Enhancing Rice Straw Media for Growing Eggplant under Modified Climatic Conditions Using Compost and Bacterial Inoculation

I. I. Sadek[1], Fatma S. Moursy[1], E. A. Salem[1], A. Schüch[2], M. A. M. Heggi[1]

[1]Central Laboratory for Agricultural Climate (CLAC), Agricultural Research Center, Giza, Egypt.
[2] Universities of Rostock, Agricultural and Environmental Faculty, Department Waste Management and Material Flow
dr.ihabsadek@yahoo.com

Abstract: Nowadays, rice straw in Egypt considered as the largest agricultural waste. Rice straw causes environmental problems when it is burned at the fields. So, it's necessary to conduct a new methods, that are capable to accommodate continues production of paddy rice straw every year. Rice straw usage as agriculture media is one of several applications or solutions. This study validates rice straw to be appropriate media for eggplants cultivation, whereby the ideal percentage of added compost to that waste was tested. Other tested hypothesis, using free living fixing bacteria (two strains) to cover the nitrogen shortage in rice straw when use it as agricultural media. Moreover, this experiment was carried out inside a net house, in order to characterize the effect of modified climatic conditions. Results showed that, it's applicable and profitable to use rice straw as a growing media for eggplant. Using rice straw plus compost (20% of the overall media volume) and inoculates it with both *Azotobacter chroococcum* and *Paenibacillus polymyxa* presented the highest crop yield and the highest profit compared to other tested treatments. Meanwhile, high air temperature and relative humidity (RH %) caused a reduction in crop yield and in the net return.

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1. Introduction:

Agricultural wastes are among the causes of environmental pollution. Their conversion into useful products may ameliorate the problems they cause. These wastes which include straw, leaves and residues from cereals crops and corn cobs etc. are highly underutilized in Africa. Rice straw represents an important summer crop by-product in Egypt. About 5 million tons of rice straw was produced every year from the rice fields. No organized practical use for this waste until now. Moreover, causes serious pollution when disposed by burning **(Abdet-Sattar *et al.*, 2008)**.

Concerning the quality of agricultural media, high quality media to grown plants is a key determinant factor to establish a successful crop production program. Media that provides optimal water-holding capacity, sufficient nutrients and that is pathogen-free results in better seedling quality prior to transplanting **(Evans, 1998)**. On the other hand, the major components of rice straw are silica, lignin and hemicelluloses which are not attractive or favourable for soil fungi or nematodes. At the same time, the raw material rice straw is very cheap, so it could represent a good substrate for sowing seeds, instead of sowing seeds in infested soil under open field conditions. Using rice straw as agricultural media for agriculture production is one of the proposed practical uses. The use of compacted rice straw bales as organic media in open field production is a new approach in Egypt **(Abdet-Sattar *et al.*, 2008)**.

Straw contains NPK, (3-7 kg N, 1.5 kg P and 15 kg K) per ton of rice straw. But10-15 kg of N is needed for rice straw decomposition. So, a shortage of N in the period of establishment of the new crop will be appearing. This, confirm the necessity of continues supplement of nitrogen.

Eggplant (*Solanum melongena* L.) which belongs to *Solanaceae* family is an important vegetable crop; eggplant has a great growing reputation and is cultivated globally. Eggplant is a valuable human diet. In addition, it is grown commercially as a fresh vegetable crop; it requires a long and warm growing season to produce optimum yields of eggplant and is highly susceptible to injury due to frosts and long periods of cold temperatures **(Sadek *et al.*, 2013)**.

Environment is the aggregate of all external conditions which influence growth and development of plants. Generally, crops are not profitable unless they are adapted to the region in which they are produced **(Reddy *et al.*, 1999)**.

Among environmental factors, light intensity, temperature and relative humidity influence crop growth and development. Radiation consists of different wave-lengths of light, in which the visible portion is useful for crop growth; ultra-violet and infrared radiations are not beneficial for crop growth, as they change molecular levels which lead to cellular disorganization. Temperature is the major regulator of development processes. Higher temperatures have more adverse influence on net photosynthesis than lower temperatures leading to decreased production of photosynthesis above a certain temperature **(Reddy *et al*., 1999)**.

Temperature can be controlled and regulated under protected conditions; better growth of plants might be expected under protected culture. Relative humidity increases availability of net energy for crop growth and improves survival of crops under moisture stress conditions. Relative humidity reduces evaporation loss from plants which lead to optimum utilization of nutrients. It also maintains turgidity of cells which is useful in enzyme activity leading to a higher yield **(Reddy *et al.*, 1999)**.

The objectives of the experiment were:

1. Evaluate the possibilities of using rice straw as agriculture media for eggplant cultivation instead of eggplant cultivation on infested soil field.
2. Determined most suitable percentage of compost should be added to rice straw.
3. Determined the most effective strain fixing nitrogen bacteria for supplemental the nitrogen for rice straw.
4. Study effect of modified climatic conditions on the growth and yield of eggplant grown in rice straw media.

2. Material and Methods:

The study investigation was carried out in Dokki Protected Cultivation Experimental site, Agricultural Research Center (ARC), Ministry of Agriculture and Land Reclamation. A net house was used; the main frame was steel structure, the net house dimension 5 x 17 x 4.5 meter. White plastic insect proof net was used to cover the shade net.

Seedlings of eggplant (Baladi Varity) were transplanted on 5/3/2012 and 10/3/2013. Twenty litter pots filled with chopped rice straw which was compacted by hand were used in this experiment. Two factors and them interaction were tested in this investigation.

First tested factor was adding compost in the growth media. Characteristics of both used rice straw and compost were shown in Table (a). Three percentages were tested 10%, 20% and 30% of the overall growth media volume. Second factor was bacterial inoculation. Two strains of free living nitrogen fixing bacteria were used to inoculate plants i.e, *Azotobacter chroococcum* and *Paenibacillus polymyxa*. Strains were used as follow to create four treatments: (1) *Azotobacter*, (2) *Paenibacillus,* (3) mixed bacterial inoculation (*Azotobacter* + *Paenibacillus*) and (4) (control) non-inoculated growth media. Each pot contain one plant is inoculated three times per season. First inoculation was add after transplanting directly, second time was add on flowering stage and the third was done after the first harvest. Each plant received 5 ml of inoculating solution. Strains were bought as a solution from Microbial Resources Centre (MIRCEN), Faculty of Agriculture Ain Shams University.

Table (a): Characteristics of used compost and rice straw.

Characteristic	Compost	Rice straw	
Bulk density (g/cm3)	0.425	*	
Moisture content(%)	24.13	8.90	
EC (1:10) (dS/m)	2.83	3.50	
pH (1:10)	7.86	6.55	
Organic matter (%)	36.20	80.25	
Organic Carbon(%)	37.70	77.56	
Total N (%)	1.46	0.76	
Total P (%)	1.14	0.63	
Total K (%)	0.91	0.42	
Ash (%)	35.00	91.10	
Chemically available, mg.kg^{-1}			
N	986	Amonical 28 ppm	Nitrate 6 ppm
P	474	*	
K	465	*	
C/N ratio	17:1	61.25:1	

C/N ratio: carbon /nitrogen ratio

Two media were used in microbiological determination. First, nutrient agar medium **(Jacobs and Gerstein, 1960)**: This medium was used to determine the total bacterial count. It has the following components (g/l): Peptone = 5.0, Beef extract = 3.0, Agar = 20 and Tap water = 1000 ml. pH of the medium equal 7.0. Second, Soil extract agar medium **(Clark, 1965)**: This medium was used to determine the densities of spore forming bacteria. It has the following components (g/l): Peptone = 5.0, Soil extract = 250 ml, Agar = 20 and Tap water = 750 ml. pH of the medium equal 7.0.

Following microbiological parameters were determined in the rhizosphere and soil apart around roots:

a- Total bacterial counts, were determined by plate count method on nutrient agar medium with incubation at 30 ºC for 48h **(Jacobs and Gerstein, 1960)**.

b- Count of spore forming bacteria, were carried out by plating on soil extract agar medium after heating the serial dilutions at temperatures 80 ºC for 15 minutes with incubation at 30 °C for 48h **(Clark, 1965)**. Total and spore forming bacterial before start the experiments were measured, data was illustrated in Table (1).

Data regarding vegetative growth and crop yield were collected as follow: plant height (cm), number of leaves, stem diameter (cm) and chlorophyll reading (SPADE) were measures after 30, 60 and 90 days from transplanting. Moreover, plant fresh and dry weights (g) were measured at the end of each growing season. In addition, fruits weight (g/plant) and number were count during all over the season.

Maximum and minimum air temperatures and average relative humidity (RH%) and radiation were recorded daily inside and outside the net house by using a digital thermo/hygrometer Art.No.30.5000/30.5002 (Produced by TFA, Germany). The results were calculated and presented as an average of every 10 days (Figures 1, 2 and 3).

All treatments were arranged in split plot design; percentages of compost were arranged in the main plot and bacterial strains were arranged in sub main plot. Obtained data were statistically analyzed using the analysis of variance method. Duncan's multiple range tests at 5% level of probability was used to compare means of the treatments. Finally, economic indicators were used to provide economic and environmental evaluation for this experiment.

Table (1): Total bacterial and spores former counts for compost and rice straw before mixed together (one day before transplanting).

Total bacterial count		Total spores count	
Compost	Rice straw	Compost	Rice straw
89 x10^5	55x10^5	100x10^4	52x10^4

3- Results:

3-1 Climatic data

3-1-1 Air temperature

Illustrated data in Figure (1) showed maximum and minimum air temperature inside and outside the net house at Dokki site during seasons 2012 and 2013. Both maximum and minimum air temperature were lower inside the net house compared to outside. The mentioned reduction results due to application of the screen net. These results are in agreement with those reported by **Willits (2001)**, **Hasni *et al.* (2006), Coelho *et al.* (2006), Bartzanas and Kittas (2006) and Teitel *et al.* (2008), EL-Sayed (2009) and Ali (2010)**. Moreover, it's noted from data in Figure (1) that, maximum and minimum air temperature was slightly higher during 2013 compared to 2012. Such increment in the measured air temperature was clear through the periods from the day 21 to 30, 51 to 60, 71 to 90 days after transplanting.

3-1-2 Relative humidity

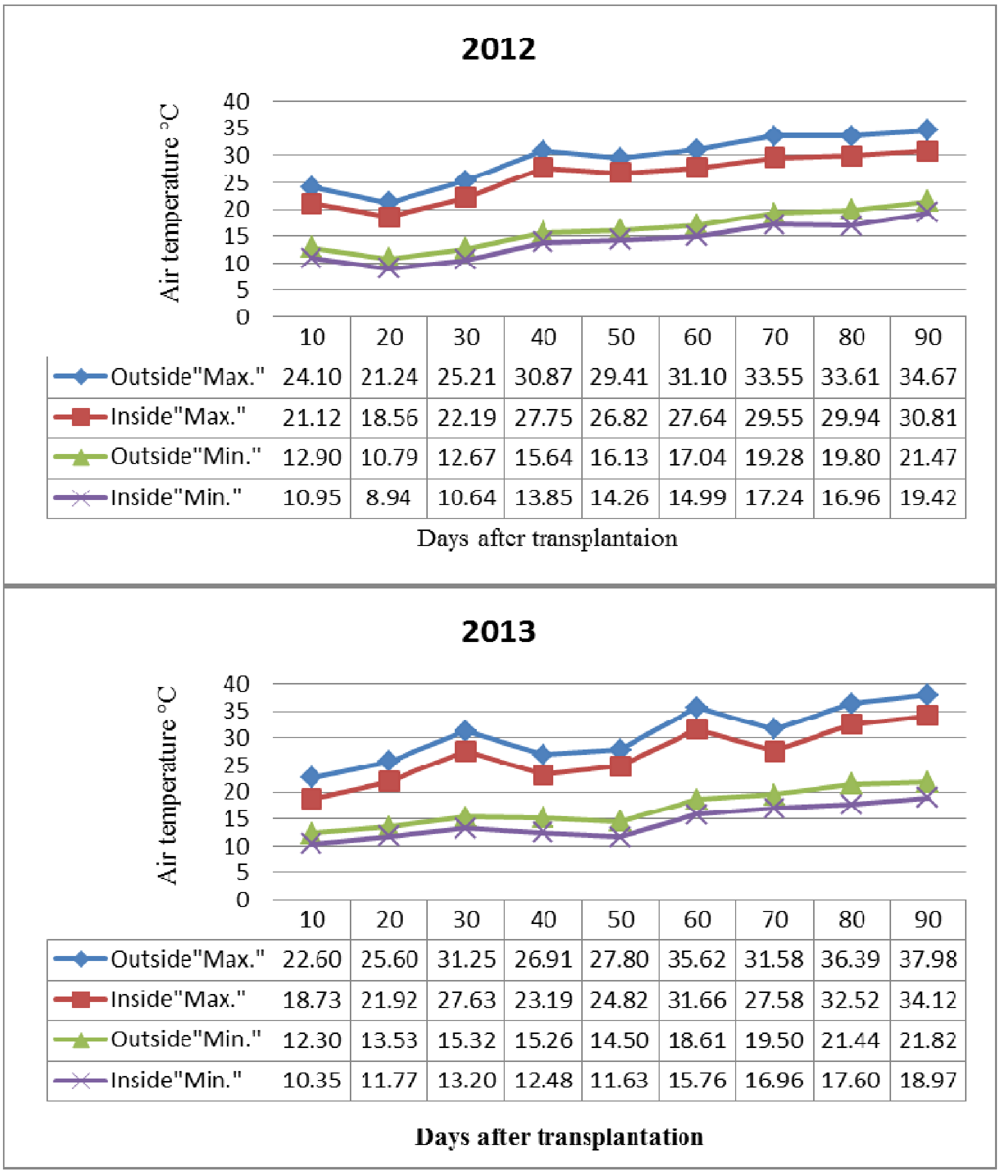
According to the presented data in Figure (2), average relative humidity (RH %) recorded the highest values outside the net house compared to inside. This means, that the used screen net reduced average relative humidity at Dokki site during 2012 and 2013 seasons. These results were in agreement with **Delfine *et al.* (2000) and El-Sayed (2009)**. Also **Nimje and Shyam (1993)** observed that the relative humidity was higher inside the greenhouse than in the open field which influenced growth and yield.

3-1-3 Radiation

Measured radiation (Maj/m^2) decreased under net house conditions compared with the same measurement outside the net house, during both studied seasons of 2012 and 2013 (Figure 3). These results are in harmony with those of **Sandri *et al.* (2003) and El-Sayed (2009)**

Summary of 3-1

From the overall illustrated results, however, inside or outside the net house, climatic condition reflected on the performance of eggplants. This result was clear in fruit yield/plant especially through different seasons. When studying climatic condition during the first season compared to the second season, it is noted that maximum and minimum air temperature, average relative humidity and radiation were higher in the second season than in the first season. Climatic condition and its reflection on the performance of both vegetative and crop yield was found by others, **Johkan *et al.* (2011)** and **Rajasekar *et al.* (2013)**. Moreover, **Ramesh and Arumugam (2010), Ganesan (2004)**, reported that, mean weekly temperature during summer and winter season were higher under open field than in the shade net house. The lower temperature increased plant height, number of branches, intermodal length, average fruit weight and yield per plant were higher inside the shade net house than in the open field condition.



2012

	10	20	30	40	50	60	70	80	90
Outside"Max."	24.10	21.24	25.21	30.87	29.41	31.10	33.55	33.61	34.67
Inside"Max."	21.12	18.56	22.19	27.75	26.82	27.64	29.55	29.94	30.81
Outside"Min."	12.90	10.79	12.67	15.64	16.13	17.04	19.28	19.80	21.47
Inside"Min."	10.95	8.94	10.64	13.85	14.26	14.99	17.24	16.96	19.42

2013

	10	20	30	40	50	60	70	80	90
Outside"Max."	22.60	25.60	31.25	26.91	27.80	35.62	31.58	36.39	37.98
Inside"Max."	18.73	21.92	27.63	23.19	24.82	31.66	27.58	32.52	34.12
Outside"Min."	12.30	13.53	15.32	15.26	14.50	18.61	19.50	21.44	21.82
Inside"Min."	10.35	11.77	13.20	12.48	11.63	15.76	16.96	17.60	18.97

Figure 1: Maximum and minimum air temperature in Celsius inside and outside the net house at Dokki site during 2012 and 2013 seasons (Begin of March until end of May).

3-2 Eggplant vegetation and crop yield

3-2-1 Plant height

Its enable to discussed performance of eggplants' plant height as affected by percentage of compost in rice straw media, type of bacterial inoculation and interaction was illustrated in Table (2). After 30 days from transplanting the highest significant plant height was found in plants grown in rice straw media containing 20% compost, followed by plants grown in rice straw media with 10% compost during the first season. Moreover, during the second season plants that were grown in media with 10% compost were significantly the highest, followed by plants grown in media with 30% compost. Moreover, lowest significant value of plant height was found in plants that grown in rice straw media with 30% compost followed by those grown in media containing 20% compost.

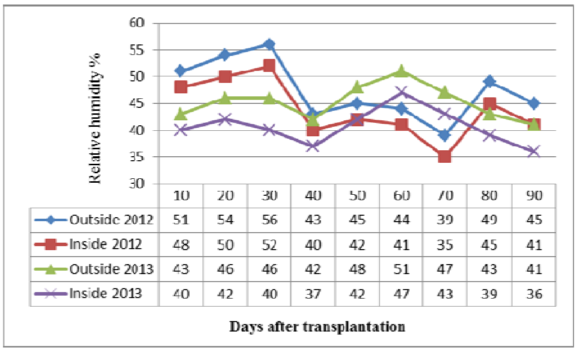
After 60 and 90 days from transplanting date, performance of eggplant plant height present a clear trend during both studied seasons. Data in Table (2) showed that, the highest significant plant height appear as a result of adding high percentage of compost to the growing media (30%). Also, the lowest plant height appears to be a result for the low percentage of (10%) compost in rice straw media.

In addition, the plant height was significantly affected by bacterial inoculation. *Azotobacter* caused significantly the highest value of plant height, while, plants were not inoculated (control) recorded the lowest significant value of plant height. The mentioned performance of plant height as a result for using bacterial inoculation was true after 30, 60 and 90 days from transplanting at both growing seasons. Moreover, there was no significant difference between plants that inoculated with *paenibacillus*, mixed inoculation (*Azotobacter* + *paenibacillus)* and without inoculation (control).

Concerning to interaction between percentage of compost and bacterial inoculation, the highest plant height was obviously found when 30% compost interacted with *Azotobacter*. Hence, the lowest value of plant height was detected in plants affected by interaction between 10% compost and without bacterial inoculation (control) during the two studied seasons.

3-2-2 Number of leaves

Data in Table (3) make it possible to study performance of eggplant's number of leaves as affected by percentage of compost in rice straw media, bacterial inoculation and treatments interaction. Number of leaves after 30 days from transplanting date was not affected significantly by the percentage of compost in rice straw media in both seasons. However, trend of results were obvious after 60 and 90 days from transplanting date, the highest significant number of leaves was found in plants grown in rice straw media contained 30% compost and the lowest was recorded in plants with the percentage of compost (10%). Concluded trend was almost true during both seasons.



	10	20	30	40	50	60	70	80	90
Outside 2012	51	54	56	43	45	44	39	49	45
Inside 2012	48	50	52	40	42	41	35	45	41
Outside 2013	43	46	46	42	48	51	47	43	41
Inside 2013	40	42	40	37	42	47	43	39	36

Figure 2: Average relative humidity (%) inside and outside the net house at Dokki site during 2012 and 2013.

Table (2): Effect of compost percentage in rice straw media, bacterial inoculation and the interactions treatments on plant height (cm) after 30, 60 and 90 days from transplanting date during 2012 and 2013.

	Aotoz.	*Paenib.*	Mixed	Control	A	*Aotoz.*	*Paenib.*	Mixed	Control	A
	First season				30 days after transplanting	Second season				
10%	47.75 b	42.50 c	38.50 d	29.25 g	39.50 B	38.20 a	34.00 b	30.80 cd	23.40 g	31.60 A
20%	50.00 ab	38.25 de	52.00 a	36.25 d:f	44.13 A	32.00 bc	24.32 fg	33.28 bc	23.20 g	28.20 B
30%	38.00 de	34.75 ef	39.25 cd	43.25 f	36.56 C	30.40 c:e	27.80 de	31.40 bc	27.40 ef	29.25 AB
B	45.25 A	38.50 B	43.25 A	33.25 C		33.53 A	28.71 B	31.83 A	24.67 C	
					60 days after transplanting					
10%	87.00 a:c	80.00 f	84.50 b:d	79.13 f	82.66 B	68.73 a	63.20 cd	66.75 b:d	62.51 d	65.30 B
20%	88.50 ab	84.25 c:e	81.00 d:f	80.25 ef	83.50 AB	70.11 ab	66.56 b:d	63.99 cd	63.15 cd	65.95 B
30%	90.25 a	81.25 d:f	87.00 a:c	85.13 b:d	85.91 A	71.30 a	64.19 cd	68.73 ab	67.25 a:c	67.87 A
B	88.58 A	81.83 B	84.17 B	81.50 B		70.05 A	64.65 B	66.49 B	64.30 B	
					90 days after transplanting					
10%	90.75 a:c	83.25 e	88.50 cd	82.75 e	86.31 B	68.06 ab	62.44 c	66.38 a:c	62.06 c	64.73 A
20%	92.75 ab	88.75 c	84.50 e	83.75 e	87.44 AB	69.38 a	66.56 a:c	63.38 bc	62.81 c	65.53 A
30%	94.25 a	84.75 de	91.00 a:c	89.00 bc	89.75 A	70.69 a	63.56 bc	68.25 ab	66.75 a:c	67.31 A
B	92.58 A	85.58 B	88.00 B	85.17 B		69.38 A	64.19 B	66.00 AB	63.88 B	

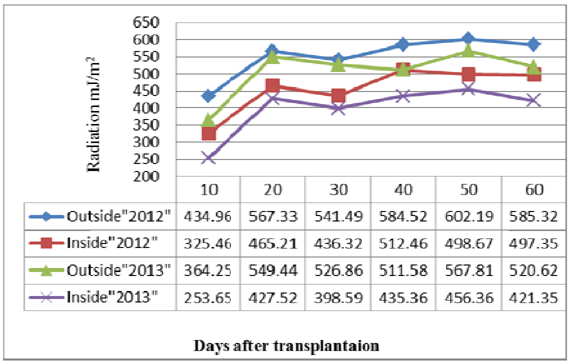


Figure 3: Radiation (Maj/m^2) inside and outside the net house at Dokki site during 2012 and 2013.

Highlighting on the effect of bacterial inoculation in the performance of eggplants' number of leaves, large number of leaves was recorded in plants that inoculated with *Azotobacter* followed by mixed bacterial inoculation with significant different between them after 30 days from transplanting date. Significant differences were not found after 60 and 90 days from transplanting date. Moreover, the lowest number of leaves was recorded in plants that not inoculated (control). The same trend of results was found in seasons of 2012 and 2013.

Focusing on interaction between percentage of compost in the cultivation media and bacterial inoculation, it's obvious that, after 30 days from transplanting date, interactions between 20% compost and *Azotobacter* and interaction between 30% compost and *Azotobacter*, recorded the highest significant number of leaves followed by the interaction between 10% compost and *Azotobacter*. No significant different was found between the mentioned three highest significant interactions.

The most negative interaction was found between 20% compost and without bacterial inoculation (control). In addition, after 60 and 90 days from transplanting interaction between 30% compost and *Azotobacter* recorded the highest significant number of leaves. Moreover, the interaction that causes the lowest number of leaves was interaction between 10% compost and without bacterial inoculation (control). Trend of the effect of interaction between percentage of compost in the growing media and bacterial inoculation was held true for the two seasons 2012 and 2013.

Table (3): Effect of compost percentage in rice straw media, bacterial inoculation and both interactions on number of leaves 30, 60 and 90 days from transplanting during 2012 and 2013.

	Aotoz.	*Paenib.*	Mixed	Control	A	*Aotoz.*	*Paenib.*	Mixed	Control	A
First season					30 days after transplanting			Second season		
10%	21.50 a	17.50 bc	15.75 bc	17.25 bc	18.00A	17.20 a	14.00 b	12.60 bc	13.80 b	14.40A
20%	23.00 a	13.00 de	15.25 cd	12.25 e	15.88A	18.40 a	10.40 cd	12.20 b:d	9.8 d	12.70A
30%	23.00 a	16.00 bc	18.00 b	16.00 bc	18.25A	18.40 a	12.80 bc	14.40 b	12.80 bc	14.60A
B	22.50 A	15.50 B	16.33 B	15.17 B		18.00 A	12.40 B	13.07 B	12.13 B	
60 days after transplanting										
10%	80.00cde	80.00 c:e	77.75 de	58.00 g	73.94C	62.65de	62.40de	60.65 e	45.24 g	57.73B
20%	89.00 b	80.25 cd	87.25 b	72.25 f	82.19B	69.42 b	62.60de	68.00bc	56.35 f	64.09A
30%	98.00 a	77.00 e	95.50 a	83.00 c	88.38A	76.44 a	60.26 ef	74.49 a	64.74 cd	68.98A
B	89.00A	79.08 B	86.83 A	71.08 C		69.50 A	61.75 B	67.71 A	55.44 C	
90 days after transplanting										
10%	91.25fg	95.25 e	90.00 fg	71.50 h	87.00C	67.34 de	70.49 d	66.60de	52.91 f	64.33C
20%	104.80d	91.25 fg	110.50c	88.00 g	98.63B	77.51 c	67.53 de	81.77 c	65.12 e	72.98B
30%	138.30a	93.00 ef	126.30b	88.75 g	111.6A	102.3 a	68.82 de	93.68 b	65.68 e	82.62A
B	111.4A	93.17 B	108.9 A	82.75 C		82.39 A	68.94 B	80.68 A	61.24 C	

3-2-3 Eggplant stem diameter

Eggplants' stem diameter affected significantly by percentage of compost in the cultivation media, bacterial inoculation and both interactions stated in (Table 4). After 30 days from transplanting date the highest value of stem diameter was significantly recorded in plants that grown in media containing 30% of compost, but, the lowest stem diameter was found in plants that grown in media containing 10% of compost. This trend of results was same in both studied seasons. Hence, after 60 and 90 days from transplanting no significant effect was recorded regarding different percentage of compost that was added. The same trend was obvious during both studied seasons.

Tested bacterial inoculation does not have a significant effect on egg plants' stems diameter after 30 and 90 days from transplanting date in both studied seasons. A significant effect for bacterial inoculation was clear after 60 days from transplanting date in the both studied seasons, plants that were not inoculated (control) and those inoculated with *Azotobacter* recorded the highest significant values of stem diameter. In addition, no significant different was found between both mentioned treatments during both studied seasons.

Concerning effect of the interaction between percentage of compost added in the cultivation media and bacterial inoculation, the obtained results showed a different trend through the growing seasons of the experiment. After 30 days from transplanting date, the highest value of stem diameter was found when 30% compost interacted with mixed bacterial inoculation. Moreover, after 60 and 90 days from transplanting date, interaction between 30% compost and without bacterial inoculation (control) gave the thickest stem diameter. The same trend was found in both seasons.

3-2-4 Chlorophyll

Studying carefully data in Table (5) make it possible to conclude that nether different tested percentage of compost in the growing media with compost (10, 20 and 30%), nor bacterial inoculation (*Azotobacter*, *paenibacillus*, mix. and control) does not affected significantly on chlorophyll content, however, after 30, 60 or 90 days from transplanting date in the two studied seasons.

Interaction between percentages of compost in the cultivation media and bacterial inoculation enhance a significant effect in eggplant stem diameter. The highest significant value of stem diameter was found when 10% compost interacted with *Azotobacter* after 30, 60 and 90 days from transplanting date in both studied seasons.

Table (4): Effect of compost percentage in rice straw media, bacterial inoculation and both interactions on stem diameter (cm) 30, 60 and 90 days from transplanting during 2012 and 2013.

	Aotoz.	*Paenib.*	Mixed	Control	A	*Aotoz.*	*Paenib.*	Mixed	Control	A
		First season			30 days after transplanting			Second season		
10%	0.86 b:d	0.91 ab	0.77 e	0.85 b:d	0.85 B	0.83 b:e	0.90 a:c	0.76 e	0.84 a:e	0.83 B
20%	0.82 c:e	0.81 de	0.92 ab	0.91 ab	0.86 AB	0.81 c:e	0.80 de	0.91 ab	0.87 a:d	0.85 AB
30%	0.88 a:c	0.91 ab	0.95 a	0.94 a	0.92 A	0.87 a:d	0.90 a:c	0.94 a	0.93 a	0.91 A
B	0.86 A	0.87 A	0.88 A	0.90 A		0.84 A	0.86 A	0.87 A	0.88 A	
					60 days after transplanting					
10%	1.18 a:d	1.05 d	1.13 cd	1.23 a:c	1.14 A	1.15 a:c	1.04 c	1.12 bc	1.19 ab	1.12 A
20%	1.25 a:c	1.15 b:d	1.23 a:c	1.28 a:c	1.23 A	1.21 ab	1.11 bc	1.13 bc	1.23 ab	1.17 A
30%	1.30 ab	1.23 a:c	1.15 b:d	1.33 a	1.25 A	1.26 ab	1.18 a:c	1.12 bc	1.28 a	1.21 A
B	1.24 AB	1.14 B	1.17AB	1.28 A		1.20 AB	1.11 B	1.12 B	1.23 A	
					90 days after transplanting					
10%	1.43 ab	1.43 ab	1.40 ab	1.40 ab	1.41 A	1.38 ab	1.38 ab	1.36 ab	1.35 ab	1.37 A
20%	1.45 ab	1.43 ab	1.38 ab	1.48 ab	1.43 A	1.40 ab	1.38 ab	1.33 ab	1.43 ab	1.39 A
30%	1.50 a	1.33 b	1.43 ab	1.53 a	1.44 A	1.45 ab	1.28 b	1.38 ab	1.48 a	1.40 A
B	1.46 A	1.39 A	1.40 A	1.47 A		1.41 A	1.34 A	1.35 A	1.42 A	

Table (5): Effect of compost percentage in media, bacterial inoculation and both interactions on chlorophyll reading 30, 60 and 90 days from transplanting during 2012 and 2013.

	Aotoz.	*Paenib.*	Mixed	Control	A	*Aotoz.*	*Paenib.*	Mixed	Control	A
	First season				30 days after transplanting			Second season		
10%	59.63 a	53.13 cd	57.70 ab	56.05 a:c	56.63 A	58.90 a	52.84 bc	54.87 Abc	55.49 a:c	55.52 A
20%	55.8 a:d	58.10 ab	58.67 ab	57.28 ab	57.46 A	55.24 a:c	57.51 ab	58.08 Ab	59.17 a	57.50 A
30%	53.33 cd	55.53 b:d	51.97 d	59.15 ab	54.99 A	52.79 bc	54.97 a:c	51.47 C	58.56 a	54.45 A
B	56.25 A	55.58 A	56.12 A	57.49 A		55.64 A	55.11 A	54.81 A	57.74 A	
					60 days after transplanting					
10%	61.40 a	55.35 c	59.93 a:c	58.28 a:c	58.74 A	60.78 a	54.79 b	59.33 B	57.69 ab	58.15 A
20%	58.05 a:c	59.85 a:c	60.97 ab	59.25 a:c	59.53 A	57.47 ab	59.25 ab	60.36 A	61.13 a	59.55 A
30%	55.25 c	57.35 a:c	56.55 bc	61.40 a	57.64 A	54.69 b	56.77 ab	55.98 Ab	60.78 a	57.06 A
B	58.23 A	57.52 A	59.15 A	59.64 A		57.65 A	56.94 A	58.56 A	59.87 A	
					90 days after transplanting					
10%	70.65 a	65.35 b	69.93 ab	68.28 ab	68.55 A	69.94 a	64.69 bc	69.22a b	67.59 ab	67.86 A
20%	68.05 ab	69.85 ab	68.47 ab	69.25 ab	68.91 A	67.37 a:c	69.15 ab	67.78a bc	68.55 a:c	68.21 A
30%	65.25 b	64.85 b	66.55 b	68.90 ab	66.39 A	64.59 bc	64.20 c	65.88 a:c	68.14 a:c	65.70 A
B	67.98 A	66.68 A	68.32 A	68.81 A		67.30 A	66.01 A	67.63 A	68.10 A	

Table (6): Effect of compost percentage in rice straw media, bacterial inoculation and both interactions on plant fresh weight 90 days from transplanting during 2012 and 2013.

	Aotoz.	*Paenib.*	Mixed	Control	A	*Aotoz.*	*Paenib.*	Mixed	Control	A
			First season					Second season		
10%	989.0 b	877.7 c:f	858.6 ef	838.3 f	890.9 C	893.0 bc	793.2 d	776.0 D	757.6 d	805.1 B
20%	919.8 cd	923.1 c	1111.0 a	909.3 c:e	965.7 A	831.2 cd	834.2 cd	1004.0 a	821.7 cd	872.7 A
30%	1035.0 b	897.4 c:e	883.5c d:f	869.2 d:f	921.3 B	935.5 ab	810.8 cd	798.4 d	785.4 d	832.5 AB
B	981.3 A	899.4 B	951.6 A	872.3 B		886.8 A	812.7 BC	859.4 AB	788.2 C	

3-2-5 Fresh weight

It's concluded from data in Table (6) that, add compost to the growing media by the rate 20% significantly cause highest plant fresh weight followed significantly by 30% compost. However, lowest significant plant fresh weight was detected when adding compost by the rate 10%.

Regarding bacterial inoculation, plants which were inoculated with *Azotobacter* and mixed bacterial inoculation recorded the highest significant plant fresh weight without significant different between them. However lowest plant fresh weight recorded when using *paenibacillus* to inoculate plants and when not inoculated (without bacterial inoculation-control) without significant different between them. The same effect of bacterial inoculation was found by **Ali (2010).**

Moreover, interaction between 20% compost and mixed bacterial inoculation reflected a high significant plant fresh weight. When, interaction between 10% compost and control gives the lowest significant plant fresh weight. Illustrated trend of results was similar in both studied seasons.

3-2-6 Dry weight

Illustrated data in Table (7) showed that, performance of plant dry weight (g) and dry weight (g)/fresh weight (100g) have the same trend of results. So, discuss any of them is enough because it's the same.

A significant different in plant dry weight was detected between the three tested percentage of compost (10, 20 and 30%) inside the growing media (Table 7). Twenty percent of compost inside the growing media ranked the significantly the first in plant dry weight during both studied seasons. Moreover, the lowest percentage of compost (10%) gave the lowest significant plant dry weight in the two seasons. Obtained results was in agreement with

While, adding mixed bacterial inoculation (*Azotobacter* + *paenibacillus)* recorded the highest significant values of plant dry weight in the two seasons followed by *Azotobacter* with significant different between them. This result is in agreements with **Ali (2010).**

Table (7): Effect of compost percentage in rice straw media, bacterial inoculation and both interactions on plant dry weight 90 days from transplanting during 2012 and 2013.

	Aotoz.	*Paenib.*	Mixed	Control	A	*Aotoz.*	*Paenib.*	Mixed	Control	A
	First season			plant dry weight (g)			Second season			
10%	76.02 d	65.22 e	78.10 d	56.11 f	68.86 C	68.79 d	58.82 e	70.79 d	50.40 f	62.20 C
20%	89.97 b	77.74 d	103.0 a	59.00 f	82.42 A	81.46 b	70.36 d	93.47 a	53.10 f	74.60 A
30%	82.94 c	69.08 e	86.06 bc	57.06 f	73.79 B	75.11 c	62.47 e	78.06 bc	51.29 f	66.73 B
B	82.98 B	70.68 C	89.04 A	57.39 D		75.12 B	63.88 C	80.77 A	51.59 D	
					Dry weight (g/100g fresh weight)					
10%	7.69 de	7.60 de	8.90 c	6.70 f	7.72 B	7.70 de	7.59 d:f	8.93 bc	6.66 e:g	7.72 B
20%	9.78 b	7.04 ef	11.16 a	6.49 f	8.62 A	9.80 b	7.06 d:g	11.2 a	6.46 g	8.63 A
30%	8.03 d	7.82 de	9.70b c	6.64 f	8.04 AB	8.05 cd	7.83 d	9.73 b	6.60f g	8.05 AB
B	8.50 B	7.49 C	9.92 A	6.61 D		8.52 B	7.49 C	9.96 A	6.57 D	

Moreover, interaction between 20% compost and mixed bacterial inoculation (*Azotobacter* + *paenibacillus)* recorded the highest significant values of plant dry weight in both studied seasons.

3-2-7 Number of fruits per plant

Data in Table (8) showed that; add compost to the growing media by the rate 20% significantly caused highest number of fruits. Second significant number of fruits was found when add compost by the rates 30% and 10%, respectively without significant different between them. Which is mean, adding compost to the growing media by the rate 10% reflected the lowest significant number of fruits.

Regarding the bacterial inoculation, using mixed bacterial inoculation (*Azotobacter* + *paenibacillus)* significantly resulted in larger number of fruits/plant followed by *Azotobacter* and *paenibacillus* without significant different between them. In addition, plants that not inoculated were the lowest significant number of fruits/plant.

Finally, studying effect of the interaction between percentage of compost and bacterial inoculation, interaction between 20% compost and mixed bacterial inoculation and interaction between 20% compost and *Azotobacter* was significantly the highest in number of fruits. Discussed results held true for both studied seasons of 2012 and 2013.

3-2-8 Eggplant fruits weight

The highest significant fruits fresh weight (yield g/plant) was clearly found in plants that grown in media containing 20% of compost in the two growing seasons, followed by plants were grown in a media containing 30% of compost with significant different between both treatments (Table 8). Lowest significant fruits weight (yield) was obviously found when using compost 10% in the growing media. Moreover, presented data in table (8) showed that, mixed bacterial inoculation (*Azotobacter* + *paenibacillus)* significantly give the highest fruits weight (yield). Followed significantly by those inoculated with *Azotobacter* and those inoculated with *paenibacillus* without significant different between them. In addition, plants that not inoculated were the lowest significant fruits weight. Discussed trend of results was true in both seasons (Table 8).

Regarding the effect of the interaction between percentage of compost in the growing media and bacterial inoculation on the fruits weight (yield), interaction between 20% compost and mixed bacterial inoculation (*Azotobacter* + *paenibacillus)* significantly give the highest fruits weight (yield). Studying the last discussed results carefully, fruits weight (yield) result seems to be a direct reflection to the dry (plant) weight obtained results. In another words, the highest dry weight means the highest fruit weight (yield).

Positive results on application of bacterial inoculation on yield of various plants reports **Suneja and Lakshminaraya, 2001; Ozturk *et al.*, 2003; Cecilia *et al.*, 2004; Singh *et al.*, 2005; Yue *et al.*, 2007 and Yasari *et al.*, 2008**.

Table (8): Effect of compost percentage in rice straw media, bacterial inoculation and both interactions on fruits number per plant and fruits weight per plant during 2012 and 2013.

	Aotoz.	*Paenib.*	Mixed	Control	A	*Aotoz.*	*Paenib.*	Mixed	Control	A
	First season				Fruits number /plant	Second season				
10%	9.00 c	9.00 c	7.75 Cd	8.00 c	8.44 B	6.30 c	6.30 c	4.90 de	5.60 Cd	5.78 B
20%	16.00 a	12.00 B	15.00 A	8.00 c	12.75 A	11.20 a	8.40 b	10.50 a	5.60 Cd	8.93 A
30%	8.00 c	12.00 b	11.00 B	6.00 d	9.25 B	5.60 cd	8.40 b	7.70 b	4.20 E	6.48 B
B	11.00 A	11.00 A	11.25 A	7.33 B		7.70 A	7.70 A	7.70 A	5.13 B	
					Fruits weight (g/plant)					
10%	494.0 f	414.0 h	827.0 B	339.0 h	533.5 C	415.0 e	348.3 f	695.0 b	335.7 F	448.5 C
20%	789.0 c	778.0 cd	1020.0 a	490.0 f	769.3 A	662.7 c	653.7 c	856.7 a	405.4 E	644.6 A
30%	765.0 d	839.0 b	530.0 E	456.0 g	647.5 B	642.6 c	704.8 b	445.5 d	393.3 E	546.6 B
B	682.7 B	677.0 B	792.3 A	448.3 C		573.4 B	568.9 B	665.7 A	378.1 C	

3-3 Total and spore forming count

3-3-1 Total count

Total count (TC) and spore forming (SF) were measured in compost and straw at the beginning of the experiment (Table 1), the numbers was close to some extent to each other, where TC was 55×10^5 in the rice straw, while in compost was 89×10^5. Also, SF in the straw was 52×10^4, while in compost SF count was 100×10^4. It is concluded from the discussed results in Table (1) that, total count of SF was lower than the TC. In other words, majority of the existing number was spore forming.

After 30 days, TC and SF numbers were slightly higher than control treatment, for instance, TC in control treatment when treated with 10 % compost was $52x10^{7,}$ while the treatments *Azotobacter*, and *Paenibacillus* and mixed bacterial inoculation gave the numbers 107 $x10^7$ and $300x10^7$ and $298x10^7$, respectively. Almost the same results were given in the treatments of 20 % and 30% of compost. The numbers in *Paenibacillus* and mixed bacterial inoculation were relatively higher than in *Azotobacter* (Table 9).

3-3-2 Spore forming count

Numbers of spore forming bacteria were found generally to be decreased weather after 30 or 60 days. The numbers in the control and in *Paenibacillus* were contrary to the expected where increased more than found in TC, that could be explained by the killing of some competing species as a result to heat treatment to the serial dilutions at 80°C for 15 min. as also noticed a steep decline in numbers in treatment mixed bacterial inoculation, as the colonies were very small in size and predominantly resemble *Aztobacter* colonies, the same note was found in the treatment I1, but colonies were larger in size (2-5 mm). Colonies were also in the treatment *Paenibacillus* in large numbers and most of them small, white and *Arbuscular*, the possible explanation may be resulting from the inhibition ability of *Aztobacter* to some other species colonies including *Paenibacillus* (Table

10). This results were in agreements with **Meshram and Jager (1983)**, **Novak and Dvorzhakova (1955).**

Table (9): Total bacterial count in rice straw and compost media apart eggplant roots after 30 and 60 days of inoculation

	Days after transplanting	*Aotoz.*	*Paenib.*	Mixed	Control
10% compost	30	$107.0\text{x}10^7$	$300.0\text{x}10^7$	$298.0\text{x}10^7$	$52.0\text{x}10^7$
	60	$31.0\text{x}10^6$	$50.5\text{x}10^5$	136.5x10	$51.0\text{x}10^6$
20% compost	30	$82.0\text{x}10^7$	$35.0\text{x}10^8$	$40.0\text{x}10^8$	$123.0\text{x}10^7$
	60	$131.0\text{x}10^5$	$171.5\ \text{x}10^6$	$154.0\text{x}10^7$	$36.0\text{x}10^5$
30% compost	30	$104.0\text{x}10^7$	$290.0\text{x}10^7$	39.0x108	$52.0\text{x}10^7$
	60	$52.5\text{x}10^5$	$54.0\text{x}10^6$	$50.0\text{x}10^7$	$56.0\text{x}10^5$

Table (10): Total bacterial count in rice straw and compost media apart eggplant roots after 30 and 60 days of inoculation

	Days after transplanting	*Aotoz.*	*Paenib.*	Mixed	Control
10% compost	30	$170.0\text{x}10^5$	$> 10^8$	$208.0\text{x}10^3$	$> 10^8$
	60	$81.0\text{x}10^4$	$74.0\text{x}10^4$	$101.0\text{x}10^2$	$31.0\text{x}10^5$
20% compost	30	$32.0\text{x}\ 10^6$	$> 10^{-8}$	$48.0\text{x}10^4$	$> 10^{-8}$
	60	$114.0\text{x}10^5$	$34.5\text{x}10^4$	$50.0\text{x}10^2$	$43.0\text{x}10^4$
30% compost	30	$58.0\text{x}10^5$	$> 10^{-8}$	$160.0\text{x}10^4$	$> 10^{-8}$
	60	$155.0\text{x}10^2$	$54.0\text{x}10^4$	$46.0\text{x}10^2$	$72.5\text{x}10^4$

3-4 Economic & environmental evaluation

It is noticeable from data in Table (11) that, to apply the tested treatment on one feddan scale (4200m^2), the highest cost in Egyptian pound (13796 L.E) was calculated for the treatment control +10% (rice straw + 10% compost + without bacterial inoculation). However, the lowest cost (11468 L.E) calculated for *Azotobacter* + 10% (rice straw + 10% compost + *Azotobacter*).

On the other hand, the net return for the same treatments on the same scale reflected that, the highest net return was calculated for 20% + Mixed bacterial inoculation (*Azotobacter* +*Paenibacillus*). The last mentioned treatment presented 8500 L.E and 5234 L.E in years 2012 and 2013, respectively.

Highlighting the lowest net return, its concluded from data in Table (11) that, a high negative net return was found in the treatment 10% + control (rice straw + 10% compost + without bacterial inoculation). When translating such negative effect to money loses, -7016 and -7082 L.E for seasons 2012 and 2013, respectively were loses when the last mentioned treatment was applied on one feddan scale.

Finally, its concluded from discussed data in Table (11) that, it will be economically sound when using rice straw media + 20% compost + Mixed bacterial inoculation (*Azotobacter* +*Paenibacillus*) to cultivate one feddan ($4200\ \text{m}^2$).

Conclusion:

Results from this study indicate that, climatic condition inside the net house was lower in maximum, minimum and average air temperature. Moreover, both average relative humidity and radiation were lower inside the net house compared to outside the net house. Climatic condition during second season (2013) was relatively higher in all measured climatic factors and that's reflected on lower growth and productivity comparing to first season (2012).

Add 30% compost to rice straw results the highest significant plant height, number of leaves and stem diameter especially after 60 and 90 days. However, using 20% compost to rice straw cause the highest significant plant fresh and dry weight, number of fruits per plant and fruit weight (g/plant). Chlorophyll reading was not affected significantly by any of the tested percentage of compost in the growing media.

Inoculated plants using *Azotobacter chroococcum* gives the highest significant plant height number of leaves and stem diameter after 60 days. Moreover, plants that inoculated with mix between *Azotobacter chroococcum* and *Paenibacillus polymyxa* were significantly the highest in fresh and dry weight, number of fruits and fruit weight. While, bacterial inoculation was not significantly affected the stem diameter and chlorophyll reading however, after 30 or 90 days.

Interaction between 30% and *Azotobacter* was obviously the highest significant plant height and number of leaves. In addition, interaction between 20% and mixed bacterial inoculation cause a significant increment in both number of fruits and fruit weight.

Regarding to the bacterial count, it's concluded that majority of existing bacterial count was spore forms before add the testing bacterial inoculation. However, after add the tested bacterial inoculation; total bacterial count and spore forms numbers were slightly higher than control treatment. Moreover, total count in *Paenibacillus* and mixed bacterial inoculation were relatively higher than in *Azotobacter*. Numbers of spore forming bacteria were found generally to be decreased weather after 30 or 60 days. Spore forms numbers in the control and in *Paenibacillus* were contrary to the expected where increased more than found in total count.

Finally, the economic evaluation showed that, add 20% compost to rice straw media and inoculate it using mixed bacterial inoculation gives a high net return compared to other tested treatment. While, when bacterial inoculation was not add to any of the tested percentage of compost due to economic loses.

Table (11): Economic evaluation for eggplant grown in rice straw media with three different percentage of compost and four treatments of bacterial inoculation during seasons of 2012 and 2013.

Season	Treatments	Cultivation cost (L.E./feddan)			Total revenue (L.E./feddan)			Net return (L.E./feddan)
		Fixed cost**	Variable cost***	Total cost	Yield	Market price	Total	
2012	10 % +*Azotobacter*	2206	9262	11468	3952	2.5	9880	-1588
	20 % +*Azotobacter*	2206	9694	11900	6312	2.5	15780	3880
	30 % +*Azotobacter*	2206	10126	12332	6120	2.5	15300	2968
2013	10 % +*Azotobacter*	2206	9262	11468	3320	2.5	8300	-3168
	20 % +*Azotobacter*	2206	9694	11900	5302	2.5	13254	1354
	30 % +*Azotobacter*	2206	10126	12332	5141	2.5	12852	520
2012	10 %+ *Paenibacillus*	2206	9262	11468	3312	2.5	8280	-3188
	20 %+ *Paenibacillus*	2206	9694	11900	6224	2.5	15560	3660
	30 %+ *Paenibacillus*	2206	10126	12332	6712	2.5	16780	4448
2013	10 %+ *Paenibacillus*	2206	9262	11468	2786	2.5	6966	-4502
	20 %+ *Paenibacillus*	2206	9694	11900	5230	2.5	13074	1174
	30 %+ *Paenibacillus*	2206	10126	12332	5638	2.5	14096	1764
2012	10 % + Mix	2206	9262	11468	6616	2.5	16540	5072
	20 % + Mix	2206	9694	11900	8160	2.5	20400	8500
	30 % + Mix	2206	10126	12332	4240	2.5	10600	-1732
2013	10 % + Mix	2206	9262	11468	5560	2.5	13900	2432
	20 % + Mix	2206	9694	11900	6854	2.5	17134	5234
	30 % + Mix	2206	10126	12332	3564	2.5	8910	-3422
2012	10 % + Control	2206	11590	13796	2712	2.5	6780	-7016
	20 % + Control	2206	10830	13036	3920	2.5	9800	-3236
	30 % + Control	2206	11070	13276	3648	2.5	9120	-4156
2013	10 % + Control	2206	11590	13796	2686	2.5	6714	-7082
	20 % + Control	2206	10830	13036	3243	2.5	8108	-4928
	30 % + Control	2206	11070	13276	3146	2.5	7866	-5410

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