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Characteristics of saline soil and effect of fertilizer application to rice yield

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Abstract

Characteristics of saline soil determine the rice yield along the seaboard. High concentration of dissolved salt decreases growth and rice yield. The study aimed to evaluate physical and chemical characteristics of saline soil in Sidoarjo and Surabaya, East Java, Indonesia. The result analysis of soil exchangeable Na^+, K^+, Ca^{++}, and Mg^{++}respectively was 0.8-1.94; 0.33-2.73; 16.32-20.4, 1.83-8.88 me.100g^{-1}.The value of soil pH was 7.35- 7.55, EC value of soil was 0.64-1.83dS.m^{-1}, and the content of organic-C was between 1.1-2,4,6 %. The result of soil characterization was then crosschecked with the rice yield in saline soil by weighing dry rice grains per clump. The rice yield was 3-4.1 ton.ha^{-1} and negatively correlated to the exchangeable values of Na, SAR, bulk density and dust content. It was positively correlated with organic-C, fertilizer, exchangeableof Ca^{++}, Mg^{++}, and K^+, as well as soil's CEC. The ratio value of Ca:Mgnamely2.2-8.2, and K:Mgnamely0.18-0.21 exceeded the limit of ideal value and caused low production. The rice yield was negatively correlated with the content of *exchangeable*Na^+, values of pH and EC. It achieved more than 4 ton.ha^{-1}when added with 300-450 g.plant^{-1} of organic materials and 1.0-1.3 g.plant^{-1} of NPK.

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Introduction

Approximately 67% of agricultural area is temporarily associated with salinity (Rengasamy, 2006). Salinization is the accumulation of water-soluble salt in soil solum or regolith to a level which endangers agricultural production, environmental health, and welfare. Characteristics of saline soil include electrical conductivity (EC) > 4 $dS.m^{-1}$, pH< 8, and Exchangeable Sodium Percentage (ESP) < 15 (Allotey *et al.*, 2008). Sodicity and salinity are able to affect the component of soil organic materials and the conductivity level is different between saline and non-saline soils (Peinemann *et al.*, 2005). Low soil's salinity significantly increases Internal Efficiency of Potassium (IEP), rice yield (nearly 20%), and 1000-seed weight. When salinity and water are limited, high nutrition supply for soil produces rice maximally 80% (Clermont-Dauphin *et al.*, 2010).

Physical and chemical characteristics of saline soil in Sidoarjo are varied and determined by the distance from beach. The content of exchangeable Na is high near the beach and it decreases along with the distance from beach (Maroeto *et al.*, 2007). Soil's Exchangeable Salinity level (EC), ESP value, and Na are generally higher, approximately 2.5 $me.100g^{-1}$ in paddy soil than in non-paddy one (Maroeto *et al.*, 2007; Rachman *et al.*, 2008) due to plots which tend to restrain saline water and mud, particularly on the surface layer (0-10 cm). Jumberi and Yufdy (2007) found out that tsunami with its salt concentration contributes impacts on the growth decrease and the yield of cereal plants and vegetables. Irrigation water with high Na^+ facilitates the increase of osmotic potency and particular ionic concentration which restrict plant's metabolism and affect soil structure (Evangelou and Mcdonald, 1999). Na ions with weak positive charge which are inadequate to neutralize negatives charges of clay particles will produce soil with no gel structure, poor aeration, aggregate dispersion, slow permeability and low capacity of water hold, contaminant to several plants in high concentration, limited water absorbance, and they usually start toxicity (Bohn *et al.*, 2001; Rengasamy, 2006). Symptoms of Na toxicity can be observed when sensitive leaves contain approximately 0.25% of Na, the leaves are tip burn, there are necrotic spots, and the leaf extension is limited. They reduce plant's photosynthesis and yield (Bernstein, 1975; Neumann *et al.*, 1988), increase the leak of potassium, and decline root extension (Nakamura *et al.*,1990), trigger the antagonist effect on Ca and Mg absorption since Na replaces Ca from the membrane of root cell (Yermiyahu *et al.*, 1997).

Sebastian (1977) found out that rice yield cultivated on saline soil in Philippines around 1.967-3.400 $tons.ha^{-1}$ (3.925 -7.580 $tons.ha^{-1}$on non-saline soil), the plant height is 77- 90 cm, the tillers are 16-19. The application of organic fertilizer is 20-30 $tons.Ha^{-1}$, gypsumis 6-9 $tons.ha^{-1}$ (Mindari *et al.*, 2009), as well as gypsum with H_2SO_4 (Niazi *et al.*, 2001) which declines soil salinity. Remediation with organic materials is significant in the 2% salt-level soil (Cha-um and Kirdmanee, 2011). Organic Matter (OM) remediation before planting RD6 rice (*Oryza sativa* L. *spp. indica*) initiates Chlorophyll-A pigment and the total of chlorophyll is greater than that without organic matter treatment. Gypsum application—either with manure or not, and humic acid decrease soil pH (8.26%), electrical conductivity (14%), and sodium adsorption ratio (13%). However, they increase root length (25%) and rice yield (14%). There is significantly negative correlation among root length and EC, SAR, (each r = –0.93; –0.94,$P \leq 0.05$), while the positive correlation and significant are with the rice yield (r = 0.96; $P \leq 0.05$) (Shaaban *et al.*, 2013). Managing location-specified nutrient needs to consider soil's capability in providing nutrient naturally for irrigated lowland rice (Dobermann and Fairhurst, 2000; Witt and Dobermann, 2002). The abundance of saline soil in East Java provides opportunities for rice production. In order to maximize rice yield in saline soil field, the basic data regarding saline soil characteristic and its cropping strategy become important. The study aimed to investigate characteristics of saline soil and rice cropping system, as well as their correlation between characteristic variable and yield. The highest correlation of rice yield toward characteristics of saline soil becomes the consideration on the next saline soil management and rice cultivation.

Material and method

Location and Soil Sampling

The study was conducted in April-July 2012 in saline soil, Sidoarjo and Surabaya, East Java, Indonesia. Sidoarjo

Regency is a delta plain with 0-25 m elevation, located on 112 5'-112 9' of East Longitude, and between 7 3'-7 5' South Latitude. Saline land is in the east part with 0-3 meter elevation from sea level, in the tropical climate with two seasons namely dry season in June-October and wet season in November-May, at the temperature between 20-35^{o}C, with the soil type namely gray alluvial and vertisols.

Soil samples were randomly taken from seven farm soil locations in Sedati District, Sidoarjo and Surabaya. On the 40x80 m^2 plot in each location, samples were taken with 3 replications on the different spot and then made into composite. Firstly, the organic waste was removed from the soil, then the soil sample was taken from 0-20 cm depth. The sample of disturbed soil was taken by a drill and made into composite to have analyses of soil's chemical and physical characteristics. Whole soil sample was taken by stainless steel ring for soil's permeability, bulk density, and specific gravity analyses.

Samples of disturbed soil were air-dried, then sifted with 2 mm sifter for analyses of soil texture, pH, and EC. Samples of dry soil were sifted by 0.5 mm diameter of sieve hole to analyze chemical characteristics of soil including exchangeable base, CEC, and soil's organic-C. Whole soil sample was soaked in water with 2-cm depth to saturate soil's pores for the preparation of soil permeability analysis.

Physical Characteristics of Soil

Physical characteristics of soil were evaluated on the contents of sand, ash, silt (soil texture), soil's permeability, bulk density (BD) and specific gravity (SG). The bulk density and specific gravity were analyzed by gravimetric method for each, namely by weighing soil baked at the temperature of 105^{o} C then divided by soil's total volume and density volume. Soil texture was analyzed by turbidimetry method for soil particles which passed 2 mm sieve and was dispersed by HCl and hydrogen peroxide. Soil permeability was analyzed by hydraulic conductivity method on samples of undisturbed soil.

Chemical Characteristics of Soil

Chemical characteristics of soil were evaluated on the values of EC, pH, exchangeable base, CEC, C-organic content, N-total and available P. EC and pH values were analyzed in soil paste 1:2 (soil : distilled water) then the soil paste was measured by pH meter and EC meter at a temperature of 25^{o}C. C-organic content was determined by Walkey dan Black method. Values of CEC and exchangeable base were analyzed by the saturation of ammonium acetate 1 *N* pH 7. Next, the exchangeable contents of Na^+ and K^+ were measured by flame photometry while the exchangeable Ca and Mg were measured by the titration of EDTA 0.1 N. The value of Sodium Absorbance Ratio (SAR) was calculated by dividing exchangeable Na^+ with the root of Ca^{++} + Mg^{++} divided by 2 (SAR = $Na/\sqrt{(Ca + Mg)/2}$). The measurement of base was applied to calculate the ratio of Ca:Mg and K:Mg.

Cropping System and Rice Production

The rice yield from saline soil is highly determined by technology input and soil's natural condition. The information on technology input in rice cropping system on saline land of Sidoarjo and Surabaya was obtained by interviewing farmers about the rice field area, planting distance, usage of varieties, application of fertilizer dosage, irrigation system, and soil management.

Data of rice cropping system in farmers' saline farm land were obtained by interviewing them about the rice field area, planting distance, plant varieties, irrigation system, and administration of fertilizers in terms of dosage, type, and delivery technique. The planting distance is applied to calculate the number of plant per planting area, the number of fertilizer for each plant, and the calibration of production per hectare.

The rice yield per family was analyzed by weighing samples of dry rice granules baked at a temperature of 70^{o} C for 24 hours. This value was calibrated by the number of plant per hectare (ton.ha^{-}), then multiplied by one hectare area divided by planting distance (rice yield = gram plant/clump x 1 ha/planting distance). The conversion of NPK fertilizer from kg.ha^{-1} into g.plant^{-1}, that of organic matter per ton.ha^{-1} into kg.plant^{-1} aimed to study the influence of adding nutrition total instead of physical and chemical characteristics.

Data Analysis

The analysis result of chemical-physical characteristics was summarized in table and graphic, and interpreted into the criteria of soil salinity level. The measurement result of exchangeable base was applied to calculate the ratio of Ca:Mg and K:Mg. The analysis result was cross-checked with the rice yield to investigate factors limiting rice production. Supporting secondary data were those of rainfall, evaporation, study's location area map and the land usage.

Result and discussion

The result analysis of chemical and physical analysis of saline soil in several areas of Sidoarjo and Surabaya was presented in Table 1. The average value of soil's EC was less than 2 dS.m and SAR was less than 14. It is included in non-saline soil according to Abrol *et al*., (1988) in which effects of salinity are negligible. The average value of soil's EC was low since samples were taken in the end of rice planting season and of wet season, in which the planting system of lowland rice could dilute and drain the concentration of salt solution; thus, it declined EC value.

The analysis result of exchangeable Na^+, K^+, Ca^{++}, dan Mg^{++} from farmland samples in saline soil, Sidoarjo and Surabaya was 0,8-1,94; 0,33-2,73; 16,32-20,4, 1,83-8,88 $me.100g^{-1}$ respectively.The value of soil pH was 7.35- 7.55, soil EC was 0.64 –1.83 $dS.m^{-1}$, C-organic content was between 1,1-2,4,6 %. Na cation generally dominates saline soil, but this salt is easily removed from the soil due to the weak soil-colloid bond when washing takes place via irrigation or rainfall precipitation. K, Ca, and Mg salts are required in different range of concentration. Potassium would compete with sodium in ionic adsorption by soil's colloid and by root. When Na^+ dominated colloid's surface, it disturbed K^+ availability. Potassium was more required by plants than calcium and magnesium. However, its availability in soil was smaller than Ca^{++} and Mg^{++} so its availability was also low for plants. Those conditions allegedly happened since the mobility of monovalent ions was higher than bivalent ones, causing their availability near the surface to reduce. The same result was obtained by Abrol *et al*., (1988).

Table 1. Average in Analysis Result of Saline Soil's Physical and Chemical Characteristics.

	Saline Soil, the origin of village						
	Betro, Sedati	Kragan, Sedati	Kwangsan, Sedati	Buduran, Buduran	Darmasi, Buduran	Gunung Anyar 1	Gunung Anyar 2
Soil's physical characteristics							
Permeability ($ml.h^{-1}$)	1,72	1,38	2,32	35,8	36,30	2,2	25,5
BD ($g.cm^{-3}$)	1,24	1,21	1,21	1,1	1,2	1,27	1,23
SG ($g.cm^{-3}$)	2,35	2,21	2,35	2,10	2,18	2,30	2,33
Texture	clay	clay	clay	sandy clay loam	sandy loam	clay	clay
Sand (%)	2,00	2,00	26,00	45	52	14	14
Silt (%)	43,00	51,00	32,00	20	26	26	24
Clay (%)	55,00	47,00	42,00	35	22	60	62
			Soil's chemical characteristics				
pH	7,50	7,55	7,40	7,45	7,35	7,55	7,50
EC ($dS.m^{-1}$)	1.18	1.23	1.20	0,99	0,64	1.77	1.83
Redox,	58,00	52,00	94,00	48,00	45,00	50,00	58,00
Exchangeable base							
Exch.Ca ($cmol.kg^{-1}$)	18,84	16,32	17,00	17,77	18,26	19,40	20,40
Exch.Mg($cmol.kg^{-1}$)	3,24	1,83	3,12	8,07	8,88	4,30	3,80
Exch. Na ($cmol.kg^{-1}$)	1,94	1,46	1,87	1,80	1,80	0,90	0,80
Exch. K ($cmol.kg^{-1}$)	0,60	0,33	0,57	2,08	2,03	2,60	2,73
CEC ($cmol.kg^{-1}$)	43,80	40,30	44,00	48,33	43,2	48,22	52,95
Ca:Mg	5,82	8,94	5,45	2,2	2,06	4,51	5,37
K:Mg	0,18	0,18	0,18	0,26	0,23	0,21	0,21
C-organic (%)	1,1	1,3	1,2	0,9	1,51	2,46	1,58

The value of permeabilitywas between 1,38-36,30 $ml.h^{-1}$, while bulk density (BD) and specific gravity (SG) were 1,1 - 1,27 $g.cm^{-3}$and 2,10- 2,35 $g.cm^{-3}$respectively.

When it was crosschecked with the cropping system and rice yield in those areas as presented in Table 2, the best rice yield will occur if the nutrition intake through organic and inorganic fertilizers is appropriate with the plant's need, neither more nor less. In this study, the application of organic fertilizer was 111.11-166.67$g.plant^{-1}$(10-20 $tons.ha^{-1}$) and NPK was 0.91-1.08$g.plant^{-1}$(100-150 $kg.ha^{-1}$) resulting 4.08-4.1 $ton.ha^{-1}$of rice. This rice yield was higher than that with the application of NPK only (without organic fertilizer) namely 1.49-1.59 g.plant-1, or than that with the application of too high NPK and organic fertilizer namely 23.34 and1953.13 g.plant^{-1}for each (Gunung Anyar village). The combination of appropriate organic and inorganic fertilizers contributed to better result than the application of inorganic fertilizer only. After the need of N was satisfied, the chlorophyll assimilation increased and carbohydrate synthesis did as well. The same result also applied in Cha-um *et al.*, (2011) in which administering 20-30 ton.Ha^{-1}of organic fertilizer in saline soil before planting RD6 rice results in higher pigments of Chlorophyll-A and chlorophyll total of plants than those without organic matter, mainly in high level of salt (1-2%). Meanwhile, Shaaban *et al.*, (2013) found out that either the application of manure or not with commercial humic acid is positively significant correlated with rice yield (r = 0.96; $P \leq 0.05$). Applying 10 ton.ha^{-1}of manure + 200 kg.ha^{-1}of urea + 100 kg.ha^{-1}of SP36+100 kg.ha^{-1}of KCl significantly increase plant's height, number of tillers, yield to 77.62% (Rochmah, 2001).

Table 2. Application of Fertilizer and Rice Production in Saline Soil, Sidoarjo and Surabaya.

Fertilizers	Saline soil, the origin of village						
	Betro, Sedati	Kragan, Sedati	Kwangsan, Sedati	Buduran, Buduran	Darmasi, Buduran	Gunung Anyar 1	Gunung Anyar 2
N (g.plant^{-1})	0,89	0,95	0,63	0,89	0,89	13,96	0,51
P (g.plant^{-1})	0,41	0,44	0,33	0,41	0,41	6,45	0,28
K (g.plant^{-1})	0,19	0,20	0,13	0,19	0,19	2,93	0,13
Total of NPK g.plant^{-1}	1,49	1,59	1,08	1,49	1,49	23,34	0,91
Total of Organic Fertilizer (g.plant^{-1})	0,00	133,33	111,11	0,00	0,00	1.953,13	166,67
Rice yield (ton.ha^{-1})	1,52	1,76	4,08	2,30	2,50	3,40	4,10

Higher NPK fertilizer resulted in its low availability due to washing, evaporation, or another cation absorption. The nutrition of N-NH_4 would be absorbed by metal or mineral and it turned to be unavailable or evaporated since volatilization and N-NO_3 were easily washed into lower surface. Higher organic fertilizer is actually beneficial since it improves physical characteristics of soil. However, in rice cropping system it is assumed that the fertilizer accelerates permeability which further reduces water availability for plants.

Table 3. Correlation between parameters of soil's chemical characteristics and rice yield.

	C-org (%)	EC (dS.m^{-1})	pH	NPK	Organic Fertilizer (kg.ha^{-1})	Eexchangeable (meq.100g^{-1})				CEC (meq.100g^{-1})	SAR
						Ca^{++}	Mg^{++}	K^{+}	Na^{+}		
Rice yield (ton.ha^{-1})	0.41	0.09	-0.58	0.16	0.31	0.23	0.20	0.36	-0.19	0.44	-0.23

Adding organic matters is expected to cover up salt cation so that its concentration in solution is declined and the availability of nutritive ions is improved (Dobermann and Cassman, 1997, Bohn *et al.*, 2001). Another effect of adding organic fertilizer was to reduce soil pH only 1 unit, but other changes in soil's characteristics were not clear. Meanwhile, Shaaban *et al.*, (2013) revealed that soil pH declines 26%, electrical conductivity declines 56%, sodium adsorption ratio declines 56%, and root length increases 140%. There was negatively significant correlation among root length and EC, SAR (r = −0.93; −0.94, $P \leq 0.05$ for each). Farmland with NPK instead of organic fertilizer caused soil pH still high, low redox and low production, namely < 4 ton.ha^{-1}.

Table 4. Correlation between parameters of soil's physical characteristics and rice yield.

	CEC (cmol.kg-1)	Permeability (ml/h)	BD (g.cm^{-3})	SG (g.cm^{-3})	Sand (%)	Silt (%)	Clay (%)
Rice yield (ton.ha^{-1})	0.44	0.46	-0.05	0.20	0.44	-0.58	-0.16

Adding Ponska dan SP 36 fertilizers increased P availability so that the P rice absorption improved as well as the rice yield. The C-organic content and clay percentage were expected to affect the soil's ability in absorbing and release nutrition; thus, they determined the nutrition availability within soil and indirectly affected rice yield. The curve graphic of result correlation on the clay and C-organic content was low, showing low correlation. When it was related to high nutrition absorption, CEC, clay, and C-organic content, however, it resulted in high CEC for representative soil around 50 $cmol.kg^{-1}$ and 40 $cmol.kg^{-1}$ for the lowest (Fig.1).

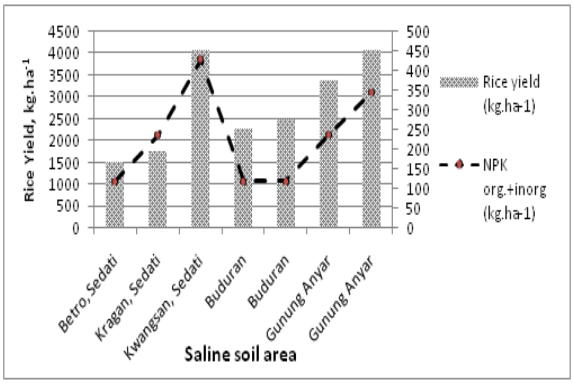

Fig. 1. The relation between NPKand Rice Yield.

When related to the cation equilibrium, amongst Ca, Mg, Na and K, the ratio values of Ca:Mg, K:Mg, and SAR were more than optimum range, in which their availability disturbed another nutrition's' availability. The previous data revealed that cation ratio was 4-5, but now it has been higher due to management model above. This ideal ratio was necessarily maintained either through adding buffer or potassium so that the cation reached equilibrium.

Balanced additional organic and inorganic fertilizers become the key point in managing farmland so that it can absorb (Na) or cover up (Ca, Mg, dan Fe) so that the availability within soil does not disturb another nutrition. A significant environment influence in saline soil cultivation is to maintain the dynamic of salt solution which always alters between dry and wet seasons due to seawater intrusion or usage of irrigation water bringing the salt solution. Therefore, it is necessary to find an alternative for soil improvement which allows for controlling the salt excess in order to keep the concentration appropriate for plant growth.

Regardless the influence of fertilizer, when rice yield was correlated to the physical and chemical characteristics of soil, parameters limiting production were the exchangeable Na, Sodium Absorbance Ratio (SAR), and soil pH (Table 3). The rice yield was declined by the increase of soil salinity criteria although the salinity of representative soil was in a low category (< 2 $dS.m^{-1}$) where the rice yield category was low (1.52- 4.1 $ton.ha^{-1}$). The same result was obtained by Sebastian (1977) who identified that the yield of rice planted in saline soil, Philippine, is lower (1.967-3.400 $ton.ha^{-1}$) than that in non-saline soil (3.925-7.580 $ton.ha^{-1}$). Higher Na in solution of soil would suppress Ca, Mg, and K causing the availability to hinder another micro cation such as Fe. Soil salinity caused salt cation to hinder soil adsorption site so that it obstructed the absorbance of another nutrition into plants, disturbed the absorbance of nutrition and water, resulting in the decline of biomass' and granule's dry weight.

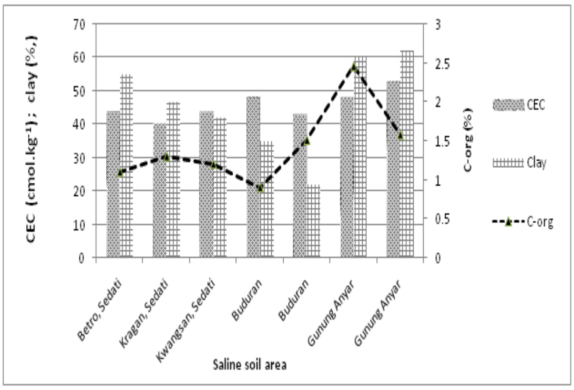

Fig. 2. Relation between CEC, Clay and C-org.

The relation between soil's Cation Exchange Capacity (CEC) value and yield was presented in the Fig.2, in which exchangeableCa^{++} value was between 17-20 $cmol.kg^{-1}$, exchangeable$Mg^{++}$was< 5 $cmol.kg^{-1}$ providing a better result than that of higher or lower value. The average of Ca/Mg ratio was 4.5-5.5 producing higher rice yield than higher or lower ratio while K/Mg ratio was confusing.

Rice yield positively correlated with soil's physical and chemical characteristics in the following order: permeability > CEC > texture of sand > organic-C > organic fertilizer > exchangeable K > NPK > exchangeable Ca > soil's exchangeable Mg. Also, it was definitely affected by soil's ability to hold or allow water (permeability) so that water supply for rice was adequate up to harvest time. Cation Exchange Capacity was absolutely determined by clay percentage and organic matters. When the two components were reduced, the management of nutrition for plants was also hindered. Organic-C became significant since the abandoned humic acid would help in control of absorption and release of nutrition, water, microbes into plant's root and make its growth better. Even thougha considerable amount of organic fertilizer was administered, unless it was fully mature, it would disturb the proses of providing nutrient, even become toxic for microbes. This probably happened in soil of GunungAnyar village (Fig.3).

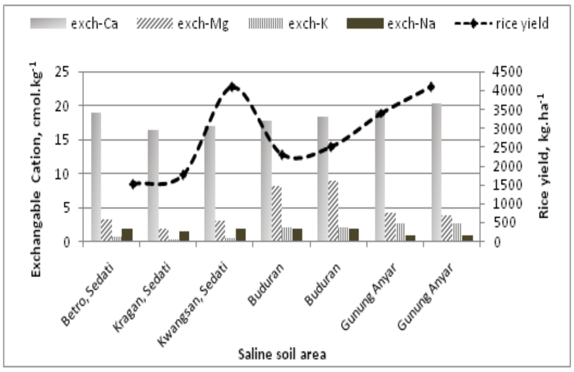

Fig. 3. Correlation between Rice Yield and Exchangeable Cation on saline soil.

The type of soil texture in Sedati and Gununganyar villages was clay, whereas Buduran's soil was sandy clay loam. The soil's C-organic content was 1.5- 2.46% and the clay was 1.1-1.58, and that of Buduran was 0.9-1.51. Therefore, the clay content and organic matters determined soil capability in holding nutrition and water (CEC). Such condition resulted in saline soil originated from Gununganyar and Kragan or Kwangsan (Sedati). The result of regression analysis and the correlation between clay and organic-C toward yield were indeed low. However, high yield was obtained when the clay content was > 40% and organic-C was 1.5%, based on CEC content. The existence of soil's cation was correlated with the value of soil's EC, in which higher content of soil's base cation resulted in more improved soil's EC (Fig2). The clay content and value of BD restrained rice growth (Table 3). The correlation of cation ratio and rice yield from 7 samplings of representative soil was certainly high, namely r value = 0.9 in line with Landon, 1984. This ideal ratio is necessarily maintained or supported by buffer so that the environment change does not affect cation equilibrium. Adding Ponska and SP 36 fertilizers also increased the availability of P so that P absorption of rice was supposed to boost and then it was indicated by the improvement of rice yield. Adding organic matter almost did not change soil's SG since the texture was not affected by organic matters.

The average of permeability was slow but that of inner layer was faster. The value of soil's BD was 1.1-1.2 showing that the porosity was small and soil's SG (around 2.2) indicated the dominating type of heavy particle, namely clay. The value of soil permeability changed in line with the addition of organic matters which reduced water flow rate and improved soil aggregation so that Na's dispersion influence was declined.

Almost all of soil's physical characteristics are the same. However, different management of fertilizer admiration changes the ratio of soil's cation affecting the balance change of soil's nutrients. Having compared to the condition three years ago, the farmland in Sedati village had cation ratio 4-5, but now it has changed depending on the difference in soil management. Adding organic matters was supposed to improve Na^+ absorption so that it released another absorbed cation which caused the balance in solution to increase. Providing mature organic matters would control cation balance better so that its availability would be ideal for plant growth. Higher Na^+ in soil's solution would suppress Ca^{++}, Mg^{++}, and $K^+$and restrain its availability.

Conclusion

Saline soil characteristics restraining rice yield was the exchangeable Na, pH, and SAR. The rice yield was highly determined by permeability, CEC, organic-C and nutrition from organic and inorganic fertilizers. The rice yield of saline soil was approximately 4 $ton.ha^{-1}$,obtained by cropping system in which applied 10-20 $ton.ha^{-1}$ (±166,67 $g.plant^{-1}$) of organic fertilizer, 150 $kg.ha^{-1}$ (±1,08 $g.plant^{-1}$) of NPK, cation ratio of Ca:Mg near 3, soil pH around 7.5, and EC around 1,3 $dS.m^{-1}$. The value of rice yield was in low category compared to that of non-saline soil.

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References

Abrol IP, Yadav JSP, Massoud FI. 1988. Salt Affected Soil and their managemen. FAO, Rome.

Allotey, DFK, Asiamah RD, Dedzoe CD, Nyamekye AL. 2008. Physico-chemical properties of three salt-affected soils in the lower Volta Basin and management strategies for their sustainable utilization. West African Journal of Applied Ecology **12,** 1-14.

Bernstein L. 1975. Effect of salinity and sodicity on plant growth. Am. Rev. of Phytopathol. **13,** 295-311.

Bohn H, McNeal BL, O’connor GA. 2001. Soil Chemistry, Third Edition. John Wiley and Sons. Inc.

Cha-um S, Kirdmanee C. 2011. Remediation of salt-affected soil by the addition of organic matter - an investigation into improving glutinous rice productivity. Sci. Agric. (Piracicaba, Braz.) **68(4),** 406-410.

Clermont-Dauphin C, Suwannang N, Grünberger O, Hammecker C, Maeght JL. 2010. Yield of rice under water and soil salinity risks in farmers’ fields in northeast Thailand. Field Crops Research **118,** 289–296..

Dobermann A, Cassman KG. 1997. Nutrient efficiency in irrigated rice cultivation. In: Plant Nutrition in 2000. IFA Agro-Economics Committee Conference, 23-25 June 1997, Tours, France, IFA, Paris.

Dobermann A, Fairhurst T. 2000. Rice: Nutrient Disorders & Nutrient Management. Potash and Phosphate Institute of Canada and International Rice Research Institute. IRRI.

Evangelou VP, Mcdonald Jr. LM. 1999. Influence of Sodium on Soils of Humid Regions. In: Handbook Of Plant And Crop Stress (Ed. Pessarakli M), Marcel Dekker, Inc.

Jumberi A, Yufdy MP. 2007. Potensi penanaman tanaman serealia dan sayuran pada tanah terkena dampak tsunami. Balai Penelitian Tanah Rawa dan Balai Pengkajian Teknologi Pertanian Sumatra Utara.

Landon. 1984. Booker tropical Soil Manual. United state of America. Longman, New york, Academic Press.

Maroeto M, Arifin, Sutoyo. 2007. Identifikasi dan diagnose sifat kimia tanah salin untuk kesesuaian tanaman Cemara Udang (*Casuarina equisetifolia*). Jurnal Pertanian Mapeta **1(10),** 13-23.

Mindari W, Maroeto, Syekhfani. 2009. Efek Pemberian Air Salin Rekayasa Pada EC Tanah DenganAmelioran Bahan Organik. Pros. Sem. Nas. FP dan LPPM UPN "Veteran " Jatim, Surabaya.

Nakamura Y, Tanaka K, Ohta E, Sakata M. 1990. Protective effect of external Ca on elongation and the intracellular concentration of K in intact mung bean root under high NaCl stress. Plant Cell Physiol **31,** 815–821.

Neumann PM, Van Volkenburgh E, Cleland RE. 1988. Salinity stress inhibits bean leaf expansion by reducing turgor, not wall extensibility. Plant Physiol. **88,** 233–237.

Niazi BH, Ahmed M, Hussain N, Salim M. 2001. Comparison of sand, gypsum and sulphuric acid to reclaim a dense saline sodic soil. Int. J. Agri. Biol. **3(3),** 316–318.

Peinemann N, Guggenberger G, Zech W. 2005. Soil organic matter and its lignin component in surface horizons of salt-affected soils of the Argentinian Pampa. CATENA, **60(2),** 113-128.

Rachman A, Erfandi D, Ali MNL. 2008. Dampak Tsunami terhadap sifat-sifat tanah pertanian di NAD dan strategi rehabilitasinya. Jurnal Tanah dan Iklim **28,** 27-38.

Rengasamy P. 2006. World salinization with emphasis on Australia. J. Exp. Bot. **57(5),** 1017- 1023.

Rochmah HF. 2001.Pengaruh Pupuk Organik dan Anorganik terhadap Pertumbuhan dan Hasil Padi Sawah (*Oryza sativa* L.). Fakultas Pertanian , IPB.

Shaaban M, Abid M, Abou-Shanab RAI. 2013. Amelioration of salt affected soils in rice paddy system by application of organic and inorganic amendments. Plant Soil Environ. **59(5),** 227–233.

Sebastian. 1977. Management of Salt-Affected Soils for Rice Production. Department of Agriculture. Philippine Rice Research Institute.

Witt C, Dobermann A. 2002. A site-specific nutrient management approach for irrigated lowland rice in Asia. Better Crops Int. **16,** 20-24.

Yermiyahu U, Shlomo N, Ben-Hayyim G, Kafkafi U, Kinraide TB. 1997. Root elongation in saline solution related to calcium binding to root cell plasma membranes. Plant Soil **191,** 67–76.