Response of some soybean (*Glycine max* L. Merrill) varieties on flooded condition with application of Benzyl Amino Purine (BAP) and Salicylic Acid (SA) in the R₃ phase

R I Damanik*, D Manurung, E S Bayu and N Rahmawati

Department of Agrotechnology, Faculty of Agriculture, Universitas Sumatera Utara, Medan, Sumatera Utara, Indonesia.

E-mail: *revandy.iskandar@usu.ac.id

Abstract. Soybean production (*Glycine max* (L.) Merril) in Indonesia has fluctuation every year. The area of wetlands in Indonesia is about 24.5 million ha, but only about 8.5 million ha of wetlands are used as rice fields, the remaining 16 million ha have not been utilized. The study aims to determine the response of some soybean varieties on the application of benzyl amino purine (BAP) and salicylic acid (SA) in flooded conditions. The research initiated in research land of the Faculty of Agriculture Universitas Sumatera Utara, using the Randomized Block Design (RBD) with 3 treatment factors namely varieties consisting of 3 varieties (Demas 1, Dering 1 and Burangrang), the concentration of plant growth regulator consisting of 3 levels (control, 50 ppm BAP + 100 ppm of SA and 100 ppm of BAP + 200 ppm of SA) and the treatment of flooding stress consisting of 2 treatments (control and flooded). The results showed that the varieties had critical effect on the parameters of number of pods per plant and the weight 100 seeds. Synthetic plant growth regulator concentration had no effect on all the observation parameters, but flooding stress had significant induce on the parameter of number of pods per plant.

1. Introduction

Soybean (*Glycine max* (L.) Merrill) as one of the many food crops cultivated by the people of Indonesia. Nowadays, soybeans are not only produced for food raw materials, but also for industrial raw materials. Soybeans contain protein, oil, insoluble carbohydrates, soluble carbohydrates, water content as well as various functional ingredients including anthocyanins, isoflavones, saponins, and dietary fibre [1].

From year to year soybean production in Indonesia has fluctuated. Soybean production in 2016 is estimated to decrease by 7.06% to 887.54 thousand tons from 2015 amounting to 963.18 thousand tons. Based on the projected results, it is estimated that the soybean production and consumption balance in Indonesia will experience an increase in deficit in year 2016-2020 an average of 36.95% per year. The shortage of soybean supply in 2016 to 2020 was 1.60 million tons, 1.78 million tons, 1.84 million tons, 1.92 million tons and 1.91 million tons, respectively [2].

The increasing variability of climate elements that are sometimes even extreme is not conducive to plants. Erratic macro and micro climatic conditions such as flooding caused by heavy rainfall or vice versa...
Dry season that lasts too long can adversely affect vegetative and generative growth of plants so that it can result in decreased productivity and harvested area, and often can lead to failure harvest [3].

Inundation is a major issue in many agricultural regions over the world, soybean is a plant that is sensitive to inundation. Based on data from the Directorate of Plant Protection, of Food Crops, during the 2011/2012 rainy season (October-December), North Sumatra Province was one of the largest areas affected by flooding in Indonesia. Likewise in 2013, in December the number of rice fields and fields experiencing crop failure (puso) due to flooding reached 25% in North Sumatra [4].

Decrease in soybean yields in stagnant soil conditions (saturated with water) ranges within 15-25% at the age of 15-30 days (vegetative phase). Inundation for 2 weeks in the full flowering phase (R2) of 23 soybean genotypes reduces seed yield by at least 37% and even causes plant death [5].

In flooded conditions, plant roots will lack oxygen (O2). This is a major factor causing soybean plants to experience physiological damage and physical damage. In normal conditions, plant roots take O2 from the soil and then use it in mitochondrial respiration. However, under stressful conditions of standing water, plants cannot absorb enough O2 to maintain normal physiological function. Therefore, plants can’t produce glucose normally and end up having diverse metabolism problems [6].

BAP (Benzyl Amino Purin) is a synthetic cytokinin derived from adenine which has the same structure as kinetin. Cytokinin is a growth regulator that acts to encourage cell division (cytokinesis) and organ formation [7]. SA (Salicylic acid) plays a substantial role in plant resistance to stress because SA has the ability to induce protection against plants in a number of adverse environmental conditions [9].

Phenotype appearance of a plant is an interaction between genetic factors and environmental factors. Each plant shows diverse growth and yields as a result of genetic and environmental influences, where genetic influences are the inheritance effects of each strain or variety while environmental influences are those caused by habitat and environmental conditions [9].

Inundation tolerant genotypes are genotypes that have high yields in flooded conditions. To obtain soybean genotypes that are tolerant of inundation must be based on special traits that have a close relationship with tolerance based on the Stress Tolerance Index (STI). One special characteristic that may be used in the form of biochemical markers. Based on the description above, the authors are interested in conducting research to determine the growth response of soybean varieties in flooded conditions for BAP and SA.

2. Materials and methods

2.1. Experimental design

This research was conducted in the initial field of the Faculty of Agriculture, Universitas Sumatera Utara, Medan, Indonesia. Materials used in this study include soybean seeds obtained from the collection of the Indonesian Institute of Bean and Tuber Crops Research Institute (Balitkabi) Malang, Indonesia, including soybean seeds of Dering 1, Demas 1 and Burangrang, top soil and compost, BAP and Salicylic Acid, water, NPK fertilizer, insecticides, and fungicides. Fertilization is carried out according to the recommended dosage of soybean fertilizer requirements [10], namely 25 kg Urea/ha, 75 kg TSP/ha and 50 kg KCl/ha. Urea, TSP and KCl fertilizers were applied 1 week after planting.

Factor I, Soybean Varieties:
V1: Dering 1
V2: Demas 1
V3: Burangrang

Factor II, Plant Growth Regulator (PGR) Concentration:
K1: control
K2: BAP (50 ppm) + SA (100 ppm)
K₃ : BAP (100 ppm) + SA (200 ppm)
Factor III, Inundation:
G₁ : control
G₂ : Inundation for 72 h (applied when the plant enter R₃ phase)

2.2. Application of BAP and salicylic acid (SA)
Plant growth regulator (PGR) BAP and Salicylic Acid which is applied by a spraying system with concentrations according to the level of treatment at the time the plant is 4 weeks after planting and is applied every week until the beginning of the R₃ stage (characterized by the formation of 0.5 cm pods in one of the four top stem nodes on the main stem).

2.3. Waterlogging method
Waterlogging is carried out after the plant enters the growing phase R₃ stage. Inundation is carried out for 72 h, by making a hole inland and coat it with plastic and then fill it with water. Then a polybag containing plants was inserted into the hole that has been filled with water.

3. Results and discussion

3.1. Number of filled pods
The number of filled pods soybean plants in Table 1 shows that the variety, PGR concentration and inundation has no significant effect for the number of filled pods.

| Varieties       | Concentrate of PGR | G₀ (Control) | G₁ (Inundated) | Mean  |
|-----------------|--------------------|--------------|----------------|-------|
| V₁ (Demas 1)    | K₀ (Control)       | 106.83       | 80.33          | 93.58 |
|                 | K₁ (50ppm BAP + 100ppm AS) | 106.80   | 100.00         | 103.40|
|                 | K₂ (100ppm BAP + 200ppm AS) | 109.83  | 88.17          | 99.00 |
| V₂ (Dering 1)   | K₀ (Control)       | 166.17       | 132.33         | 149.25|
|                 | K₁ (50ppm BAP + 100ppm AS) | 149.83   | 138.17         | 144.00|
|                 | K₂ (100ppm BAP + 200ppm AS) | 188.17  | 124.00         | 156.09|
| V₃ (Burangrang) | K₀ (Control)       | 53.17        | 50.50          | 51.84 |
|                 | K₁ (50ppm BAP + 100ppm AS) | 57.33    | 40.50          | 48.92 |
|                 | K₂ (100ppm BAP + 200ppm AS) | 49.50   | 52.17          | 50.84 |
| Mean            |                    | 109.74       | 89.57          |       |

Based on Table 1, it can be seen that the best treatment is seen at V₂K₂ (156.09) while the lowest is at V₃K₁ (48.92). Each variety shows a decrease in the number of filled pods due to inundation treatment. V₃ shows the lowest results and V₂ shows the highest number of filled pods. Based on the results above, each variety shows a different response to inundation treatment, this is because the nature of each variety is controlled by internal factors of the plant. Each variety is controlled by many genes and the genetic makeup is different, the different genes from each (variety) are expressed in character that varies due to environmental conditions. This is consistent with the [9], which states the appearance of a plant's phenotype is an interaction between genetic factors and environmental factors.
3.2. **Weight of 100 seeds**

The perform weight of 100 seeds in Table 2 shows that the variety has a significant effect on the weight of 100 seeds, while the concentration of PGR, submergence, and connection within treatments has no significant effect on the weight of 100 seeds.

| PGR Concentration | G₀ (Control) | G₁ (Inundated) | Mean |
|-------------------|-------------|----------------|------|
| V₁ K₀ (Control)   | 11.39       | 11.34          | 11.37|
| K₁ (50ppm BAP + 100ppm AS) | 10.61      | 9.60           | 10.11|
| K₂ (100ppm BAP + 200ppm AS) | 11.28      | 10.54          | 10.91|
| K₀ (Control)      | 10.03       | 9.94           | 9.99 |
| V₂ K₁ (50ppm BAP + 100ppm AS) | 9.33       | 9.30           | 9.32 |
| K₂ (100ppm BAP + 200ppm AS) | 9.91       | 9.25           | 9.58 |
| K₀ (Control)      | 18.63       | 17.77          | 18.20|
| V₃ K₁ (50ppm BAP + 100ppm AS) | 17.63      | 17.58          | 17.61|
| K₂ (100ppm BAP + 200ppm AS) | 18.33      | 17.87          | 18.10|
| Mean              | 13.02       | 12.58          |      |

Based on Table 2 shows that there is a decrease in the weight of 100 soybean seeds due to inundation treatment, which is 12.58 g (G₁) and 13.02 g (Control). The best treatment was shown in the V₁K₀ treatment (18.20 g) and the lowest was in the V₁K₁ treatment (9.32 g). Each variety shows a different response to inundation treatment, this is because the nature of each variety is controlled by internal factors of the plant. Each variety is controlled by many genes and the genetic makeup is different, the different genes from each (variety) are expressed in character that varies due to environmental conditions. This is consistent with the [9], which states the appearance of a plant's phenotype is an interaction between genetic factors and environmental factors.

3.3. **Protein analysis**

Analysis of protein content can be seen in Figure 1, which shows the highest protein content in the treatment of V₃K₂G₁ (0.263 mg/g) and the lowest V₁K₀G₁ (0.140 mg/g).

The results of the investigation showed the response of varieties from the PGR treatment and inundation to protein content showed a trend or a decreased pattern except in the treatment of V₃K₀, V₂K₂, and V₁K₂ which showed an upward trend when given inundation treatment. This is because inundation can reduce crop productivity, this is consistent with [4], which states inundation is a main issue in many agricultural areas in the earth and soybean is a plant that is sensitive to inundation. Based on data from the Directorate of Plant Protection of Food Crops, during the 2011/2012 rainy season (October-December), North Sumatra Province was one of the largest areas affected by flooding in Indonesia. Likewise in 2013, in December the number of rice fields and fields experiencing crop failure (puso) due to flooding reached 25% in North Sumatra.
3.4. Analysis of Superoxide Dismutase (SOD)

Observation of superoxide dismutase enzyme analysis can be seen in Figure 2, which shows that the highest average of SOD activity is in the V3K2G1 treatment (642.85 units/mg protein) and the lowest treatment is in the V2K2G0 treatment (332.56 units/mg protein).

The results of the study showed the response of varieties from the PGR treatment and inundation to SOD enzyme activity showed an upward trend except in the V2K0 and V3K0 treatments which showed a declining trend when treated with inundation. This is due to the inundation of an increase in SOD enzyme secretion to prevent stressed on plants, this is in accordance with [6] which states in flooded conditions, plant roots will lack oxygen (O2). This is a major factor causing soybean plants to experience physiological damage and physical damage. In the normal situation, plant roots take O2 from the soil and
therewith use it in mitochondrial respiration. Moreover, in stressful conditions of standing water, plants unable to consume enough O₂ to preserve the normal physiological function. Hence, plants cannot produce glucose normally and end up having various metabolism problems.

4. Conclusion

The soybean varieties tested showed differences in character in every variety of soybean plants. Dering 1 variety show the highest response on produces of the filled pods, the Burangrang variety produces the highest weight of 100 seeds. The synthetic plant growth hormone showed that the application of PGR 50 ppm BAP + 100 ppm SA shows the highest number of Filled Pods soybean plants. Inundation stress can increase SOD enzyme activity.

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