V.1 SALINITY PROBLEM AND RICE DEVELOPMENT IN EGYPT

ZAYED, B.A., S.M. SHEHATA, A.E. DRAZ and H.F. EL-MOWAFI

Rice Res. Dep., Field Crops Res. Inst., ARC, Giza, Egypt.

Abstract

Salinity problem ever presents in Egypt. Rice (Oryza sativa L.) crop is more relevant and common crop under area affected by salt stress in Egypt. Grain yield of rice under target area is still low as compared to normal soil or national average grain yield in Egypt. Furthermore, people living in such area suffer from severe poverty thereby, increasing grain yield of rice in these areas is badly needed for food security and poverty alleviation. Sowing rice on early date of April 20th with higher seedling quality and vigor, young seedlings of 25 to 30-d old were found to be effective under salt stress in Egypt. The proper spacing of 15x15 cm with 3-6 seedling hill^{-1} based on salinity levels and rice cultivars was appropriate under saline condition. The economic rates of N,P,K and Zn nutrients under saline soils are 165, 54, 58 and 24 Kg N, P_2O_5, K_2O and $ZnSO_4$ ha^{-1}, respectively. Nitrogen basal application is not recommended for saline soil and application of small nitrogen dose at the end of booting stage significantly delayed senescence under salt stress, resulting in improving grain filling and leading to high grain yield. The experiments conducted under such dilemma revealed that potassium spray at 2% of K_2SO_4 at mid-tillering, panicle initiation and end of booting stages could substitute the application of 58 kg K_2O ha^{-1} and the application of 7t of FYM and 5t rice compost straw for two or three successive years and could reduce chemical nitrogen fertilizer to half of the recommended dose. The irrigation intervals every 3 or 4 days was suitable under high salinity level and the irrigation intervals could be prolonged up to 6 days with moderate salt level with water ponded depth of 6 cm. Mixed water with salinity level of 1.9-2.1 dS m^{-1} could be used all season or up to panicle initiation and shifting to drainage water with salinity level of 5 dS m^{-1} up to harvest. The transplanting on bed under newly reclaimed saline soil could be applied for higher water productivity with proper management of water.

Keywords: *Oryza sativa* L., Soil salinity, cultural practices, fertilization and irrigation management.

INTRODUCTION

The everlasting salinity problem in Egyptian soil, is ascribed to climate, more salt in Nile river resulted from water pollution, water shortage, sea water intrusion, and irrational human practices (Pessarakli and Szabolcs, 1999, Wassmann *et. al.,* 2004). High salt content in soils is a persisting problem constraining crop production in vast areas in Egypt, estimated at 0.9 million ha, out of 3.2 million ha cultivated area in which they are mainly irrigated by poor quality water such as El -Salam Canal, Bahr

El Bakar, Qoshenar canal and several unknown canals. Furthermore, climate change induced sea water level rising causing more submergence problems with salt water in large area of coastal area. Saline soils have an excess of neutral soluble salts such as chlorides and sulfates. Plant growth is adversely affected because of reduced water uptake, salt toxicity, and nutrients imbalance. There are also areas where both salinity and alkalinity occur simultaneously. Rice is moderately sensitive to salt stress, yet still preferred as a reclamation crop due to its unique ability to thrive in standing water. Sensitivity also varies with the climate and the stage of development, with poor association between tolerance at the two most sensitive stages, early seedling and reproduction (Zayed, 2002, Moradi *et. al.,* 2003, Peng and Ismail, 2004).

For most rural poor framers in these areas, their only hope is to make the best out of their poor-quality water and land to meet their food needs. In Egypt, present rice yields are below 5.50 t ha^{-1} under saline soil based on salinity level, while, the national average is 10.2 t ha^{-1}. Thereby, releasing new elite cultivars and proper recommendation package has to be developed to landslide this gab. In some coastal areas, rice is the only crop that can be grown in the summer season. The limited time period of freshwater supply constrains cropping intensification, and farmers are risk-averse in these difficult environments. Also, salinity occurs in association with other soil-related stresses. Improving crop productivity in these areas addresses the primary concern of the poor and mainly subsistence farmers, which assurs household food supplies. The ability to achieve higher productivity in less time and by using land and water resources that are otherwise unusable would also release pressure on crop production in other more favorable areas where, in time periods when farmers can engaged in other farming activities to generate more income.

Salinity tolerance at the seedling and reproductive stages is critical but good cultural practices and fertilizers management program could cope with the 10 low salt tolerance at these stages The physiological bases of salt tolerance during the seedling stage are fairly well understood in rice and key traits were identified such as high seedling vigor, salt exclusion, compartmentation in structural and older tissues, up-regulation of the antioxidant system, and high tissue tolerance (Flowers and Yeo, 1986).

Water management, together with soil reclamation and crop management strategies, hold the key to enhancing crop survival and productivity, as well as improving soil quality. Improving recommendation packages of rice crop under saline soil were found to be effective in enhance salinity tolerance and increasing grain yield of rice under salt affected area (Zayed, 1997 and 2002, Zayed *et. al.,* 2004, 2005, 2006 and 2007, and Shehata *et. al.,* 2007).

The objectives of the present review were to briefly review recent efforts to better recommendation package of rice adaptation to salt stresses that are common in irrigated soil cultivated by rice in Egypt and to highlight efforts to integrate results of advances in rice agronomy and crop natural resources management into rice agronomy program.

3-Management of rice under saline soil

Tackling salinity problems would include the use of various interventions such as reclamation, good drainage system, water management and soil amendments. In the second stage of soil reclamation in Egypt, rice is grown as main summer crop, usually following barley or berseem or sugar beet and wheat. Nowadays, rice is annually grown in the northern part of Delta whereas salinity problem is widely spread in order to maintain favorable salt balance. High productivity of rice under salt affected soils could be obtained by merging elite cultivar with high capability to salt tolerance and develop integrated water, soil, and nutrient management strategies to cope with the effect of salt stress.

3.1. Releasing salt tolerant cultivars

To accomplish this avenue, rice salinity breeding program, RRTC, FCRI, ARC, is conducting annual experiment under field and green house conditions to evaluate release and indentify salt tolerant cultivars and sources for genes salt tolerance. During the last two seasons, there were some rice genotypes with high capability for salinity tolerance

Table 1. The promising lines selected from FYT (inbreeds) and AYT (hybrids).

Inbred Genotype	Grain yield t ha^{-1} (FYT)	Hybrid Genotype (AYT)	Grain yield (t ha^{-1})
Sakh 105 (sensitive)	4.03	EHR1	6.5
Sakha 106(S)	3.95	EHR2	6.43
Giza178(tolerant)	6.55	SK2027H	6.45
Giza 179 (T)	6.70	SK2128H	6.35
GZ9461-4-2-3-1	6.90	Giza178	6.1
GZ9399	6.60	GZ9399	5.9
LSD0.05	0.2	-	7.5
EC(dS m^{-1})	7.0	-	7.5

Sources (2014, RRTC Annual Report), FYT-final yield trial, AYT, advanced hybrid yield trial.

As furnished in Table 1 there are some inbred and hybrid rice new cultivars with high salt and alkaline tolerance have been released and tested.

3.2. Cultural practices management

The Agronomy Salinity Program of Rice Research and Training Center (RRTC) in Egypt is conducted at El-Sirw Agricultural Research Station, which is located at the north-east part of the Delta under salt stress condition with poor irrigation quality water. The overall goal of this program is to improve the rice cultivation management for tackling salinity problem facing rice planting in the Nile Basin.

The experiments conducted under saline soil conditions indicated that direct seeded rice either, broadcasting or dibbling planting methods was found to be superior to transplanted rice. Furthermore, dibbling seeded rice surpassed other planting methods (Abd El-Rahman *et. al.,* 1990) (Table2).

Table 2. Means of grain yield (t ha-1) as affected by the interaction between rice cultivars and planting methods.

Planting method	Giza172		Giza 176	
	1989	1990	1989	1990
Broadcasting	5.4	5.7	5.5	5.9
Dibbling	5.4	6.0	6.4	6.3
Transplanting	4.5	5.0	5.3	5.6
LSD0.05	0.36	0.31	0.36	0.31

Source: AbdEl Rhman *et. al.* (1990)

3.3 Raising seedling vigor of rice under salt stress

Initial seedling vigor is one criterion needed for enhancing rice salt tolerance either during seedling or reproductive stages. High seedling vigor could be achieved by using modern breeding tools. Interestingly, good nursery management including fertilizer, seed rate and pre-sowing seed treatment or chemical spray treatment during nursery could significantly improve seedling quality and vigor (Zayed *et. al.,* 2005). Zayed *et. al.* (2005) stated that the seedling vigor of hybrid rice was significantly better under saline soil in Egypt when low seed rate was used.

Bassiouni (2008) studied the effect of pr-sowing seed and nursery treatment on seedling vigor, growth and yield of hybrid rice under saline soil in Egypt. He found that di-ammonium phosphate (DAP) spray at the concentration of 2% at 14 days after sowing in nursery gave positive and significant effect on seedling vigor, rice healthness, rice growth, rice salt tolerance and ultimately, high grain yield under such conditions (Tables 2, 3 and 4).

Table 3. Seedling characteristics as affected by various pre-sowing and nursery chemical treatments during 2006 and 2007 seasons under saline conditions.

Treatment	Root volume seedling^{-1} (cm)^3		Number of white roots seedling^{-1}		Number of tillers seedling^{-1}	
	2006	2007	2006	2006	2007	2006
Control	0.52d	0.73e	12.5d	13.4d	3.1f	2.8f
Soaking in ZnSO4 (2%)	0.76bc	0.953cd	13.2bc	16.6abc	3.8bc	3.4bcd
Soaking in DAP (2%)	0.76bc	0.97bcd	13.7ab	16.6abc	3.5de	3.4bcd
Soaking in NaCl (1%)	0.90a	1.28a	13.9a	17.7a	4.1a	3.9a
Soaking in cytokinin (75 ppm)	0.73bc	0.99bcd	12.7cd	15.5c	3.6bcd	3.2cde
Soaking in GA3 (100 ppm)	0.84ab	1.23a	14.0a	17. 9a	3.9ab	3.7ab
2% of N and K spray at14 DAS	0.73bc	0.98bcd	13.4ab	16.89ab	3.7bcd	3.2de
2% of ZnSO4 spray at 14 DAS	0.70c	0.93cd	12.4d	c	3.2ef	2.9ef
2% of DAP spray at 14 DAS	0.84ab	1.13ab	137ab	15.8bc	3.9ab	3.5ab
75 ppm of cytokinine spray at 14	0.84ab	1.00bc	13.6ab	17.1ab	3.4def	3.0def
DAS	**	**	**	16.8abc	**	**
F test				**		

Table 4. Seedling characteristics and rice grain yield as affected by various pre-sowing and nursery chemical treatments during 2006 and 2007 seasons under saline conditions.

Treatment	N% in shoot		Chlorophyll content (SPAD)		Grain yield (t ha^{-1})	
	2006	2007	2006	2007	2006	2007
Control	2.113c	2.00c	26.48d	25.10e	4.80d	5.55d
Soaking in $ZnSO_4$ (2%)	2.390ab	2.373ab	29.60ab	31.92abc	6.08bc	6.46bc
Soaking in DAP (2%)	2.320ab	2.417a	28.60b	29.65cd	5.63c	6.22c
Soaking in NaCl (1%)	2.407ab	2.417a	30.13a	32.40ab	6.56ab	6.81ab
Soaking in cytokinin (75 ppm)	2.330ab	2.393a	27.85c	30.17bcd	5.66c	6.46bc
Soaking in GA3 (100 ppm)	2.467a	2.477a	30.18a	32.70a	6.90a	7.26a
2% of N and K spray at 14 DAS†	2.470a	2.473a	29.23ab	30.90bcd	6.19bc	6.41bc
2% of ZnSO4 spray at 14 DAS	2.313b	2.373ab	27.93c	29.37d	5.74c	6.44bc
2% of DAP spray at 14 DAS	2.473a	2.487a	30.23a	32.85a	6.94a	7.30a
75 ppm of cytokinine spray at 14 DAS	2.343ab	2.333ab	29.55ab	29.25d	6.04bc	6.39bc
F-test	**	**	**	**	**	**

Sources: (Tables, 3 and 4) Bassiouni (2008).

† DAS, days after sowing.

3.4.Sowing date: Seedling age and plant density

The optimum sowing date might promote salinity tolerance in rice and its productivity. Interestingly, early sowing date, i.e ,late April and beginning of May was found to be more suitable for sowing rice under saline soil (Abd El-Rahman *et. al.* 1992). Assey *et. al.* (1992), Dewedar (2004) and Zayed *et. al.* (2005a) found that sowing rice at late April and beginning of May first gave superior growth, yield and its components of rice under saline soil that enabled rice plant growing under such conditions to avoid the high temperature and irrelevant relative humidity particularly at sensitive rice growth stages to salt stress (Table5)

Table 5. Grain yield and straw yield of Sakha 104 rice cultivar as affected by sowing date under saline soil.

Treatment	Straw yield (t ha^{-1})		Grain yield (t ha^{-1})	
	2003	2004	2003	2004
Sowing date (D):				
April, 25	5.27	5.58	3.75	4.08
May,10	5.01	5.06	3.53	3.61
May,25	4.86	4.95	3.24	3.45
June,10	3.90	4.14	2.39	2.51
$LSD_{0.05}$	0.16	0.12	0.19	0.129

Source: Zayed et. al. (2005).

Seedling age, under Egyptian condition and Egyptian cultivars, the young seedlings performed better under saline soil than the older seedling. RRTC (1991) and Zayed (2006) stated that the 25 day–old seedlings gave the highest grain yield and that was fact for both hybrid and inbred rice. The old seedling up to 40 days severely restricted the grain yield as follows :

Grain yield of Giza 178 rice cultivar as affected by seedling age under salt stress conditions.

Seedling age (days)	25	30	35	40	LSD0.05
Grain yield (t ha^{-1})	7.80	7.0	6.0	4.5	0.5

Source: RRTC (2002)

Plant density

The optimum density has to be well defined to obtain high yield of rice crop under saline soil. The low tillering capacity gave lower panicles m^{-2}, while the high tillering capacity caused competition and shading and consequently lower yield of paddy. Under saline soil conditions, Abd El- Rahman *et. al.* (1996), El- Hawary and

Gabr (1998), Zahran (2000), Abd El salam (2003) Zayed *et. al.* (2005a) and Shehata *et. al.* (2006) stated that the narrow spacing of 20 x 10, 15 x 20 or 15 x 15 and 15 x 10 were the best for rice growing under such conditions where they gave best rice growth, leaf area index (LAI), dry matter production, tiller numbers, effective tillers, grain yield, straw yield and harvest index, while they gave the lowest values of panicle weight, filled grains panicle^{-1} and 1000-grain weight against wider spacing of 20 x 20 or 20 x 25cm.

Abd El-Rahman *et. al.* (1990) under saline soil conditions, stated that, plant height, number of grains panicle^{-1}, and weight of grains panicle^{-1} were slightly decreased as number of seedlings hill^{-1} increased from 3 to 9 seedlings, while grain yield was increased by increasing up to 9 seedlings as increasing number of panicles hill^{-1} and dry matter. Moreover, Attia *et. al.* (1994), Hundal *et. al.* (1999), Panda *et. al.* (1999), Zayed (2005) and Kengo and Kitano (2005) reported that increase in yield and yield attributes was found as a result of increasing of seedling hill^{-1} to 4 or 5 and 6. Abd El- Salam (2006) under newly reclaimed soil stated that increasing number of seedlings hill^{-1} up to 7, significantly increased plant height, panicle length, harvest index, dry matter production, panicle numbers, number of filled grains panicle^{-1}, 1000-grain weight and grain yield of rice crop.

Table 6. Average of grain yield of Giza 178 as affected by the interaction between spacing and No. seedlings hill^{-1} during 2005 and 2006.

Spacing	No. Seedlings. hill^{-1} 2005 season		
	3	6	9
15 x 10	4.09	4.49	4.53
15 x 15	4.83	5.98	5.16
15 x 20	3.58	4.89	4.88
LSD $_{0.05}$	0.53		
2006 season			
15 x 10	4.60	5.54	5.38
15 x 15	5.44	6.51	5.65
15 x 20	4.07	5.30	5.43
LSD $_{0.05}$	0.32		

Source: Shehata *et. al.* (2007)

4-Fertilizer management

Out of a number of factors responsible for salt-induced inhibition in plant growth, nutrient deficiency which is the most crucial factor that reduces plant growth and crop productivity because both macro- and micronutrients are important constituents of enzymes, hormones, and cellular structures. However, nutrient uptake by the plant from soil is influenced by the activity of membrane transporters that mediate their intra- and inter-cellular distribution (Epstein and Bloom, 2005, Marschner, 1995 and Tester and Davenport, 2003), for example, Ca2-ATPases (Ca^{2+}pumps) for Ca^2 (Geisler *et. al.,* 2000), inward- and outward-rectifying K channels for Na and K (Maathuis and Amtmann, 1999), HVSTI for SO_4 (Smith *et. al.,* 1997), and different kinds of transporters for nitrate and ammonium (Epstein and Bloom, 2005). In view of a number of reports, it is suggested that salt-induced nutrient deficiency may have been due to Na-induced blockage or reduced activity of these transporters (Maathuis and Amtmann, 1999, Qi and Spalding, 2004, Rus *et. al.,* 2004 and Tester and Davenport, 2003). However, salt-induced nutritional disorders can be alleviated by the addition of mineral nutrients in the growth medium

Availability of plant nutrients in problem soils is severely limited to sustain high production of crops. Successful crop under saline environments requires the optimum nutrients management. Good fertilizer management might enhance salinity tolerance and improve rice growth besides correcting the ion imbalance occurs under salt stress.

4.1. Nitrogen fertilizer management

4.1.A Nitrogen level, At early stage under saline soil whereas the modern and more salt tolerance did not release the optimum nitrogen level was found to be 100 Kg N ha^{-1} under high pH level (AbdEl-Rahman *et. al.,* 1990 and AbdEl-Rahman *et. al.,* 1996). Recently; since the more salt tolerant cultivars have been developed, the optimum nitrogen level was found to be 165 kg N ha^{-1} (Abd-El- Rahman, 1999 and Zayed *et. al.,* 2005a). Zayed *et. al.* (2006) found that the hybrid rice significantly responded to nitrogen application up to 180 kg N ha^{-1}. Sometimes the farmer under saline planted the sensitive cultivar thereby, Zayed *et. al.* (2006) stated that high nitrogen level of 180 kg N ha^{-1} could be relevant to sensitive rice cultivar under saline soil (Table7).

Table 7. 1000- Grain wt (g) and grain yield (t ha^{-1}) of rice as affected by the interaction between rice cultivars and nitrogen levels during 2005 and 2006 seasons.

cultivar	N level kg ha^{-1}	1000- grain wt (g)		Grain yield (t ha^{-1})	
		2005	2006	2005	2006
SK 2034H	0	19.83	19.36	4.53	4.48
	60	20.71	20.03	5.68	6.08
	120	21.56	20.58	6.33	6.71
	180	22.57	21.60	7.97	8.13
	240	22.10	22.03	8.13	8.18
SK 2025H	0	23.03	20.28	3.74	4.09
	60	21.63	20.63	4.89	5.13
	120	22.18	21.68	5.19	5.44
	180	22.93	22.45	5.80	6.21
	240	22.70	23.08	5.88	6.23
Giza178	0	19.63	19.23	4.22	4.39
	60	20.33	19.96	5.29	5.42
	120	21.48	20.69	6.08	6.18
	180	22.21	21.73	6.81	7.18
	240	22.08	22.18	6.51	6.91

Source, Zayed *et. al.* (2006)

4.1.B. Methods of nitrogen application-Under saline soil conditions, high nitrogen use efficiency could be achieved by splitting recommended nitrogen level in three or four doses. The basal nitrogen application under salt stress is not recommended under and small nitrogen dose it has to be applied at the end of booting stage (Zayed, 1997 and Zayed *et. al.,* 2007). The later authors found that in the first study two third of recommended nitrogen application in two equal doses at 15 and 35 days after transplanting as topdressing + 6.75 kg of urea applied as foliar at panicle initiation gave the highest grain yield under saline soil compared to all top-dressing or all foliar application at mentioned stages. Zayed *et. al.* (2007) reported that any basal nitrogen application under saline soil failed to exert any yield improvement in salt stressed rice plant. Furthermore, more nitrogen splitting after transplanting, one of them at booting stage has to be applied under saline soil, particularly for hybrid rice (Table 8).

Table 8. Grain yield (t ha-1) as affected by the interaction between rice cultivars and time of nitrogen applications under saline soil.

Time of nitrogen application	cultivar			
	Sakha104	SK2025H	SK2058H	Sk2047H
2/3B+1/3PI	5.800	5.03	5.25	5.25
1/3B+1/3MT+1/3PI	5.65	6.20	6.05	6.05
1/3T+1/3MT+1/3PI	5.98	6.80	6.63	6.63
1/3T+1/3PI+1/3F	6.55	7.60	6.40	6.40
B+1/4MT+1/4PI+1/4F¼	5.70	6.85	6.23	6.23
T+1/4MT+1/4PI+1/4F¼	6.95	7.35	7.40	7.40
B+1/4T+1/4MT+1/4PI-2%F¼	5.75	6.93	6.78	6.78
Weekly application	5.60	6.88	6.55	6.55
LSD $P \leq 0.05$	0.48			

Source: Zayed et. al. (2007a).

B, basal, MT Mid tillering, PI, panicle initiation, F, flowering

4.1.C. Nitrogen source-Urea and ammonium sulfate gave similar results but the ammonium sulfate could be recommended under high sodicity (RRTC, 1998).

4.1.D. Organic fertilizer

Raising rice production under saline soil with less input may help in poverty alleviation and contribute to food security and sustainability. Using farm yard manure (FYM) is more important as organic nitrogen source, soil amendment and improving soil fertility and environment. El–Rewainy (2002), Gosh and Singh (2003), Reddy *et. al.* (2003) and Baig *et. al.* (2004) stated that increasing (FYM) up to 5 t fed^{-1} or 10 t ha^{-1} significantly increased rice growth and yield attributing traits as well as grain yield and its nutrient content. Zayed *et. al.* (2005b) under saline soil found similar results. Interestingly, Zayed *et. al.* (2006c) indicated that the application of 10 t FYM ha^{-1} was found to be an efficient to save around 50 –65 kg N ha^{-1} under saline soil. Recently, more studies were conducted under saline soil by Zayed (2008) about using of rice straw compost and (FYM) under saline soil, whereas, this experiment was mainly aimed to explore the utilization of organic and bio fertilizer for rice production to enhance soil and water productivity under newly reclaimed saline soil in rice-wheat cropping system.

The data listed in Table 9 showed that nitrogen chemical fertilizer at the rate of 165 kg N h^{-1} gave the highest grain yield of rice without any significant differences with those produced by 0.5 t FYM+83kg N ha^{-1} 5.0 t rice compost straw +83kg N ha^{-1}

and *Azospeerillum* inoculation. However, it was deduced that, the chemical nitrogen fertilizer could be reduced under saline soil by applying 5 t rice compost straw and FYM or using bacteria *Azospeerillum* inoculation with half of recommended for several years .Also the previous mentioned combination without any chemical used could be used effectively after its application for several years. The present study will be continued in the next year to confirm its results with wheat too (Zayed, 2008).

Table 9. Grain yield of rice cop as influenced by organic and bio-fertilizer.

Organic applied B. Rice Grain yield (t ha^{-1})	cultivar	Organic applied B. Grain yield (t ha^{-1}) (Wheat)
5.39	Giza178	4.20
6.28**	SK2034H	4.99**
-	Treatment	-
3.50	Control	3.4
6.60	165Kg N ha^{-1}	6.40
6.40	7.5t FYM+83kg N ha^{-1}	5.50
6.50	5.0 t RCS +83kg N ha^{-1}	5.53
6.50	Azosperrilum+83 kgN ha^{-1}	6.00
5.80	7.5t FYM+5.0RCS+AZO	5.40
0.60	LSD0.05	0.70
7.50	ECe dS m^{-1}	8.0

Source: Zayed (2008),

FYM, Farm yard manure, AZO-Azosperillum

4.2. Phosphorous (P^+) fertilizer:

Long ago, Champagnol (1979) reported in a comprehensive review that 34 of 37 different studies showed that addition of P to saline soil increases crop growth and yield. At early stage, results of fertilizer experiments on Egyptian soil indicated that P application had little effect on grain yield and straw yield whereas, rice response to phosphorous application was not definite in many areas that mainly might due to using high P fertilizer rate with the previous crop. It is very interesting to mention that the Egyptian farmers applied more P in the form of Calcium super phosphate at early stage of soil salinity reclamation because it might be had high ability to improve soil characteristics such as soil drainage and also the phosphorus suppressed Cl uptake.

Interestingly, the optimum grain yield of rice was obtained when the rate of 36 KgP_2O_5 ha^{-1} was used in the form of calcium super phosphate (Abdel Rahman, 2002). Zayed. (2009) stated that the modern rice cultivars are more salt tolerant and responded to P fertilizer application up to 72 Kg P_2O_5 ha^{-1} particularly for hybrid and high yielding cultivars (Table 10).

Table 10. Grain yield of some rice cultivars as affected by various rates of phosphorous under saline soil.

P rates Kg P_2O_4 ha^{-1}	Rice cultivar			
	Giza177	Giza178	Sakha104	SK2034H
0	4.60	6.11	5.92	7.34
36	5.44	7.52	6.88	8.10
72	6.61	8.29	7.50	9.04
108	6.02	7.61	6.88	8.20

Source: Zayed (2009)

4.3 Potassium fertilizer

Potassium has essential functions in osmoregulation, enzyme activation, regulation of clever pH, cation- anion balance, regulation of transpiration by stomata, and the transport of assimilates and subsequently raised rice tolerance of salinity. (Lee and Senadhira, 1996 and Zayed *et. al.,* 2002) found that increasing the K uptake ability under stress enables rice plant to grow healthy under salt stress. Muhammed and Neue (1987), and Qadar (1998) referred that K^+ addition to saline culture solution markedly improved rice yield and yield attributes as a results of increasing K^+ uptake and decreasing Na^+ uptake.

4.3. a Optimum potassium rate

In Egypt under salt stress, Zayed (2002), Abd El Rahman *et. al.* (2004) and Zayed *et. al.* (2007a) stated that rice plants grown under salt stress significantly responded to potassium application up to the rate of 72 Kg K_2O ha^{-1}. Furthermore, they stated that potassium application improved salt tolerance via reducing Na uptake and Na/K ratio, increases rice growth and minimize sterility happened under salt stress.

Table 11. Grain yield t ha-1, Na and K mmol kg-1 leaf contents and Na/K ratio

Traits	K rate kg K_2O ha^{-1}				
	0	24	48	72	LSD 0.05
Grain yield t ha^{-1}	4.82	5.50	6.10	6.84	0.21
Na^+ ppm	729	678	611	530	15.0
K^+ ppm	504	541	600	672	9.0
Na/K ratio	1.49	1.27	1.03	0.79	0.04

Source: Zayed *et. al.* (2007a)

4.3. b. Improving potassium application:

Ghoshi *et. al.* (1995), Devasenapathy (1997), Thakur *et. al.* (1999), Meena *et. al.* (2003) and Zayed *et. al.* (2006b) reported that rice crop performed better when splitting application of potassium. Under saline soil in Egypt, RRTC (2006) and Zayed *et. al.* (2007b) stated that dividing potassium application into splits 1/3 Basal + 1/3 mid tillering +1/3 panicle initiation significantly improved rice growth, rice salt tolerance and ultimately rice grain yield (Table 12). Furthermore, potassium splitting significantly improvedleaf area index (LAI), drr matter (DM) ,chlorophyll content , N and K^+ leaf contents at heading, grain yield attributing characters and grain yield in both seasons of study.

Potassium application at one dose, as basal, significantly failed to exert any improvement in rice growth or enhancing its withstanding to water and salinity stresses. The splitting, including dressing at panicle initiation, showed its superiority in enhancing rice tolerance to both water and salinity stresses and, subsequently, improved rice growth and grain yield. Also, the potassium application at the maximum tillering or tillering stages, with panicle initiation encouraged rice plants to grow healthy under such stresses. The triple potassium splitting as follows: 1/3 basal +1/3 maximum tillering (MT) + 1/3 panicle initiation (PI gave the highest values of all studied traits (Table 12).

Table 12. Panicle weight (g), grain yield (t ha-1), N% and K+ content (mmol kg-1 dry leaf)as affected by potassium splitting treatments in 2005 and 2006 seasons.

Trait	Panicle wt		Grain yield		N%		K^+ content	
Treatment	2005	2006	2005	2006	2005	2006	2005	2006
K^+ Splitting treatments:								
All basal (B)	2.64	2.66	5.46	5.71	2.234	2.211	476	481
1/2 B +1/2 MT	2.79	2.83	6.19	6.61	2.337	2.327	513	518
1/2 T + 1/2 PI	2.91	2.92	6.90	7.22	2.396	2.403	539	547
1/3 B + 1/3 MT +1/3 PI	2.97	3.04	7.25	7.57	2.487	2.461	576	584
LSD(0.05)	0.08	0.11	0.18	·0.16	0.35	0.03	8	12

Source: Zayed *et. al.* (2007b). B, basal, MT Mid tillering, PI, panicle initiation

4.4. Zinc fertilizer:

Rice under saline –alkaline soil and submergence conditions suffers from Zn deficiency under saline soil in Egypt. It was found that applying Zn to rice growing under saline soil significantly increased rice grain yield and improved rice performance under such conditions. Most of the experiments conducted under saline soil in Egypt indicated that the optimum Zn rate for rice grown under saline soil is 24 Kg Zn SO_4 ha^{-1} (RRTC, 1999) (Table 13). Foliar application of 2% zinc sulfate will help to correct Zn deficiency in rice under saline soil.

Table 13. Grain yield of Sakha 101 rice cultivar as affected by zinc rate under salt stress.

Zinc rate (Kg $ZnSO_4$ ha^{-1})	0	12	24	36	LSD 0.05
Grain yield t/ha^{-1}	4.30	5.27	5.52	5.51	0.19

5. Water management

5.1. Optimum irrigation interval

Continuous sub-mergence irrigation in saline soil is generally recommended with good drainage system under saline soil to help leaching salt by drainage from the root zone, particularly with poor quality water in which fresh water is always unavailable under salt affected soil. It was found that irrigation every 4-day interval under saline soil gave the highest grain yield and received the highest amount of water, which leached the salt and decreased the amount of salt in the root zone compared with 6- and 8-day intervals (Table 14) (El-Mowelhi *et. al.,* 1995 and Zayed, 1997)

Table 14. Grain yield of rice (t ha^{-1}) as affected by irrigation intervals under saline soil.

Irrigation interval	Grain yield t ha^{-1}	
	1995	1996
4-d	4.03	6.49
6-d	3.76	5.68
8-d	3.29	4.54
LSD0.05	0.18	0.12

Source: Zayed, (1997)

5.2. Using poor quality water:

Continuous flooding with saline water resulted in decreasing in rice growth, yield and leaf contents of Ca^{+2} and K^{+1} (Sultana *et. al.,* 2001 and Shehata, 2004). In addition, using poor quality water significantly increased when the poor qualtity water was continuously used while the K^{+1} was decreased (Al- Nabulsi, 1998 and Atwa, 1999). It was found that the effect of saline water was less hazardous when it was used at late growth stage as plant becomes more salt tolerant. Recently, in Egypt under saline soil, Zayed *et. al.* (2006) foun d that the mixed water with salinity level of 1.9-2.1dS m^{-1} could be used all season or up to panicle initiation and shifting to drainage water with salinity level of 5 dS m^{-1} up to harvest. Furthermore, Zayed *et. al.* (2006) stated that the mixed water or drainage water from high salted soil level could be used with water depth of 6 cm every 4 days. However, Zayed *et. al.* (2007b) found that the proper ponded water depth was 6 cm when the poor quality or fresh water was used under saline soil.

5.3. Enhancing water productivity

Recently, Zayed *et. al.* (2007b) found that the 6-day irrigation interval was comparable to 3-day irrigation interval under newly reclaimed saline soil as for grain yield, while 9-day interval significantly restricted the grain yield of rice, yield components, N% and K^+ content (Table 15). Regarding water productivity, Zayed *et. al.* (2007b) reported that the irrigation interval of three days gave the highest values of evapotranspiration (ETa) mm, percolation, water requirement and total applied water in the two seasons of study. On the contrary, watering every nine days gave the lowest values of such water measurements (Table 15). However, the medium irrigation interval of six days gave the highest values of water productivity either economically or physically (Tables 16, 17 , 18)

Table 15. Panicle weight (g), 1000- grain weight (g), grain yield (t ha^{-1}), N% and K^+ content (mmol kg^{-1} D leaf)as affected by irrigation intervals and potassium splitting treatments in 2005 and 2006 seasons.

trait	Panicle wt		Grain yield		N%		K^+ content	
Treatment	2005	2006	2005	2006	2005	2006	2005	2006
Irri .intervals days:								
3	2.96	2.97	7.07	7.37	2.483	2.496	562	573
6	2.81	2.86	6.90	7.19	2.413	2.428	543	549
9	2.71	2.76	5.38	5.75	2.195	2.127	473	477
LSD (0.05)	0.1	0.12	0.17	0.19	0.094	0.03	18	18

Table 16. Evapo-transpiration ETa (mm), percolation (mm),water requirement (WR) (mm) and total applied water (I) m3 ha-1 as affected by three irrigation intervals during 2005 and 2006 seasons.

Irrigation interval (days)	Evapotranspiration (ETa)(mm)		Percolation (mm)		Water requirement (WR)(mm)		Total water applied (I) $m^3 ha^{-1}$	
	2005	2006	2005	2006	2005	2006	2005	2006
3	827	836	320	350	1147	1186	15207	15300
6	810	816	280	300	1090	1096	13790	13898
9	777	780	215	215	986	995	10978	11350

Table 17. Physical water productivity for Evapotranspiration (ETa), water requirement (WR) and total applied water (I) in 2005 and 2006 seasons.

Irrigation interval (days):	Physical water productivity ETa Kg grain m^{-3} water		Physical water productivity (WR) Kg grain m^{-3} water		Physical water productivity (I) Kg grain m^{-3} water	
	2005	2006	2005	2006	2005	2006
3	0.85	0.88	0.61	0.62	0.47	0.48
6	0.85	0.88	0.63	0.63	0.50	0.52
9	0.69	0.74	0.55	0.58	0.47	0.50

Table18. Economic water productivity for evapotranspiration (ETa), water requirement (WR) and total applied water (I) in 2005 and 2006 seasons.

Irrigation interval (days):	Economic water productivity ETa L.E m^{-3} water		Economic water productivity (WR) L.E m^{-3} water		Economic water productivity (I) L.E m^{-3} water	
	2005	2006	2005	2006	2005	2006
3	0.55	0.62	0.39	0.40	0.30	0.34
6	0.55	0.63	0.41	0.42	0.32	0.37
9	0.33	0.33	0.26	0.33	0.23	0.29

5. 4.Raising rice on bed for water saving under newly reclaimed saline soil.

During the 2007 and 2008 seasons an experiment was conducted to develop rice plant on bed and levees for water saving (Zayed, 2008). The results of this experiment indicated that the lowest value of total applied water was obtained when drilling planting on bed was followed as in the table above .The planting on levees gave reasonable total applied water after drilling . Both regular and irregular transplanting gave the same values of total applied water of 11800 m^{-3}. The data in Tables 19 and 20 indicated that regular transplanting on bed gave the highest values of physical water productivity and economic water productivity and it gave the lowest values of yield reduction which was amounted to be 7% (Table 20).

From the above discussion, it was concluded that transplanting on bed confirmed its superiority regarding water productivity and rice yield under such conditions .It could be recommended that more studies is needed to confirm the planting methods and disseminate it with other studies about salinity balance resulting from using this technology.

Table 19. Physical and economic water productivity of rice as influenced by bed planting methods in saline soil.

Trait / Treatment	PWP kg rice m^{-3}	EWP L.E m^{-3}
Watering every 4 d.	0.53	0.45
Sub.water. every 8d.	0.33	0.20
Sat water. Every 8 d.	0.30	0.17
Drilling rice on bed	0.57	0.45
Ireg. Transplanting. on bed	0.54	0.44
Reg. transplanting .on bed	0.60	0.52
Levees	0.55	0.44

Table 20. Water save and corresponding yield reduction % as affected by rice planting on bed under saline soil.

Trait / Treatment	Water save (m^3)	Yield reduction%
Watering every 4 d.	-	-
Sub. water. every 8d.	1100	41%
Sat water. every 8 d.	2100	51%
Drilling rice on bed	3350	18%
Ireg. transplant. on bed	2700	17%
Reg. transplanting .on bed	2700	7%
Levees	2900	17%

CONCLUSION

It could be concluded that the following points have to be disseminated in the target area through special technology transfer program to salt affected soil in Nile Basin of Egypt.

1-Giza 179, Giza179 and HER, could be used under salt stress. The most relevant planting method of rice under salt stress is broad cast seeded rice.

2-Early sowing in the terms of April 2, May 10, ensures seedling at 30d old is being effective. Zinc application at rate of 12Kg $ZnSO_4$ fed^{-1} at the beginning of the season. Ammonium sullphate and urea at the rate of 69KgN fed^{-1} and recommended for rice under alkaline and saline soil, respectively.

3-Nitrogen spitted into three or four doses, one of them at the commencement of booting stage showed better growth and high yield. All nitrogen has to be applied as topdressing since; basal application was inferior.

4-Potassium at the rate of 12Kg K_2O fed^{-1} as basal and 2% spraying at panicle initiation and booting stage. Phosphorus application in the form of calcium super phosphate at the rate of 25Kg P_2O_5 fed^{-1} as basal application seems to be fruitful for improving soil properties and increasing rice yield under salt stressed soil. The irrigation intervals every 6 d at the depth of 6 cm is recommended for salt leaching and rice grain yield as well as improving soil properties

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٥-١ مشكله الملوحه وتطور زراعه الأرز فى مصر

بسيونى عبد الرازق زايد ، سعيد محمد شحاته ، عبد السلام عبيد دراز ،
حمدى فتوح الموافى

قسم بحوث الأرز - معهد بحوث المحاصيل الحقلية - مركز البحوث الزراعية - الجيزة - مصر.

تعتبر مشكله الملوحة من أكبر المشاكل التي تواجه إنتاج المحاصيل في مصر خاصة محصول الأرز المنزرع تحت هذه الظروف الملحية حيث يتعرض لنقص في الإنتاجية في هذه المساحات بالمقارنه بالأراضى العاديه غير الملحية. ويتعرض سكان تلك المناطق لظروف معيشية قاسية، لذلك فإن زياده إنتاجيه محصول الأرز فى مثل هذه المساحات يضمن أمن غذائى جيد ويزيد مستوى معيشة المزارعين ويرفع متوسط إنتاجيه الأرز فى مصر. يوجد ثلاث نقاط رئيسية لزيادة إنتاجيه الأرز تحت مثل هذه الظروف وهى: ١) إنتاج أصناف من الأرز متحملة للملوحة عالية الإنتاجية تحت ظروف مثل هذه المناطق وكذلك متحملة للمشاكل المرتبطة بالملوحة مثل نقص الزنك، ٢) إستحداث التوصيات الفنية المناسبة لمحصول الأرز تحت ظروف المناطق المتأثرة بالملوحة، ٣) العمل على تطوير برنامج إرشادي مناسب لهذه الأراضي ونقل التقنيات الحديثة الخاصه بتلك الأراضي تحت مثل هذه الظروف القاسية. وتشتمل هذه البرامج على زراعة الأصناف المتحمله للملوحه مثل جيزه١٧٨ وهجين مصرى ١ وجيزه ١٧٩، وكذلك زراعه الأرز فى ميعاد مبكر حوالي ٢٠ أبريل بشتلات ذات جودة عالية صغيرة العمر من ٢٥-٣٠ يوم حيث وجد أنها فعالة تحت ظروف الأراضي الملحية فى مصر. كما يوصى أيضا بالزراعة على مسافة ١٥x١٥ سم وذلك بإستخدام من ٣-٦ شتلات في الجورة وذلك تحت ظروف الملوحة. كما يوصى باستخدام أصناف الأرز المتحملة للملوحة في تلك الأراضي كما سبق ذكره واستخدام معدلات التسميد بالنيتروجين والفسفور والبوتاسيوم والزنك بمعدلات ١٦٥ ،٥٨،٢٤،٥٤ كجم N, $ZnSO_4$ P_2O_5,K_2O ، على التوالي. ولاينصح بإضافة النيتروجين على الشراقي تحت ظروف الأراضي الملحية وإضافة معدلات منخفضة من النيتروجين أثناء مراحل النمو المتأخرة أو في بداية طور الحبل حيث أدى ذلك بشكل ملحوظ إلى زياده تحمل الملوحة وزيادة امتلاء الحبة وبالتالي زيادة المحصول. ووجد أيضا أن إضافة البوتاسيوم رشا ٢% K_2SO_4 أثناء مرحلة التفريع المتوسط وبداية الطرد ونهاية الحبل قد يعوض استخدام ٥٨ كجم K_2O للهكتار وإضافه السماد البلدى ٧ طن/هكتار وذلك لمدة سنتين إلى ثلاث سنوات مما يجعل الأرض تحتفظ بالسماد النيتروجيني بنسبه تصل إلى نصف المعدلات الموصى بها للسماد الكيماوى. كما يمكن التوصية أيضا بالري كل ٣ إلى ٦ أيام للأرز النامي تحت مثل هذه الظروف طبقا لدرجة ملوحة التربة ونوع الأملاح السائدة. وقد وجد أيضا أن ماء الصرف الزراعي يمكن إستخدامه حتى ملوحة ٥ ملليموز/سم حتى الحصاد. ومن الجدير بالذكر أن الشتل على مصاطب تحت ظروف الأراضي المستصلحة حديثا يمكن اتباعه مع إعطاء رية غمر لغسيل أي أملاح متراكمة للحصول على محصول عالي مع توفير قدر كبير من المياه يصل إلى ٢٠ إلى ٢٥ %.