Simulation of Stress Salinity Conditions in the Phase of Germination of National and Local Aceh Peanut Variety

Halimursyadah[1*], Agam Ihsan Hereri[2] and Melika Bosniana[3]
[1,2,3]*Department of Agrotechnology, Agriculture Faculty, University of Syiah Kuala*

Keyword: Saline condition, variety, peanut, viability and vigor

Abstract: The degradation of agricultural land in Indonesia due to salinization has become one of the national issues. Mapping of saline land in Indonesia has not been widely implemented, but has identified many farms that are saline. The tsunami in Aceh in 2004 increased the salinity of the land (DHL 2-40 dS / m) damaging more than 120,000 ha of agricultural land. The decrease in peanut production is followed by the limited land and environmental factors required for peanut cultivation. The use of improved varieties and local varieties with good cultivation techniques will increase the doubling of peanut productivity and is the means used for planting on land with limited water. This research was conducted at Seed Technology Laboratory of Agricultural Faculty of Syiah Kuala University, Darussalam Banda Aceh in April 2017. The purpose of this research is to know the viability and vigor to grow several varieties of peanut seeds at various levels of salinity stress with some concentration of NaCl solution. This study used a complete randomized design with three replications. The first factor is varieties of Local Aceh, Talam 2, Kancil and Kelinci. The second factor was control salinity (0 dSm^{-1}, 1 g L^{-1}=1.89 dSm^{-1}, 3 g L^{-1}=3.90 dSm^{-1}, 5 g L^{-1}=4.93 dSm^{-1}, and 7 g L^{-1}=5.77 dSm^{-1}. The parameters observed are maximum growth potential, germination, vigor index, simultaneity growth, speed growth, time required to achieve total germination 50%, root length of normal seedling, and dry weight of normal seedling. The results showed that the varieties of Talam 2 and Kelinci showed more tolerance to salinity stress compared with Kancil and Local Aceh based on all parameters observed. While on the factor of NaCl concentration of 3 g L^{-1} has shown decreased viability and vigor of seed growth in all peanut varieties. There is a significant interaction between varieties with NaCl concentrations in viability and vigor based on maximum growth potential, germination, speed growth, time required to achieve total germination 50% and dry weight of normal seedling.

1 INTRODUCTION

Peanut (*Arachis hypogaea* L.) plays an important role in improving people's nutrition. Fat content composition 45.15% and 23.97% protein has made this commodity has the potential as a raw material agroindustri (Danuwarsa, 2006). However, peanut productivity tends to fluctuate due to the diminished productive cultivation area. Production and total area of peanut harvest in 2015 is 605 thousand tons with harvest area of 454 thousand ha, while in 2016 production is 510 thousand tons with harvested area of 393 thousand ha (BPS, 2016). This condition has caused a deficit in this commodity and attempted to import peanuts as much as 150-200 thousand tons in line with the high demand.

Efforts can be made to overcome the lack of production is using of peanut varieties that are able to adapt to conditions of marginal areas such as high salinity. Local Aceh varieties still dominate over 50% of the peanut growing area, followed by Gajah and Kelinci varieties, each released in 1950 and 1987. Each variety has its own resistance to sub optimum conditions such as saline conditions. The data reveal that newly released varieties in 2010 (Talam 1) and 2012 (Takar 1 and Takar 2) are produced for adapting to saline soil conditions (Kasno and Harnowo, 2014).

High salinity in a field is caused by the intrusion of sea water and heavy fertilization. Salinity problems will arise when the concentrations of NaCl, Na_2CO_3, Na_2SO_4 and Magnesium salts present on the land are in high state. NaCl salt is the most dominant in which sodium ions (Na^+) will accumulate in the soil layer. This causes seeds grown on land with high salinity, difficult or even

Halimursyadah, ., Hereri, A. and Bosniana, M.
Simulation of Stress Salinity Conditions in the Phase of Germination of National and Local Aceh Peanut Variety.
DOI: 10.5220/0010040101730178
In *Proceedings of the 3rd International Conference of Computer, Environment, Agriculture, Social Science, Health Science, Engineering and Technology (ICEST 2018)*, pages 173-178
ISBN: 978-989-758-496-1

not germinate at all. Water absorption by seed will decrease with increasing osmotic pressure of the solution or salt concentration in the medium. To germinate seed requires water averaging more than 50% of the seed weight (Hasanuddin, 2015).

The results of Zakaria and Fitriani (2006) suggest that seed sorting using NaCl solution with 1.5% concentration can be used as an alternative for peanut seed sorting. However, the use of NaCl with a 3.0% concentration may negatively affect the viability and vigor of the seed. Hajar *et al*. (1993) in his research stated that the growth of peanut seeds in NaCl 5000 ppm still able to grow well, despite the decrease in wet weight. The ability of seed germination on different saline conditions between plants even there is a noticeable variation among the varieties of that same plant.

Plant performance during germination is often used to assess plant tolerance to salinity (Khan *et al*., 2000). Wijayanti *et al*. (2014) of 29 peanut strains tested in saline condition showed that the salinity of 7 grams L^{-1} NaCl had significant effect on germination behavior, the number of live plants at 6 weeks after planting, the number of live plants at harvest, the number of pods and dry weight pods. This study aims to find out the viability and vigor of growing several varieties of local Aceh and national at various levels of salinity stress.

2 MANUSCRIPT OF PREPARATION

This research was conducted in Agricultural Science and Technology Laboratory of Agrotechnology Study Program of Agriculture Faculty of Syiah Kuala University from March to May 2017. The materials used are Local Aceh varieties from Aceh Barat Daya District, and Talam 2, Kancil and Kelinci national varieties from Balai Penelitian Tanaman Kacang-kacangan dan Umbi-umbian (BALITKABI). Peanut seeds used had an average initial germination of 79.0% (Local Aceh), 86.0% (Talam 2), 82.0% (Kancil), 92.7% (Kelinci). The total required seed is 1500 grains. Other materials used are 20 g NaCl Pro analysis, paper merang and aquades as much as 7 liters. The tools used are analytical scales (Mettler PM 100), 1 liter volume meter, electric oven, electro conductivity meter, and germinator.

2.1 Preparation of Planting Media

The paper media substrate is moistened using a NaCl solution according to a predetermined concentration. Each NaCl solution consisting of concentrations is filled into the container slowly, which has previously been filled with paper on each container until the paper is wet and field capacity. This research used the Rolled Paper Test Method Established in plastic based on International Seed Testing Association (ISTA) rules. This method begins by preparing a thin transparent plastic measuring 20cm x 30cm overlaid on the table, and then preparing 7 sheets of paper that have been soaked with NaCl solution in accordance with the concentration. A sheet paper substrate is placed overlaid on preprinted plastic paper. Four varieties of peanuts were added as many as 25 grains on paper. The seeds are then covered with three sheets of paper that have been soaked in a concentrated NaCl solution. Then the rolled paper is placed in the container and put into the germinator for 10 days.

Observations were made on the viability and vigor parameters based on ISTA standard that is maximum growth potential, germination, simultaneity growth, relative growth rate, vigor index, time required to achieve 50% relative total germination, root length of normal primary sprout and dry weight of normal sprouts.

2.2 Experimental Design

The experimental design used was a complete randomized design (CRD) with three replicates and there were two factors studied. The first factor of peanut varieties consists of four levels: Local Aceh, Talam 2, Kancil, and Kelinci. The second factor was the concentration of NaCl consist of five level: Control, 1 g L^{-1} simulation with salinity level 1.89 dSm^{-1}), 3 g L^{-1} simulation with salinity level 3.90 dSm^{-1}), 5 g L^{-1} simulation with salinity level 4.93 dSm^{-1}), 7 g L^{-1} simulation with salinity level 5.77 dSm^{-1}). The data obtained were analyzed using Analysis of Variance (ANOVA), and continuous differences test with Honestly Significant Difference (HSD) at the test level of 0.05.

3 RESULT AND DISCUSSION

Table 1 shows that the correlation (r) of NaCl treatment on the maximum potential growth measuring parameter r = 0.892 and the percentage of influence was 79.55%. At germination r = 0.969 and the percentage of influence is 93.95%. On the index vigor r = 0.956 and the percentage of influence r = 91.35%. In the simultaneity growth r = 0.915 and the percentage of influence is 83.7%. At speed growth r = 0.947 and the percentage of influence is 89.63%. At time required to achieve total germination 50% r = 0.974 and the percentage of influence is 94.82%. At normal dry weight of normal seedling r = 0.962 and the percentage effect of 92.5%. While the root length of the normal seedling r = 0.957 and the percentage of influence of 91.62%. If the value of correlation and determination closer to 1, that means the relationship between the concentration of NaCl to the viability and vigor parameters peanut seeds very closely. The relationship of linear regression equation can be seen in the following Table 1.

Table 1: Linier Regression Equation, Correlation Coefficient and Determination Coefficient due to NaCl concentration on viability and vigor of peanut seed

Parameters	Linier Regression Equation	Corre-lation Coeffi-cient (r)	Determi-nation Coeffici-ent (R^2)
Maximum growing potential (%)	y = -0.662x + 97.183	0.892	0.795
Germination (%)	y = -12.853x + 81.061	0.969	0.939
Vigor index (%)	y = -2.127x + 13.273	0.956	0.913
Simultaneity growth (%)	y = -7.900x + 46.413	0.915	0,837
Speed growth (% etmal^{-1})	y = -5.162x + 30.858	0.947	0.896
Time required to achieve total germination 50% (day)	y = 0.038x + 1.140	0.974	0.948
Dry weight of normal seedling (g)	y = -1.557x + 9.592	0.962	0.925
Root length of normal seedling (cm)	y = -2.565x + 20.092	0.957	0.916

Based on the results of the study on the viability and vigor parameters of seed growth, the treatment without NaCl solution resulted in the highest viability and vigor of seed growth and the lowest in the administration of NaCl solution with a concentration of 7 g L^{-1}. Peanut seeds are still tolerant of NaCl solution with a concentration of 3 g L^{-1}. The provision of salinity stress is aimed at knowing the resistance response of peanut varieties.

A NaCl solution with a concentration of 7 g L^{-1} was the optimum dose to create a diversity of growth and yield properties (Hajar *et al*., 1993). The concentration has exceeded the peanut batch dose of 3.2 dSm^{-1} (Yadav *et al*., 2011). Pohan (2005) also reported that at a concentration of 3 g L^{-1} NaCl has inhibited peanut growth as indicated by root xylem change.

This result was in line with Zakaria and Fitriani (2006) research, the highest peanut vigor was obtained in the treatment without NaCl, while the lowest sprout vigor was obtained in NaCl treatment with concentration of 1.5%. Salinity relationship with peanut shell vigor shaped linear, where the higher level of salinity then decrease the viability and grow peanut seed vigor with value r = 0,98. The effect of salinity on seed germination involves two things: the high influence of osmotic pressure so that the seeds are difficult to absorb water and chemical or poisoning by specific ions that make up the salt. According to Widoretno (2002), a seed will decrease its germination if planted on less water-growing media or drought stress conditions due to simulation by salt. The addition of a salt solution (solute) to the seed germination medium causes the occurrence of plasmolysis (shrinkage due to fluid depreciation in the cell) if the solute is increased, the cytoplasm is not permeable to the solute either inside or outside the cell. The potential of the vacuous aqueous solution will be greater than the outer water potential of the solution, so that the water diffuses outward, as a result of the outflow of water. The middle vakuole will shrivel up and protoplasm and the clinging cell walls also shrink together with the vacuoles. If the vacuole volume is so large then the protoplasm will be separated from the cell wall and the seed will be very sensitive to drought stress. Increasing the NaCl concentration may inhibit the seeds imbibition process because salt solubility can decrease the osmotic pressure so that the seeds can not absorb water from the growing environments needed for enzyme activation for the germination process. Rini *et al*. (2005) stated that salinity in planting medium of seed can affect seed germination process because it can decrease water potential in planting medium thus inhibiting water absorption by germinating seeds.

Although seeds can germinate under saline conditions, the seeds germinate become abnormal. The higher the concentration of NaCl, the higher the seeds that germinate abnormally or the dead seed.

Erinnovita *et al*. (2008) suggest that salinity causes some abnormalities in seeds and propagules during germination. Inhibition of plant growth by salinity can occur in two ways, namely by damaging the cells that are growing and limiting the supply of essential metabolic products. If the salinity concentration increases continuously then the tissue damage occurs, even the death of seed or seed can germinate but grow abnormally (Duan *et al*., 2004). The effects of NaCl on the germination process include reducing the hydration of the embryo and cotyledon, inhibiting and reducing the appearance of radicles and plumules, and reducing the growth of sprouts (Erinnovita *et al*., 2008)

There is a very significant interaction between peanut varieties treatment with salinity stress to maximum growth potential, germination, and speed growth, time required to achieve 50% total germination, and dry weight of normal (Table 2).

Table 2: Mean of viability and vigor value due to interaction between peanut varieties and NaCl concentration

Peanut varieties	NaCl concentration (g L^{-1})				
	Control	1	3	5	7
	Maximum potential growth (%)				
Local Aceh	94,66 Aa	97,33 Aa	97,33 Ab	94,66 Aab	90,66 Ab
Talam 2	98,66 Aa	100 Aa	98,66 Ab	98,66 Ab	98,66 Ab
Kancil	93,33 Ca	90,66 BCa	82,66 ABa	88,00 BCa	77,33 Aa
Kelinci	100 Aa	100 Aa	100 Ab	100 Ab	100 Ab
$HSD_{0,05}$	10,47				
Peanut varieties	Germination (%)				
Local Aceh	66,67 Cab	66,67 Cab	36,00 BCab	2,67 Aba	0,00 Aa
Talam 2	93,33 Bb	94,67 Bb	9,33 Aa	8,00 Aa	0,00 Aa
Kancil	57,33 Ca	57,33 Ca	37,33 BCab	4,00 Aba	0,00 Aa
Kelinci	98,67 Cb	96,00 Cb	60,00 Bb	10,67 Aa	0,00 Aa
$HSD_{0,05}$	33,70				
Peanut varieties	Speed Growth (% $etmal^{-1}$)				
Local Aceh	26,69 Db	23,82 Cb	8,25 Bb	0,41 Aa	0,00 Aa
Talam 2	40,79 Dc	39,45 Dd	7,09 Cab	2,31 Bb	0,00 Aa
Kancil	20,31 Ca	18,99 Ca	6,41 Ba	1,17 Aab	0,00 Aa
Kelinci	45,07 Dd	32,33 Cc	13,70 Bc	0,00 Aa	0,00 Aa
$HSD_{0,05}$	1,81				
Peanut varieties	Time required to achieve total germination 50% (day)				
Local Aceh	0,96 Aab	1,32 Ab	1,26 Ab	1,42 Aa	1,46 Aa
Talam 2	0,68 ABa	0,50 Aa	0,66 ABa	1,02 Aba	1,20 Ba
Kancil	1,47 Ab	1,49 Ab	1,48 Ab	1,50 Aa	1,50 Aa
Kelinci	1,49 Ab	1,46 Ab	1,46 Ab	1,47 Aa	1,93 Aa
$HSD_{0,05}$	0,54				
Peanut varieties	Dry weight of normal seedling (gram)				
Local Aceh	5,36 Ca	8,54 Da	3,84 Ba	0,26 Aa	0,00 Aa
Talam 2	11,68 Db	8,15 Ca	2,80 Ba	0,73 Aa	0,00 Aa
Kancil	6,56 Ca	8,27 Da	3,41 Ba	0,39 Aa	0,00 Aa
Kelinci	14,55 Dc	12,11 Cb	5,54 Bb	0,00 Aa	0,00 Aa
$HSD_{0,05}$	1,22				

Description: The numbers followed by the same letter in the same row (capital letter) and the same (lower case) columns are not significant at the 5% level (HSD Test 0.05)

Increased salinity concentration adversely affected seed viability and vigor that is in the parameters of maximum growth potential, germination rate, growth speed rate, time required to achieve total germination 50% (T50) and root length of normal root germination in all four varieties studied. The results showed that Kelinci, viability and vigor varieties grew better or had tolerant properties than Local varieties, Talam 2 and Kancil on increasing the concentration of NaCl to 3 g L^{-1}.

Waskom (2003) states that soil salinity can inhibit seed germination, irregular growth in agricultural crops such as beans and onions. Meanwhile, according to Noor (2004) high salt solubility can inhibit the absorption of nutrients and water by plants due to increased osmotic. In particular, high salt levels can lead to plant poisoning.

According to Adisyahputra *et al*., (2004) drought stress in the seed germination phase will increase with increasing salinity levels. The presence of salt in the growing medium negatively affects the ability of seed germinating. The mechanisms of salinity influence on seed germination include two mechanisms: (1) high osmosis media pressure so that the seeds are difficult to absorb water and (2) the toxic effects of salt-making ions (Albregts and Howard, 1972).

Another possible influence of the NaCl salt solution is suspected to be poisoning by Na^+ and Cl^- ions. The ions generally can achieve sufficient concentration of solution to cause osmotic problems in plants without first having specific toxicities that cause death are chloride and sulphate. Sodium will affect soil properties if present in excessive state. This resulted in the seeds difficult to absorb water so that the germination process will be inhibited.

The presence of salt in the growing medium also shows an adverse effect on germination, because of its concentration on germination media, resulting in changes in enzyme activity either directly or reducing the potential for water. Bad influence of salts for plants is generally indirectly through increased osmotic pressure in groundwater making it difficult for plants to absorb water, especially for plant sprouts and roots. So the effect is the same as dry land (Harnowo, 2002).

Sipayung (2003) stated that the level of stress experienced by plants varies in different species with unequal tolerance to different salt concentrations. According to Yuniati (2004), the growth response to salinity is considered the basis of evaluation for tolerance. Different individuals will respond differently to the salinity stress provided. Karajol and Naik (2011) say that salinity-tolerant varieties that germinate quickly under normal conditions like as germinate under saline conditions. Varieties that have higher germination rates have more salinity tolerance opportunities. Inhibition of canopy and root growth is a common response to salinity stress and is an important indicator for assessing crop tolerance. Root is the first organ exposed to salinity stress so its role in tolerance is very important especially in the process of water absorption. Inhibition of canopy and root growth is a common response to salinity stress and is an important indicator for assessing crop tolerance. This phenomenon can be a simulation of a condition of water deprivation or drought that affects plant compensation prolonging the rooting part.

4 CONCLUSIONS

Talam 2 and Kelinci showed more tolerance to salinity stress compared with Kancil and Local Aceh varieties based on all parameters of viability and vigor of peanut seed. Increasing salinity at simulated conditions above 3 g L^{-1} or equivalent to 3.99 dSm^{-1} resulted in a significantly decreased germination value of four varieties.

REFERENCES

Adisyahputra, S. Ilyas dan Sudarsono. 2004. *Penggunaan polyethylene glycole untuk menguji tanggap kacang tanah terhadap cekaman kekeringan pada tahapan perkecambahan*. Departemen Agronomi dan Hortikultura. Institut Pertanian Bogor. Bogor.

Albregts, E. C. dan C. M. Howard. 1972. *Influence of temperature and moisture stress from sodium chloride salinization on okra emergence*. Crop Sci. 836-837.

Badan Pusat Statistik. 2016. *Data produksi, luas panen, dan produktivitas palawija di indonesia 2013 – 2016.* www.bps.go.id. [13 Oktober 2017]

Danuwarsa. 2006. *Analisis proksimat dan asam lemak pada beberapa komoditas kacang-kacangan. Buletin Ilmu Pertanian.* Vol 11 (1): 5-8

Duan, D., X. Liu, M.A. Khan, and B. Gul. 2004. *Effect of salt and water stress on the germination of Chenopodium glaucum L. seed.* Pak J. Bot. 36 (4) : 793-800.

Erinnovita, M. Sari, D. Guntoro. 2008. *Invigorsi benih untuk memperbaiki perkecambahan kacang panjang (Vigna unguiculata Hask ssp sesquipendalis) pada cekaman salinitas.* Bul. Agro (36) 214-220.

Flowers, T.J. and S.A. Flowers. 2005. *Why does salinity pose such as a difficult problem for plant bredding.* Water Management. 78: 15-24.

Hajar, A.S., M.M. Heikal, Y.M. Maghrabi and R.A. Abuzinadah. 1993. *Responses of peanut to salinity stress*. K.A.U. Scie. (5): 5-13.

Halimursyadah, A.I. Hereri, dan A. Hafnizar. 2013. *Penggunaan polyethylene glycole sebagai media simulasi cekaman kekeringan terhadap viabilitas dan vigor beberapa varietas benih kacang tanah (Arachis hypogaea L.) pada stadia perkecambahan.* J. Floratek 8: 73 – 79.

Harnowo, D. 2002. *Pertumbuhan kecambah kedelai akibat cekaman salinitas.* Jakarta: BPPT. 192-202

Hasanuddin. 2015. *Pengujian model simulasi vigor kekuatan tumbuh benih kedelai (Glycine max L. merril) pada lahan salin.* Jurnal Floratek 10(2):72-77.

Karajol, K., dan G.R. Naik. 2011. *Seed germination rate as a phenotypical marker for the selection of NaCl tolerant cultivars in pigeon pea (Cajanus cajan (L.) Millsp.).* World J. of Sci. and Tech. 1(2): 1-8.

Kasno, A. dan D. Harnowo. 2014. *Karakeristik varietas unggul kacang tanah dan adopsinya oleh petani. Balai Penelitian Tanaman aneka Kacang dan Umbi,* Malang.

Khan, M.A., I.A. Ungar and A.M. Showalter. 2000. *Effects of sodium chloride treatments on growth and ion accumulation of the halophyte haloxylon recurvum. Coummun. Soil Sci.* Plant Anal. 31: 2763–2774.

Marusoh, S.T. 2008. *Uji cekaman garam (NaCl) pada perkecambahan beberapa kultivar kedelai (Glycine max (L.) Merril).* Skripsi. Universitas Islam Negeri Malang. Malang.

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

Noor, M. 2004. *Lahan rawa, sifat dan pengelolaan tanah bermasalah sulfat masam.* Raja Grafindo Persada. Jakarta.

Pohan, FA. 2005. *Uji ketahanan pada beberapa kultivar kacang tanah (Arachis hypogea L.)* terhadap salinitas. Thesis.Program Pascasarjana.USU.

Purnomo. 2007. *Keragaan varietas kacang tanah unggul di lahan ultisol masam. peningkatan produksi kacang-kacangan dan umbi-umbian mendukung kemandirian pangan.* Badan Penelitian Dan Pengembangan Pertanian. Pusat Penelitian dan Pengembangan Tanaman Pangan. Bogor.

Rini, D.S., Mustikowe., dan Surtiningsih. 2005. *Respon perkecambahan benih sorgum (Sorgum bicolor L. Moerch) terhadap perlakuan osmoconditioning dalam mengatasi cekaman salinitas.* Jurnal Biologi 7(6) :307-313.

Sipayung, R. 2003. *Stres garam dan mekanisme toleransi tanaman.* Skripsi. Universitas Sumatera Utara. Medan.

Taufiq, A dan Purwaningrahayu R. D. 2013. *Tanggap Varietas kacang hijau terhadap cekaman salinitas.* Jurnal Penelitian Tanaman Pangan. 32(3):159-170

Waskom, R. 2003. *Improved growth of salinity stressed soybean after Inoculation with salt pre-treated mycorrhizal fungi. Plant Physiology Elsevier.* http://www.science direct.com diakses pada tanggal 13 Agustus 2017.

Widoretno, W. 2002. *Efektivitas polietilena glikol untuk mengevaluasi tanggapan genotipe kedelai terhadap cekaman kekeringan pada fase perkecambahan.* Hayati. 9(2): 33–36.

Wijayanti, W., Taryono dan Toekidjo. 2014. *Keragaan 29 galur kacang tanah (Arachis hypogaea L.) pada kondisi salin.* Vegetalika. 3(4): 40 – 51.

Yuniati, R. 2004. *Penapisan galur kedelai Glycine max (L.) Merrill toleran terhadap NaCl untuk penanaman di lahan salin.* Makara Sains. 8(1): 22.

Yadav, S., I. Mohammad, A. Aqil dan H. Shamsul. 2011. *Causes of salinity and plant manifestations to salt stress: A review.* Journal Environtmental Biology 32:667–685.

Zakaria, S. dan C.M. Fitriani. 2006. *Hubungan antara dua metode sortasi dengan viabilitas dan vigor benih kacang tanah (Arachis hypogaea L.) serta aplikasinya untuk pendugaan ketahanan salinitas.* Jurnal Floratek (2): 1-11.