% MF + RS + RSDF + PGPR	1.062 a	1.099 a	4.473 a	4.482 a	24.95 a	25.01 a
50% MF + RS	0.283 f	0.248 f	2.063 e	2.073 f	11.50 f	11.56 f
50% MF + RS + RSDF	0.373 e	0.338 e	2.243 d	2.256 e	12.52 e	12.59 e
50% MF + RS + PGPR	0.627 d	0.594 d	3.078 c	3.088 d	17.20 d	16.99 d
50% MF + RS + RSDF + PGPR	0.712 c	0.679 c	3.082 c	3.118 cd	17.20 d	17.40 d

Means followed in same column by similar letters are not statistically different at 0.05 level according to Tukey test.
MF = mineral fertilizer RS = rice straw
RSDF = rice straw decomposing fungi PGPR = plant growth promoting rhizobacteria

Conclusions

In conclusion, this study showed that incorporation of rice straw into soil instead of burning. This process increase of carbon and nutrient sequestration in soil, thus increase of soil fertility and decrease of CO_2 emission. As well as, incorporation of rice straw into soil with decomposing fungi and plant growth promoting rhizobacteria, improved the production of eggplant in the clay soil at Giza governorate, Egypt. The recommended treatments under the study was 100% mineral fertilizer + rice straw + plant growth promoting rhizobacteria with or without decomposing fungi that recorded the highest yield. More research is need to present accurate monitoring and effect of sequestrate CO_2 and organic matter in soil through rice straw and microorganisms incorporation.

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References

Abdulla, H.M., 2007. Enhancement of rice straw composting by lignocellulolytic actinomycete strains. Int. J. Agri. Biol., 9(1): 106-109.
Abou Hussein, S.D. and O.M. Sawan, 2010.The utilization of agricultural waste as one of the environmental issues in Egypt. J. Appl. Sci. Res., 6(8): 1116-1124.
Abul-Soud M.; M. A. Abdrabbo and A. A. Farag. 2014. Increasing organic soil matter content as a key factor for sustainable production of sweet pepper. International Journal of Plant & Soil Science, 3 (6): 707 – 723.

Chapman, H.D. and P.F. Pratt, 1961. Methods of Analysis for Soil, Plant and Water Division of Agric. Sci., Calif. Univ.

Cole, C.V., 1997. Global estimates of potential mitigation of greenhouse gas emissions by agriculture. Nutr. Cycl. Agroecosyst., 49: 221–228.

Cottenie, A., M. Verloo, L. Kiekers, G. Velghe and R. Camrbynek, 1982. Chemical Analysis of Plants and Soils. Hand Book, 1-63, Ghent, Belgium.

Dai Z.G., J.W. Lu, X.K. Li, M.X. Lu, W.B. Yang and X.Z. Gao, 2010. Nutrient release characteristic of different crop straws manure. Trans. CSAE 26(6): 272-276.

Dobermann, A and T.H. Fairhurst. 2002. Rice Straw Management. Taken from Better Crops International, Special supplement publication: Rice Production. Volume 16. Published by the Potash and Phosphate Institute of Canada.

FAO, 1980. Soil and Plant Analysis., Soils Bulletin 38/2,250.

Glinwood, R.V. Ninkovic and J. Pettersson, 2011. Chemical interaction between undamaged plants – Effects on herbivores and natural enemies. Phytochem., 72(13): 1683-1689.

Hou, Y., X. Hu and B. Zhou, 2012. Hot pepper growth promotion and inhibition of fusarium wilt with different crop stalks. Afr. J. Agric. Res., 7(35): 5005-5011.

IPCC, 2007. Summary for Policymakers. In: Metz, B., Davidson, O.R., Bosch, P.R., Dave, R., Meyer, L.A. (Eds.), Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Irfan, M., Q. Syed, M. Yousaf, M. Nadeem, S. Baig and S.A. Jafri, 2010. Studies on the Pretreatment of wheat straw for improve production of Carboxymethyl Cellulase by thermophilic Trichoderma viride- FBL1 in Solid State fermentation. Academia Arena, 2(7): 18-30.

Janzen, H.H., 2004. Carbon cycling in earth systems a soil science perspective. Agric. Ecosyst. Environ., 104: 399-417.

Joseph, B., R.R. Patra and R. Lawrence, 2007. Characterization of plant growth promoting rhizobacteria associated with chickpea. International Journal of Plant Production, 1(2): 141-152.

Kausar, H., M. Sariah, H.M. Saud, M.Z. Alam and M.R. Ismail, 2010. Development of compatible lignocellulolytic fungal consortium for rapid composting of rice straw. Inter Biodeter Biodegrad, 64(7): 594-600.

Lal, R., 2004. Soil Carbon Sequestration Impacts on Global Climate Change and Food Security. Science 304(5677): 1623-1627.

Latha, P., S. Jeyaraman and R. Prabakaran, 2014. Effect of microbial and chemical fertilizer on eggplant. Int. J. Pure App. Biosci., 2(4): 119-124.

Man, L.H. and N.N. Ha, 2006. Effect of decomposed rice straw at different times on rice yield. Omonrice, 11: 74-82.

Man, L.H., V.T. Khang and T. Watanabe 2003. Improvement of soil fertility by rice straw manure. Omonrice, 11: 74-82.

Mashhoor, W.A., M.A. El-Borollosy, H.H.A. Abdel-Azeem, S.A. Nasr and S.M. Selim, 2002. Biofertilization of wheat plants exposed to environmental conditions. J. Agric. Sci, Ain Shams univ., Cairo 10(2): 543-565.

Ministry of Agriculture and Land Reclamation, Economic Affairs Sector (EAS), 2013. Bulletin of The Agriculture Statistics.

Ministry of Agriculture and Land Reclamation, 2009. Symptoms of Nutrient Deficiency on Some Field and Horticultural Crops. Soils, Water and Environment Research Institute, Agricultural Research Center

Nakhla, D.A., M.G. Hassan and S. El Haggar, 2013. Impact of biomass in Egypt on climate change. Natural Science, 5(6): 678-684.

Nandi, N., F.H. Rahman, N.B. Sinha and J.N. Hajra, 2000. Compatibility of lignin-degrading and cellulose decomposing fungi during decomposition of rice straw. J. Indian Soc. Sci., 48(2): 387-389.

Paustian, K., 2004. Agricultural mitigation of greenhouse gases: science and policy options. Council on Agricultural Science and Technology (CAST) report, R141 2004, ISBN 1-887383-26-3, p. 120, May, 2004.

Saharan, B.S. and V. Nehra, 2011. Plant Growth Promoting Rhizobacteria: A Critical Review. Life Sciences and Medicine Research, 21.

Shahein, M.M., S. Abou El Hassan and A.A. Ragab, 2013. Reduction of mineral fertilizers in lettuce production by using microbial inoculation, Potassium Humate and Potassium Silicate. Hortscience J. Suez Canal University, 1: 77-84.

Shehata, S.M., H.S. Abdel-Azem, A. Abou El-Yazied and A.M. El-Gizawy, 2010. Interactive effect of mineral nitrogen and biofertilization on the growth, chemical composition and yield of celeriac plant. European Journal of Scientific Research, 47(2): 248-255.

Singh, Y. and B. Singh, 2001. Efficient management of primary nutrition in the rice-wheat system. In: Tataki, P. K. (ed) The rice-wheat cropping systems of South Asia: Efficient production management. pp. 23-85. Food Products Press. New York, USA.

Sirisena, D.M. and T.P. Manamendra, 1995. Isolation and characterization of cellulolytic bacteria from decomposing rice straw. J Natu. Sci. Coun. Sri Lanka, 23(1): 25-30.

Smith, P., 2004b Engineered biological sinks on land. In The global carbon cycle. Integrating humans, climate, and the natural world (eds C. B. Field & M. R. Raupach), pp. 479–491. Washington, DC: Island Press.

Snedecor, G.W. and W.G. Cochran, 1980. Statistical methods. Sixth Edition, Iowa state university press, Ames., Iowa, U.S.A.

Suge, J.K., M.E. Omunyin and E.N. Omami, 2011.Effect of organic and inorganic sources of fertilizer on growth, yield and fruit quality of eggplant (Solanum Melongena L). Arch. Appl. Sci. Res., 3(6): 470-479.

Watanabe, F.S. and S.R. Olsen, 1965. Test of an ascorbic acid method for determining phosphorus in water and Na HCO_3 extracts from soil. Soil Sci. Soc. Amer. Proc., 29: 677- 678.

Wu, W., M. Yang, Q. Feng, K. McGrouther, H. Wang, H. Lu and Y. Chen, 2012. Chemical characterization of rice straw derived-biochar for soil amendment. Biomass and Bioenergy, 47. pp. 268-276.

Yu Z.D. and S.Y. Song, 2003. Effects of straw mixed with biopreparate on improvement of soil in greenhouse. Trans, CSAE 19:177-179.

Zenia, M. and B. Halinam, 2008. Content of microelements in eggplant fruits depending on nitrogen fertilization and plant training method. J. Elementol, 13(2): 269-274.