JOURNAL OF DEGRADED AND MINING LANDS MANAGEMENT
ISSN: 2339-076X (p); 2502-2458 (e), Volume 5, Number 4 (July 2018): 1307-1318
DOI:10.15243/jdmlm.2018.054.1307

Research Article

Nitrogen and phosphorus fertilization for groundnut in saline soil

A. Taufiq*, A. Wijanarko, A. Kristiono

Indonesian Legumes and Tuber Crops Research Institute (ILETRI), Jl. Raya Kendalpayak km 8, PO Box 66 Malang 65101, Indonesia

* corresponding author: taufiq.malang@gmail.com

Received 9 April 2018, Accepted 17 May 2018

Abstract: Groundnut cultivation on saline soil facing complex problems associated with high electrical conductivity (EC), toxic effects of Na cation, imbalance nutrients, and N and P deficiency. Objective of this research was to determine optimum rate of N and P fertilizers for groundnut on saline soil. The trial was conducted on saline soil in Lamongan (EC 8-15 dS/m, pH>8.0, low N, high P) and Tuban (EC 8-16 dS/m, pH>8.0, low N and P) during dry season year 2017. Treatment consisted of two factors, and the combinations were arranged in a completely randomized block design with three replications. The first factor was four N fertilizer rates (0, 23, 46, and 69 kg N/ha), and the second factor was four P fertilizer rates (0, 36, 72, and 108 kg P_2O_5/ha). Results showed that nitrogen fertilization had no effect on plant height, number of filled pod and plant stand, but improved chlorophyll content, increased100 seed weight, harvest index and yield. Phosphorus fertilization had no effect on all parameters observed, except on 100 seed weight and plant stand. The yield response to N fertilization was linear and quadratic, depending on the location. The optimum N rates was 62-69 kg N/ha. The results indicated that N fertilization had more important role than P fertilization for increasing groundnut yield on saline soil, although the growth did not improve.

Keywords*: fertilization, groundnut, saline soil, yield*

To cite this article: Taufiq, A., Wijanarko, A. and Kristiono, A. 2018. Nitrogen and phosphorus fertilization for groundnut on saline soil. J. Degrade. Min. Land Manage. 5(4): 1307-1318, DOI: 10.15243/jdmlm. 2018.054.1307.

Introduction

Agricultural land degradation due to salt effect has become global issue, including in Indonesia. Salt affected land in America, Asia, Australia and Europe is estimated 932.2 million hectares, and 38.3% is distributed in Australia that costs the farming economy about Aus$1330 million per annum (Rengasamy, 2006). Among the agriculture land, FAO estimates that 19.5% of total irrigated-land (230 million hectares) and 2.1% of total dry land (150 million hectares) is affected by salt (Arora, 2017). In Indonesia, salt-affected land covering about 0.44 million hectares (Alihamsyah et al., 2002).

The main charracteristics of saline soil are electrical conductivity (EC) >4 dS/m and Na saturation <15% (Gorham, 2007). Soil pH of saline soil vary from acidic to alkaline, as saline soil in Bangladesh (Rahman et al., 2010; Azad and Bala, 2011) and also in India (Mahajan et al., 2015). High soluble salt and sodium (Na) in soil exchange complex, and soil physical properties become constrains in salt-affected soil (Arora, 2017). Bad crop growth in saline condition is mainly due to high Na ion (Tester and Davenport, 2003) that disturbs hormonal function in leaf (Munns, 2002), carbohydrate metabolism (Pattanagul and Thitissaksakul, 2008) resulting in low photosynthesis rate (Loreto et al., 2003). Application of K (Kopittke, 2012; Chakraborty et al., 2016), and compost (Radwan and Awad, 2002; Smith, 2009; Chaum et al., 2011; Kahlon et al., 2012; Murtaza et al., 2013) reduce the toxic effect of Na. Application of gypsum and manure reduce exchangeable Na, Na saturation, and soil salinity (Taufiq et al., 2016). Saline soil has low organic matter content and available P (Pervaiz et al., 2002; Rahman et al., 2010), low N and micro nutrient content, except Zn (Arora, 2017). Macro nutrient deficiency becomes limiting factor for crop growth (Zang et al., 2015). The macro nutrient deficiency in saline soil is not only because of low nutrient content, but also because of absorbtion inhibition due to high salt content in the root zone, such as absorbtion inhibition of K^+, Ca^{2+}, and NO^{3-} (Asch et al., 2000; Hu and Schmidhalter, 2005; Jouyban, 2012), Mg^{2+} (Hu and Schmidhalter, 1997), N and P (Hirpara et al., 2005), and induce nutrient imbalance (Rogers et al., 2003). Planting salt tolerant cultivar and nutrient management of crops are important solutions for crop production under saline soils (Swarajyalakshmi et al., 2003), because salt-tolerance cultivar excludes Na^+ (Chakraborty et al., 2016). Research on N and P fertilization on groundnut on saline soil in the field is very limited. Objective of the research was to identify optimum rates of N and P fertilization for groundnut on saline soil.

Material and Methods

The research was conducted on saline soil at Lohgung Village, Brondong Sub District, Lamongan District (6°53’59.89801”S; 112°11’15.31277” E; 26 m above sea level), and at Gesikharjo Village, Palang Sub district, Tuban District (6°54’ 19.5196” S; 112°8’17.7947” E; 4 m above sea level) during dry season year 2017 (July to September). The soil at experimental plot in both locations had high salinity (>4 dS/m), low N and organic content, high exchangeable cations (K, Na. Ca, and Mg), low available P in Lamongan and high available P in Tuban (Table 1). The experiment was conducted in a randomized complete block design with three replications.

Table 1. Chemical characteristics of top soil (0-20 cm) at experimental site in Lamongan and Tuban.

No.	Variable	Method	Lamongan	Tuban
1	pH H_2O	1:5 (soil:water)	8.7	8.3
2	N total (%)	Kjeldahl	0.13	0.26
3	C-org (%)	Walkley & Black	1.63	2.4
4	P (ppm P_2O_5)	Bray 1	70.1	7.44
5	Exchangeable cation ($cmol^+$/kg)	NH_4OAc pH 7		
	K		1.32	1.79
	Na		3.91	4.77
	Ca		56.63	56.81
	Mg		14.7	15.2
6	CECe ($cmol^+$/kg)	Cation summation	76.56	78.57
7	Na saturation (%)	(Na/CECe)*100%	5.11	6.07
8	SAR[1)]	Na/√[(Ca+Mg)/2]	0.93	1.12
9	EC (dS/m)	1:1 (soil:water)	5.65	7.20

[1)] SAR: sodium absorption ratio

Treatments tested consisted of two factors. The first factor was four levels of N fertilizer (0, 23, 46, and 69 kg N/ha) using urea (46% N). The second factor was four levels of P fertilizer (0, 36, 72, and 108 kg P_2O_5/ha) using super phosphate (SP36; 36% P_2O_5). The P fertilizer treatments were broacast-applied just after sowing, while N fertilizer treatments were applied twice (15 DAS and 50 DAS) with 50% of N dosage each. N fertilizer was applied next to plant raw and covered with soil along with weeding and ridging. The field was prepared by clearing weeds and previous crop residues, and then cultivated. The groundnut seed of Hypoma 2 cultivar (salt-tolerant) was sown in plot measuring of 4.2 m x 3 m with plant space 40 cm x 15 cm, two seeds per hole. Organic fertilizer (trade mark Petroganik) 5 t/ha, 750 kg S/ha and 100 kg KCl/ha use as basal fertilization applied just before planting, except KCl that applied just after planting. No rainfall during the experiment, so that the crops was irrigated using water from the adjacent well (Table 2). Irrigation was done by splashing water along the rows of plants using plastic pipes. Weed control was done manually at 15-20 DAS and at 50 DAS. Pest and disease control was conducted using chemical pesticide accordingly. Observations consisted of soil analysis before treatment (EC, pH, organic-C, N-total, available P, exchangeable K, Na, and Ca), and at 60 DAS (N-total and available P; composite sample over replication). Soil moisture content (gravimetric methods), EC (using portable EC meter Hanna) and leaf chlorophyll index (using Chlorophyll meter SPAD-502) were recorded at 20, 35, 45, 60 and 75 DAS, plant height at 20, 35, 45, 60, and 75 DAS and at harvest. N and P tissue analysis was performed at 60 DAS (composite sample over replication). Observations at harvest consisted of number of hasvested plant, weight of fresh and dry pod, number of filled pod, number of immature pod, and weight of dry seed. Agronomic data were analysed using analysis of variance (ANOVA) according to randomized complete block design, and mean comparation using least significant difference (LSD) at 0.05 probability level.

Table 2. Irrigation date and quality of irrigation water during crops growth

Irrigation	Lamongan			Tuban		
	Crop age (DAS)	EC (dS/m)	pH	Crop age (DAS)	EC (dS/m)	pH
1	0	3.78	7.42	0	nd	nd
2	17	nd[1)]	nd	16	4.10	7.19
3	38	3.88	7.26	36	5.16	7.36
4	46	4.04	6.91	43	5.82	7.36
5	66	3.78	6.89	49	5.81	8.02
6				61	5.86	7.31

[1)] nd=no data. DAS = days after sowing

Results and Discussion

Soil salinity

Soil salinity as indicated by electrical conductivity (EC), during crops growth in both locations showed the same pattern. Soil EC increased sharply at 35-45 DAS, up to 16 dS/m, then decreased to about 8 dS/m at 60 DAS and tended to constant until harvest (Figure 1). The hot weather condition, no rainfall during crops growth, and low soil moisture content increased salt concentration in the top soil during evaporation process, and hence soil EC at 35 DAS and 45 DAS increased. As salt concentration become higher, it will encourage salt crystallization and reduce salt concentration in the soil water as indicated by reduction of soil EC after 45 DAS. High soil EC at 35 DAS up to 45 DAS caused salt injury as indicated by leaf chlorosis, necrosis and then died.

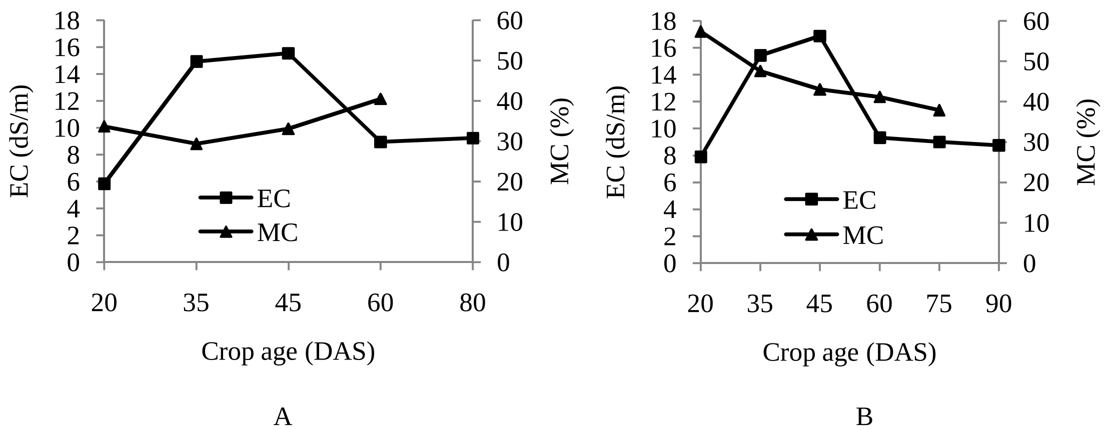
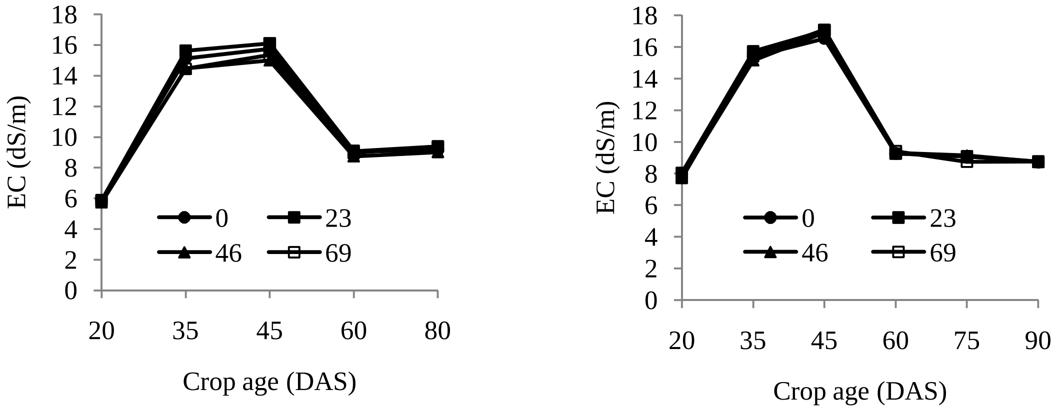


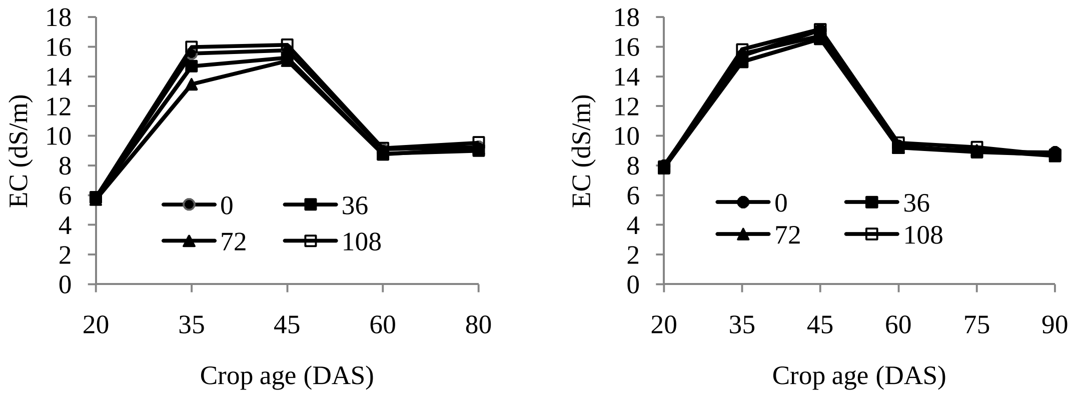
Figure 1. Electrical conductivity (EC) and soil moisture content (MC) during groundnut growth in Lamongan (A) and Tuban (B).

Plant death due to salt injury at Lamongan site was 12% at 45 DAS and increased to 28% at 60 DAS, while at Tuban site was 5% at 45 DAS and increased to 36% at 60 DAS. EC of irrigaton water also tended to increase, as shown in Table 2, and increased the severity of salinity stress. Application of N fertilizer up to 69 kg N/ha and P fertilizer up to 108 kg P_2O_5/ha had no effect on soil EC at Tuban and Lamongan sites (Figures 2 and 3). Urea $[(NH_2)_2CO]$ as source of N fertilizer is non electrolyte organic compound, and hence gives no effect on soil EC. SP36 (CaH_2PO_4) as source of P fertilizer is weak electrolyte compound, and therefore gives relatively no effect on soil EC. The effect of urea and SP36 fertilizers on salinity is different from KCl, that is a salt compound and strong electrolyte. Taufiq et al. (2017) reported that KCl at rate of 120 kg K_2O/ha increased soil EC by 1.5 dS/m.



A B

Figure 2. Electrical conductivity (EC) during groundnut growth in Lamongan (A) and Tuban (B) with four levels of N fertilizer.



A B

Figure 3. Electrical conductivity (EC) during groundnut growth in Lamongan (A) and Tuban (B) with four levels of P fertilizer.

Plant height

The growth of plant at Tuban was slower then at Lamongan site, because of relatively higher soil EC. Plant height of 15 cm at Lamongan site was attained at 20 DAS, while at Tuban it was attained at 60 DAS. Final plant height of groundnut at both sites was relatively same, about 23 cm (Figure 4 and 5). In greenhouse experiment, Taufiq et al. (2015) showed that plant height of ten groundnut cultivars was only 10-12 cm at EC 4.5-6.5 dS/m, and in the field was about 15 cm at EC 7.0-15.0 dS/m (Taufiq et al., 2016). In non saline soil, the height of Hypoma 2 is 35 cm (based on the cultivar description). Plant height reduction due to high salinity was also shown by Osuagwu and Udogu (2014). This indicates that high soil EC disrupts plant growth, because reduction in plant cell expansion (Parida and Das, 2005).

The soil contained low N and P, except P in Lamongan that was high as described in Table 2. Application of P or N fertilizer increased N and P contents at both sites. Phosphorus fertilization increased available P by 36.5% on saline soil at Lamongan site and 109.1% at Tuban site, and also increased total-N by 16.7% at both sites. Nitrogen fertilization increased total-N by 19.4% only at Lamongan site, and also increased available P by 20.6% at Lamongan site and 73.9% at Tuban site (Table 3). However, application of N fertilizer up to 68 kg N/ha and P fertilizer up to 108 kg P_2O_5/ha and their interaction did not significantly affect plant height. Soil salinity as prescribed in Figure 1 was very high. This data indicated that high salinity retard crop growth, and it became more dominant as limiting factors for groundnut growth than N and P nutrients.

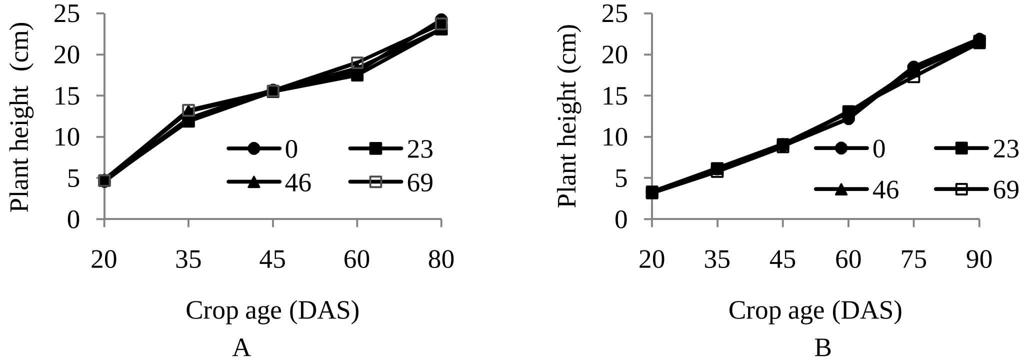


Figure 4. Plant height of groundnut on saline soil in Lamongan (A) and Tuban (B) with four levels of N fertilizer dosage.

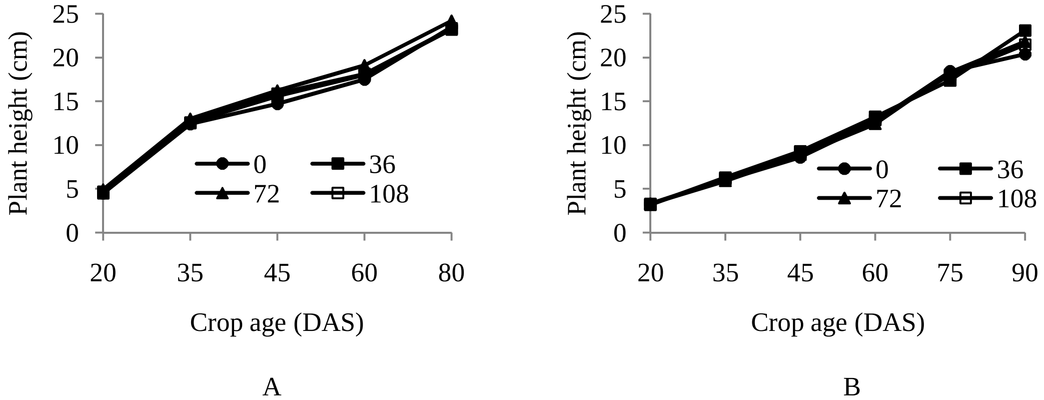


Figure 5. Plant height of groundnut on saline soil in Lamongan (A) and Tuban (B) with four levels of P fertilizer dosage.

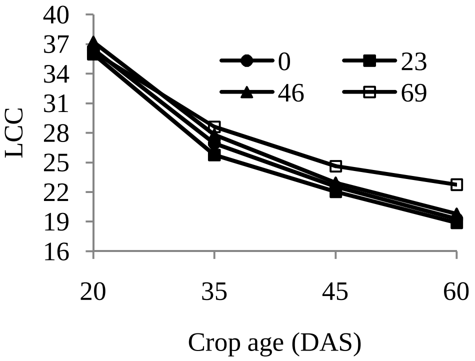
Table 3. Total N and available P in saline soil at 60 DAS with application of N and P fertilizers.

Fertilizer rate	**Lamongan**		**Tuban**	
	Total N (%)	**P-Bray 1 (ppm P_2O_5)**	**Total N (%)**	**P-Bray 1 (ppm P_2O_5)**
P_2O_5(kg/ha)				
0	0.12	59.44	0.22	1.94
36	0.13	87.89	0.20	4.60
72	0.14	65.58	0.22	3.38
108	0.15	89.93	0.23	4.19
N (kg/ha)				
0	0.12	59.44	0.22	1.94
23	0.15	75.81	0.22	3.58
46	0.14	66.20	0.22	2.35
69	0.14	72.95	0.23	4.19

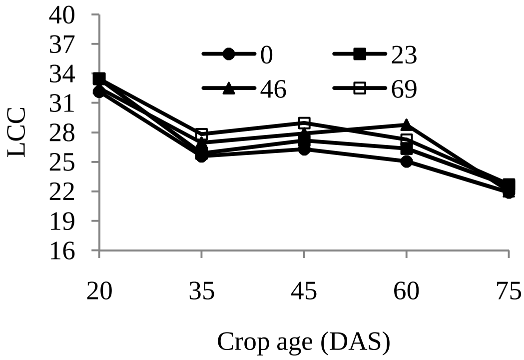
Leaf Chlorophyll Content Index (LCC)

LCC value indicates chlorophyll density on certain leaf area. Higher LCC value indicates higher chlorophyll content, it means that the leaf is more green. LCC at both sites was 32-37 (normal) at 20 DAS, but it drastically dropped to 25-28 (moderate chlorosis) at 35 DAS. The LCC in Lamongan continued to reduce up to 19 (severe chlorosis) at 60 DAS (Figure 6A), while in Tuban was relatively constant up to 60 DAS and then reduced to 22 (severe chlorosis) at 75 DAS (Figure 6B). This indicates that high soil EC reduces chlorophyll content. The similar effect was also demonstrated by Munns (2002), Hammad et al. (2010) and Taufiq at el. (2016). Salt stress led to disordering synthesizing chlorophyll (Parida and Das, 2005), increasing the activity of chlorophyll degrading enzyme, chlorophyllase (Santos, 2004) and inducing destruction of chloroplast ultra structure (Shu et al., 2013).

Application of N fertilizer up to 68 kg N/ha significantly affected the LCC at Lamongan site at 35 and 60 DAS, while at Tuban site at 45 and 60 DAS. Application of P fertilizer up to 108 kg P_2O_5/ha, and it's interaction did not significantly affect the LCC at both sites.The highest LCC at Lamongan site was obtained at N rate of 69 kg N/ha, while at Tuban site was at rate of 46-69 kg N/ha. LCC due to P fertilization up to 108 kg P_2O_5/ha had the same pattern as N fertilization, but it had no significant effect on LCC (Figure 7). The result indicates that N fertilization is important in increasing and maintaining leaf chlorophyll on saline soil, because nitrogen has an important role in chlorophyll formation. Despite N fertilization at higher rate improved the LCC, it could not increase to the level of normal.

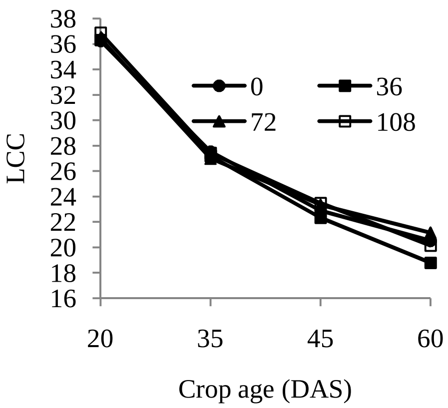


A (LSD5% at 35 and 60 DAS=1.95 and 2.28)

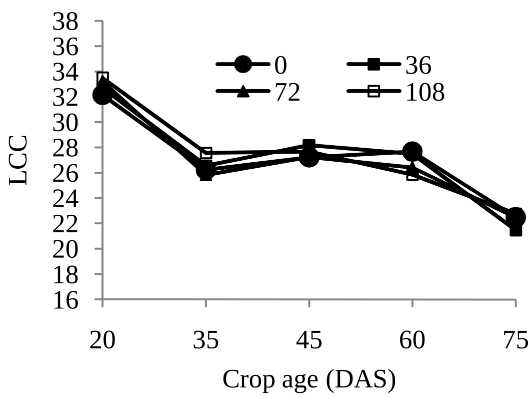


B (LSD5% at 45 and 60 DAS=1.37 and 2.37)

Figure 6. Leaf chlorophyll content index (LCC) on saline soil in Lamongan (A) and Tuban (B) with four levels of N fertilizer rate.



A



B

Figure 7. Leaf chlorophyll content index (LCC) on saline soil in Lamongan (A) and Tuban (B) with four levels of P fertilizer rate.

Yield and yield components

Nitrogen fertilization had no effect on plant population and number of filled pod, but at N dosage 46-69 kg N/ha increased weight of 100 seeds and harvest index (HI). Phosphorus fertilization had no effect on number of filled pod and HI, but at P dosage 36-72 kg P_2O_5/ha improved plant population and increased weight of 100 seeds (Table 4). Increasing HI due to N fertilization increased partition of photosynthate to pod (Table 5). The yield positively correlated with weight of 100 seeds with r=0,73** and 0,57**, and correlate with HI with r=0,84** and r=0,83**, consecutively in Lamongan and Tuban. It means that N or P fertilization may increase yield through increasing weight of 100 seeds and HI. On saline soil with low N and high P contents (Lamongan site), response of groundnut yield to N fertilization up to 69 kg N/ha was linear with Y=1544.1+10.613X (R^2=0.74) for fresh pod, and Y=589.5+7X (R^2=0.77) for dry pod (Figure 8A), where Y is pod yield (kg/ha) and X is N fertilizer rate (kg N/ha). There was a significant interaction between N and P fertilization on dry pod yield (Figure 8B).

Table 4. Yield components of groundnut with N and P fertilizer treatments on saline soil in Lamongan and Tuban.

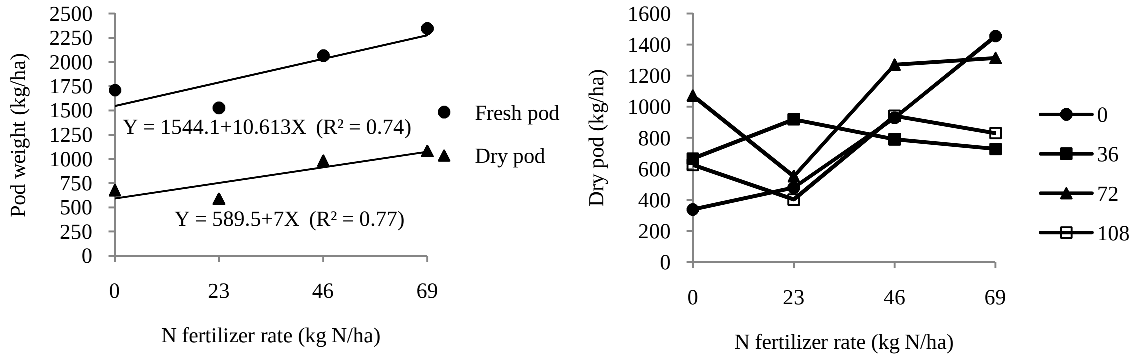
Fertilizer rate (kg/ha)	**Lamongan**				**Tuban**			
	Final plant population (%)[1]	**Filled pod/ plant**	**100 seed weight (g)**	**Harvest index**	**Final plant population (%)[1]**	**Filled pod/plant**	**100 seed weight (g)**	**Harvest index**
N								
0	90	5	35.5 a	0.21 bc	65	3 b	33.2 bc	0.17
23	88	4	30.9 b	0.19 c	64	4 a	33.1 c	0.20
46	85	4	32.9 ab	0.24 ab	67	3 b	34.5 a	0.21
69	88	5	33.3 ab	0.25 a	64	4 a	34.2 ab	0.21
P_2O_5								
0	83 b	5	31.6	0.21	60	3	33.1 b	0.19
36	90 a	4	32.2	0.22	69	4	34.6 a	0.21
72	92 a	5	35.3	0.25	66	3	34.0 ab	0.19
108	86 ab	5	33.5	0.22	66	3	33.4 b	0.21

Notes: numbers in one coloum in each factor and location with the same letter or without letter means not significantly different with LSD 5%; [1)] percentage to the initial plant population.

Table 5. Nitrogen fertilization and partition of phothosynthate of groundnut on saline soil in Lamongan and Tuban.

N fertilizer rate (kg/ha)	**Partition of phothosynthate (%)**			
	Lamongan		**Tuban**	
	Pod (%)	**Shoot (%)**	**Pod (%)**	**Shoot (%)**
0	18.2	81.8	17.2	82.8
23	17.1	82.9	20.4	79.6
46	23.8	76.2	22.0	78.0
69	26.8	73.2	21.6	78.4

However, highest yield of 1,454 kg/ha dry pod or 2,518 kg/ha fresh pod attained at N rates of 69 kg N/ha without P fertilization, or dry pod increased by 330% compared to no N. The pod yield reduced when N fertilizer rate was less than 69 kg N/ha or if N fertilizer was combined with P fertilizer (Table 6). The result revealed that in the range of N fertilizer rate tested, the optimal N rates was 69 kg N/ha. Seed to pod ratio average was 0.63±0.05, this means that 1,454 kg/ha of dry pod will produce 843-989 kg/ha of dry seed. The rate of N fertilizer can be reduced to 46 kg N/ha combined with 72 kg P_2O_5/ha to produce 1,269 kg/ha dry pod or increased by 275% compared to no N and P.



A (LSD5% = 505 kg fresh pod and 185 kg dry pod) B (LSD5% N*P=370kg)

Figure 8. Groundnut yield performance on saline soil in Lamongan with N fertilization (A) and its interaction with P fertilization (B).

Table 6. N and P fertilization with yield of groundnut on saline soil in Lamongan.

P rates (kg P_2O_5/ha)	**N rates (kg N/ha)**				**N rates (kg N/ha)**			
	0	**23**	**46**	**69**	**0**	**23**	**46**	**69**
	Fresh pod (kg/ha)				**Dry pod (kg/ha)**			
0	1258	1318	1988	2518	338 i	478 ghi	928 cde	1454 a
36	1702	2192	1964	1900	666 e-i	918 c-f	790 d-g	727 d-h
72	2277	1436	2032	2957	1071 bcd	552 f-i	1269 abc	1313 ab
108	1603	1152	2268	2001	625 e-i	402 hi	940 cde	829 d-g

Note: numbers in same coloum and variable with same letter or without letter mean no significant different with LSD 5%.

Application of N fertilizer on saline soil in Lamongan increased total N compared to control (without N), but there was no different between N rates 23 kg N/ha and the higher level. However, N content in the shoot was lower than control. Application of P fertilizer increased available P as well as P concentration in the shoot compared to control (without P), but they reduced at P dosage higher than 36 kg P_2O_5/ha (Figure 9). At the highest yield level, nutrient content in shoot at 60 DAS was 1.41% N and 0.39% P. Nutrient up take at the highest yield level was 114.6 mg N, 31.7 mg P per plant (Table 7). Plant population at harvest was 394,367 plants/ha, meaning that total nutrient up take in groundnut shoot was 45.2 kg N/ha and 12.5 kg P/ha (28.6 kg P_2O_5).

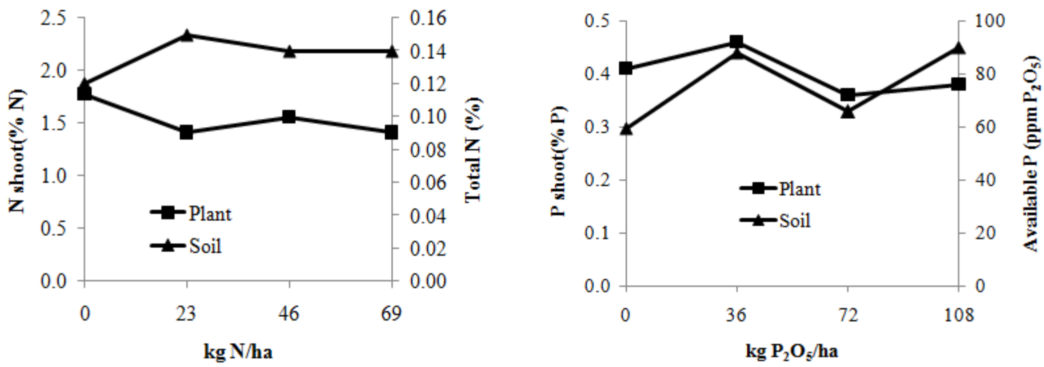
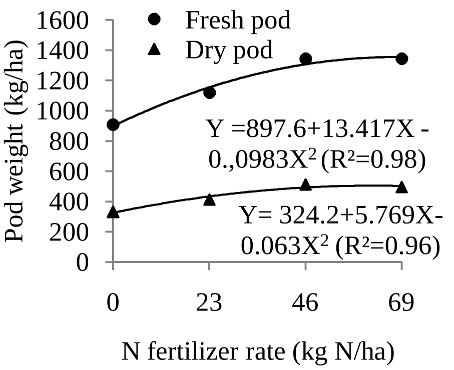


Figure 9. N and P content in groundnut shoot and soil at 60 DAS with four levels of N and P fertilizer rates on saline soil in Lamongan.

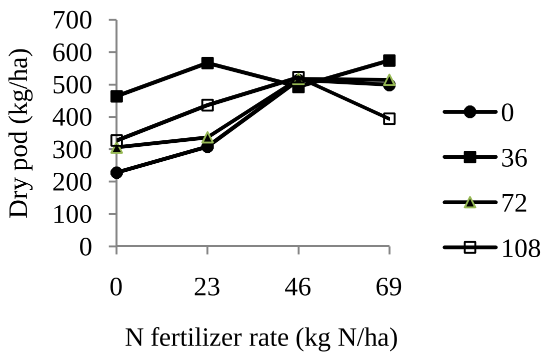
Table 7. N and P uptake in groundnut shoot at 60 DAS at four levels of N fertilizer on saline soil in Lamongan.

N rate (kg N/ha)	Nutrient uptake (mg/plant)			
	Lamongan		Tuban	
	N	P	N	P
0	119.5	27.5	97.4	29.3
23	117.7	38.4	110.2	33.1
46	178.8	47.0	140.2	33.3
69	114.6	31.7	134.6	28.2

On saline soil which contains low N and P (Tuban site), response of groundnut yield to N fertilization up to 69 kg N/ha was quadratic with $Y=897.6+13.417X-0.0983X^2$ ($R^2=0.98$) for fresh pod, and $Y=324.2+5.769X-0.0463X^2$ ($R^2=0.96$) for dry pod, where Y is pod yield (kg/ha) and X is N fertilizer rate (kg N/ha) (Figure 10A). Based on the equation, maximum yield of fresh pod (1,355 kg/ha) was obtained with N rate 68 kg N/ha, while maximum yield of dry pod (504 kg/ha) was obtained with N rate 62 kg N/ha or fresh and dry pod increased consecutively by 34% and 56% compared to no N. There was no interaction between N and P fertilization. However, it seemed that there was a relationship between N and P fertilization. High yield of 1.487 kg/ha fresh pod or 566 kg/ha dry pod was obtained with 23 kg N/ha and 36 kg P_2O_5/ha (Figure 10B), or increased by 144% compared to no N and P (228 kg/ha dry pod). Seed to pod ratio was in average of 0.64±0.07, it means that 566 kg/ha dry pod will produce 323-402 kg/ha seeds. The result indicates that high yield on saline soil which contain low N and P can be obtained with N fertilization 62-68 kg N/ha or 23 kg N/ha + 36 kg P_2O_5/ha.



A (LSD%=303 kg fresh pod and 127 kg dry pod)



B (LSD% N*P=not significant)

Figure 10. Groundnut yield performance on saline soil in Tuban with N fertilization (A) and it's interaction with P fertilization (B).

Application of N fertilizer on saline soil in Tuban did not increase total N in soil compared to control (without N), but increased N content in the shoot as N rates applied increased. Application of P fertilizer increased soil available P as well as P concentration in the shoot compared to control (without P), but soil available P was lower at P dosage higher than 36 kg P_2O_5/ha (Figure 11). At the highest yield level, nutrient content in shoot at 60 DAS was 2.15% N and 0.45% P. Nutrient up take at the highest yield level was 134.6 mg N and 28.2 mg P per plant (Table 7). Plant population at harvest was 291,683 plants/ha, meaning that total nutrient absorbtion in groundnut shoot was 39.3 kg N/ha and 8.2 kg P/ha (18.8 kg P_2O_5). Groundnut yield increased as N fertilizer rate increased, but it seemed that N fertilization efficiency was very low as indicated by low absorption by plant. Nitrification of NH_4-N to NO_3-N is the process responsible to N availability to plant. Nitrification reduced as salinity increased from 0.2 dS/m to 4.1 dS/m (Irshad et al., 2004). N losses in the form of ammonia (NH_3) volatilization increased 2-5 fold after 14 days and reached 6 fold at 42 days in soil with salinity >9 dS/m (Akhtar et al., 2012). High N volatilization in high salinity reduces the amount of nitrogen fixed into soil and also N uptake by the roots from the soil (Osuagwu and Udogu, 2014). Total N in the soil also relates to activity of urease enzyme in the soil (Xie et al., 2017), and activity of this enzyme deceases as soil pH and soil salinity increases (Guangming et al., 2017). This indicates that N fertilization has an important role in increasing groundnut yield on saline soil, but the efficiency is very low because of high soil pH and salinity. Reseach on increasing N efficiency on saline soil is still needed. On saline soil with low to high P status, P fertilization up to 108 kg P_2O_5/ha increased soil available P and P absorbed by plant compared to control, but it did not significantly increase groundnut yield. This indicates that the effectiveness of P fertilization on saline soil is very low because of high soil pH, soil EC and Ca content. SP36 (CaH_2PO_4) fertilizer in the soil will transform into H_2PO_4+ $CaHPO_4$.

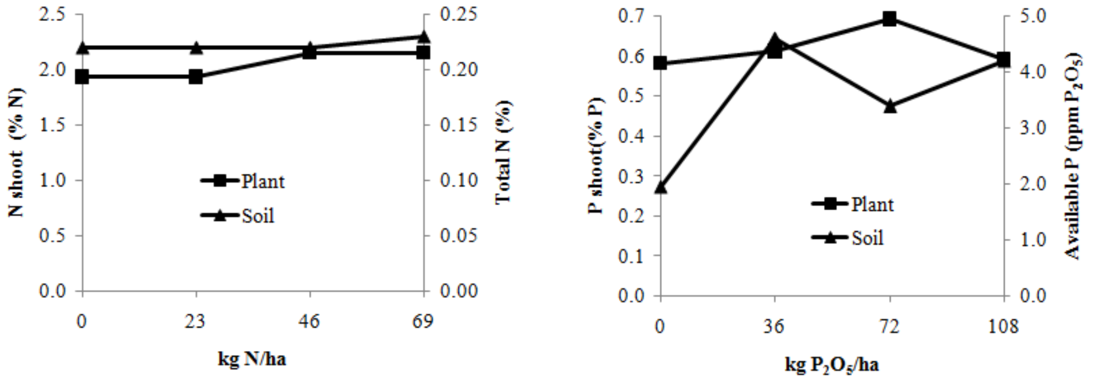


Figure 11. N and P content in groundnut shoot and soil at 60 DAS with four levels of N and P fertilizer rates on saline soil in Tuban.

In high soil pH and Ca content, $CaHPO_4$ ion will react with Ca to form $Ca_3(PO_4)_2$ that is insoluble for plant and therefore restricts P absorption.The dynamic of P in the soil relates to soil pH and activity of phosphatase enzyme in soil (Xie et al., 2017). Available P reduces as soil pH and salinity increase (Guangming et al., 2017).

Results showed that groundnut yields of Hypoma 2 cultivar on saline soil in Lamongan were 69% (fresh pod) and 173% (dry pod) higher than in Tuban. Yield components in Tuban was lower than in Lamongan, because of massive soil structure in the root zone that restricted pod formation and development. Plant stand at harvest in Lamongan (88%) was higher than in Tuban (65%). Soil salinity in both locations is relatively similar, but EC of irrigation water in Tuban is higher than that in Lamongan, that resulted in additional salinity stress which caused more plant death before the end of pod filling stage. Ahmed et al. (2012) revealed that irrigation with saline water increased soil salinity.

Conclusion

On saline soil with low N, fertilization up to 69 kg N/ha had no effect on plant height, number of filled pod and plant stand. However, it improved chlorophyll content, increased 100 seed weight, harvest index and yield. The optimum N rates for pod yield was 62-69 kg N/ha, or the yield increased by 56% in Tuban (from 324 kg/ha to504 kg/ha dry pod) and 330% in Lamongan (from 338 kg/ha to 1,454 kg/ha dry pod). Although the soil has low to high P content, but fertilization up to 108 kg P_2O_5/ha had no effect on all parameters observed, except on 100 seed weight and plant stand. The result indicates that N fertilization has more important role than P fertilization in increasing groundnut yield on saline soil.

Acknowledgement

The research is funded by Indonesian Government through Indonesian Agency for Agriculture Research and Development (IAARD) year 2017. Highly appreciation is addressed to Widosendiko for his good assistance during implementation of the research.

References

Ahmed, C.B., Magdich, S., Rouina, B.B., Boukhris, B. and Abdullah, F.B. 2012. Saline water irrigation effects on soil salinity distribution and some physiological responses of field grown Chemlali olive. *Journal of Environmental Management* 113:538-544.

Akhtar, M., Hussain, F., Ashraf, M.Y., Qureshi, T.M., Akhter, J. and Awan, A.R. 2012. Influence of salinity on nitrogen transformations in soil. *Communications in Soil Science and Plant Analysis* 43(12):1674-1683.

Alihamsyah, T., Sarwani, M. and Ar-Riza, I. 2002. Tidal land as a source of future rice production area. In: B. Suprihatno, A.K. Makarim, I.W. Widiarta, Hermanto, and A.S. Yahya (eds). *Kebijakan Perberasan dan Inovasi Teknologi Padi*. Buku 2.

Pusat Penelitian dan Pengembangan Tananam Pangan, Bogor. pp. 263-287 (*in Indonesian*).

Arora, S. 2017. Diagnostic properties and constraints of salt-affected soils. In: S.Arora, A.K. Singh, and Y.P. Singh (eds). *Bioremediation of Salt Affected Soils: An Indian Perspectives*. Springer International Publishing. pp. 41-52.

Asch, F., Dingkuhn, M., Dorffling, K. and Miezan, K. 2000. Leaf K/Na ratio predicts salinity induced yield loss in irrigated rice. *Euphytica* 113:109-118.

Azad, A.K and Bala, P. 2011. Chemical properties of different saline and non saline soils of Bangladesh. *Journal Soil Nature* 5(1):1-5.

Chakraborty, K., Bhaduri, D., Meena, H.N. and Kalariya, K. 2016. External potassium (K^+) application improves salinity tolerance by promoting Na^+-exclusion, K^+-accumulation and osmotic adjustment in contrasting peanut cultivars. *Plant Physiology and Biochemistry* 103:143-153.

Chaum, S., Pokasombat, Y. and Kirdmanee, C. 2011. Remediation of salt-affected soil by gypsum and farmyard manure−Importance for the production of Jasmine rice. *Australian Journal of Crop Science* 5(4):458-465.

Gorham, J. 2007. Sodium. p. 569-575. In: Barker, A.V. and D.J. Pilbeam (eds). *Handbook of Plant Nutrition*. Taylor & Francis. 613 pages.

Guangming, L., Xuechen, Z., Xiuping, W., Hongbo, S., Jingsong, Y. and Xiangping, W. 2017.Soil enzymes as indicators of saline soil fertility under various soil amendments. *Agriculture, Ecosystems & Environment* 237:274-279.

Hammad, S.A.R., Shaban, K.A. and Tantawy, M.F. 2010. Studies on salinity tolerance of two peanut cultivars in relation to growth, leaf water content: Some chemical aspects and yield. *Journal of Applied Science Research* 6(10):1517-1526.

Hirpara, K.D., Ramolia, P.J., Patel, A.D and Pande, A.N. 2005. Effect of salinisation of soil on growth and macro- and micro-nutrient accumulation in seedlings of *Butea monosperma* (Fabaceae). *Anales de Biologia* 27:3-14.

Hu, Y. and Schmidhalter, U.1997. Interactive effects of salinity and macronutrient level on wheat: 2. Composition. *Journal Plant Nutrient* 20:1169-1182.

Hu, Y. and Schmidhalter, U. 2005. Drought and salinity: A comparison of their effects on mineral nutrition of plants. *Journal Plant Nutrition and Soil Science* 168:541-549.

Irshad, M., Honna, T., Yamamoto, S., Eneji, A.E. and Yamasaki, N. 2004. Nitrogen mineralization under saline conditions. *Communications in Soil Science and Plant Analysis* 36(11-12):1681-1689.

Jouyban, Z. 2012. The Effects of Salt stress on plant growth. *Technical Journal Engineering & Applied Science* 2(1):7-10.

Kahlon, U.Z., Murtaza, G. and Ghafoor, A. 2012. Amelioration of saline-sodic soil with amendments using brackish water, canal water and their combination. *International Journal Agricultureand Biology* 14(1):38-46.

Kopittke, P.M. 2012. Interactions between Ca, Mg, Na and K: alleviation of toxicity in saline solutions. *Plant and Soil* 352:353-362.

Loreto, F., Centritto, M. and Chartzoulakis, K. 2003. Photosynthetic limitations in olive cultivars with different sensitivity to salt stress. *Plant Cell & Environment* 26:595-601.

Mahajan, G.R., Manjunath, B.L., Latare, A.M., D'Souza, R., Vishwakarma, S and Singh, N.P. 2015. Fertility status of the unique coastal acid saline soils of Goa. *Journal of the Indian Society of Soil Science* 63(2):232-237.

Munns, R. 2002. Comparative physiology of salt and water stress. *Plant Cell and Environment* 25:239-250.

Murtaza, G., Murtaza, B., Usman, H.M. and Ghafoor, A. 2013. Amelioration of saline-sodic soil using gypsum and low quality water in following sorghum-berseem crop rotation. *International Journal Agriculture Biology* 15(4):640-648.

Osuagwu, G.G.E. and Udogu, O.F. 2014. Effect of salt stress on the growth and nitrogen assimilation of *Arachis hypogea* (L). *Journal of Pharmacy and Biological Sciences* 9(5):51-54.

Parida, A.K. and Das, A.B. 2005. Salt tolerance and salinity effects on plants. A Revew. *Ecotoxicology* and *Environmental Safety* 60:324-349.

Pattanagul, W. and Thitissaksakul, M. 2008. Effect of salinity stress on growth and carbohydrate metabolism in the three rice (*Oryza sativa* L.) cultivars differing in salinity tolerance. *Indian Journal of Experimental Biology*. 46:736-742.

Pervaiz, Z., Kazmi, S.S.H., Gill, K.H. and Makhtar, M. 2002. Soil fertility and salinity status of Gujrat District. *Pakistan Journal Soil Science* 21:11-14.

Radwan, S.M.A. and Awad, N.M. 2002.Effect of soil amendment with various organic wastes with multi-biofertilizer on yield of peanut plants in sandy soil. *Journal of Agriculture Sciences of Mansoura Univ*. 27(5):3129-3138.

Rahman, O., Ahmad, B. and Afzal, S. 2010. Soil fertility and salinity status of Attock District. *Journal Agricultural Research* 48(4):505-5016.

Rengasamy, P. 2006. World salinization with emphasis on Australia. *Journal of Experimental Botany* 57(5):1017-1023.

Rogers, M.E., Grieve, C.M. and Shannon, M.C. 2003. Plant growth and ion relations in Lucerne (*Medicago sativa* L.) in response to the combined effects of NaCl and P. *Plant and Soil* 253: 187-194.

Santos, C.V. 2004. Regulation of chlorophyll biosynthesis and degradation by salt stress in sunflower leaves. *Scientia Horticulturae* 103(1):93-99.

Smith, A.P., Chen, D. and Chalk, P.M. 2009. N_2 fixation by faba bean (*Vicia faba* L.) in a gypsum-amended sodic soil. *Biology and Fertility of Soil* 45:329-333.

Shu, S., Yuan, L., Guo, S., Sun, J. and Yuan, Y. 2013. Effects of exogenous spermine on chlorophyll fluorescence, antioxidant system and ultrastructure of chloroplasts in *Cucumis sativus* L. under salt stress. *Plant Physiology and Biochemistry* 63:209-216.

Swarajyalakshmi, G., Gurumurthy, P. and Subbaiah, G.V. 2003. Soil Salinity in South India: Problems

and solutions. *Journal of Crop Production* 7(1-2):247-275.
Taufiq, A., Kristiono, A. and Harnowo, D. 2015. Responses of groundnut varieties to salinity stress. *Jurnal Penelitian Tanaman Pangan* 34(2):153-164. (*in Indonesian*)
Taufiq, A., Wijanarko, A. and Kristiono, A. 2016. Effect of amelioration on growth and yield of two groundnut varieties on saline soil. *Journal of Degraded and Mining Lands Management* 3(4):639-647.
Taufiq, A., Wijanarko, A. and Kristiono, A. 2017. Effect of mulching and amelioration on growth and yield of groundnut on saline soil. *Journal of Degraded and Mining Lands Management* 4(4):945-954.
Tester, M. and Davenport, R. 2003. Na^+ tolerance and Na^+ transport in higher plants. *Annals of Botany* 91:503-527.
Xie, X., Pu, L., Wang, Q., Zhu, M., Xu, Y. and Zhang, M. 2017. Response of soil physicochemical properties and enzyme activities to long-term reclamation of coastal saline soil, Eastern China. *Science of the Total Environment* 607-608:1419-1427.
Zhanga, T., Wang, T., Liu, K.S., Wang, L., Wang, K. and Zhou, Y. 2015. Effects of different amendments for the reclamation of coastal saline soil on soil nutrient dynamics and electrical conductivity responses. *Agricultural Water Management* 159:115-122.