Natural Hazards Induced Salt-affected Soils for Rice Production in Myanmar

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Abstract

Myanmar is exposed in nature to natural hazards such as cyclone, drought, earthquake, fire, flood, landslide and storm surge. This paper emphasized on inland salinity problem due to drought in Central Dry Zone (CDZ) area and flood related seawater salt intrusion in Ayeyarwady Delta. To grow double rice crop in brackish and salt water intrusion area of Ayeyarwady, selection of short life varieties, irrigation according to the lunar calendar, balanced fertilizer application are three main points essential for success rice growing in this area. IR 84649-308-24-1-B, IR 10T-107, CSR36, and IR 846495-305-6-1-B are, so far, promising salt tolerant rice varieties for inland salinity areas and coastal and delta areas. According to experimental results, application of cow dung manure at the rate of 5 ton ha^{-1} was the best for non-saline, slightly sodic soil (S2) of Pale Township, Sagaing Region, CDZ and application of gypsum at the rate of 2 ton ha^{-1} was the appropriate amendment for slightly saline, highly sodic soil (S3) of Shwebo township, Sagaing Region, CDZ.

Key Words: natural hazards, salinity, sodic, lunar calendar, salt tolerant rice varieties, amendments.

INTRODUCTION

Agriculture plays the pivotal role in Myanmar, accounting for more than 22 percent of GDP and employing 60 percent of labour force and the Government of Myanmar has also positioned agricultural development as one of seven key pillars supporting for sustained economic development. Since the advent of military government in 1962, Socialism has been launched and its consequent agricultural policies including land nationalization and planned cultivation, Myanmar, the largest rice exporter in world in the 1950s, has the record of considerably decline in the 1960s (Dawe, 2002). The political transition that started in 2011 and current government via Ministry of Agriculture and Irrigation (MoAI), has deploy the strengths of the country's rice sector to enable not only food security but also rural development and overall economic growth.

The country is divided into three major agro-ecological zones: (1) Central Dry Zone, (2) Coastal Zone, and (3) Hilly Zone. The CDZ covers approximately 54, 390 square kilometers and it is 10% of the country's total land area (Figure 1 and 2). High temperature with low rainfall accelerates drought making inland salinity problem in some area.

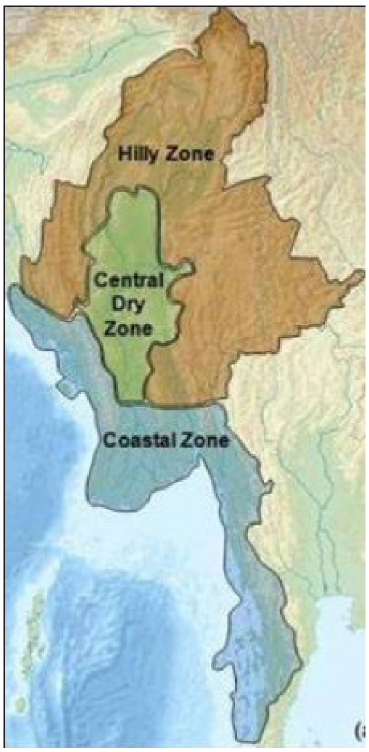

Figure 1. Map of Myanmar's agro-ecological Zones

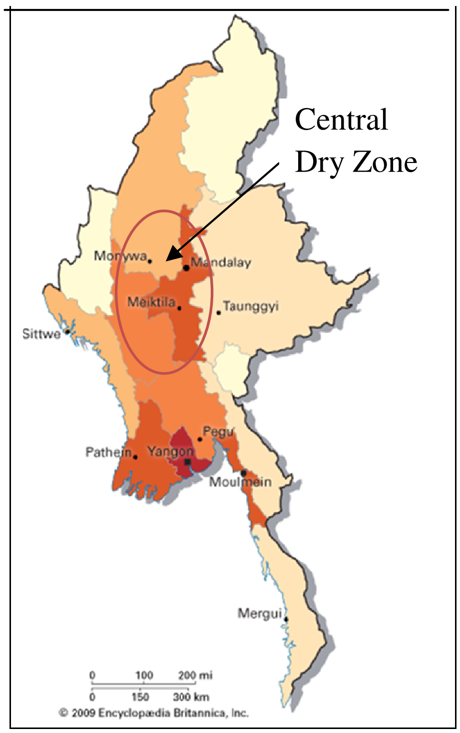

Figure 2. Map of the Central Dry Zone

The Ayeyarwady delta, (Figure 3), the rice bowl of Myanmar, covers 35,032 square kilometers (MoAI, 2014). Of the total 2.89 M ha of rice area in delta 22, 416 ha are salt-affected (Department of Agricultural Research unpublished data) due to seawater intrusion. Of the various problem soils in the world, saline and sodic soils occupy the largest area approximately 323 M ha and 634 x 10^3 ha occurs in Myanmar as salt-affected soils (FAO, 1988).

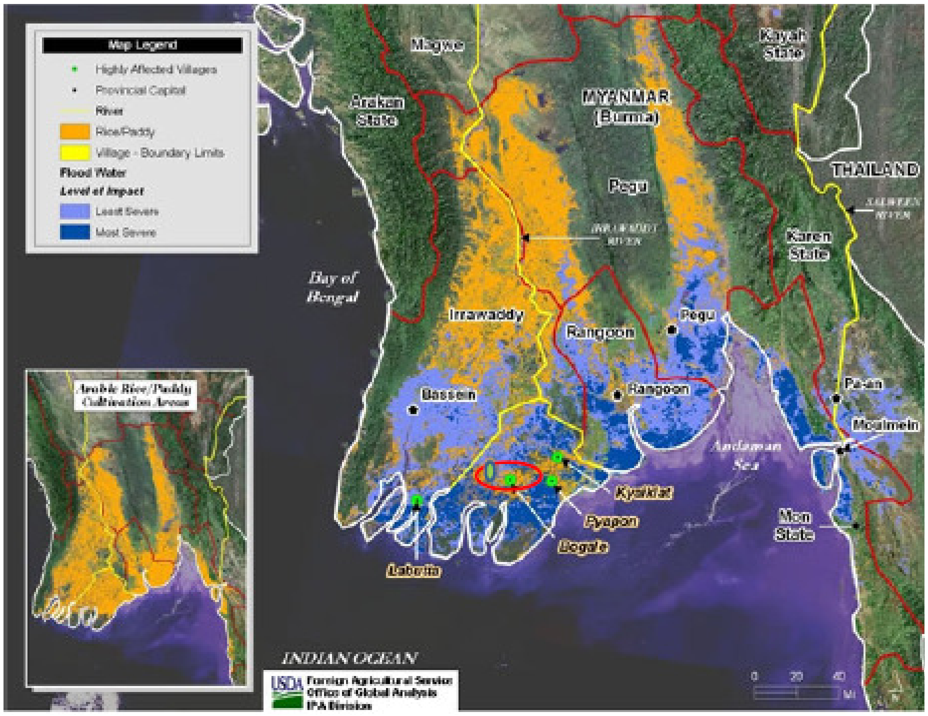

Figure 3. Map of Ayeyarwady delta

RESULTS AND DISCUSSION

Yetagon, one of Myanmar NGOs, Department of Research (DAR), and research team of Yezin Agricultural University (YAU) try to find salinity management practices in Myanmar. Their attempts to solve salinity problems and management practices are as follows:

No.	Salinity Problem	Management Practices
1	Coastal and sea water intrusion	Double rice cropping in brackish and salt water intrusion area by using lunar calendar e.g. Maulemyinegyun and Bogale townships (NGOs)
2	Inland salinity Irrigation salinity	Selection of salt tolerant varieties (DAR)
3		Classification of salt-affected soils & investigation of the effective reclamation methods In Central Dry Zone (CDZ), (YAU)

MATERIALS AND METHODS

For classification of salt-affected soils and investigation of the effective reclamation methods in CDZ, two experiments were conducted to compare the saturated hydraulic conductivity of problem soils before application (T1) and to determine the saturated hydraulic conductivity of problem soils using amendments 5 (T2), 10 (T3), and 15 (T4) ton ha^{-1} cow dung manure according to Gupta et al. (1984) and 2 (T5), 4 (T6), 6 (T7) ton ha^{-1} gypsum application rates according to Yadav (1973). Using seven treatments and three different soils were assigned as Completely Randomized Design with 4 replications, totally (7 x 4 x 3) eighty four experimental units. Three soil samples, S1 from WunDin Township, Mandalay Region, S2 from Pale Township, Sagaing Region and S3 from Shwe Bo Township, Sagaing Region (Yin Mar Soe, 2014).

RESULTS AND DISCUSSION

Yetagon NGO suggested that to grow double rice crop in brackish and salt water intrusion area of Ayeyarwady, selection of short life varieties, irrigation according to the lunar calendar, balanced fertilizer application are three main points essential for success rice growing in this area (Table 1, Figure 4, 5, and 6). They also pointed out that salt concentration of water is higher during high tides than during low tides and irrigation should be done during low tides using pumps.

Table 1. Selection of short life rice varities

Monsoon rice	Life span	2nd crop	Life span
Yetagon	90 DAS	Yetagon	90 DAS
Sin Thwe Latt	135 DAS	Sticky rice	95-96 DAS
Paw San Yin	145-150 DAS	Pan Khan Shwe War	100-105 DAS
Pa Khan Shwe War	100-105 DAS	Thee Htet Yin	110-115 DAS
Thee Htet Yin	110-115 DAS		

Salinity tolerant ability of rice differs during growth stages and 1 DAS, 15 DAS and at flowering stage, rice plants are very sensitive to salinity, however, rice plants are tolerant to salinity at 30 DAS and 45 DAS. Realizing on this point, farmers can adjust the time of sowing to critical sea water intrusion period.

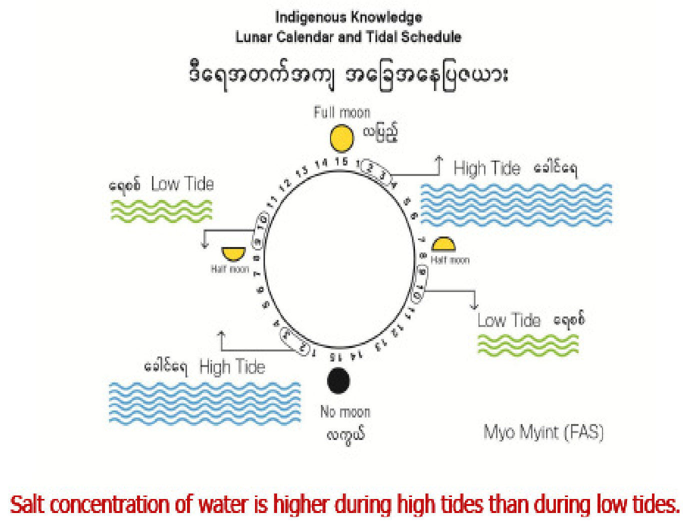

Figure 4. Irrigation based on Lunar Calendar

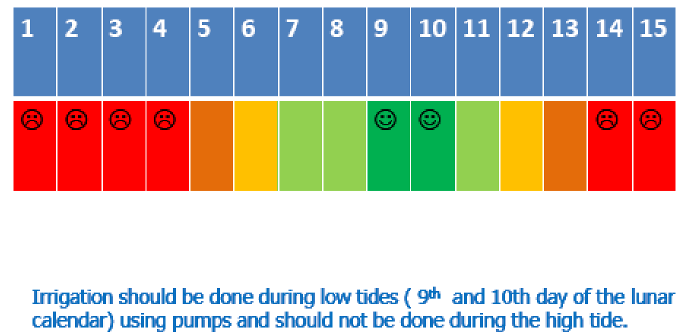

Figure 5. Lunar Calendar and safe time for irrigation

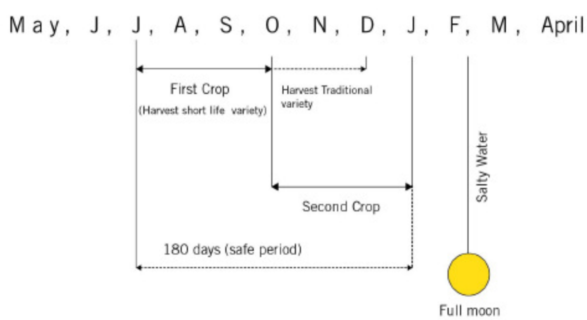

Figure 6. Strategy for double cropping in salt intrusion area

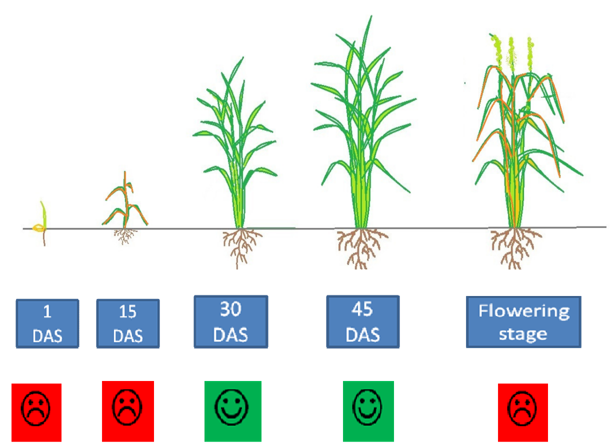

Figure 7. Salinity tolerance of paddy during growth

Figure 8. Recommended Irrigation Method during the Low Tide using pumps

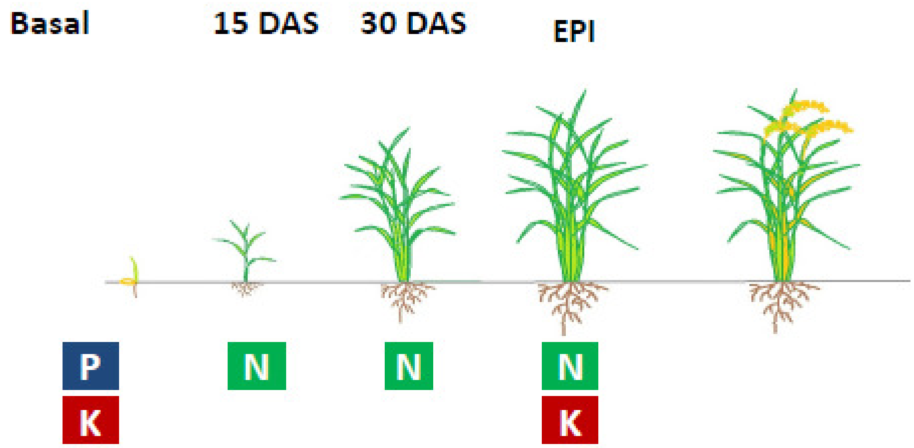

Figure 9. Balanced fertilizer application for rice

Yetagon NGO also suggested one time P fertilizer application at basal, two times split K application at basal and EPI, three times N application at 15 DAS, 30 DAS and EPI.

Department of Agricultural Research (DAR) has tested rice breeding lines under three levels of EC and obtained some promising rice varieties (Figure 10, Table 2 and 3). Breeding lines were tested on both station and on farm.

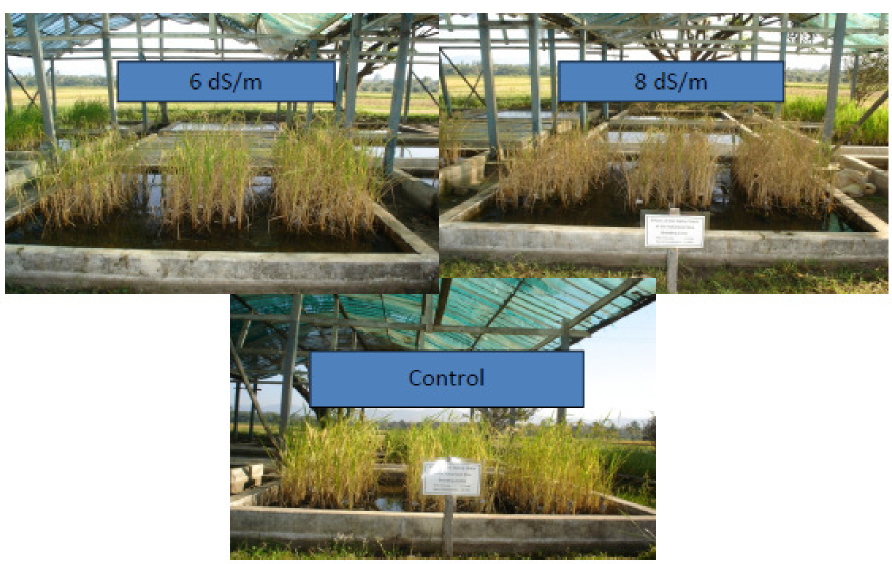

Figure 10. Breeding lines under three levels of EC at Research Station, Department of Agricultural Research (DAR)

Table 2. Average yield of tested rice varieties

No.	State / Division	Yield (t ha⁻¹)				
		IR84649-308-24-1-B	IR 10T-107	CSR 36	IR846495-305-6-1-B	Pokkali
1	Sagaing	1.23	1.34	1.83	1. 72	1.07
2	Thanintharyi	0.68	2.34	2.34	2.15	0. 78
3	Bago east	3.15	3.50	2.11	2.80	1.32
4	Magwe	4.25	2.98	2.42	2.42	1.86
5	Mandalay	2.31	4.56	4.11	2. 77	3.30
6	Mon	0.27	0.06	0.19	0.50	1.39
7	Yangon	3.68	3.42	1.63	3.41	2.11
8	Rakhine	0.67	1.24	0.81	0. 74	1.05
9	Aeyarwady	2.43	2.57	3.08	1.89	1.64
	Average	2.02	2.44	2.31	2.04	1.65

Table 3. Characters of promising rice varieties

No.	Characters	IR84649-308-24-1-B	IR 10T- 107	CSR 36	IR84645-305-6-1-B	Pokkali
1	Maturity days	123	124	109	124	140
2	Plant height (cm)	111	113	108	110	162
3	Effective tillers per hill	11	13	14	11	11
4	Total grain per panicle	152	117	150	124	110
5	Filled grain per panicle	90	93	92	93	96
6	1000 grain weight (gm)	25.1	24.5	25.2	29.8	24.2
7	Yield (t /ha)	3.65	4.55	4.1	3.4	3.25
9	Amylose Content (%)	30.5	24.55	23.61	30.10	30.40
10	Gel Consistency (mm)	31.00	29.50	31.50	31	50.00
11	Gelatinization Temp.	2.0	5.25	5.91	2.0	4.41
12	Salt tolerance	6 dS/m	6 dS/m	6 dS/m	6 dS/m	9 dS/m
13	Suitable place	Inland salinity areas and coastal and delta areas				Check-variety

A research team of Soil and Water Science Department, Yezin Agricultural University conducted an experiment to classify the types of salt-affected using indicators of pH, ECe and SAR. According to FAO (1988), these indicators were used to determine the collected soil samples were whether salt affected or not. Table (4, 5) showed the results and some physic chemical properties of soil samples.

Table 4. Classification of the collected soil samples as salt affected soils using pH, EC and SAR data

Soil	pH(1:2) (soil :water)	ECe(dS/m)	SAR	Remarks
S1	7.4	0.4	0.833034	Non-saline,Non-sodic
S2	8.8	1.6	5.413073	Non-Saline, sodic
S3	8.3	3.7	16.78627	Slightly saline,Highly sodic

Table 5. Some physical and chemical properties of the collected soil samples

soil type	BD (g/cm3)	PD (g/cm3)	Porosity (%)	OM (%)	Sand (%)	Silt (%)	Clay (%)	pH (1:5)	AS
S1	1.40	2.57	43.12	1.60	56	19	25	6.7	0.39
S2	1.50	2.25	33.16	1.94	35	36	29	9.2	0.65
S3	1.57	2.25	30.39	1.60	58	9	33	9.0	0.34

*BD= Bulk Density, PD=particle Density, OM= Organic Matter, AS=Aggregate Stability

Comparison of saturated hydraulic conductivity for salt-affected soils before applying amendments

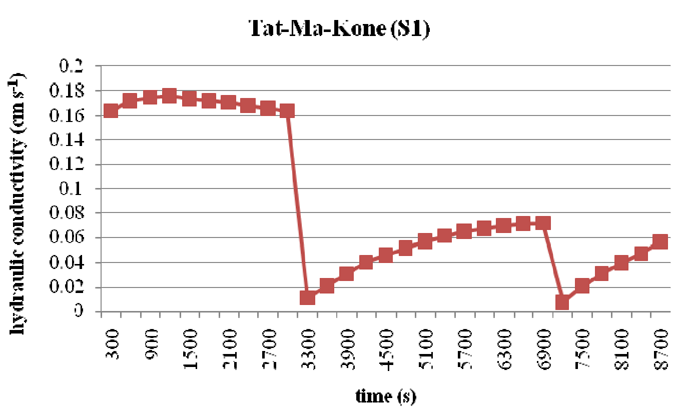

Figure 11.Saturated hydraulic conductivity of S1 soil before applying amendments.

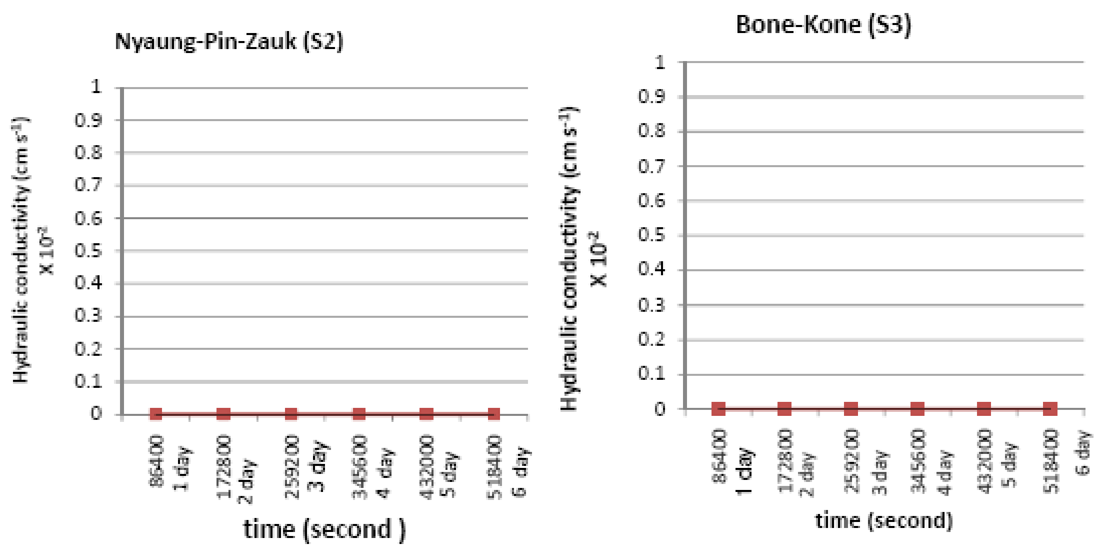

Figure 12.Saturated hydraulic conductivity of S2 sand S3 soil before applying amendments.

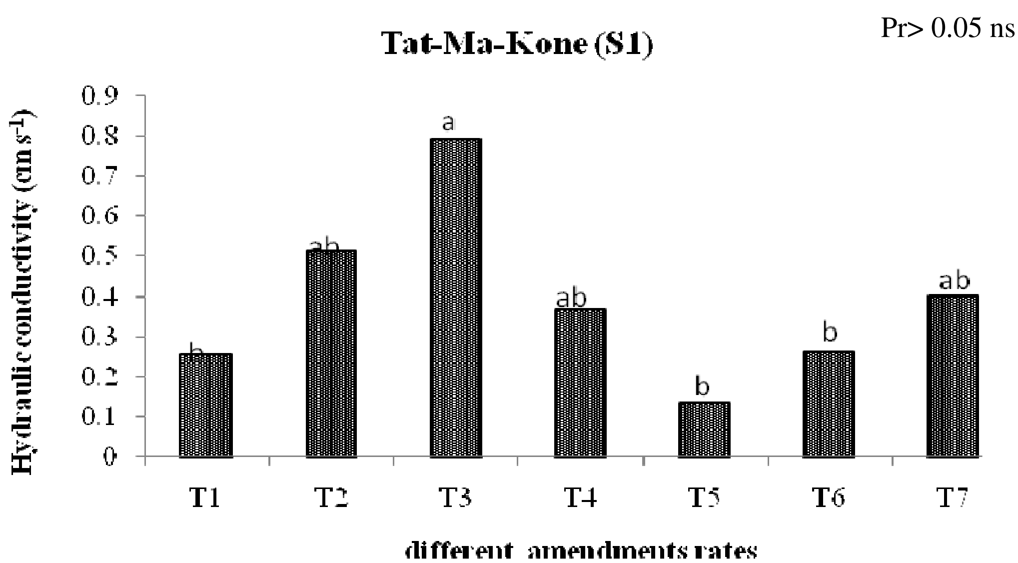

Figure 13. Effect of different amendments rates on saturated hydraulic conductivity of S1 soil.

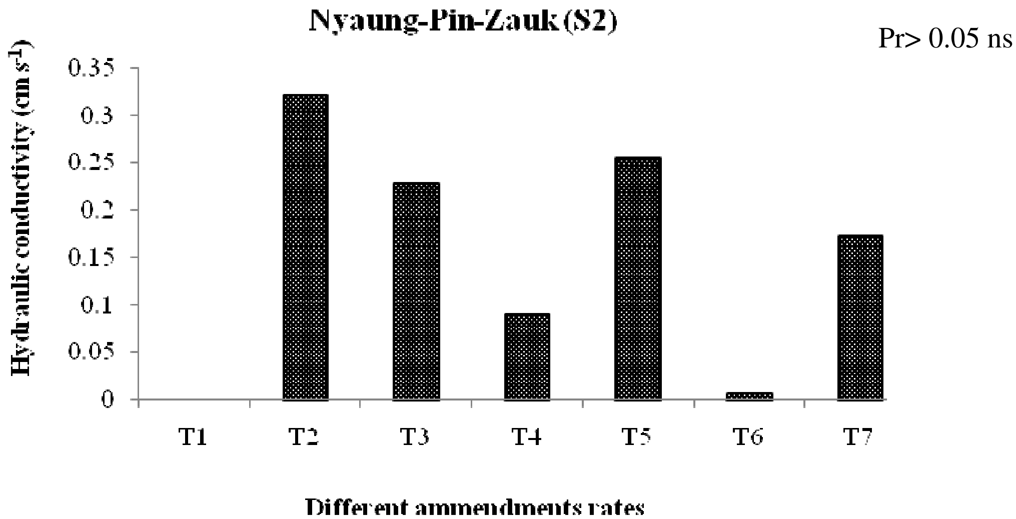

Figure 14. Effect of different amendments rates on saturated hydraulic conductivity of S2 soil.

Figure 12 showed that no water can penetrate through soil S2 and S3 before applying soil amendments based on hydraulic conductivity values of these soils. Dane et al (2005) discussed that hydraulic conductivity was very much dependent on soil structure, i.e., on the occurrence of aggregates and/or cracks.

However, Figure 13, 14 and 15 showed the effect of different amendments and their rates on hydraulic conductivity values of three soils.

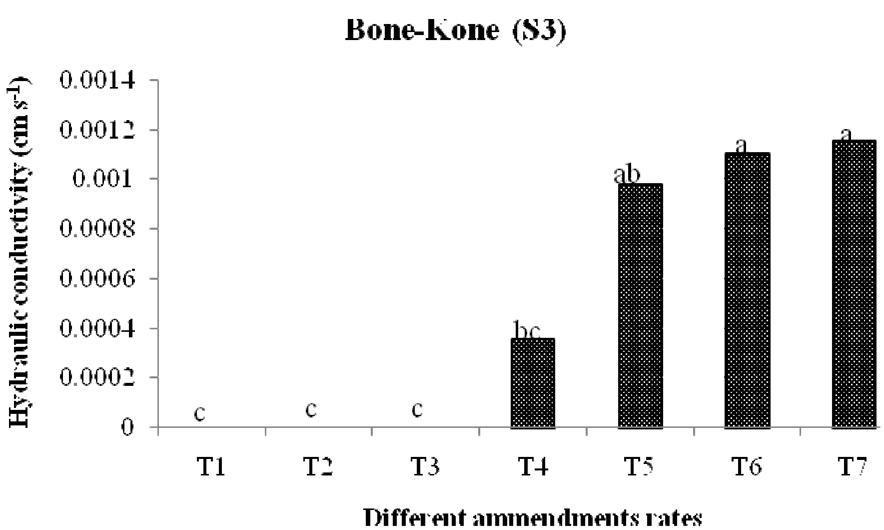

Figure 15.Effect of different amendments rates on saturated hydraulic conductivity S3 soil.

According to different amendments rates, there was no statistically significant difference on saturated hydraulic conductivity of two soils (S1) and (S2). However, (S3) showed that there was a highly significant difference at 1% level due to application of different amendments rates. For S1and S2, T2 (10 ton cow dung ha^{-1}) amendment rate was well enough to improve soil physical properties based on costs.

For S3, there was no improvement in soil hydraulic conductivity till the addition of cow dung manure at the rate of 15 t ha^{-1}. Although there was a highest saturated hydraulic conductivity due to the application gypsum at the rate of 6 t ha^{-1} gypsum (T7), application of gypsum at 4 t ha^{-1} gypsum (T6) and T5(2 t ha^{-1} gypsum) were not statistically different with T7. With the consideration of the economic point of view, application of T5 (2 t ha^{-1} gypsum) would be appropriate for farmers.

Conclusion

Integrated approaches such as indigenous knowledge, salt-tolerant crop, leaching salt, applying acid forming fertilizer or amaendments, improved cultivation practices are essential for reclamation of salt-affected soil. Moreover, it is needed to classify which type of salt-affected soil first and then the proper method should be considered.

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