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THE DETECTION OF APPROPRIATE ORGANIC FERTILIZER AND MYCORRHIZAL METHOD ENHANCING SALT STRESS TOLERANCE IN RICE (*Oryza sativa* L.) UNDER FIELD CONDITIONS

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Abstract: This study was performed in order to identify the appropriate organic fertilizer and mycorrhizal methods for promoting rice tolerance in response to salty environmental conditions. For this purpose, some agronomic, biochemical and physiological parameters were investigated in rice under natural salt stress. The plants were grown in saline field conditions from germination to harvest stage and fertilizing consisted of only a mixture of different ratios of mycorrhizal, municipal solid waste (MSW), waste tea leaves, straw, olive manure and chicken manure. Samples of the plants were taken when they reached harvesting stage and their agronomical properties (plant height, number of leaves, leaf sheaths length, tillering, leaf area, panicle length, total and milled rice values and 1000 grain weight) were recorded and biochemical (chlorophyll a and b) and physiological analysis (Na, K, Ca, Si amounts in roots) were performed. The results showed that improvements in vegetative characters except leaf number were obtained with trials with MSW, MSW+waste tea leaves+straw or MSW+waste tea leaves+straw+chicken or olive manure including fertilizers, increase in chlorophyll b content was obtained with trials except with mycorrhiza, and decreased root Na levels and increases in chlorophyll a content (biochemical parameter) were obtained particularly with trials with of the mycorrhiza+MSW pair or mycorrhiza+MSW+waste tea leave mixture. The best fertilizing mixture, straw (100kg/decare) + MSW (75g/2.5m^2), was in experiment no: 2. Additionally, there was no change in the low yield; but certain additives were necessary. In conclusion, organic waste and mycorrhizal fertilizer applications with specific ratios were determined to have a protective effect on plants against salt stress.

Key words: Stress, organic waste, olive, straw, chicken manure, municipal solid waste.

Çeltikte (*Oryza sativa* L.) Tarla Koşullarında Tuz Stresine Toleransı Arttıracak Uygun Organik Gübreleme ve Mikorizal Yöntemlerin Tespiti

Özet: Çalışmanın amacı; çeltikte tuzlu ortamlarda toleransı artıracak uygun organik gübreleme ve mikorizal yöntemlerin tespitidir. Bunun için doğal tuz stresi altındaki çeltiklerde bazı agronomik, biyokimyasal ve fizyolojik parametreler araştırılmıştır. Çimlenme aşamasından hasat dönemine kadar bitkiler tuzlu nehir suları ile tarla koşullarında yetiştirilmiş ve sadece gübreleme olarak mikoriza, belediye katı atık, çay yaprakları, saman, zeytin gübresi ve tavuk gübresinin değişik oranlarda karışımları ile elde edilen gübrelerle uygulama yapılmıştır. Hasat dönemine gelen bitkilerden örnekleme ile bitkiler alınarak bunlardan agronomik (bitki boyu, yaprak sayısı, yaprak kın uzunluğu, kardeşlenme, yaprak alanı, salkım boyu, kavuzlu, kırıklı/kırıksız ve 1000 dane ağırlıkları), biyokimyasal (klorofil a ve b değerleri), fizyolojik analizler (köklerde Na, K, Ca, Si) yapılmıştır. Sonuç olarak; vejetatif karakterlerin (yaprak sayısı hariç) MSW, MSW+çay yaprakları+saman, MSW+çay yaprakları+saman+tavuk veya zeytin gübreli denemelerle, klorofil b miktarının mikoriza hariç diğer denemelerle (saman, tavuk ve zeytinli denemeler), kökte düşük Na mineral seviyesinin ve klorofil a seviyesindeki artışlarının (biyokimyasal parametre) özellikle mikorizal + MSW ikilisi veya mikoriza + MSW + çay'lı denemelerle sağlandığı tespit edilmiştir. Bunlara ilaveten verim düşüşünde bir değişim olmamıştır; ama bazı katkılar gerekmektedir. En iyi denemenin, 2 no'lu test yani saman (100kg/dönüm) + MSW (75g/2,5m^2) olduğu tespit edilmiştir. Dolayısıyla tespit edilen oranlarla yapılan organik atık ve mikorizal gübrelemenin tuz stresine karşı bitkiyi koruyucu olduğu anlaşılmıştır.

Anahtar kelimeler: Stres, organik atık, prina, saman, tavuk gübresi, katı şehir atıkları

Introduction

According to the 2012 FAO (Food and Agriculture Organisation) records, salinity affected more than 80 million ha of arable land in the world and the amount of the affected land cover is increasing (FAOSTAT 2012). Salinity is dangerous for plants because it decreases plant biomass, modifies root characteristics, inhibits photosynthesis and relative water content (RWC), increases salt ion contents within the plants (Wu et al. 2015) and creates osmotic stress, nutritional imbalance and ionic toxicity (Campanelli et al. 2013). Furthermore, it results in structural damage of the plant cells, limitations if growth and even death (Li et al. 2014). Of all the cereals, rice (*Oryza sativa* L.) is the most salt-sensitive crop because it is ineffective in controlling the influx of salt (Na^+) into the roots, causing rapid salt accumulation at toxic concentration levels in the plant (Singh & Flowers 2011), and rice exposed to salt stress show the above-mentioned adverse effects. Different organic fertilization methods were performed on different plants in order to combat this stress.

Because the composting of several organic wastes and their subsequent applications to agricultural land are gaining popularity due to their environmentally-friendly effects, there is a possibility to use them against salt stress. These organic wastes are also being considered for recycling. For example, municipal solid waste (MSW) compost in agriculture has been reported to possess many beneficial effects on soil, crops and the environment (Rodd et al. 2002). Thus, MSW may be regarded as a good fertilizer for high content of plant nutrients such as potassium (K), nitrogen (N), phosphorus (P) and magnesium (Mg) and organic matter (Lozano-Garcia et al. 2011). Also, the positive effects of applications of chicken manure, olive waste cake (prina) and wheat straw cover crop, tea waste were emphasized on soil characteristics and plant's yield against salt stress. Regarding Arbuscular mycorrhizal (AM) fungi, it makes the host plant more tolerant to abiotic stresses (Dodd and Ruíz-Lozano 2012). No study has been performed so far based on organic fertilization experiments or mycorrhizal work on rice grown in full-time real natural field and irrigation conditions (from germination to harvest). Another important point is that work without alternative dose trials does not give better results because Ouni et al. (2014) stated that the inappropriate utilization of biosolids may adversely impact on the agrosystem productivity. Therefore, to fill the gap, this study aims for the identification of suitable methods for organic fertilizer or mycorrhizal input to increase rice tolerance against salt stress.

Figure 1. General view of the experimantal fields.

Materials and Methods

Osmancik rice cultivar was used as the material in the present study. The experiments were conducted in 2014 and 2015 in a natural field in Ergene Basin (41.236564, 26.602377) under the influence of sub-humid and sub-tropical Mediterranean type climate conditions. The rice grains were sown in a field in Salarlı village, Uzunköprü-Edirne-Turkey, which is located in the middle of the Ergene basin. The temperature ranged from 21 to 31°C during the day, and from 25 to 32 °C during the night. The humidity ranged from 50 to 75% during the growing period. Ergene River water was used for irrigation. Also irrigation water and soil characteristics were determined by measuring of the relevant governmental agencies. The soil and water analysis of the river and the basin are as follows: soil pH: 7.47 (light alkali), soil electrical conductivity (EC) 1,591.00mmhos/cm; water pH: 7.96, ECx108: 3580micromhos/cm; Sodium absorption ratio (SAR): 18.71 and irrigation water class: C4S3 (Fig. 1). While no organic fertilizer application was carried out in control field soil, olive cake (prina), chicken manure, municipal solid waste (MSW), the waste of used, dried tea leaves and mycorrhiza were used test fields. 56 different organic fertilizer and mycorrhizal trial applications were carried out in total (Table 1). The straw was obtained from wheat fields after the harvest. The ingredients of the fertilizers (olive cake, chicken manure and mycorrhiza) were given below;

Olive cake; moisture (%) 56.9, pH 6.45, electrical conductivity (dSm^{-1}) 4.12, organic substance (gKg^{-1}) 869.9, cellulose (gKg^{-1}) 250.9, Total organic carbon (gKg^{-1}) 524.9, total N (gKg^{-1}) 12.3, C/N ratio 40.2, total fat (gKg^{-1}) 92.8, soluble phenols (gKg^{-1}) 20.8, P (gKg^{-1}) 1.8, K (gKg^{-1}) 15.8, Ca (gKg^{-1}) 2.5, Mg (gKg^{-1}) 0.8, Na (gKg^{-1}) 2.3, Fe (gKg^{-1}) 86, Cu (gKg^{-1}) 15, Mn (gKg^{-1}) 8.9, Zn (gKg^{-1}) 15.3.

Chicken manure; total organic substance: 45%, total N: 3%, Organic N: 1%, total P205: 3, max. moisture: 20%, pH: between 7 and 9 (according to the package description), EC: 5-7mmhos/cm.

Mycorrhizal inoculant; commercial products were used so that the total viable fungal content reached 27.55% when dissolved in water. Its ingredients (given as %) are Glomus intraradices (25), Glomus aggregatum (24), Glomus mosseage (24), Glomus clarum (1), Glomus monosporus (1), Glomus deserticola (1), Glomus brasilianum (1), Glomus etunicatum (1) and Gigaspora margarita (1). The trials were done in field parts covering an area of 2 x 1m. A 2m space was left between the two trial plots. All test fields were excavated with a digger and the fertilizers were applied in amounts given in Table 1. These amounts were thoroughly mixed into the 15cm of top layer soil with a spatula. The seeds were sown in the fields and Ergene river water was used for irrigation.

Table 1. List of the experiments carried out (The red ones, which were better than others according to the salt injury tests, were included in this study).

No	Organic Fertilizer Contents
1.	Straw (100kg/dec) + cow manure (100g/m^2)
2.	Straw (100kg/dec) + MSW (75g/m^2)
3.	Straw (100kg/dec) + MSW (75g/m^2) + cow manure (50gr/m^2)
4.	Straw (100kg/dec) + MSW (75g/m^2) + tea waste (20g/m^2)
5.	Straw (100kg/dec) + MSW (75g/m^2) + tea waste (40g/m^2)
6.	Straw (100kg/dec) + MSW (75g/m^2) + tea waste (60g/m^2)
7.	Straw (100kg/dec) + chicken manure (50g/m^2)
8.	Straw (100kg/dec) + prina (50g/m^2)
9.	Straw (350kg/dec) + cow manure (50g/m^2)
10.	Straw (350kg/dec) + MSW (75g/m^2)
11.	Straw (350kg/dec) + MSW (75g/m^2) + cow manure (50g/m^2)
12.	Straw (350kg/dec) + MSW (75g/m^2) + tea waste (20g/m^2)
13.	Straw (350kg/dec) + MSW (75g/m^2) + tea waste (40g/m^2)
14.	Straw (350kg/dec) + MSW (75g/m^2) + tea waste (60g/m^2)
15.	Straw (350kg/dec) + chicken manure (50g/m^2)
16.	Straw (350kg/dec) + prina (50g/m^2)
17.	Straw (600kg/dec) + cow manure (50g/m^2)
18.	Straw (600kg/dec) + MSW (75g/m^2)
19.	Straw (600kg/dec) + MSW (75g/m^2) + cow manure (50g/m^2)
20.	Straw (600kg/dec) + MSW (75g/m^2) + tea waste (20g/m^2)
21.	Straw (600kg/dec) + MSW (75g/m^2) + tea waste (40g/m^2)
22.	Straw (600kg/dec) + MSW (75g/m^2) + tea waste (60g/m^2)
23.	Straw (600kg/dec) + chicken manure (50g/m^2)
24.	Straw (600kg/dec) + prina (50g/m^2)
25.	Straw (800kg/dec) + cow manure (50g/m^2)
26.	Straw (800kg/dec) + MSW (75g/m^2)
27.	Straw (800kg/dec) + MSW (75g/m^2) + cow manure (50g/m^2)
28.	Straw (800kg/dec) + MSW (75g/m^2) + tea waste (20g/m^2)
29.	Straw (800kg/dec) + MSW (75g/m^2) + tea waste (40g/m^2)
30.	Straw (800kg/dec) + MSW (75g/m^2) + tea waste (60g/m^2)
31.	Straw (800kg/dec) + chicken manure (50g/m^2)
32.	Straw (800kg/dec) + prina (50g/m^2)
33.	Arundo donax (chopped parts) + MSW (75g/m^2)
34.	Arundo donax (chopped parts) + MSW (75g/m^2)+ cow manure (50g/m^2)
35.	Arundo donax (chopped parts) + MSW (5%)+ tea waste (20g/m^2)
36.	Arundo donax (chopped parts) + MSW (5%) + tea waste (40g/m^2)
37.	Arundo donax (chopped parts) + MSW (5%) + tea waste (60g/m^2)
38.	Mycorrhiza (0.30g) + legume manure (plants chopped and mixed into soil)
39.	Mycorrhiza (0.30g) + cow manure (50g/m^2)
40.	Mycorrhiza (0.30g) + MSW (50g/m^2) + legume manure (plants chopped and mixed into soil)
41.	Mycorrhiza (0.30g) + MSW (50g/m^2)
42.	Mycorrhiza (0.30g) + MSW (50g/m^2) + cow manure (50g/m^2)
43.	Mycorrhiza (0.30g) + MSW (50g/m^2) + tea waste (20g/m^2)
44.	Mycorrhiza (0.30g) + MSW (50g/m^2) + tea waste (40g/m^2)
45.	Mycorrhiza (0.30g) + MSW (50g/m^2) + tea waste (60g/m^2)
46.	The seeds were soaked in Salicylic acid before germination
47.	The seeds were soaked in mycorrhizal solution before germination
	a. application salicylic acid (100mg/l-1) to a part of the developing seedlings.
SA Foliar spray applications	
48.	0.75mM
49.	50mg/l-1
50.	100mg/l-1
51.	150mg/l-1
52.	200mg/l-1
53.	250mg/l-1
54.	300mg/l-1
55.	**Chicken manure**
	a. 100g/2m^2
	b. 200g/2m^2
56.	**Prina**
	a. 100g/2m^2
	b. 150g/2m^2

Morphological appearance of the plants at the filling stage was evaluated by a rice specialist according to specific instructions of agricultural value measurement techniques (Anonymous, 2003) and rice standard evaluation system (SES) (2013) including Salt Injury (Scale 1, 3, 5, 7 and 9). Based on the ratings, the best trials were determined and agronomic, biochemical and physiological studies were performed on only these trials (No: 2, 4, 7, 16, 22, 23, 30, 41, 43 and 55a, indicated in Table 1). 25 different plants were taken randomly from the parcels and morphological (leaf number, leaf sheath length, leaf size and panicle length), agronomic (plant height, tillering ability and 1000-grain weight) evaluations and biochemical (chlorophyll a and b amounts) and physiological (mineral amounts in roots) analysis were performed.

The morphological evaluations

Leaf size and length measurements of the leaf just below the flag leaf were performed at growth stage 6 according to SES. Leaf width (LW) was also measured at this stage as the widest portion of the leaf blade just below the flag leaf. Panicle length measurements were taken from panicle base to tip at growth stage 8. All measurements were given in cm.

Agronomical evaluations

Tillering at growth stage 5 (Booting stage) was evaluated considering the described scale analysis of SES (2013). Plant height (Ht) was measured in cm from the soil surface to the tip of the tallest panicle (awns excluded). For the height measurements at the other growth stages, specify the stage. At growth stage 7-9, the Scale analysis was performed (SES 2013).

Brown rice, total milled rice and head rice values were determined from a total 100 g grain, and 1000-grain weight evaluations were carried out based on instructions of agricultural value measurement techniques (Anonymous 2003).

Biochemical and physiological analysis

Chlorophyll a and b contents were determined by modified Lichtenthaler and Wellburn (1983)'s method at the end of the experimental cycle by spectrophotometric analysis. Leaf samples of 0.1g from each pot were ground and extracted in an 80% (v/v) aqueous solution of acetone. The mixture was centrifuged for 3 min at 2500 rpm, the pellet was re-suspended in 80% acetone and total chlorophyll content of the pooled supernatant was assayed with a spectrophotometer (DU800, Beckman Coulter, Fullerton, CA, USA) at 663nm and 643nm and calculated as described by Lichtenthaler and Wellburn (1983).

Na^+, K^+ and Ca^{2+} concentrations in the roots were determined on the nitric-perchloric acid digests using inductively coupled plasma optical emission spectrometry for Na^+ / K^+ and Na^+/Ca^{2+} ratios in the samples (ICP atomic emission spectrometer, Perkin-Elmer Co., Norwalk, CT, USA). The K, Na and Ca contents represent the concentrations (mg kg^{-1} dry wt) in the roots (Crosland et al. 1995).

All the tests were repeated independently three times and the differences between the agronomic, biochemical and physiological analysis of the control and the experimental groups were compared using a one-way ANOVA test and the means separation by the Duncan's test using SPSS 18 statistical software at a significance level of $P \leq 0.05$.

Results

Morphological Evaluations

The number of the leaves was typically 4 and no significant difference was found between the test groups in terms of leaf number (Table 2). The lengths of the leaf sheaths of the test groups 23, 55a, 41 and 16 showed a significant increase than the other while the test groups 43, 22 and 30 showed a decrease. The increase or the decrease in leaf sheath lengths of the other test groups were found to be non-significant (Table 2).

Leaf lengths were more prolonged in the groups 43, 2 and 7 but they were shortened in the groups 22, 30 and 4 (Table 2). The leaf width was found to decrease significantly in all groups (Table 2). Panicle lengths of the groups 43, 7, 55a, 16 and 30 increased significantly, but decreased in the group 23. The differences in panicle lengths in other test groups were not significant (Table 2).

Agronomical Evaluations

The plant heights in the groups 23, 55a, 2, 16, 30 and 4 were almost identical to that of the control, but those in 7, 41 and 43 were longer and in 22 was shorter compared to the control group (Table 3). Tillering was more in the groups 7, 43, 55a, 16, 41 and 30, but less in 22, 2 and 4. However, a high degree of tillering occurred in the group 41 (Table 3). Brown rice weight decreased significantly in the groups 23, 22, 41 and 4, partly increased in 2 or decreased in 43, 16 and 30 (not significant) and remained unchanged in the groups 7 and 55a (Table 3). The total milled rice values decreased significantly in all test groups compared to the control group (Table 3). The head rice values also decreased significantly, except the groups 2, 16 and 7 (Table 3). The 1000-grain weight of paddy rice decreased in the groups 43, 7, 2, 41 and 4, but increased significantly in the groups 22 and 16 compared to the control group. A partial increase in 30 and a partial decrease in 55a and 23 were also determined (Table 3). 1000-grain weight of milled rice decreased significantly in the groups 23, 41 and 43 but no change occurred in the other test groups (Table 3).

Biochemical and Physiological Analysis

Chlorophyll a contents of the sampled plants were found to increase in the groups 23, 43, 22, 2, 41 and 30 but to decrease in the groups 7 and 4. All Chlorophyll a content values were significantly different from the control group except 55a, where a partial decrease was

Table 2. Morphological evaluation data of the experimental groups.

	Leaf Number	Leaf sheath length			Leaf length			Leaf width			Panicle length		
	Mean	*Mean*	*SE*	*Sign.**	*Mean*	*SE*	*Sign **	*Mean*	*SE*	*Sign **	*Mean*	*SE*	*Sign **
Control	4.0	16.0	1.24	-	31.50	2.35	-	15.3	0.87	-	14.60	0.27	-
2	4.5	16.0	2.87	0.067	32.80	2.61	0.000*	12.8	0.81	0.000*	14.45	2.07	0.068
4	4.0	16.0	1.91	0.057	29.60	3.09	0.000*	12.9	1.18	0.000*	14.40	0.89	0.052
7	4.0	16.8	3.24	0.072	32.38	3.64	0.000*	13.7	1.07	0.000*	15.40	3.02	0.000*
16	4.0	18.3	1.82	0.000*	31.05	1.38	0.092	13.7	1.02	0.000*	15.22	1.84	0.000*
22	4.0	14.0	1.87	0.000*	24.50	2.84	0.000*	10.3	1.38	0.000*	13.80	1.97	0.057
23	4.0	20.0	2.35	0.000*	29.50	2.07	0.000*	12.6	1.23	0.000*	13.70	1.38	0.000*
30	3.4	14.6	0.97	0.000*	25.50	2.81	0.000*	11.6	0.81	0.000*	15.09	1.19	0.000*
41	3.4	19.5	1.29	0.000*	31.71	2.34	0.059	13.3	2.31	0.000*	14.63	2.51	0.081
43	4.0	14.7	2.08	0.000*	33.00	3.25	0.000*	13.5	0.97	0.000*	15.95	2.07	0.000*
55a	3.5	17.9	2.71	0.000*	31.35	0.91	0.067	12.8	1.71	0.000*	15.60	0.81	0.000*

* Significance at the level 5%.

SE: standard error.

Sig.: significant.

Table 3. Agronomical evaluation data of the experimental groups.

	Pl.hght[1*]	**Tl.ab[2*]**	**Brown rice[3*]**			**Total milled rice[3*]**			**Head rice[3*]**			**1000gwofpr[5*]**			**1000gwofmr [6*]**		
	Min-max	*Mean*	*Mean*	*SE*	*Sig.[4*]*	*Mean*	*SE*	*Sig. [4*]*	*Mean*	*SE*	*Sig. [4*]*	*Mean*	*SE*	*Sig. [4*]*	*Mean*	*SE*	*Sig. [4*]*
Control	93-94	11.60	83.0	2.31	-	75.0	2.08	-	63.0	1.96	-	28.3	2.35	-	21.6	2.03	-
2	90-95	9.66	83.4	3.62	0.084	74.0	2.82	0.000[4*]	62.2	3.61	0.097	27.3	3.04	0.000[4*]	21.7	3.87	0.072
4	95-96	7.80	81.0	5.34	0.000[4*]	72.0	4.97	0.000[4*]	59.9	4.27	0.000[4*]	27.2	1.99	0.000[4*]	21.8	3.06	0.061
7	105-106	20.25	83.0	3.81	0.082	74.2	5.81	0.062	62.0	2.94	0.057	27.7	1.82	0.000[4*]	21.4	3.07	0.051
16	93-94	13.50	82.5	4.01	0.091	74.0	2.96	0.000[4*]	62.5	2.57	0.087	29.4	1.27	0.000[4*]	21.2	2.43	0.081
22	75-76	3.50	82.0	4.91	0.000[4*]	74.0	3.67	0.000[4*]	50.4	5.12	0.000[4*]	29.3	2.71	0.000[4*]	21.3	2.71	0.057
23	93-96	-	82.0	6.82	0.000[4*]	73.0	3.98	0.000[4*]	58.0	2.84	0.000[4*]	28.0	1.98	0.052	20.9	1.98	0.000[4*]
30	90-98	18.60	82.4	6.08	0.052	73.0	5,87	0.000[4*]	54.8	1.99	0.000[4*]	28.6	2.85	0.057	21.4	2.81	0.080
41	104	26.30	81.4	7.25	0.000[4*]	72.5	2.78	0.000[4*]	59.0	2.74	0.000[4*]	26.4	2.17	0.000[4*]	20.6	1.87	0.000[4*]
43	104-105	14.30	82.7	4.95	0.051	73.5	5.81	0.000[4*]	57.7	3.67	0.000[4*]	27.4	3.57	0.000[4*]	20.5	2.87	0.000[4*]
55a	93	15.25	83.0	5.37	0.094	73.0	5.19	0.000[4*]	58.7	2.41	0.000[4*]	27.8	2.14	0.097	21.4	2.76	0.097

Pl.hght[1*]: Plant height, min-max.
Tl.ab[2*]: Tillering ability.
[3*] Brown rice, total milled rice and head rice values, and the average weight (g) was calculated from the total 100g grain.
[4*] Significant at the level of 5%.
[5*] **1000gwofpr** : 1000-grain weight of the paddy rice.
[6*] **1000gwofmr**: 1000-grain weight of milled rice.

Table 4. The results of the biochemical analysis of the test groups.

	Chl. a			***Chl. b***		
	Mean	*St.err*	*Sig.*	*Mean*	*St.err.*	*Sig.*
Control	14.9695	0.250	-	7.9621	1.240	-
2	17.2490	0.060	0.000*	5.0557	0.340	0.000*
4	13.8180	0.007	0.000*	7.2811	0.240	0.000*
7	9.0475	1.600	0.000*	3.1871	0.006	0.000*
16	13.1835	0.070	0.000*	5.1786	0.009	0.000*
22	17.9540	0.540	0.000*	5.7090	0.980	0.000*
23	29.2800	1.200	0.000*	8.2800	0.085	0.000*
30	27.3400	2.004	0.000*	7.8800	1.730	0.061
41	16.3325	1.070	0.000*	5.1864	0.420	0.000*
43	21.5495	0.005	0.000*	6.6354	1.370	0.000*
55a	14.1235	0.850	0.059	4.8618	0.370	0.000*

* significance at the level 5%.

found (Table 4). Chlorophyll b content of the group was found to significantly increase in 23, but decrease in the groups 43, 22, 7, 55a, 2, 16, 41 and 4. The decrease determined in the group 30 was not significant (Table 4).

Na amounts were found to increase significantly in the groups 23, 22, 55a, 41 and 30, to decrease in the groups 7 and 2 and remain almost unchanged in the groups 43, 16 and 4 (Table 5). K amounts were found to increase significantly in the groups 23 and 22, to decrease in the groups 43, 7, 2, 16, 41 and 55a, and remain almost unchanged in the group 4 (Table 5). Ca values significantly increased in the group 16, decreased in the groups 43, 22, 7, 55a, 41, 30 and 4 and remained unchanged in the groups 23 and 2 (Table 5). Si amounts significantly increased in the groups 7 and 30, decreased in the groups 43, 22 and 55a, partly increased in the groups 2, 41 and 23, and decreased in the group 16 (Table 5). Na/K ratio, remained almost the same in the groups 2, 4, 22 and 16, slightly increased in the groups 23, 41 and 30, but a considerable increase was observed in other groups (Table 5). Na/Ca ratio almost unchanged in the groups 2, 4, 16, 30, 7, 23 and 41, but increased in the groups 43 and 22 (Table 5).

Discussion

According to the results of morphological evaluations, the leaf width decreased in all groups when compared to the control but the leaf numbers remained unchanged. Morphological evaluation data revealed that the groups no: 7 (100kg/dec. straw+50g chicken manure) and 55a (100g prina) had the best applications than the other groups (Table 2, 6, 7).

Although the group no: 16 (350kg straw + 50g prina) was considered to be in good condition according to the results of morphological and agronomic evaluations and physiological analysis, its biochemical analysis results revealed low values. Similarly, although the group no: 41 (Mycorrhiza + 50g MSW) was good with respect to its morphological evaluations and biochemical and physiological analysis results, its yield values were still lower. The group no: 30 (800kg / dec straw + 75g MSW + 60g tea waste) and no: 22 (600kg / dec straw + 75g MSW + 60g tea waste) were found to have low morphological evaluation values, but they made significant progress under saline conditions as revealed by biochemical and physiological analysis. The group no: 7 was partially in a good condition according to morphological and agronomic evaluations and to Si value results of physiological analysis. In conclusion, one or more parameters were good in one or more of the test groups, while the others showed decreasing patterns in almost all groups.

As an exception, the group no: 2 (100kg / dec straw + 75g MSW), was found to be the group with the best conditions based on all tested criteria (morphological, agronomic, biochemical and physiological) followed by the groups 2, 16, 30, 22, 7 and 55a (Table 6, 7). When the groups with the best results are considered, the straw application appeared to possess a protective effect on plants with regard to soil salinity. The 100kg / dec straw application was determined to be the adequate application and applications with higher straw contents, for instance with 350kg, 600kg and 800kg / dec (the groups 16, 22 and 30), did not lead to a higher yield. Similar studies reported that mulching with different materials reduced water evaporation (Li et al. 2013), improved fallow efficiency and increased the amount of stored soil water available for plant use (Wang et al. 2001), and reduced salt build-up in the soil (Pang et al. 2010). Mulumba and Lal (2008) reported that the crop residues placed on the soil surface shade the soil, reduce unproductive water evaporation and enhance available water capacity, moisture retention and aggregate stability. Zhao et al. (2014) denoted that the highest sunflower shoot biomass was always obtained from the straw mulch and buried straw mulch and these combined applications may be an effective saline soil management. Also, it has been shown that 50g / 2m^2 of olive fertilizer (prina) alone is not enough and a straw compost application, as well as prina, provides a higher yield. Similar studies also reported that different prina input trials must be performed by composting for particularly ensuring stability of C / N and increasing the value of N, K (Soyergin et al. 2011).

A mixture of 50g chicken manure with straw was found to protect the plants against salt stress, when considering their biochemical and morphological data, because chicken

Table 5. The results of the physiological analysis of the test groups.

	Na			***K***			***Ca***			***Si***			***Na/K***	***Na/Ca***
	Mean	*SE*	*Sig.*	*Mean*	*SE*	*Sig.*	*Mean*	*SE*	*Sig.*	*Mean*	*SE*	*Sig.*	*Mean*	*Mean*
Control	7721	20.8	-	2911	67.8	-	9350	123.7	-	542	36.8	-	4.49	1.43
2	6378	27.9	0.000*	2441	97.8	0.000*	9221	206.7	0.052	379	21.6	0.000*	4.43	1.20
4	7996	87.5	0.910	2874	123.7	0.913	8176	190.2	0.000*	556	63.7	0.062	4.71	1.70
7	6798	86.7	0.000*	1590	79.5	0.000*	7380	108.2	0.000*	724	94.1	0.000*	7.24	1.60
16	7897	31.2	0.590	2736	93.7	0.000*	11237	61.7	0.000*	524	65.7	0.057	4.89	1.22
22	9697	63.7	0.000*	3331	99.8	0.000*	7228	96.7	0.000*	484	96.7	0.000*	4.93	2.33
23	9159	36.7	0.000*	3021	73.7	0.000*	9288	96.7	0.092	565	96.7	0.073	5.14	1.71
30	8564	93.1	0.000*	2727	96.7	0.572	8174	139.2	0.000*	711	26.7	0.000*	5.32	1.82
41	8193	96.7	0.000*	2457	120.7	0.000*	8006	203.4	0.000*	320	23.1	0.000*	5.65	1.77
43	7811	27.3	0.810	1475	91.2	0.000*	5526	263.7	0.000*	239	32.7	0.000*	8.97	2.45
55a	10227	36.7	0.000*	1942	100.8	0.000*	8810	96.1	0.000*	248	29.7	0.000*	8.92	2.01

* significance at the level 5%.

Table 6. The evaluation of all test groups based on all tested criteria.

Control	23	43	22	7	55a	2	16	41	30	4
Leaf num.[a]	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow
Leaf sh. length[b]	green	red	red	yellow	green	yellow	green	green	red	yellow
Leaf length	red	green	red	green	yellow	green	yellow	yellow	red	red
Leaf width	red	red	red	red	red	red	red	red	red	red
Pan. length[c]	red	green	yellow	green	green	yellow	green	yellow	green	yellow
Pl. hght[d]	yellow	green	red	green	yellow	yellow	yellow	green	yellow	yellow
Tl. ab[e]	yellow	green	red	green	green	red	green	green	green	red
Brown rice	red	yellow	red	yellow	yellow	yellow !↑	yellow	red	yellow	red
Tot. mill. rice[f]	red	red	red	red	red	red	red	red	red	red
Head rice	red	red	red	yellow !	red	yellow !	yellow !	red	red	red
1000gwofpr[g]	yellow	red	green	red	yellow	red	green	red	yellow	red
1000gwofmr[h]	red	red	yellow	yellow	yellow	yellow	yellow	red	yellow	yellow
Chl. a[i]	green	green	green	red	yellow	green	red	green	green	red
Chl. b[j]	green	red	red	red	red	red	red	red	yellow	red
Na	green	yellow	green	red	green	red	yellow	green	green	yellow
K	green	red	green	red	red	red	red	red	yellow	yellow
Ca	yellow	red	red	red	red	yellow	green	red	red	red
Si	yellow	red	red	green	red	red	yellow	red	green	yellow
Na/K	yellow	red	yellow !	red	red	yellow !	yellow !	yellow	yellow	yellow !
Na/Ca	yellow	red	red	yellow	red	yellow	yellow	yellow	yellow	yellow

[a] Leaf number, [b] Leaf sheath length, [c] Panicle length, [d] Plant height, [e] Tillering ability, [f] Total milled rice, [g] 1000-grain weight of paddy rice, [h] 1000-grain weight of milled rice, [i] Chlorophyll a, [j] Chlorophyll b (Green, yellow and red areas indicate increasing, sameness and decreasing of the character, respectively).

manure whose total and extractable plant nutrient contents are high and their dry matter content is suitable as a substitution for inorganic fertilizers in agricultural production. Furthermore, chicken manure is preferred as a fertilizer because its C / N ratio is lower than 20 (İnal et al. 1996). Chicken manure was also reported to have the potential to cause salt stress to soil, and the importance of composting in appropriate formulations with this manure was emphasized (Taban et al. 2013).

Considering the MSW, it was determined that the maximum of 75g of compost application will benefit to the plants. In similar studies, MSW applications were not shown to have any phytotoxic effects on plants; on the contrary, SOMW-treated trees showed higher vegetative activity, which was evaluated as shoot length, canopy volume and pruning weight, and greater olive fruit productive efficiency. The fruit dry weight was also higher (Soumar et al. 2003, Nasini et al. 2013). MSW compost supply significantly increased shoot and root dry weights and chlorophyll and carotenoid contents were positively influenced. Furthermore, MSW compost application increased net photosynthetic rate, stomatal conductance and water-use efficiency in plants (Ouni et al. 2014). However acidic pH and heavy-metal contents, the high content of potentially increased plant phytotoxic and anti-microbial compounds, such as phenols, tannins and fatty acids were expressed as negative effects of MSW (Mechri et al. 2011). Extreme applications of OMWs sometimes can damage germination (Barbera et al. 2013), and MSW compost was also reported to have high salt concentrations which can inhibit plant growth (Hargreaves et al. 2008). So, MSW compost applications should be performed in appropriate formulations, as described in present experiments. In another study, it was denoted that levels of soil organic carbon, available P, Fe, Mn, Zn, Cu, K and pH increased by using MSW compost application (Soumar et al. 2003). Based on these findings, the authors concluded that MSWC application improved the aggregate stability and permeability coefficient of saline-sodic soils (Soumar et al. 2003). Based on the present MSW data, straw-MSW mixture with 60g of tea leaves was determined as an alternative appropriate composting. In similar study, N and P values was found to be significantly correlated with Biosolid and tea waste (Özdemir et al. 2009). In our present study, the rice plants showed remarkable tolerance in saline conditions considering their yields and biochemical and physiological parameters, particularly in the test groups no: 30 and 22.

Table 7. Summary of the overall assessment

Criteria	*Featured groups*
Morphological criteria	2, 7, 16, 41 and 55a
Agronomical criteria	2, 7, 16, (22 !) 30 and 55a
Biochemical criteria	2, 22, 23, 30, 41 and 43
Physiological criteria	2, 4, 16, 22, 23, 30 and 41
Si mineral	4, 7, 16 and 30

Regarding the Mycorrhizal tests, significant increases were observed in all the parameters except yield. At this point, it is considered that the composting was insufficient in terms of their nutritional value and needed additional components. Because, AM fungi in saline soils can increase plant salt tolerance, decreasing plant yield losses (Ruíz-Lozano et al. 1996, Al-Karaki et al. 2001, Cantrell and Linderman 2001, Hajiboland et al. 2010). In addition, in my opinion, in trials, combined use of all the mycorrhizal fungus was probably adversely affecting the results. Similar studies indicated that different *Glomus* taxa influenced the plant tolerance either positively or negatively (Tian et al. 2004).

In conclusion, although the indicated applications are appropriate for salt tolerance, they are still not enough to increase the yield. Therefore, there is a need to provide additional nutritional contributions to increase the yield. The present study marks the preliminary efforts in this direction. Such a use of organic waste is very environmentally friendly way of fertilization and reduces the use of chemical fertilizers that cause natural pollution. By doing so, the agricultural economy will profit and as a result more agricultural production will take place with lower costs.

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