Jurnal Kultivasi Vol. 25 (1) April 2026
ISSN: 1412-4718, eISSN: 2581-138x

Tarigan PL · Moeljani IR · Suryandika F · Munarko H

Response of chlorophyll, morphology, and yield of several East Java superior soybean (*Glycine max* L.) varieties to levels of salinity

Abstract. Soybean production has been extended to saline areas. This development is a strategy to expand planting areas to suboptimal land to increase worldwide production. To support cultivation in these locations, it is necessary to develop superior varieties that are resistant to salinity and provide supporting technological inputs. In saline conditions, soybeans may face stress that leads to morphological, physiological, and yield disturbances. Consequently, the response of several soybeans in East Java should be observed. This study is a pot experiment and arranged in a Factorial Completely Randomized Design (CRD) consisting of two factors, soybean varieties and NaCl concentrations. The treatments comprise several NaCl levels: 0 g/L (non-saline), 5 g/L (moderate salinity), 15 g/L (high salinity), and 25 g/L (very high salinity). The observation used several parameters: chlorophyll content, plant height, leaf number, flowering time, pod forming time, number of pods, number of seeds, weight of 100 seeds, and harvest time. The soybean varieties used were Anjasmoro, Wilis, Dering 1, and Dering 3. Anjasmoro was identified as the soybean variety most tolerant to salinity stress based on chlorophyll content, morphology, and yield.

Keywords: Chlorophyll · NaCl · Soybean · Salinity

Submitted: 8 February 2026, Accepted: 29 April 2026, Published: 30 April 2026
DOI: https://doi.org/10.24198/kultivasi.v25i1.69758

Tarigan PL[1*] · Moeljani IR[1] · Suryandika F[1] · Munarko H[2]
[1]Program Study of Agrotechnology, Faculty of Agriculture, Universitas Pembangunan Nasional "Veteran" Jawa Timur. Jl. Rungkut Madya, Gn. Anyar, Surabaya 60294, East Java, Indonesia
[2]Program Study of Food Technology, Faculty of Engineering and Science, Universitas Pembangunan Nasional "Veteran" Jawa Timur. Jl. Rungkut Madya, Gn. Anyar, Surabaya 60294, East Java, Indonesia
*Correspondence: puji.lestari.agro@upnjatim.ac.id

Tarigan PL, Moeljani IR, Suryandika F, Munarko H. 2026. Response of chlorophyll, morphology, and yield of several East Java superior soybean (*Glycine max* L.) varieties to levels of salinity. Jurnal Kultivasi, 25 (1): 76-86.

Introduction

Soybean (*Glycine max* L.) faces many problems and limits the potential varieties in yield and quality, affected by the regions (Vogel et al., 2021). Salinity is one of the harmful threats to plant productivity, particularly in high concentrations (Dong et al., 2025). Among the factors, salinity affects several physiological and morphological characteristics in plants, leading to severe yield reductions (Otie et al., 2021). The continuous transformation of arable farming to non-arable land has led sustainable agriculture systems to extend into marginal areas (Sackey et al., 2025). Considering those areas with saline tendencies, successful extensification requires a strict selection and evaluation of genotypes tolerant to these conditions (Jha et al., 2022). Moreover, increasing global warming is increasing sea levels, leading to saltwater introduction to aquifers and agroecosystems (Chen and Mueller, 2018; Sultan et al., 2023).

NaCl on plant tissue can cause disturbance in physiological and molecular activity, such as the regulation process, decreased photosynthesis, and thus an excess of reactive oxygen species (Kumari et al., 2024; Mohajan et al., 2025). This is related to chlorophyll synthesis decreasing due to salinity by activating the chlorophyllase enzyme (Al-Ashkar et al., 2020; Alam et al., 2022). Due to the reduced photosynthetic capacity associated with salt stress, there are many fewer available resources, leading to inhibition of cell growth and expansion (Zelm et al., 2020; Peng et al., 2025). Because of low water potential due to increased salt levels, thus reducing the ability of plant cells to absorb water and reduces cell turgor pressure, which ultimately affects cell expansion. These initiate the shrinkage of plant tissue and the release of water from plant cells (Van Zelm et al., 2020;).

Salinity led to noticeable changes in the plant's shape, such as shorter plant height, fewer leaves on each plant, thinner and shorter stems, and less growth in both the shoots and roots (Kokebie et al., 2024). Salinity stress in soybean cultivation on tidal lands can reduce growth and yield, particularly during the early stages of plant development (Basuni, 2017; Nasution et al., 2024). When plants are exposed to salt for a long time, their leaves start to age, turn yellow, and eventually fall off. Too much salt can lower the amount of pigment, like chlorophyll, in the leaves and also decrease the area where photosynthesis can happen efficiently (Razmjooei et al., 2022; Mousavi et al., 2022).

Plant reaction to salinity is a multifaceted trait formed from the integration of various physiological processes. Thus, the morphological trait is not enough to evaluate when facing the salinity condition. Comprehensive studies should integrate physiological and biochemical parameters to characterize adaptation to salinity (Hasegawa et al., 2000; Bougrine et al., 2025).

Salinity has been identified as an important abiotic stress constraining the spread and productivity of soybean on marginal and salinized soils. Although the influences of salinity stress on soybean growth have been well documented, there is little information available on varietal differences in physiological responses, particularly to the stability of chlorophyll and photosynthetic activity. It is therefore very important to develop such screening techniques as well as experiments aimed at comparing soybean varieties for salt stress tolerance. Hence, the morphological, physiological, and yield characteristics of salt tolerance are the principal stages in establishing resistant soybean varieties.

Materials and Methods

The research was conducted at the Experimental Field, Faculty of Agriculture, Universitas Pembangunan Nasional "Veteran" Jawa Timur. The activities were carried out from October to November 2023. The materials used are soybean seeds, NaCl, polybag, planting media, Rhizobium, Urea fertilizer, KCl, and TSP. The equipment used are hoe, watering tools, buckets, shade netting, labels, stationery, and a camera.

The study was conducted as pot experiment and arranged in a Factorial Completely Randomized Design (CRD) consisting of soybean varieties and NaCl concentrations. The treatments consisted of several NaCl concentration levels: S0=0 g/L (non saline), S1=5 g/L (moderate salinity), S2=15 g/L (high salinity), and S3=25 g/L (very high salinity). The soybean varieties used were: V1=Anjasmoro, V2=Wilis, V3=Dering 1, and V4=Dering 3. There were 16 treatment combinations, with each treatment replicated three times, resulting in 48 experimental units.

The treatments were applied in accordance with the salinity classification by Rhoades and

ISSN: 1412-4718, eISSN: 2581-138x

Loveday (1992) and Kristiono et al. (2013). The treatment volume applied was 500 mL per polybag. Treatments were applied at 10, 30, and 50 days after planting (DAP), and fertilization was performed at 7 and 21 DAP. The fertilizer doses per polybag were Urea = 0.4 g/plant, KCl = 0.4 g/plant, and TSP = 0.3 g/plant. Besides that, the application of Rhizobium when planting as a soybean seed cover and additionally, paranet 90% during early growth to avoid high temperatures.

The observation parameters are plant height, leaf number, chlorophyll content (a, b, and total), flowering time, pod forming time, number of pods, number of seeds, weight of 100 seeds, and harvest time. Chlorophyll content was analyzed by the Harbourne (1987) method. The data were analyzed using SAS 9.4 software. The data underwent analysis of variance (ANOVA), followed by further testing using Duncan's Multiple Range Test (DMRT) at the 5% significance level.

Results and Discussion

Table 1 shows that there is no interaction between salinities and varieties on plant height. Growth is a key factor in determining plant tolerance to stress. Salinity is a limiting element for plants. Soybeans can grow in a wide range of salinities. The level of soybean resistance is determined genetically by the cultivar individually. In the first week, the Dering 3 was significantly different from Anjasmoro and Dering 1 in plant height. From the second to the fifth week, all kinds except Dering 1 showed more consistent improvements. Among the tested soybean varieties, Dering 3 indicates the highest plant height mean, followed by Anjasmoro and Wilis, while Dering 1 consistently showed the lowest plant height across observation periods. In general, the soybean plant height of the Anjasmoro and Wilis varieties was higher than that of Dering 1 and Dering 3, consistent with the morphological characteristics of these varieties under normal conditions. Based on the mean plant height in this study, Dering 3 is highly tolerant, Anjasmoro and Wilis are moderately tolerant, while Dering 1 is susceptible to salinity. According to Hamayun et al. (2010) and Pujiati et al. (2021), salinity stress reduced gibberellic acid production, which in turn reduced cell expansion, thereby affecting crop growth. Novita et al. (2023) added that the differences in plant height among various species in different environtment condition could be attributed to their genetic ability to adapt to salinity stress conditions.

In the first week, salinity factors were not treated. From the 14 DAP to the 28 DAP, salinity had no significant effect on plant height. A significant effect became evident only in the fifth week, when very high salinity markedly reduced plant height compared with the non-saline treatment. In moderate to very high saline tolerance, the mechanism instinct actived in the way to stay alive. In the early stage, treatment at 10 DAP does not affect plant height compared to non-saline as a control in 14, 21, and 28 DAP. Treatment at 30 DAP, very high saline decrease on plant height.

Table 1. Plant height of superior soybean (*Glycine max* L.) varieties from East Java on several levels of salinity at 7, 14, 21, 28, and 35 DAP

	Plant Height				
	7 DAP	14 DAP	21 DAP	28 DAP	35 DAP
Varieties	cm	cm	cm	cm	cm
V1 (Anjasmoro)	9.92b	23.1a	33.1a	39.5a	48.6a
V2 (Wilis)	10.58ab	23.7a	32.3a	39.3a	47.0a
V3 (Dering 1)	8.25c	15.0b	21.6b	28.0b	35.2b
V4 (Dering 3)	12.08a	23.1a	38.4a	44.0a	53.0a
Salinities (NaCl)					
S0 (0 g/L) (Non Saline)	8.83b	21.0	29.7	38.9	49.3a
S1 (5 g/L) (Moderate Saline)	9.92ab	21.4	30.9	38.8	49.0ab
S2 (15 g/L) (Very Saline)	10.58a	21.5	31.1	37.5	44.3ab
S3 (25 g/L) (Very High Saline)	11.50a	21.2	30.0	35.7	41.3b

Note: Means followed by the same letter in the table are not significantly different at 5% DMRT Soybean growth salinity. DAP: Days After Planting

The potential of salinity to inhibit plant growth through ion toxicity, nutritional imbalances, or a combination of these factors is linked to a decline in growth indices (Wasif et al., 2023; Kokebie et al., 2024). Sodium chloride (NaCl) is also taken up as a solution through the xylem and translocated to the leaves. Given that the plants are still able to grow, it is suggested that soybean tolerance is achieved through the compartmentalization of excess ions into cell vacuoles. Machado & Serralheiro (2017); Aboh & Eyong (2023) reported that plants grow less in saline environments because of less water availability, greater stomatal resistance, and excessive ion Na and Cl accumulation in the plant tissue.

Salt stress disturbs ionic homeostasis in plants by facilitating excessive Na^+ influx, thereby impeding the absorption of important ions such as K^+, Ca^{2+}, and Mg^{2+}. The negative effect of disturbance cell system tissue, ion exchange, activity adjustment, and finally interrupts physiological and metabolic functions (Wang et al., 2022; Han et al., 2025).

The salt tension that causes ionic and osmotic pressure interferes with normal cell function (Javaid et al., 2024; Tanveer et al., 2025). Hence, high salinity inhibits meristem activity and cell elongation in plants (Dolatabadian et al., 2011; Narayana et al., 2023).

Table 2. Leaf number of superior soybean (*Glycine max* L.) varieties from East Java on several levels of salinity 2, 3, 4, and 5 weeks

Varieties	Leaf Number			
	14 DAP	21 DAP	28 DAP	35 DAP
V1 (Anjasmoro)	1.75a	3.66a	5.08a	7.16a
V2 (Wilis)	1.58a	3.83a	5.75a	7.66a
V3 (Dering 1)	1.08b	2.57b	4.16b	5.41b
V4 (Dering 3)	1.83a	3.08a	5.58a	8.33a
Salinities (NaCl)				
S0 (0 g/L) (Non Saline)	1.58	3.33	5.33	7.58ab
S1 (5 g/L) (Moderate Saline)	1.66	3.91	5.16	8.25a
S2 (15 g/L) (Very Saline)	1.58	3.83	5.25	6.75bc
S3 (25 g/L) (Very High Saline)	1.41	3.25	4.83	6.00c

Note: Means followed by the same letter in the table are not significantly different at 5% DMRT. DAP: Days After Planting

Table 3. Chlorophyll a content of superior soybean (*Glycine max* L.) varieties from East Java on several levels of salinity

Treatment	Chloropyll a
0 g/L (non saline) + Anjasmoro	17,68 ± 0,29
0 g/L (non saline) + Wilis	17,51 ± 0,49
0 g/L (non saline) + Dering 1	16,97 ± 0,06
0 g/L (non saline) + Dering 3	17,03 ± 0,15
5 g/L (moderate salinity) + Anjasmoro	17,04 ± 0,16
5 g/L (moderate salinity) + Wilis	16,92 ± 0,07
5 g/L (moderate salinity) + Dering 1	17,21 ± 0,19
5 g/L (moderate salinity) + Dering 3	17,16 ± 0,21
15 g/L (high salinity) + Anjasmoro	17,08 ± 0,23
15 g/L (high salinity) + Wilis	17,04 ± 0,16
15 g/L (high salinity) + Dering 1	17,29 ± 0,34
15 g/L (high salinity) + Dering 3	17,05 ± 0,18
25 g/L (very high salinity) + Anjasmoro	17,03 ± 0,14
25 g/L (very high salinity) + Wilis	17,11 ± 0,27
25 g/L (very high salinity) + Dering 1	17,30 ± 0,33
25 g/L (very high salinity) + Dering 3	17,04 ± 0,17

Note: Data are presented as mean ± standard deviation

Table 4. Chlorophyll b and Total content of superior soybean (*Glycine max* L.) varieties from East Java on several levels of salinity

Salinities \ Varieties	V1 (Anjasmoro)	V2 (Wilis)	V3 (Dering 1)	V4 (Dering 3)
	Chlorophyll b Content			
S0 (0 g/L) (Non Saline)	19.68f	21.15e	27.08bc	19.13f
S1 (5 g/L) (Moderate Saline)	26.64bc	28.18ab	25.59cd	30.12a
S2 (15 g/L) (Very Saline)	28.08ab	25.94cd	29.87a	26.80bc
S3 (25 g/L) (Very High Saline	26.86bc	25.97cd	23.64d	26.98bc
	Total Chlorophyll Content			
S0 (0 g/L) (Non Saline)	36.99g	38.59f	44.08c	36.56g
S1 (5 g/L) (Moderate Saline)	44.01c	45.04b	43.14d	47.57a
S2 (15 g/L) (Very Saline)	45.79b	43.01d	47.06a	43.94d
S3 (25 g/L) (Very High Saline	43.95c	43.25d	41.10e	44.06c

Note: Means followed by the same letter in the table are not significantly different at 5% DMRT.

Table 2 shows that there is no interaction between salinities and varieties. When plants are exposed to environmental conditions, leaf organs represent the most apparent response. Changes in the leaves of broad-leaved and trifoliate soybean plants are readily observable. Dering 3 consistently exhibited the highest number of leaves at all observation times, although it was not significantly different from Anjasmoro and Wilis. On the other hand, Dering 1 always exhibited the least number of leaves and differed significantly from the rest of the cultivars. In terms of the varietal effect of the number of leaves, Dering 3, Anjasmoro, and Wilis exhibited better adaptability.

The genetic diversity for salt tolerance in soybean is mainly due to the variation in ion exclusion from shoots, particularly photosynthetically active mesophyll cells (Thanh et al., 2023; Açıkbaş et al., 2023). Furthermore, salinity causes certain genes to be expressed, which increases positive regulation of antioxidant enzymes, thereby improving salt plant resilience (Hasanuzzaman et al., 2022).

The effect of salinity on leaf number was not significantly different from the second to the fourth week. However, by the fifth week, very high salinity (25 g/L NaCl) significantly reduced leaf number compared with non saline and moderate salinity treatments. Cakir et al. (2004) and Trușcă et al. (2023) found that salinity disrupts plants in many ways. High salinity holds back cell growth, makes it harder for seeds to sprout, cuts down on the water plants can use, bumps up cellulose in the leaves, and basically stunts leaf growth. When Na^{+} levels go up to stomatal and chloroplast tissues, membranes get leakier, water potential drops, and stomata close up. Moreover, the respiration part, such as the electron transport chain bother and decreases photosynthesis rate (Assaha et al., 2017; Lin et al., 2025). An increasing salinity level causes a lower leaf area, stunted leaf growth, less light absorption, and a hindered photosynthesis rate (Manchanda & Garg, 2008; Majidian & Ghorbani, 2023). Principally, a saline condition causes osmotic pressure, which makes soybean water and nutrient disruption. Additionally, salinity triggers reactive oxygen species production in the cell. That leads to cell toxicity, damages membranes, and can end in cell death (Mo et al., 2020; Abulfaraj & Jalal, 2021).

Table 3 shows that there are no significant differences in combination of salinities and varieties in chlorophyll a content. Although not statistically significant, an upward trend in chlorophyll a was observed in Dering 1 as salinity concentrations increased. Chlorophyll a is the primary pigment involved in the photosynthesis process, and it is usually kept in higher amounts. According to Juwarno et al. (2018), salinity affected the content of chlorophyll a (might also be on chlorophyll b), the higher the salinity, the more chlorophyll a (and b) were present. Lenis et al. (2011), as cited in Newsome (2016), reported an increase in chlorophyll content under salt stress in some salt-tolerant Glycine accessions.

On the other hand, Table 4 shows that the combination of (5 g/L) (Moderate Saline) and Dering 3 shows a significant difference compared to the other chlorophyll b and total chlorophyll content, except for (15 g/L) (Very Saline) and Dering 1. Chlorophyll b is part of the light-harvesting complex and helps the plant adapt better to stressful conditions.

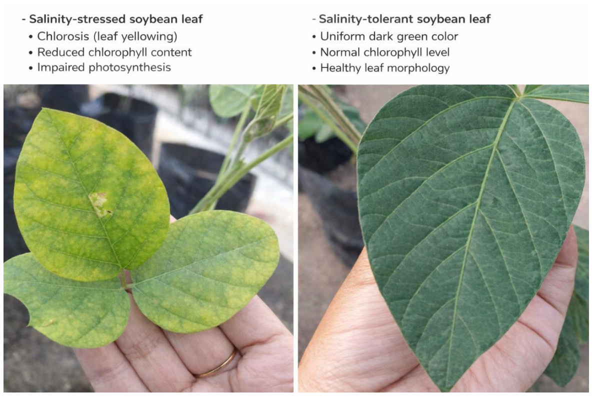
Chlorophyll b content increases at moderate salinity, then tends to decrease at very high salinity, except for Dering 1. At lower salt levels, soybeans can boost their chlorophyll levels, which helps improve their ability to perform photosynthesis. Chloroplast stability is only possible under conditions of moderate salinity. Adaptation mechanism of salinity stress Dering 3 and Wilis only up to (5 g/L) (Moderate Saline), and Dering 1 and Anjasmoro up to 15 g/L (Very Saline). Based on the reduction in chlorophyll levels, Anjasmoro and Dering 3 show the highest stability, Wilis demonstrates moderate stability, and Dering 1 shows the greatest sensitivity.

Salt stress greatly reduces the ability of plants to perform photosynthesis. This happens because salt affects the electron transport chain and causes oxidative damage, which harms the cell structure and the chlorophyll molecules. As a result, the metabolic processes within the plant are disrupted (Dai et al., 2024; Batool et al., 2026). The Na+ and Cl ions that accumulate in the chloroplast will inhibit photosynthesis because chlorophyll is the major photosynthesis pigment directly associated with plant growth and development (Saleem et al., 2020; Barus et al., 2023). The salinity-induced reductions in chlorophyll may be attributed to oxidative damage-induced membrane breakdown and chlorophyllase, which negatively impacts pigment synthesis (Aljuaid et al., 2022; Nasrallah et al., 2022; Qian et al., 2024).

Chlorophyll biosynthesis can be inhibited through a series of step-by-step reactions, resulting in a reduced chlorophyll level (Tanaka et al., 2006; Qian et al., 2024). Also, photosynthesis becomes disturbed by abiotic stress because damage to the enzyme connected with chlorophyll synthesis (Rajput et al., 2021; Alzahrani, 2024).

Several varieties exhibit stability in the configuration of total chlorophyll even in high saline conditions. The other varieties exhibit a significant decrease. This study finds that the interaction between salinity condition and variety as geneticly influence. Genetic character more affects the response of the plant to salt stress. There is a decline in total chlorophyll content caused by the salinity condition indicate negative impact on photosynthetic ability rather than each pigment composition. The inter-varietal variability in maintaining total chlorophyll indicates different levels of salinity tolerance, which can be the basis for selecting varieties tolerant to salt stress.

Salinity stress impacts obstacle on gas exchange, stomatal conductance capability, and electron transport optimization, thereby limiting the biosynthesis of chlorophyll. Chlorophyll degradation may be caused by ROS and essential nutrient transport configuration, as well as Na$^+$ and Cl$^-$ (Amjad et al., 2020; Alizadeh et al., 2024).



(a) (b)

Figure 4. The chlorophyll expression as greenness of soybean leaves: a) Dering 1 (susceptible), b) Anjasmoro (resistant)

In the salinity condition, soybeans tend to be threatened, and this is reflected in leaf chlorosis, reduced growth, and lower biomass (Tomaškinová et al., 2025). Dering 1 exhibits obvious chlorosis symptoms, leaves characther able to changing color from pale green to yellowish. Chlorophyll content status indicates the pigment damage, especially chlorophyll a and total chlorophyll, because of biosynthesis disruption or degradation of chlorophyll under salinity conditions. Chlorosis as physiology reflection of a decrease in photosynthetic capability and pigment light-capturing efficiency, related to ionic and osmotic stress caused by the accumulation of Na$^+$ and Cl$^-$ ions in leaf tissues.

On the other hand, Anjasmoro leaves exhibit a dark green color with normal leaf shape morphology. This study exhibits relative stability of chlorophyll production, indicate photosynthethic capability undisturbed in saline conditions. These visual observations are consistent with the data for chlorophyll b and total chlorophyll, where Anjasmoro is able to

ISSN: 1412-4718, eISSN: 2581-138x

maintain higher chlorophyll levels rather than Dering 1 on various salinity treatments. Although it is technically at severity Dering 3 based on the data, in terms of phenotypic expression, Anjasmoro appears the greenest. This is suspected to be due to its leaf thickness and the structure of the leaf mesophyll tissue.

Overall, Dering 1 was more sensitive to salinity, indicated by an intense decrease in total chlorophyll and the appearance of chlorosis, while Anjasmoro exhibited salinity tolerance extensively, evident by its ability to maintain chlorophyll b and total chlorophyll content. Thus, the observed differences in chlorophyll expression in further research support the quantitative analysis by indicating that the photosynthetic response of soybeans to salinity is more influenced by the genetic factors of the variety.

Salt stress on plants tend indicated by chlorosis due to increased salt accumulation (Linh & Thang, 2021). The influence on the height of enzyme chlorophyllase activity under salinity stress, which leads to degraded chlorophyll accumulation, eventually causing leaf senescence and chlorosis (Rahman et al., 2016; Otie et al., 2021). Stress in the salinity condition depresses nitrogen nutrients in plants, this contribute in chlorophyll reduction (Khademian et al., 2019; Yaghoubian et al., 2021).

Table 5 shows that there is no interaction between salinities and varieties in yield parameters. Soybeans may grow in saline conditions. Growth is regarded as successful when it reaches the highest stage of its life cycle, which is the generative phase. Soybeans use a variety of strategies to deal with stress. Flowering time generally did not exhibit any delay among the tested varieties. All varieties, except Dering 1, showed no significant differences in mean flowering time. The pod formation stage, Dering 1 and Dering 3 did not differ significantly from each other; however, both varieties differed significantly from the remaining varieties. Regarding the number of pods per plant, Dering 3 produced the highest number of pods. This value was not significantly different from those of Anjasmoro and Wilis, but it was significantly higher than that of Dering 1. In terms of seed number, Anjasmoro produced the highest number of seeds and did not differ significantly from Wilis and Dering 3, whereas it differed significantly from Dering 1. The weight of 100 seeds is generally low across all varieties. Anjasmoro is not significantly different from Wilis and Dering 3, but shows a significant difference compared to Dering 1. Harvest age average has no significant difference among varieties. Anjasmoro, Wilis, Dering 1, and Dering 3 reach harvest time between 87 and 90 days after planting (DAP), these results are still close to the respective variety descriptions under normal conditions. Salinity stress basically affected the yield components more than the harvest time. During the generative phase, Anjasmoro and Wilis mostly exhibited greater stability compared with Dering 1 and Dering 3. This condition indicates adaptation of the generative stage following NaCl treatment at 30 and 50 DAP.

Table 5. Flowering time, pod forming time, number of pods, number of seeds, weight of 100 seeds, and harvest time of superior soybean (*Glycine max* L.) varieties from East Java on several levels of salinity

	Flowering Time	Pod Forming Time	Number of Pods	Number of Seeds	Weight of 100 Seeds	Harvest Time
	DAP	DAP	pod	seed	g	DAP
Varieties						
V1 (Anjasmoro)	43.17a	54.25a	44.83a	82.83a	4.80a	88.1ab
V2 (Wilis)	43.75a	54.83a	27.25b	56.50ab	4.07a	87.0ab
V3 (Dering 1)	50.75b	64.17b	7.17c	5.08b	0.07b	90.0b
V4 (Dering 3)	44.33a	61.25b	37.50ab	80.92a	1.75b	90.0b
Salinities (NaCl)						
S0 (0 g/l) (Non Saline)	47.83	58.92	45.67a	106.17a	3.22	88.8
S1 (5 g/l) (Moderate Saline)	43.75	57.75	33.67ab	60,42ab	3.39	88.6
S2 (15 g/l) (Very Saline)	44.10	57.56	21.33bc	34.50b	2.72	89.1
S3 (25 g/l) (Very High Saline)	44.10	56.78	16.08c	24.25b	1.36	88.9

Note: Means followed by the same letter in the table are not significantly different at 5% DMRT.
DAP: Days After Planting

Salinity as a single factor did not significantly affect flowering time, pod emergence time, 100-seed weight, or harvest time. However, the number of pods and seeds per plant is significantly different between non-saline and high-salinity conditions.

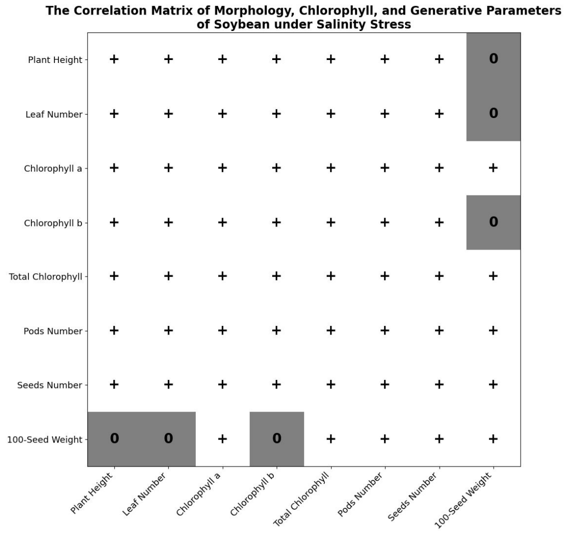
Salinity stress reduces soybean growth parameters, pod number per plant, and yield by disrupting nutrient balance and plant water relations (Essa, 2002; Tareq et al., 2022). In this study, a reduction in the number of pods at 26.3-64.8% and the number of seeds at 43.1-77.2%. The weight of 100 seeds was reduced by 15.5-57.8% in very and very high saline conditions. Seed number is the most sensitive parameter to salinity stress.

Salt stress also affects essential physiological and metabolic systems in plants, such as protein synthesis, nutrient and water absorption, assimilate translocation, and cytosolic and mitochondrial responses. These abnormalities result in less biomass accumulation and reduced reproductive development (Alharby et al., 2021; Toshtemirovna & Raufovna, 2025).

The differences in the varieties are the factor was linked to genetically influence that are genetically influenced and affect plant adaptation, nutrient uptake, and how well it can handle stress from the environment. The impact of the salinity factor tends in higher salinity levels head to slow down plant growth in higher salinity levels. Since they cause ionic imbalance, lower osmotic tension, and disruption of photosynthesis. Observations indicate a single factor is able to control plant response, even without significant interaction between the combination factors. Therefore, every single factor is considered an important parameter in the evaluation of plant growth and stress tolerance.

Salinity is one of the abiotic stressors that is able to limit crop productivity by affecting plant growth until generative. Plants modify many resistance mechanisms in response to salt stress periods (Asif et al, 2014; Kang et al., 2023). Sensitivity to salinity in soybean peaks during flowering and the early stages of grain development (Kondetti et al., 2012; Pavli et al., 2021). Salinity stress adversely affects soybean growth, seed quality and quantity, and overall yield (Khan et al., 2019; Khan et al., 2021).

The most vegetative and physiological parameters exhibit positive relationships with generative traits. Total chlorophyll shows the strongest and most closely positive association with yield components, though the relationship between vegetative growth traits and 100 seed weight appears weak. The relationship between the weight of 100 seeds and some parameters cannot be established. Chlorophyll b barely changed across all salinity treatments. Reduction in chlorophyll b was not significantly affected even under high saline conditions. The weight of 100 seeds really depends on photosynthesis yield availability during the seed-filling stage. Therefore, it shows a stronger association with chlorophyll a than with chlorophyll b.



+: Positive correlation o: No correlation
(Pearson's correlation coefficient (Pearson, 1896))

Figure 5. The Correlation matrix of chlorophyll, morphology, and generative parameters of soybean under salinity stress

Saline condition desructive on gas exchange activities, photosynthetic component, and nutrient transportation, eventually decreases yield component. It also degrades chlorophyll pigments, both chlorophyll a and chlorophyll b (Pan et al., 2021; Shahriar-Tareq et al., 2021).

In general, every single factor indicates different genes among soybean varieties, as revealed in saline level consistently. Salinity plays a role as a main effect in a single significant effect on generative character, tend increasing salt levels uniformly reduce plant performance regardless of variety.

Anjasmoro was identified as a superior soybean variety from East Java that was evaluated in this study and found to be the most

ISSN: 1412-4718, eISSN: 2581-138x

salt-tolerant. This variety constantly indicates more stable generative and physiological parameters under salinity stress. Resistance trait is evident in tolerance mechanism till very high salinity conditions. However, further observation on genetic analysis is needed to explain the main mechanisms of this salt tolerance.

Ion homeostasis is a key mechanism underlying salt tolerance in soybeans, and major genes such as GmCHX1 in the soybean genome have been validated. As a result, targeting ion transport processes is one of the most effective strategies for developing or selecting salt-tolerant cultivars (Leung et al., 2023). At the side genetic factor, abiotic management improvement through technology inovation as important factor. Plants resilient under stress conditions use management strategies of exogenous agronomic treatment.

Conclusion

Based on chlorophyll content, morphological parameters, and yield, Anjasmoro was identified as the most salt-tolerant soybean variety. Tolerance rate indicates high to very high salinity levels (15–25 g L^{-1} NaCl) by the stability of the number of pods, seed number, 100 seeds weight, chlorophyll a, and total chlorophyll. The salinity resistance order is: Anjasmoro, Dering 3, Wilis, and Dering 1.

Acknowledgments

The author sincerely thanks to LPPM UPN "Veteran" Jawa Timur for supporting this research through the 2023 Flagship Research funding scheme.

References

Açıkbaş S, Özyazıcı M.A., Bıçakçı E, Özyazıcı G. 2023. Germination and seedling development performances of some soybean (*Glycine max* (L.) Merrill) cultivars under salinity stress. Turkish Journal of Range and Forage Science, 4: 108-118.

Aboh AA, Eyong, OI. 2023. Effects of Salinity Stress on Growth Parameters of Soybeans (*Glycine max*) Cultivated in Obubra Local Government Area, of Cross River State Nigeria. Asian Journal of Research in Crop Science, 8: 465-470.

Abulfaraj AA, Jalal RS. 2021. Use of Plant Growth-Promoting Bacteria to Enhance Salinity Stress in Soybean (*Glycine max* L.) plants. Saudi journal of biological sciences, 28: 3823-3834.

Alam P, Arshad M, Al-Kheraif AA, Azzam MA, Al Balawi T. 2022. Silicon nanoparticle-induced regulation of carbohydrate metabolism, photosynthesis, and ROS homeostasis in Solanum lycopersicum subjected to salinity stress. ACS omega, 7: 31834−31844.

Alizadeh MM, Gerami M, Majidian P, Ghorbani HR. 2024. The Potential Application of Biochar and Salicylic Acid to Alleviate Salt Stress in Soybean (*Glycine max* L.). Heliyon, 10: 1-16.

Alzahrani Y. 2024. Evaluation of drought and salinity tolerance potentials of different soybean genotypes based upon physiological, biochemical, and genetic indicators. Frontiers in Plant Science, 15: 1-13.

Batool M, El-Badri AM, Zheng L, Wang C, Wang Z, Ikram M, Ullah M, Ikram M, Waqas M, Kuai J, Zhang C. 2026. Comprehensive Morpho-Physiological Responses Underlying Salt Tolerance at Different Time Points in Brassica napus Seedlings. Plants, 15: 1-21.

Barus WA, Sulistiani R, Utami S, Tarigan DM, Lestami A. 2023. Black Soybean Response to Antioxidant Application for Growth and Yield under Salinity Stress Conditions. SABRAO Journal of Breeding and Genetics, 55: 417-426

Bougrine H, Hadjout S, Zouidi M, Belkendil A, Zeghmar A, Boulekdam C, Ouaret W, Soufan W, Belhouadjeb FA, Mebarkia A. 2025. Assessment of Salinity Tolerance and Ecotypic Variability in *Vicia narbonensis* L.: Morphological, Physiological, and Biochemical Responses. Phyton, 94: 251-267.

Colin L, Ruhnow F, Zhu JK, Zhao C, Zhao Y, Persson S. 2023. The cell biology of primary cell walls during salt stress. Plant Cell, 35: 201-217.

Dong T, Yan L, Wang J, Niu Y, Wang L. 2025. Salt Tolerance in Soybean (*Glycine max* L.): A Comprehensive Review of Molecular Mechanisms, Key Regulators, and Future

Perspectives for Saline Soil Utilization. Plants, 14: 1-21.

Han L, Ge L, Fei L, Huang C, Li Y, Fan W, Zhu D, Zhao L. 2025. A Comprehensive Evaluation of Soybean Germplasm Resources for Salt Tolerance During Germination. Plants, 14: 1-16.

Hasanuzzaman M, Parvin K, Anee TI, Masud AAC, Nowroz F. 2022. Salt Stress Responses and Tolerance in Soybean. In Plant stress physiology-perspectives in agriculture. IntechOpen. London.

Jha S, Singh J, Chouhan C, Singh O, Srivastava RK. 2022. Evaluation of multiple salinity tolerance indices for screening and comparative biochemical and molecular analysis of pearl millet [*Pennisetum glaucum* (L.) R. Br.] genotypes. Journal of Plant Growth Regulation, 41: 1820-1834.

Juwarno J, Suparjana TB, Abbas M. 2018. Mahameru soybean (*Glycine max*) cultivar, high salinity tolerant. Biosaintifika: Journal of Biology & Biology Education, 10: 23-31.

Kang SM, Hoque MIU, Woo JI, Lee IJ. 2023. Mitigation of Salinity Stress on Soybean Seedlings Using Indole Acetic Acid-Producing Acinetobacter Pittii YNA40. Agriculture, 13: 1-15.

Khan MA, Sahile AA, Jan R, Asaf S, Hamayun M, Imran M, Adhikari A, Kang SM, Kim KM, Lee IJ. 2021. Halotolerant Bacteria Mitigate The Effects of Salinity Stress on Soybean Growth by Regulating Secondary Metabolites and Molecular Responses. BMC Plant Biology, 21: 1-15.

Kokebie D, Enyew A, Masresha G, Fentie T, Mulat E. 2024. Morphological, physiological, and biochemical responses of three different soybean (*Glycine max* L.) varieties under salinity stress conditions. Frontiers in Plant Science, 15: 1-14.

Leung HS, Chan LY, Law CH, Li MW, Lam HM. 2023. Twenty years of mining salt tolerance genes in soybean. Molecular Breeding, 43: 1-17.

Lin T, Haider FU, Liu T, Li S, Zhang P, Zhao C, Li X. 2025. Salt Tolerance Induced by Plant Growth-Promoting Rhizobacteria Is Associated with Modulations of the Photosynthetic Characteristics, Antioxidant System, and Rhizosphere Microbial Diversity in Soybean (*Glycine max* (L.) *Merr*.). Agronomy, 15: 1-18.

Linh NT, Thang VN. 2021. Effects of salinity stress on the growth, physiology, and yield of soybean (*Glycine max* (L.) Merrill). Vietnam Journal of Agricultural Sciences, 4: 1043-1055.

Mahajan M, Poor P, Kaur H, Aher RR, Palakolanu SR, Khan MIR. 2025. Salt stress tolerance and abscisic acid in plants: associating role of plant growth regulators and transcription factors. Plant Physiology and Biochemistry, 228: 1-13.

Majidian P, Ghorbani H. 2024. Salinity stress in plants: challenges in view of physiological aspects. In Abiotic stress in crop plants-ecophysiological responses and molecular approaches. IntechOpen. London.

Mousavi SS, Karami A, Maggi F. 2022. Photosynthesis and chlorophyll fluorescence of Iranian licorice (*Glycyrrhiza glabra* L.) accessions under salinity stress. Frontiers in Plant Science, 13: 1-19.

Narayana RC, Anwar S, Karno K. 2024. Respons Morfologi dan Produksi Tanaman Kedelai (*Glycine max* L.) terhadap Penggunaan Berbagai Dosis Asam Salisilat dalam Cekaman Salinitas. Buana Sains, *23*: 107-116.

Nasution SN, Ghulamahdi M, Melati M. 2024. Impact of salinity stress on soybean growth and yield under saturated soil culture in tidal lands: A comparative study of tolerant varieties. Journal of Tropical Crop Science, 11: 287-298.

Newsome JA. 2016. Dissecting Salt Tolerance in Soybean by Profiling Differential Physiological Responses under Salt Stress. University of Arkansas. US.

Otie V, Udo I, Shao Y, Itam MO, Okamoto H, An P, Eneji EA. 2021. Salinity Effects on Morpho-Physiological and Yield Traits of Soybean (*Glycine max* L.) as Mediated by Foliar Spray With Brassinolide. Plants, 10: 1-22.

Pavli OI, Foti C, Skoufogianni G, Karastergiou G, Panagou A, Khah, E.M. 2021. Effect of Salinity on Seed Germination and Seedling Development of Soybean Genotypes. Int J Environ Sci Nat Res., 27: 1-9.

Pearson K. 1896. Mathematical contributions to the theory of evolution. III. Regression, heredity, and panmixia. Philos Trans R Soc Lond A, 187: 253-318.

Peng Y, Zhu H, Wang Y, Kang J, Hu L, Li L, Zhu K, Yan J, Bu X, Wang X, Zhang Y. 2025. Revisiting the role of light signaling in plant responses to salt stress. Horticulture Research, 12: 1-11.

Jurnal Kultivasi Vol. 25 (1) April 2026
ISSN: 1412-4718, eISSN: 2581-138x

Pujiwati H, Suharjo UK, Prameswari W, Husna M, Gonggo B, Ginting S, Susilo E. 2021. Morphological and physiological performances of 18 soybean varieties exposed to salinity stress. J. Agron. Indonesia, 49: 251-258.

Qian Z, Lu L, Zihan W, Qianyue B, Chungang Z, Shuheng Z, Jiali P, Jiaxin Y, Shuang Z, Jian, W. 2024. Gamma-aminobutyric acid (GABA) improves salinity stress tolerance in soybean seedlings by modulating their mineral nutrition, osmolyte contents, and ascorbate-glutathione cycle. BMC Plant Biology, 24: 1-18.

Sackey OK, Feng N, Mohammed YZ, Dzou CF, Zheng D, Zhao L, Shen X. 2025. A comprehensive review on rice responses and tolerance to salt stress. Frontiers in Plant Science, 16: 1-26.

Sathiyamurthi S, Saravanan S, Karuppannan S, Balakumbahan R, Sivasakthi M, Praveen Kumar S, Ramya M, Hussain S, Tariq A. 2024. Agricultural land suitability of Manimutha Nadhi watershed using AHP and GIS techniques. Discover Sustainability, 16: 1-20.a

Shahriar-Tareq M, Mannan MA, Al Mamun MA, Hossain MS, Higuchi H, Karim MA. 2021. Salinity induced changes in growth and physiology of field crops. Bangladesh Journal of Ecology, 3: 1-9.

Sultan MT, Mahmud U, Khan MZ. 2023. Addressing soil salinity for sustainable agriculture and food security: Innovations and challenges in coastal regions of Bangladesh. Future Foods, 15: 1-16.

Tanveer M, Mahmood A, Alawadi HFN, Adiba A, Javaid MM, Khan BA, Wahid A, Abdullah F, Seleiman MF. 2025. Impact of boron on Glycine max L. to mitigate salt stress by modulating the morpho-physiological and biochemical responses. BMC Plant Biology, 25: 1-21.

Tareq MS, Mannan MA, Rahman MM, Mamun MAA, Karim MA. 2022. Salinity-induced changes in growth, physiology and yield of soybean genotypes. Annals of Bangladesh Agriculture, 26: 29-48.

Tomaškinová J, Tomaškin J, Drimal M, Bellido J. 2025. The Impact of Abiotic Environmental Stressors on Fluorescence and Chlorophyll Content in *Glycine max* (L.) Merrill. Agronomy, 15: 1-18.

Toshtemirovna NU, Raufovna KG. 2025. The Effect Of Salinity On The Growth and Development of Soybean Varieties. Modern American Journal of Biological and Environmental Sciences, 1: 78-87.

Trușcă M, Gâdea Ș, Vidican R, Stoian V, Vâtcă A, Balint C, Stoian VA, Horvat M, Vâtcă S. 2023. Exploring the Research Challenges and Perspectives in Ecophysiology of Plants Affected by Salinity Stress. Agriculture, 13: 1-19.

Van Zelm E, Zhang Y, Testerink C. 2020. Salt tolerance mechanisms of plants. Annual review of plant biology, 71: 403-33.

Vogel JT, Liu W, Olhoft P, Crafts-Brandner SJ, Pennycooke JC, Christiansen N. 2021. Soybean yield formation physiology–a foundation for precision breeding based improvement. Frontiers in plant science, 12: 1-15.

Yaghoubian I, Ghassemi S, Nazari M, Raei Y, Smith DL. 2021. Response of Physiological Traits, Antioxidant Enzymes and Nutrient Uptake of Soybean to Azotobacter Chroococcum and zinc sulfate under salinity. South African Journal of Botany, 143: 42-50.