Growth and yield characteristics of soybean on the usage of several varieties and fertilizers N, P, K in tidal lowland

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Abstract. The increasing soybean production by expanding areas to marginal land, such as tidal lowland, has become the target of Indonesian government. The objective of the research was to select several varieties of soybeans and the appropriate dosage of N, P, K fertilizers to increase the soybean growth and yields characteristics. This research was conducted at tidal lowland in Sei Ular Village, Secanggang sub-District, Langkat District from July to December 2019, use a factorial randomized block design with two factors and three replications. The first factor is soybean varieties (Anjosmoro; Deja-1; Dena-1 and Dering-1). The second factor is application of N, P and K fertilizers at dosage namely un-fertilizer; 50kg ha⁻¹ N, 40kg ha⁻¹ P₂O₅, 50kg ha⁻¹ K₂O ; 100kg ha⁻¹ N, 80kg ha⁻¹ P₂O₅, 100kg ha⁻¹ K₂O and 150kg ha⁻¹ N, 120kg ha⁻¹ P₂O₅, 150kg ha⁻¹ K₂O. The result of the research showed that the soybean varieties significantly differ affected on the plant height of soybeans at 30 DAP, volume and length of root in tidal lowland. The dosage of N, P, K fertilizers were significantly different on the plant height and root length, and their interactions significantly different on the shoot root ratio.

1. Introduction
The increasing soybean yield by expanding areas to insufficient nutrient land, such as tidal lowland, has become the target government of Indonesia. The potential for tidal lowland for agriculture in Indonesia is around of 8.92 million ha and was spread at Sumatra of 3.03 million ha, Kalimantan of 2.99 million ha, Papua of 2.43 million ha, Sulawesi of 0.32 million ha, Jawa of 0.09 million ha and Maluku of 0.07 million ha [1]. The area soybean in tidal lowland caused by high salt rates will decrease yield and quality of plants.

The main issue of saline land is the high content of Na⁺ and Cl⁻ in the plant root that the osmotic pressure of the soil solution increases. Excessive quantity of Na damages the soil colloid thus affecting to the soil physical properties such as infiltration, aggregation, permeability, soil porosity be disturbed [2,3]. The excessive salt causes phytotoxicity, nutrient imbaance and water deficiency in the soil [4]. A reduction process in flooded conditions on acid sulphate soils can increase the pH and reduces the solubility of Al. However, it can increase the solubility of Fe³⁺, H₂S, CO₂ and organic acids which are toxic to plants [5].

The effort are needed to increase soybean yielis in tidal lowland such as basic fertilization, addition of organic matter and lime to fulfill the macro and micro nutrient and the use of salinity-tolerant varieties. According to [6] the fertilization must be balanced wuth the nutrient content available in the
soil, which affects the yield of varieties to be planted [7] stated that the use of inorganic fertilizer remains the main priority for the viability of the food plant and other plants have the economic value [8] reported that to increase soil fertility can be done by adding organic matter, lime and NPK fertilizer. Based on the study of tolerant plants [9,10] reported the mechanism of salinity tolerant plants through osmotic tolerance, ability to exclude Na+ or Cl−, and the abilitu of plant tissue to tolerate high Na+ or Cl−concentrations. The soybeans varieties of Deja-1 and Deja-2 were officially released by the government as new superior varieties in 2017. Both varieties have high yield potential and are tolerant of flooded stress [11].

Previous researches on Anjasmoro and Dering-1 varieties has been carried out, including the physiological characteristics of these varieties under dry land condition with application of MgSO4/kieserit [12,13], role of technological packages of these varieties under dry land condition [14,15], isoflavone content of Anjasmoro with N nutrient management under dry land condition [16], response of growth and N uptake of Anjansmoro variety on inoculation of Bradyrhizobium sp in Ultisol [17]. Thus, further research is needed on the usage of soybean varieties with the appropriate fertilization to support soybean growth and yield under salinity stress. The research was to select several varieties of soybeans and the appropriate dosage of N, P, K fertilizers to improve the soybean growth and yield under tidal lowland condition.

2. Materials and methods
A field research was conducted at tidal lowland Sei Ular Village, Secanggang sub-district, Langkat District, with high rate salinity at 4.01 mmhos/cm was classified as moderate [18]. The research was done from July until December 2019. This research used a factorial randomized block design with two factors and three replications. The first-factor using soybean varieties such as V1= Anjasmoro ; V2=Deja-1 ; V3 = Dena ; V4 = Dering-1. The second factor was application of NPK fertilizer combination from Urea, TSP and KCl at dosage P0= without fertilizer ; P1 = 50 kg ha⁻¹ N, 40 kg ha⁻¹ P₂O₅, 50 kg ha⁻¹ K₂O ; P2 = 100 kg ha⁻¹ N, 80 kg ha⁻¹ P₂O₅, 100 kg ha⁻¹ K₂O and P3 = 150 kg ha⁻¹ N, 120 kg ha⁻¹ P₂O₅, 150 kg ha⁻¹ K₂O.

The research was made a plot with the size of 2.2 m x 1.4 m. Each experiment in one replication was limited by a drainage ditch with the width of 50 cm, while the distance between blocks were 100 cm. Soil tillage was incubated for one week. Planting was conducted at one week after soil tillage. Measurements were made when the plants were 30 days after planting (DAP) when the vegetative phase of soybean plants ended, which was around of 11 until 30 DAP [18].The root was cleaned and put in beaker glass that has been filled with water. Then measured the amount of increase in the volume of water. Root volume and root length were measured when the plants were 30 DAP. Weighing the fresh weight of shoot and root was conducted at 30 DAP. The root were cleaned from the soil and dried for 2 hours then then weighed with analytical scales. The shoot and root put in the oven for 3 x 24 hours at the temperature of 65°C. Parameters in this research were processed using analysis of variance (ANOVA) then was followed by the DMRT at rate of 5% using SPSS software.

3. Results and discussion

3.1. Result

3.1.1. Plant height (cm). The usage of several varieties and dosage of N, P, K fertilizer significantly affect on the plant height of soybean at 30 DAP, but the combinations were not significantly affect on the plant height of soybean at 30 DAP (table 1).The plant height of Anjosmoro (V1) variety was significantly different and had the highest plant height by 26.92 cm compared to other varieties at 30 DAP. The un-fertilizer treatment showed that the highest plant height of soybean by 27.32 cm.
Table 1. Plant height, root volume and root length of soybean varieties at 30 DAP with application of N, P, K fertilizer.

| N, P, K fertilizer (kg ha⁻¹) | Varieties (V) | Mean |
|-----------------------------|---------------|------|
|                             | V1 (Anjasmoro) | V2 (Deja-1) | V3 (Dena) | V4 (Dering-1) |
| Plant height (cm)           |               |               |           |               |
| P0                          | 33.51         | 28.05         | 21.25     | 26.47         | 27.32 a |
| P1                          | 21.66         | 26.07         | 19.39     | 23.25         | 22.59 b |
| P2                          | 26.02         | 23.28         | 20.38     | 25.05         | 23.68 b |
| P3                          | 26.48         | 21.73         | 19.54     | 23.99         | 22.94 b |
| Mean                        | 26.92 a       | 24.78 a       | 20.14 b   | 24.69 a       |
| Root Volume (cc)            |               |               |           |               |
| P0                          | 1.64          | 1.62          | 1.43      | 1.43          | 1.53   |
| P1                          | 1.35          | 1.59          | 1.49      | 1.41          | 1.46   |
| P2                          | 1.61          | 1.58          | 1.63      | 1.67          | 1.62   |
| P3                          | 1.51          | 1.42          | 1.51      | 1.42          | 1.47   |
| Mean                        | 1.53          | 1.55          | 1.52      | 1.48          |
| Root Length (cm)            |               |               |           |               |
| P0                          | 15.13         | 13.55         | 13.03     | 13.53         | 13.81 b |
| P1                          | 12.03         | 14.10         | 13.76     | 13.32         | 13.30 b |
| P2                          | 15.06         | 14.59         | 14.82     | 17.55         | 15.50 a |
| P3                          | 14.21         | 12.92         | 13.69     | 13.09         | 13.48 b |
| Mean                        | 14.11         | 13.79         | 13.82     | 14.37         |

Note: Means followed by the same letter are not significantly different by DMRT at rate of 5%. Dosage of N, P, K fertilizer (P), P0= un-fertilizer; P1= 50 kg ha⁻¹ N, 40 kg ha⁻¹ P₂O₅, 50 kg ha⁻¹ K₂O; P2= 100 kg ha⁻¹ N, 80 kg ha⁻¹ P₂O₅, 100 kg ha⁻¹ K₂O; P3= 150 kg ha⁻¹ N, 120 kg ha⁻¹ P₂O₅, 150 kg ha⁻¹ K₂O. This note is used to table 1-3

3.1.2. Volume and length of root. The N, P, K fertilizer showed significant affect on root length, but it was not significant on the root volume of soybean in tidal lowland at 30 DAP. The usage of several varieties of soybean and their interaction were not significantly different on the volume and length of the root in tidal lowland at 30 DAP (table 1). The N, P, K fertilizer at P2 showed significantly increased the highest root length of soybean by 15.50 cm at 30 DAP compared to other fertilizer doses.

3.1.3. Dry weight od shoot and root. The soybean varieties, N, P, K fertilizers and their interaction insignificant affect on the dry weight of shoot and root of soybean at 30 DAP under tidal lowland condition (table 2). The Anjasmoro (V1) and Deja 1 varieties showed that highest dry weight of shoot and root. The fertilizer N, P, K at doses P2 showed that the highest dry weight of shoot and root. The interaction of N, P, K fertilizer at P2 with Dena 1 and Anjasmoro varieties showed that highest dry weight of shoot and root of soybean by 3.56 g and 0.72 g respectively at 30 DAP although it was not significant affect.

3.1.4. Shoot- root ratio. The interaction of Dena 1 (V3) variety with fertilizer N, P, K at doses of P2 were significantly increase the highest shoot root ratio of soybean by 5.39 at 30 DAP on tidal lowland compared to other interactions. The usage of Deja 1 (V2) and Anjasmoro (V1) variety showed that the highest shoot root ratio by 4.25 at 30 DAP compared to other varieties. The fertilizer N, P, K at P2 showed that the highest shoot root ratio by 4.38 at 30 DAP compared to other fertilizer doses, although it was not significantly affect (table 2)
Table 2. The dry weight of shoot and root, shoot root ratio in soybean varieties at 30 DAP with application of N, P, K fertilizer.

| N, P, K fertilizer (kg ha⁻¹) | Varieties (V) | Mean |
|-----------------------------|---------------|------|
|                             | V1 (Anjasmoro) |      |
|                             | V2 (Deja-1)    |      |
|                             | V3 (Dena)      |      |
|                             | V4 (Dering-1)  |      |

|                     | Dry Weight of Shoot (g) |      |
|---------------------|-------------------------|------|
| P0                  | 2.77                    | 2.39 |
|                     | 2.01                    | 1.64 |
|                     | 1.39                    | 2.03 |
|                     | 2.46                    | 3.01 |
|                     | 2.75                    | 2.33 |
| Mean                | 2.55                    | 2.50 |
|                     | 2.47                    | 2.06 |

|                     | Dry Weight of Root (g)  |      |
|---------------------|-------------------------|------|
| P0                  | 0.57                    | 0.65 |
|                     | 0.64                    | 0.53 |
|                     | 0.60                    | 0.62 |
|                     | 0.69                    | 0.70 |
|                     | 0.56                    | 0.56 |
| Mean                | 0.60                    | 0.67 |
|                     | 0.65                    | 0.56 |

|                     | Shoot root ratio        |      |
|---------------------|-------------------------|------|
| P0                  | 4.95 a-d                | 4.30 a-g |
|                     | 3.50 c-g                | 4.30 d-g |
|                     | 4.04                    |      |
| P1                  | 4.25 a-g                | 3.31 efg |
|                     | 3.21 g                  | 3.28 f-g |
|                     | 3.51                    |      |
| P2                  | 4.11 a-g                | 4.27 a-g |
|                     | 5.39 a                  | 3.75 a-g |
|                     | 4.38                    |      |
| P3                  | 3.68 b-g                | 4.18 a-g |
|                     | 3.72 a-g                | 5.35 ab |
|                     | 4.23                    |      |
| Mean                | 4.25                    | 4.02 |
|                     | 3.96                    | 3.95 |

3.1.5. Number of seed. The usage of varieties soybean, the fertilizers N, P, K and their interactions were not significantly affect the number of dry seeds per sample and per plot of soybean after harvest (table 3). The Dering 1 (V4) and Dena 1 (V3) variety showed that the highest number of dry seeds per sample and per plot of soybean at 266.98 and 6,943.83 respectively compared to other varieties although it was not significant affect.

Table 3. Effect of soybean varieties and N, P, K fertilizer on number of seed per plant

| N, P, K fertilizer (kg ha⁻¹) | Varieties | Mean |
|-----------------------------|-----------|------|
|                             | V1 (Anjasmoro) |      |
|                             | V2 (Deja-1)    |      |
|                             | V3 (Dena)      |      |
|                             | V4 (Dering-1)  |      |

|                     | 269.93          | 140.67          | 270.53          | 293.00          | 243.53          |
|---------------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| P1                  | 235.07          | 263.60          | 225.60          | 219.80          | 236.02          |
| P2                  | 161.40          | 218.87          | 274.40          | 279.13          | 233.45          |
| P3                  | 235.93          | 315.40          | 285.87          | 276.00          | 278.30          |
| Mean                | 225.58          | 234.63          | 264.10          | 266.98          |                  |

3.2. Discussion
The results showed that the soybean varieties significantly differ affected on the plant height of soybeans at 30 DAP, root volume, and root length, in contrast it was not significant on the root shoot ratio of soybean in tidal lowland. Anjasmoro (V1) variety had the highest plant height of 26.92 cm and Deja 1 (V2) variety had the highest root volume, root length at 1.39 cc and 13.74 cm, respectively compared to other varieties in tidal lowland. It was caused the Anjosmoro and Deja 1 varieties of soybean have a higher tolerant mechanism in tidal lowland conditions at the location of this research with the salinity rate of 4.01 (moderate) compared to Dena 1 (V3) and Dering 1 (V4) varieties through increased volume and length of the roots. This salinity level will affect the availability of nutrients for soybean, especially for salinity sensitive-soybean.
It has been reported by Sagala et al [19] that the tidal lowland had soil pH by 3.8 (very acidic); Fe of 1.19%; pyrite of 0.47% ; lower rate of K range by 1.28 until 1.56% and higher level of Mn range by 142.58 until 169.50 ppm. Usnawiyyah et al [20] reported that the Deja 1 and Deja 2 varieties of soybean are new superior varieties and flooded-stress tolerant and have the potential yield of 2.87 tons.ha\(^{-1}\) and 2.75 tons.ha\(^{-1}\), respectively. Anjasombo variety had 100-seeds weight more higher and indicated that variety is tolerant to high salinity conditions [21]. Al-stress at the dose of 1.5 g and 3 g could be decrease the fresh weight of tomato by 57.64 until 69.49%, dry weight of 47.33 until 62.21%, the root epidermis size of 12.28 to 82.44%, the cortex of 4.52 until 60.40%, and the stele was 17.40 until 75.75% compared to Al un-treated [22]. The plant height of Anjasombo was higher by 44.19 cm compared to Dena-1, Deja-1 and Detam-1 [23].

The results showed that the N, P, K fertilizers significantly different on the plant height and root length at 30 DAP, in contrast it was not significant effect on root volume and root shoot ratio. Treatment un-fertilizer N, P, K showed the highest plant height of 27.32 cm and the dosage of 100 kg.ha\(^{-1}\) N, 80 kg.ha\(^{-1}\) P\(_2\)O\(_5\), 100 kg.ha\(^{-1}\) K\(_2\)O (P2) showed the longest root length of 15.50 cm compared to other doses in tidal lowland. It was caused the P2 dose given can stimulate root growth cells of soybean. Previous researches reported that the addition of P-fertilizer could increase nitrogenase activity in rhizobium. The nutrient uptake of N, P, and K in soybean leaves was higher in flooded cultivation systems of 210.83%, 203.51% and 218.62%, respectively compared to dry land cultivation systems. The giving of lepin, NPK fertilizer (15:15:15) and urea can increase the nutrient content of N, P-total in shoot and the formation of soybean root nodules. The giving at the dose of 33.75 kg.ha\(^{-1}\) N and 108 kg.ha\(^{-1}\)P\(_2\)O\(_5\) significantly increase the highest the number leaves of soybean by 7.53% and 9.03% respectively compared to un-treated in lowland swamps [24,25].

The results showed that the interaction of several varieties with N, P, K fertilizer significantly different on the shoot root ratio at 30 DAP, in contrast it was not significant affect on plant height, volume and length of root for soybean in tidal lowland. The interaction of Deja 1 variety with the fertilizer dosage of 50 kg.ha\(^{-1}\) N, 40 kg.ha\(^{-1}\) P\(_2\)O\(_5\), 50 kg.ha\(^{-1}\) K\(_2\)O (V2P1) significantly increased the highest fresh and dry weight of shoot, compared to other interactions. It was caused the Deja 1 variety was classified as tolerant varieties in flooded-stress including tidal lowland and added with fertilization of 50 kg.ha\(^{-1}\) N, 40 kg.ha\(^{-1}\) P\(_2\)O\(_5\), 50 kg.ha\(^{-1}\) K\(_2\)O with the result that it supports the varieties in absorption of nutrients to promoting the growth of soybean such as increasing fresh and dry weight of shoot.

The higher of dry weight of the shoots indicates greater nutrient absorption. Plants can absorb the great nutrients with the results that produce high biomass [26]. The yield level the optimal requirement for N, P, and K nutrients for soybean is linearly related to yield [27]. The interaction of Dena 1 variety with the fertilizer dosage of 100 kg.ha\(^{-1}\) N, 80 kg.ha\(^{-1}\) P\(_2\)O\(_5\), 100 kg.ha\(^{-1}\) K\(_2\)O (V3P2) was significantly increased the highest ratio of the root shoot by 5.39 compared to other interactions. It was caused the Dena 1 variety are thought to accumulate Al, Fe, and Mn in the shoots (accumulator) from tidal lowland so that the giving of fertilizer dosage (P2) is sufficient for soybean nutrient needs during the vegetative period with the result that the shoots weight is higher than the roots weight. In line with previous research that the giving P-fertilizer can increase the number of total pods, the number of filled pods, and plant productivity. Therefore, to get the required high nutrients in sufficient quantities and balanced, then N and P must be balanced with the K-availability nutrient [28].

4. Conclusions
The soybean varieties significantly differ affect on the plant height of soybeans at 30 DAP, volume and length of root in tidal lowland. The dosage of N, P, K fertilizers were significantly different on the plant height and root length, and their interactions significantly different on the shoot root ratio. The application Anjasombo and Deja 1 varieties with the fertilizer dosage of 100 kg.ha\(^{-1}\) N, 80 kg.ha\(^{-1}\) P\(_2\)O\(_5\), 100 kg.ha\(^{-1}\) K\(_2\)O can be used in tidal lowland to increase the yield of soybean.
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