Response of edamame growth and production in the lowlands by spacing treatment and application of liquid organic fertilizers

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Abstract. Edamame soybeans have excellent prospects for development in the lowlands. In order to grow well, edamame soybeans need liquid organic fertilizer as a nutrient supply and proper spacing. The objective of the research was to evaluate the effect of spacing treatment and application of liquid organic fertilizer (LOF) on soybean edamame growth and production. A field research was conducted in Medan from September until December 2019, using a factorial randomized block design with two factors and three replications. The first factor is spacing treatment of edamame, namely 40cm x 20cm; 30cm x 20cm and 20cm x 20cm. The second factor is LOF application consisting of 40; 60 and 80 mL/L of water. Research result showed that spacing of 30cm x 20cm treatment increased the number of productive branches. LOF treatment of 40mL/L of water increased the dry weight of 100 seeds. The interaction between plant spacing and LOF application had no significant effect on all observed variables.

1. Introduction

Vegetable soybean or better known as edamame (Glycine max (L.) Merr.) is very nutritious for health and usually consumed in the form of fresh pods that are boiled as a health snack. Edamame is source of carbohydrate, protein, fiber, bioactive peptides, omega-3 fatty acids, minerals (potassium, calcium, phosphorous, magnesium, iron), folic acid and phytochemicals components, namely isoflavone (0.1-3.0%), sterols (0.23-0.46%), and saponin (0.17-6.16%). Edamame is only one legume that contains essensial amino acids such as phenylalanine, isoleucine, lysine, threonine, tyrosine, valine, tryptophan, methionine, and cysteine [1,2].

Iisofoxavones in soybean are antioxidants that protect again free radical and strengthen the body’s immune system [3]. Genistein, daidzein and glycitein are major types of isoflavones of soybean [4,5]. Several research have proven the isoflavone role in preventing osteoporosis, cardiovascular disease, dementia, diabetes and cancer [6-10], anti-inflammatory [11] and relieve menopausal syndrome [12,13].

The prospect of developing Edamame in Indonesia is very good, because it has a high productivity advantage (an average of 3.5 tons/ha), larger pod size, relatively shorter lifespan and sweeter taste than ordinary soybeans. Edamame soybean cultivation in Indonesia is still relatively small, while the market needs are very large. Edamame market share is also very good, because export opportunities to Japan are still wide open and cannot be met. Japan is the main consumer and edamame market in both fresh and frozen forms. The total frozen of edamame market needs in Japan range from 150,000-160,000 tons/year. Therefore, it is necessary to increase edamame production in terms of quantity and quality in order to compete with China and Taiwan as the largest edamame exporting country [14].
The problem faced in edamame soybean cultivation is that the production cost is very capital intensive because it requires high inputs in the form of fertilizers, pesticides and other matters. The use of chemical fertilizer and pesticides is at risk of soybean produced which still contains chemical residues that endanger health. These problems can be overcome by using liquid organic fertilizer which is proven to be environmentally friendly. One type of fertilizer that is widely circulating on the market and it is generally applied through leaves is Liquid Organic Fertilizer (LOF). Liquid organic fertilizer is containing essential macro and micro nutrients and also organic matter.

Several benefits of LOF are that it can encourage and improve the formation of leaf chlorophyll thereby increasing the ability of plant photosynthesis and nitrogen absorption, can increase plant vigor, so that plants become sturdy and strong, increase plant resistance to drought, increase flower and ovary formation, reduce flower fall and ovaries and stimulate the growth of production branches [15].

Plants productivity is affected by plant spacing. The level of plant density associated with plant population will determine the yield of plant. Soybean varieties that are of medium age, recommended spacing are 40 cm x 15 cm, and short-lived varieties, should use spacing of 40cm x 10 cm or 30 cm x 15 cm [16].

Research on soybeans has been widely reported, such as physiological characteristics of soybean with elicitor treatment [17], effect of magnesium [18,19], use of cultivation technology packages in dry land [20,21], Bradyrhizobium sp. inoculation and its effect on growth and N uptake in soybean [22], the role of onion extract for soybean production [23], edamame productivity by cytokinin treatment [24], the role of N sources on the isoflavone content of several soybean varieties [25], production and physiology of soybean induced by genistein [26], effect of type and time of pesticide application on growth and yield of edamame (27) and edamame-based functional food [28].

Generally, edamame soybeans are cultivated in areas at altitude of more than 300 m above sea level. Research on the role of LOF and differences in plant spacing on edamame growth and production in the lowlands has not been reported. The application of LOF aims to increase nutrient content hence the plant’s nutritional needs are met while the spacing of planting aims to reduce competition between plants in utilizing their environment, including a competition to obtain nutrients. Therefore, the purpose of the research is to evaluate the effect of spacing treatment and LOF application on edamame growth and production in lowland area.

2. Materials and methods

2.1. Research site and materials

The research has been carried out in Medan (± 25 m above sea level) on September to December 2019. Soil analysis the research site and LOF analysis conducted at PT Socfindo Seed Production and Laboratory (table 1).

| Parameter       | Result of soil analysis | Result of LOF analysis |
|-----------------|-------------------------|------------------------|
| pH (H₂O)        | 4.83                    | Acid                   |
| C-organic (%)   | 1.37                    | Low                    |
| N-Kjedhal (%)   | 0.10                    | Low                    |
| P (%)           | 0.09                    | Moderate               |
| K (%)           | 0.22                    | Moderate               |

Note: *) Assessment criteria based on Mukhlis [29]

The materials used were edamame soybean varieties R 75, liquid organic fertilizer, NPK fertilizer, insecticide. The tools used are hoes to cultivate the soil, machetes for preparing land clearing, watering cans, analytical scales for weighing the shoot and root dry weight, ovens for drying the shoots and roots, stationery, cameras for research documentation.
2.2. Experimental design and research implementation

The study used factorial randomized block design with 2 factors and 3 replications, the first factor is treatment of spacing, namely J1: 40 cm x 20 cm; J2: 30 cm x 20 cm; and J3: 20 cm x 20 cm. The second factor was the concentration of LOF, namely P1: 40 ml/L of water; P2: 60 ml/L of water and P3: 80 ml/L of water.

The research stage consists of land preparation, planting, fertilizing, taking care of the plants (watering, controlling pest and weeds), harvesting and post-harvesting. Edamame soybean seed planting is carried out by making a planting-hole in the land with a sharp pole-stick as much as 2 seeds/planting holes, with spacing according to the treatment. At the time of planting, basic fertilization was carried out, namely Urea 150 kg/ha (14.4 g/plot), SP-36 150 kg/ha (14.4 g/plot) and KCl 100 kg/ha (9.6 g/plot) in an array. Urea when planting was applied at half the dose and the rest 28 days after planting (DAP).

Before applying the LOF, a calibration was carried out to determine the spray volume requirements of each individual plant. Application of LOF is carried out in the morning starting at 7, 14, 21, and 28 DAP by dissolving LOF with the appropriate concentration of treatment in 1 L of water, then spraying it to all parts of the plant evenly using a sprayer.

Observed variables included plant height, shoot dry weight, stem diameter, root dry weight, number of productive branches, number of filled and empty pods, seed dry weight per plant, pod weight, and dry weight of 100 seeds.

2.3. Data analysis

Data were analysed using analysis of variance. If the result of the analysis of variance show a significant effect, then proceed with the Duncan’s Multiple Range Test at the level of $\alpha =0.05$.

3. Results and discussion

3.1. Edamame soybean growth

The result showed that the atment of spacing has a significant effect on the number of productive branches, but has no significant effect on plant height, shoot and root dry weight and also stem diameter. The LOF treatment and interaction between spacing treatment and LOF application did not significantly effect the edamame growth observed variables (table 2).

Although not significant, there was a tendency that treatment 20 cm x 20 cm spacing increased plant height at 5-6 WAP, shoot and root dry weight, but significantly reduced the number of productive branches. This showed that spacing of 20 cm x 20 cm is quite good in increasing plant growth which is indicated by an increase in plant height and canopy and root dry weight. Plant spacing greatly affects the amount of sunlight received and the amount of nutrients absorbed from the soil. In accordance with the statements of Umami et al [30], that setting the right planting distance will increase plant growth and yield. The important role to apply the right planting distance (spacing) in soybean plants is easy in caring, equal distribution in getting sunlight radiation, humidity, aeration, rooting, reducing competition in the use of growth factors, and increasing crop yields. The spacing of 20 cm x 20 cm significantly affected the dry weight of plants.

The application of 60 ml/L LOF tends to increase the number of productive branches, shoot and root dry weight. This emerge an indication that the LOF of 60 ml/L is sufficient in increasing the growth observation variables. The application of LOF can assist the process of metabolism in plants, due to the water contained in the LOF can assist the process of nutrient solubility hence nutrient transport from the root to all parts of the plant will take place properly. Most of the LOF contains elements of growth regulators (hormones that regulate growth) hence the application of LOF can stimulate plant growth. The application of LOF can also influence the enzyme activity in plants which will support the process of cell division and extension. Besides, the application of liquid organic fertilizer can assist physiological processes, maintain moisture, and increase seed germination [31].
Table 2. Effect of different spacing and application of LOF on soybean edamame growth.

| Treatment | Plant height 5 WAP (cm) | Plant height 6 WAP (cm) | Stem diameter (cm) | Shoot dry weight (g) | Root dry weight (g) | Number of productive branches |
|-----------|--------------------------|-------------------------|-------------------|----------------------|---------------------|-------------------------------|
| Spacing (J) |                          |                          |                   |                      |                     |                               |
| J₁ (40 cm x 20 cm) | 24.48                    | 25.13                   | 7.68              | 1.52                 | 0.93                | 6.36b                         |
| J₂ (30 cm x 20 cm) | 26.98                    | 27.17                   | 7.72              | 1.44                 | 0.96                | 6.64 a                        |
| J₃ (20 cm x 20 cm) | 27.77                    | 28.42                   | 6.68              | 1.64                 | 0.99                | 5.80 c                        |
| LOF (P)      |                          |                          |                   |                      |                     |                               |
| P₁ (40 ml/L) | 26.87                    | 27.48                   | 7.88              | 1.45                 | 0.95                | 6.09                          |
| P₂ (60 ml/L) | 26.77                    | 26.88                   | 7.12              | 1.63                 | 0.98                | 6.58                          |
| P₃ (80 ml/L) | 25.59                    | 26.37                   | 7.09              | 1.53                 | 0.94                | 6.13                          |
| J x P        |                          |                          |                   |                      |                     |                               |
| J₁P₁        | 25.60                    | 26.30                   | 8.05              | 1.47                 | 0.90                | 5.87                          |
| J₁P₂        | 25.20                    | 25.67                   | 7.05              | 1.74                 | 0.98                | 6.67                          |
| J₁P₃        | 29.80                    | 30.47                   | 7.92              | 1.35                 | 0.91                | 6.53                          |
| J₂P₁        | 25.57                    | 25.60                   | 8.49              | 1.22                 | 0.93                | 6.33                          |
| J₂P₂        | 29.67                    | 29.53                   | 7.46              | 1.59                 | 0.99                | 6.93                          |
| J₂P₃        | 25.07                    | 25.50                   | 7.22              | 1.52                 | 0.94                | 6.67                          |
| J₃P₁        | 22.27                    | 23.50                   | 7.09              | 1.65                 | 1.02                | 6.07                          |
| J₃P₂        | 26.07                    | 26.30                   | 6.85              | 1.54                 | 0.97                | 6.13                          |
| J₃P₃        | 28.43                    | 29.30                   | 6.11              | 1.72                 | 0.97                | 5.20                          |

Mean’s followed by different letter are significantly different based on Duncan’s Multiple Range Test (p=0.05)

3.2. Edamame soybean production

The LOF application only has significant effect on the weight of 100 seeds. The spacing treatment and interaction between spacing treatment and LOF application had no significant on all observed variables of edamame production (table 3).

The application of 40 mL/L of LOF was good enough to increase dry weight of 100 seeds. This is presumably because the macro nutrients of nitrogen, phosphor and potassium contained in LOF can meet the needs of plants hence these elements can be absorbed by plants as activating enzymes for photosynthesis which results in the form of photosynthesis. Photosynthate is transplanted to fill pods and seeds. P element is a component of the plant cell membrane compiler, enzyme compiler, and P element also plays a role in protein synthesis, especially in green tissue, synthetic carbohydrates and stimulates seed formation. The element of P stimulates the formation of flowers, fruit and seeds while potassium prevents the loss of flowers [32].

In line with Martínez-Alcantara [33] that reported several effect of LOF such as increase the growth and development of plant, plants are more resistant to stress, pests and diseases, increase crop yields and improve crop quality. The application of LOF greatly helps plants in their growth process. This is because both macro and micro-nutrients needed by plants can be directly absorbed and utilized by plants. Micro-nutrients are nutrients that are usually available only in a few amounts in the soil and competition often occurs with other plants or weeds to absorb it. Hence, when it applied directly to the soil, it will greatly assist plants in growing.

In general, the pod filling period is strongly influenced by nutrients, water, and the availability of light. These factors are very necessary for the growth of soybean plants which will be allocated in the form of dry matter during the growth phase, then at the end of the vegetative phase there will be a accumulation of photosynthesis results in plant organs such as stems, fruits and seeds. Hence by fulfilling the above factors, the formation and filling of pods will be good.
Table 3. Effect of difference spacing and application of LOF on soybean edamame production

| Treatment | Number of filled pod (pod) | Number of empty pod (pod) | Pod weight (g) | Seed dry weight/plant (g) | Dry weight of 100 seeds (g) |
|-----------|---------------------------|---------------------------|----------------|---------------------------|-----------------------------|
| Spacing (J) |                           |                           |                |                           |                             |
| J₁ (40cm x 20cm) | 13.56                     | 0.91                      | 10.13          | 6.15                      | 33.52                       |
| J₂ (30cm x 20cm) | 13.71                     | 0.82                      | 10.56          | 6.61                      | 34.19                       |
| J₃ (20cm x 20cm) | 14.31                     | 0.96                      | 11.14          | 6.07                      | 36.65                       |
| LOF (P) |                           |                           |                |                           |                             |
| P₁ (40ml/L) | 14.67                     | 0.91                      | 12.22          | 6.91                      | 36.78a                      |
| P₂ (60ml/L) | 13.98                     | 0.76                      | 10.69          | 6.37                      | 32.44c                      |
| P₃ (80ml/L) | 12.93                     | 1.02                      | 8.91           | 5.56                      | 35.65b                      |
| J x P |                           |                           |                |                           |                             |
| J₁P₁ | 15.13                     | 1.07                      | 12.54          | 6.75                      | 34.23                       |
| J₁P₂ | 13.13                     | 0.80                      | 9.45           | 6.23                      | 32.69                       |
| J₁P₃ | 12.40                     | 0.87                      | 8.40           | 5.46                      | 33.63                       |
| J₂P₁ | 14.60                     | 0.93                      | 12.81          | 7.17                      | 37.05                       |
| J₂P₂ | 13.67                     | 0.67                      | 10.30          | 6.43                      | 31.17                       |
| J₂P₃ | 12.87                     | 0.87                      | 8.57           | 6.24                      | 34.36                       |
| J₃P₁ | 14.27                     | 0.73                      | 11.32          | 6.82                      | 39.06                       |
| J₃P₂ | 15.13                     | 0.95                      | 12.31          | 6.45                      | 33.45                       |
| J₃P₃ | 13.53                     | 1.33                      | 9.77           | 4.96                      | 37.46                       |

Means followed by a different letter are significantly different based on Duncan’s Multiple Range Test (p=0.05)

4. Conclusions

The spacing treatment of 30 cm x 20 cm increased number of productive branches. The liquid organic fertilizer application of 40 ml/L increased dry weight of 100 seeds. For all observed variables, there were no significant effect between spacing treatment and LOF application.

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