Liquid organic fertilizer and types of organic mulch toward photosynthesis translocation of green beans (Phaseolus vulgaris L.)

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Abstract. Green bean productivity is closely related to the accumulation of photosynthesis translocation. Organic base matter for fertilizer and mulch provide eco-friendly system to support plant productivity. Liquid organic fertilizer and types of organic mulch serve the optimum condition for growing environment of green beans. This study aimed to determine the concentrations of liquid organic fertilizer and types of organic mulch toward biomass addition in green beans. The experiment was conducted on Andisol soil in Cisalak, Subang West Java from January to March 2018. A factorial randomized block design was used to arrange the first factors (0 ml l⁻¹, 1 ml l⁻¹, 2 ml l⁻¹, and 3 ml l⁻¹ liquid organic fertilizer) and the second factors (without mulch, paddy straw mulch, and reeds mulch). The results obtain no interaction between liquid organic fertilizer and types of organic mulch for number pods per plant, pods weight per plant, dry stover weight, shoot root ratio and harvest index. Liquid organic fertilization in 2 ml and paddy straw mulch, independently, gave the best recommendation to increase green bean productivity.

1. Introduction
Green bean productivity is closely related to the accumulation of photosynthesis translocation. Abebe et al., [1] stated the major reasons for the low productivity and quality of green bean are low nutrient status of the soil in the most bean growing areas and inadequate application of fertilizers. During the flowering and pod-wall growth phases, the pod-setting percentage is determined depending upon the availability of carbohydrates to develop pods, the sink capacity generally exceeds the source capacity due to the overlapping of growth phases, and also to active consumption of photosynthates for nitrogen fixation by root-nodules [2]. Additional fertilizer and other cultivation management is needed to form the optimum pod numbers and seed.

Liquid organic fertilizer provides the nutrients needed by the plant and is eco-friendly cultivation management. Application of organic fertilizers, which increase soil-organic matter whilst, provide a steady release of nutrients to the crops as the organic matter breaks down [3]. Nutrient uptake efficiency might be defining as total element recovery in plant (mg) per fertilizer applied (mg). Additional organic phosphate fertilizer (fine or granule rock phosphate) increases the vegetative growth and yield of green beans [4]. Ji et al., [5] stated the liquid organic fertilizers significantly promoted root and aboveground
growth by 10.2–77.8% and 10.7–33.3%, respectively, in Chrysanthemum. Nevertheless, this liquid organic fertilizer is easy to evaporate over the soil, thus mulch application can help to minimize the evapotranspiration.

Different types of organic fertilizers associated to the use of mulches in a crop production. Azevedo et al., [6] found cowpea grown under manure and mulch interaction had higher phyto-mass and grain production. The organic mulches significantly decreased soil temperature, higher soil moisture content, higher amount of available phosphorus in the soil, decreasing weed density, and higher crop yields [7,8]. Paddy straw and reeds are common cover-crop used as mulches [9,10]. The interaction between organic mulches and organic fertilizer (solid types) had been reported but none of them used liquid organic fertilizer for the combination. The liquid organic fertilizer provides the simplicity in use and complete nutrient content, which plants can absorb directly. This research aimed to determine the sufficient concentrations of liquid organic fertilizer and types of organic mulch toward biomass addition in green beans.

2. Methods
This research was conducted at Cisalak, Subang, West Java from January to March 2018. The land was on 400 m above sea level with climate types of C in Schmidt – Ferguson classification. The experiment was arranged in a factorial randomized block design with three replications. The first factor was concentrations of liquid organic fertilizer i.e. 0 ml l\(^{-1}\), 1 ml l\(^{-1}\), 2 ml l\(^{-1}\), 3 ml l\(^{-1}\), and the second factor consisted of without organic mulch, paddy straw mulch, and reeds mulch.

Green beans were planted on 35 x 35 cm planting space in 135 x 100 cm row plot with base fertilizer during the planting used N, P, K as much 8.37 g, 33.75 g, 12.15 g per plot, respectively. While after, the mulches were dried and applied for 675 g per plot. The liquid organic fertilizer calculated according to 10 l.h\(^{-1}\) dose and applied on 10 days after planting with concentration of 122.5 ml, 61.25 ml, and 40.83 ml spray volume for 1 ml l\(^{-1}\), 2 ml l\(^{-1}\), 3 ml l\(^{-1}\) doses, respectively, for each plant.

The observed parameters were number of pods per plant (pcs), pods weight per plant (g), dry stover weight (g), shoot-root ratio (%), and harvest index. Dry stover weight (g) measured by drying all parts of green beans plant to the oven with temperature 80°C for 48 hours until the weight was constant and weighed on a digital balance. Shoot-root ratio (%) measured by separating shoot and root and individually weighed on a digital balance. The ratio was:

$$\text{Shoot Root Ratio} = \frac{\text{Dry Shoot Weight}}{\text{Dry Root Weight}} \times 100$$

Harvest index was calculated as the equation below:

$$\text{Harvest Index} = \frac{\text{Dry Pod Weight per Plant}}{\text{Dry Pod Weight per Plant} + \text{Dry Stover Weight}}$$

The analysis of data used analysis of variance (ANOVA). If F value significantly different among the variables, then post-test analysis used Duncan Multiple Range Test in 5%.

3. Results and discussion
3.1. CEC, Temperature, and RH
Soil analysis conducted before planting the green beans. The soil on the research site had high cation exchange capacity (CEC) for 24.50 cmol kg\(^{-1}\). CEC affects the soil ability to keep the essential nutrients and obtain a buffer to soil acidification [11] which provides sufficient texture, organic matter content and pH for plant growth. Daily average temperature during green beans cultivation was 24.43°C, with the optimum range of temperature for green beans is 24°C - 27°C. The average relative humidity (RH) during the cultivation was 89.59%. It indicated high transpiration due to high intensity of rainfall and affected the green beans production [12], started at flowering stage.
3.2. Analysis of variance for biomass addition of green beans

The analysis of variance for biomass addition of green beans showed no interaction between liquid organic fertilizer and types of organic mulch for all parameters. Liquid organic fertilizer and types of organic mulch affect the biomass addition of green beans plant, independently, thus the DMRT 5% applied for independent test in each component treatment.

Table 1. Analysis of variance for number of pods per plant (pcs) of green beans.

| Treatments               | Number of Pods per Plant (pcs) |
|--------------------------|---------------------------------|
| Liquid Organic Fertilizer|                                 |
| 0 ml l⁻¹                 | 13,91 a                         |
| 1 ml l⁻¹                 | 16,33 b                         |
| 2 ml l⁻¹                 | 17,11 b                         |
| 3 ml l⁻¹                 | 16,49 b                         |
| Types of Organic Mulch   |                                 |
| Without mulch            | 15,15 a                         |
| Paddy straw mulch        | 16,55 b                         |
| Reeds mulch              | 16,18 ab                        |

Note: number followed by the same letter on the same column indicate significant difference based on DMRT α = 5%

The number of pods per plant showed the 2 ml l⁻¹ gave the best result (Table 1). Independently, types of organic mulch gave the best result of paddy straw mulch in number of pods per plant. Meanwhile, pods weight per plant showed the best results in 2 ml l⁻¹ liquid organic fertilizer and paddy straw mulch, independently (Table 2). Season plays important role in pod characteristics of green beans [12], including temperature, RH and precipitation intensity.

Table 2. Analysis of variance for pods weight per plant (g) of green beans.

| Treatments               | Pods Weight per Plant (g) |
|--------------------------|----------------------------|
| Liquid Organic Fertilizer|                            |
| 0 ml l⁻¹                 | 67,55 a                    |
| 1 ml l⁻¹                 | 80,87 b                    |
| 2 ml l⁻¹                 | 85,88 b                    |
| 3 ml l⁻¹                 | 82,03 b                    |
| Types of Organic Mulch   |                            |
| Without mulch            | 74,01 a                    |
| Paddy straw mulch        | 82,96 b                    |
| Reeds mulch              | 80,28 ab                   |

Note: number followed by the same letter on the same column indicate significant difference based on DMRT α = 5%

The dry stover weight obtained the best results in 2 ml l⁻¹ of liquid organic fertilizer and paddy straw mulch, independently (Table 3). Otherwise, shoot root ratio showed no significance different for concentrations of liquid organic fertilizer and types of organic mulch (Table 4). The application of liquid organic fertilizer significantly promotes root development especially root tips, SPAD value of leaves and aboveground biomass [13].
Table 3. Analysis of variance for dry stover weight (g) of green beans.

| Treatments                      | Dry Stover Weight (g) |
|---------------------------------|-----------------------|
| **Liquid Organic Fertilizer**   |                       |
| 0 ml l⁻¹                        | 15,98 a               |
| 1 ml l⁻¹                        | 19,07 b               |
| 2 ml l⁻¹                        | 19,89 b               |
| 3 ml l⁻¹                        | 18,89 b               |
| **Types of Organic Mulch**      |                       |
| Without mulch                   | 17,31 a               |
| Paddy straw mulch               | 19,42 b               |
| Reeds mulch                     | 18,64 ab              |

Note: number followed by the same letter on the same column indicate significant difference based on DMRT α = 5%

Shoot root ratio explains how nutrient translocation distributed most to sink or source of the plant. The pod numbers are controlled by the source capacity during the blooming and the pod-wall growth phases. The source capacity is frequently larger than the sink size during the grain growth phase [2]. Thus, the limiting factor of yield is generally the set-pod number and make the root had higher weight than the shoot.

Table 4. Analysis of variance for shoot root ratio (%) of green beans.

| Treatments                      | Shoot Root Ratio (%) |
|---------------------------------|----------------------|
| **Liquid Organic Fertilizer**   |                      |
| 0 ml l⁻¹                        | 18,48 a              |
| 1 ml l⁻¹                        | 18,63 a              |
| 2 ml l⁻¹                        | 18,17 a              |
| 3 ml l⁻¹                        | 18,28 a              |
| **Types of Organic Mulch**      |                      |
| Without mulch                   | 18,33 a              |
| Paddy straw mulch               | 18,43 a              |
| Reeds mulch                     | 18,42 a              |

Note: number followed by the same letter on the same column indicate significant difference based on DMRT α = 5%

The analysis of variance for harvest index showed non-significant in each treatment. Harvest index indicates the photosynthesis translocation to economic part of the plant. This result showed that the photosynthesis translocation only approx. 37% distributes to the pods of green beans and 63% distributes to all part of the plant.

Table 5. Analysis of variance for harvest index of green beans.

| Treatments                      | Harvest Index      |
|---------------------------------|--------------------|
| **Liquid Organic Fertilizer**   |                    |
| 0 ml l⁻¹                        | 0,3782 a           |
| 1 ml l⁻¹                        | 0,3714 a           |
| 2 ml l⁻¹                        | 0,3722 a           |
| 3 ml l⁻¹                        | 0,3749 a           |
| **Types of Organic Mulch**      |                    |
| Without mulch                   | 0,3768 a           |
| Paddy straw mulch               | 0,3727 a           |
| Reeds mulch                     | 0,3730 a           |

Note: number followed by the same letter on the same column indicate significant difference based on DMRT α = 5%
The use of mulches for crop cultivation have the purpose for weed management and no significant effect on other yield components on sweet potato [14], Allium cepa, Beta vulgaris L., Brassica oleracea L., and Solanum tuberosum [7]. Otherwise, inorganic mulches (black polythene, plastic mulch, etc.) showed the significant effect and increase green beans production [10]. The comparison between inorganic and organic mulches may be differs for each crop and environment.

4. Conclusion
The results obtained no interaction between liquid organic fertilizer and types of organic mulch for numbers of pod per plant, pods weight per plant, dry stover weight, shoot root ratio and harvest index. Liquid organic fertilization for 2 ml l⁻¹ concentration and paddy straw mulch, independently, gave the best recommendation to increase green bean productivity.

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