The effect of the type of planting medium and the dosage of vermicompost fertilizer on the growth and yield of bean (Phaseolus vulgaris L.) Kenya varieties

A Sudrajat¹, Y S Rachmawati¹*, C N N Qurani¹, Akmaliya², Sarbini³

¹Agrotechnology Department, Faculty of Science and Technology, UIN Sunan Gunung Djati, Bandung, Indonesia
²Islamic Study Department, Faculty of Tarbiyah, UIN Sunan Gunung Djati Bandung, Indonesia
³Da’wah Management Department, Faculty of Da’wah, UIN Sunan Gunung Djati Bandung, Indonesia

E-mail: yatisetiati@uinsgd.ac.id

Abstract. The superiority of the Kenya variety of beans has the opportunity to increase export value; with good market prospects, it is necessary to increase the production of Kenyan varieties of beans. This study aims to determine the effect of the type of planting medium and the dosage of vermicompost fertilizer on the growth and yield of green beans. This research was conducted from February until April 2020 in Ngamprah, Kab. West Bandung, West Java. This research was conducted using an experimental design in the form of a factorial randomized block design (RBD) with three replications consisting of two factors. The first factor is the type of planting media which consists of 3 levels (m0 = soil, m1 = soil + rice husk charcoal (1 :1), m2 = soil + cocopeat (1:1)). The second factor was vermicompost consisting of 4 levels (k0 = 0 t ha⁻¹, k1 = 7.5 t ha⁻¹, k2 = 15 t ha⁻¹, and k3 = 22.5 t ha⁻¹). Based on the study results, there was an interaction between the soil planting media with a dosage of 15 t ha⁻¹ of vermicompost on the growth and yield of upright beans. Soils with a silty loam texture and high P nutrient content in vermicompost can support growing places and sufficient nutrient availability for the growth and yield of upright beans.

1. Introduction
Upright beans are a source of vegetables that contain nutrients that are beneficial for human growth[1]. Increasing bean production needs to pay attention to agricultural sustainability and land productivity [2]. Land productivity can run by paying attention to the components used in the production process, including the use of organic fertilizers and planting media. The use of topsoil growing media with the addition of inorganic materials continuously can reduce soil productivity and limited planting media [3]. Beans need a medium with a clay texture, good drainage, sufficient water holding capacity, are porous, sufficient in nutrients, free from organisms and harmful substances[4], [5].

The utilization of organic materials such as rice husk charcoal and cocopeat can be used as an alternative planting medium to reduce topsoil use. Another effort to increase bean production is the application of organic fertilizer from worm scars. Vermicompost is an organic fertilizer that uses earthworms in its decomposition, [6]. Giving vermicompost fertilizer can increase the humus content in the soil [7]. The vermicompost contains other ingredients needed by plants for growth, namely the hormone auxin, gibberellin, and cytokinins, containing many microbes. [8], [9]. One of the microbes contained in vermicompost is Azotobacter sp [10]. This study aims to determine the effect of the type of planting medium and the dosage of vermicompost fertilizer on the growth and yield of beans.
2. Materials and Method

This research was conducted from February to April 2020 in Ngamprah, Kab. West Bandung, West Java. The tools used in this study were hoes, shovels, analytical scales, polybags (30 x 30 cm), ropes, tape measure, plastic labels, thermohygrometers, stationery and cameras. The materials used in this study were the seeds of the Kenyan variety of upright beans (*Phaseolus vulgaris* L.). Soil planting media, vermicompost, rice husk charcoal media, cocopeat media and NPK fertilizer.

This research was conducted using an experimental design in the form of a factorial randomized block design (RBD) with three replications consisting of two factors. The first factor is the type of planting media which consists of 3 levels (m0 = soil, m1 = soil + husk charcoal, m2 = soil + cocopeat). The second factor was vermicompost consisting of 4 levels (k0 = 0 t ha\(^{-1}\), k1 = 7.5 t ha\(^{-1}\), k2 = 15 t ha\(^{-1}\), and k3 = 22.5 t ha\(^{-1}\)). The main observations included soil and vermicompost analysis, plant height 28, 35 and 42 day after planting (DAP), leaf area using dry weight method, Weight of the pods per plant, and harvest index. Data analysis was carried out with variance, followed by the 5% DMRT test (Duncan’s multiple range test).

3. Result and Discussions

3.1. Soil and vermicompost analysis

Based on the results of laboratory tests, the soil used in this study has a dusty clay texture, with a high nitrogen content of 0.56%, with a very low P content available in the soil of 1.54 ppm. This land has a high cation exchange capacity (Table 1).

| No. | Analysis type | Unit | Result   | Criteria     |
|-----|---------------|------|----------|--------------|
| 1   | Tekstur       |      |          |              |
|     | Pasir         | %    | 27       | Silty loam   |
|     | Debu          | %    | 52       |              |
|     | Liat          |      | 21       |              |
| 2   | pH :          |      |          |              |
|     | H\(_2\)O      |      | 5,3      | Alkalis      |
|     | KCl           |      | 4,5      | Alkalis      |
| 3   | C-Orgánik    | %    | 5,64     | Very high    |
| 4   | N             | %    | 0,56     | High         |
| 5   | C/N           |      | 10       | Low          |
| 6   | P\(_2\)O\(_5\), Bray 1 | Ppm  | 1,4      | Very low     |
| 7   | K             |      | 1108,1   |              |
| 8   | P\(_2\)O\(_5\), HCL 25% | Mg/100 g | 257,99   | Very high    |
| 9   | K\(_2\)O HCL 25% | Mg/100 g | 175,47   | Very high    |
| 10  | Al-dd         |      | 0        | -            |
| 11  | H-dd          |      | 0,33     | -            |
| 12  | Ca            |      | 9,32     | Medium       |
| 13  | Mg            | cmol (+) kg | 1,78     | Medium       |
| 14  | K             |      | 3,38     | Very high    |
| 15  | Na            |      | 0,08     | Very low     |
| 16  | CEC           |      | 29,64    | High         |
| 17  | Kb            | %    | 49       | Medium       |

The laboratory test results of vermicompost had a high C-organic content of 25.4%, C / N ratio of 18.7, had low macro and micro nutrients, but the vermicompost used contained high P elements of 2.4% (Table 2).
Table 2. Results vermicompost analysis in the laboratory of the vegetable research center

| No. | Analysis Type | Unit | Result | Criteria |
|-----|---------------|------|--------|----------|
| 1   | C-Organik     | %    | 25.4   | High     |
| 2   | C/N           | -    | 18.7   | Medium   |
| 3   | pH            | -    | 7.5    | -        |
| 4   | N             | %    | 1.4    | Medium   |
| 5   | P₂O₅          | %    | 2.4    | High     |
| 6   | K₂O           | %    | 0.3    | Low      |
| 10  | Fe            | ppm  | 4.5    | Low      |
| 11  | Mn            | ppm  | 23.5   | Low      |
| 12  | Cu            | ppm  | 50.9   | Low      |
| 13  | Zn            | ppm  | 110.3  | Low      |
| 14  | Co            | ppm  | 4.9    | Low      |
| 15  | Mo            | ppm  | 20.3   | High     |
| 16  | B             | ppm  | 228.1  | Low      |

3.2. Plant height (cm)

Based on the analysis of variance, there was an interaction between the planting medium and the vermicompost fertilizer (Table 3). Vermicompost at the age of 28 DAP, 35 DAP and 42 DAP shows that the treatment of soil (m0) and vermicompost fertilizer with a dosage of 15 t ha⁻¹ (k2) was significantly different from other treatments. The treatment of soil growing media gave the highest results compared to other treatments on plant height parameters.

Table 3. The Effect of Planting Media Types and Vermicompost Fertilizer on Plant Height 28, 35 and 42 DAP

| Time (DAP) | Media | Average plant hight (cm) | Vermicompost |
|------------|-------|--------------------------|--------------|
|            |       | k0 | k1 | k2 | k3 |
| 28         | m0    | 31.60 b | 32.97a | 41.32b | 34.23a |
|            | m1    | 26.58a | 31.84a | 32.27a | 31.03a |
|            | m2    | 28.02ab | 31.80a | 31.90a | 31.65a |
| 35         | m0    | 32.22b | 33.65a | 42.17a | 35.00b |
|            | m1    | 26.97 a | 32.20a | 32.03a | 31.45a |
|            | m2    | 28.42a | 32.27a | 32.47a | 32.20a |
| 42         | m0    | 32.65b | 33.82a | 42.28b | 35.38b |
|            | m1    | 27.20a | 32.57a | 32.65a | 31.55a |
|            | m2    | 28.60a | 32.60a | 32.83a | 32.75ab |

Note: The average number followed by the same letter (horizontal direction capital letters, vertical direction lowercase letters) shows no significant differences according to Duncan’s Multiple Distance Test at the 5% level

The soil used in this study has a silty loam texture. Soils that have a silty loam soil texture have better soil aeration and drainage, are more porous so that plant root development [11]. The soil has an important role as a medium for roots, stores nutrients, provides water and as water storage, provides air
for root respiration and as a place to plant [12]. The highest results were obtained on plant height parameters by providing vermicompost fertilizer at a dosage of 15 t ha\(^{-1}\). The vermicompost dosage of 15 t ha\(^{-1}\) on the soil medium used is the optimal dosage. This is because the soil used as the medium has a silty loam texture where this texture has a higher cation exchange capacity (CEC) [13]. The indicator of fertile soil is that it has a high CEC, so that cation exchange is able to provide macro and micro nutrients that can be absorbed by plants [14]. If the vermicompost dosage is increased to 20 t ha\(^{-1}\), there will be excess nutrients so that plant height growth is inhibited. Meanwhile, if the dosage is less than 15 t ha\(^{-1}\) there is a lack of macro and micro nutrients for the plant so that plant growth is less than optimal, namely at a dosage of 10 t ha\(^{-1}\).

Bean plants at the age of 35 and 42 DAP have entered the generative phase, however, the treatment of vermicompost fertilizer at a dosage of 15 t ha\(^{-1}\) (k2) and soil planting medium (m0) showed a significant difference from other treatments, presumably because the plants have high growth. occurs throughout life or a process known as indeterminate growth [15].

3.3. Leaf area (cm\(^2\))

Leaf growth by nutrient content of nitrogen (N). Soil that has a silty loam soil texture is able to store macro and micro nutrients for plants, if the soil combines with rice husk charcoal and cocopeat (m1 and m2) then the media texture will change, so that the nutrients for plants are limited. Vermicompost contains macro and micro nutrients, with the high availability of N in silty loam texture soils (Table 1), with the application of a dosage of 15 t ha\(^{-1}\) (k2) vermicompost is able to meet the N needs in upright bean plants.

Leaf area is a factor that determines the photosynthetic process in plants. The photosynthate affects plant height extension, branch formation and new leaf formation [16]. In the treatment of soil growing media (m0) in the results of soil analysis, it is known that the nitrogen content is classified as high in accordance. That leaf formation is influenced by the availability of nitrogen and phosphorus nutrients in the medium and those available for plants [17].

| Table 4. The Influence of Type of Planting Media and Dosage of vermicompost fertilizer on leaf area (cm\(^2\)) |
|---------------------------------------------------------------|
| Media | Average leaf area (cm\(^2\)) | Vermicompost |
|       | k0   | k1   | k2   | k3   |
| m0    | 234.36a | 371.43a | 1002.34b | 327.8a |
|       | A    | A    | B    | A    |
| m1    | 274.17a | 276.34a | 174.00a | 304.91a |
|       | A    | A    | A    | A    |
| m2    | 100.70a | 135.92a | 255.54 a | 142.5 a |
|       | A    | A    | A    | A    |

Note: The average number followed by the same letter (horizontal direction capital letters, vertical direction lowercase letters) shows no significant differences according to Duncan's Multiple Distance Test at the 5% level.

3.4. Weight of the pods per plant (g)

Pod fresh weight was measured by weighing all pods from the first harvest to completion. Treatment of soil growing media type (m0) and vermicompost fertilizer dosage 15 t ha\(^{-1}\) (k2) were significantly different from other treatments. The fresh weight of the pods is an illustration of metabolic activity, including the response of plants to the nutrients present in the media and the vermicompost fertilizers. The nutrient P and K act as a regulator of photosynthate distribution in generative organs, improve the quality of generative organs, form carbohydrates, increase fruit size and increase plant root development [18].
Table 5. The effect of the type of planting medium and vermicompost fertilizer on the fresh weight of the pods planted.

| Media | Average weight of the pods planted (g) | Vermicompost |
|-------|----------------------------------------|--------------|
|       |                                        | k0 | k1 | k2 | k3 |
| m0    | 147.37c                                |    |    | 211.20c | 174.00c |
|       | A                                      |    |    | C   | B  |
| m1    | 103.47b                                |    | 176.57c | 177.07b | 154.10b |
|       | A                                      |    | C   | C   | B  |
| m2    | 97.87a                                 | 145.30a | 155.27a | 109.87a |
|       | A                                      | C   | C   | B  |

Note: The average number followed by the same letter (horizontal direction capital letters, vertical direction lowercase letters) shows no significant differences according to Duncan's Multiple Distance Test at the 5% level.

3.5. Harvest Index

The harvest index is the ratio between the economic dry weight and the total dry weight of the plant. The type of soil growing medium (m0) has an effect on the harvest index, with an average harvest index value of 0.65 (Table 6).

These results indicate that the P and K content in the soil planting medium affects the dry weight of the pods, so that the photosynthetic partitions in the canopy are mostly translocated to the pods, in other words the plants no longer produce total dry weight but divide more of their dry weight into yields [19]. The potential yield of several varieties of kenya beans and different cultivations in Laikipia County, the harvest index value was 0.65.

Table 6. The Influence of Type of Planting Media and Dosage of Vermicompost Fertilizer on Harvest Index

| Treatment | Average harvest index |
|-----------|-----------------------|
| Media     |                       |
| m0        | 0.65                  | b          |
| m1        | 0.44                  | a          |
| m2        | 0.43                  | a          |
| Vermicompost |                  |
| k0        | 0.41                  | a          |
| k1        | 0.49                  | a          |
| k2        | 0.58                  | a          |
| k3        | 0.54                  | a          |

Note: The average number followed by the same letter shows no significant differences according to Duncan's Multiple Distance Test at the 5% level.

4. Conclusion

Soils that have a silty loam texture and high P nutrient content in vermicompost 15 t ha⁻¹ are able to support growing places and sufficient nutrient availability for the growth and yield of upright beans.

Acknowledgments

Thank you for the support from the department of Agrotechnology UIN Sunan Gunung Djati Bandung for funding the publication.
References
[1] F. C. U. S. D. of Agriculture, “Beans, snap, green, raw,” 2019.
[2] E. K. Nassary, F. Baijukya, and P. A. Ndakidemi, “Assessing the productivity of common bean in intercrop with maize across agro-ecological zones of smallholder farms in the Northern highlands of Tanzania,” Agric., vol. 10, no. 4, pp. 1–15, 2020.
[3] A. P. Papadopoulos, A. Bar-Tal, A. Silber, U. K. Saha, and M. Raviv, Inorganic and synthetic organic components of soilless culture and potting mixes, no. April 2019. 2008.
[4] H. R. El-Ramady et al., Soil Quality and Plant Nutrition, no. October. 2014.
[5] T. Dejene, T. Tana, and E. Urage, “Response of Common Bean (Phaseolus vulgaris L.) to Application of Lime and Phosphorus on Acidic Soil of Areka, Southern Ethiopia,” IISTE, vol. 6, pp. 2224–3186, 2016.
[6] Y. I. Ramnarain, A. A. Ansari, and L. Ori, “Vermicomposting of different organic materials using the epigeic earthworm Eisenia fetida,” Int. J. Recycl. Org. Waste Agric., vol. 8, no. 1, pp. 23–36, 2019.
[7] G. S. Rekha, P. K. Kaleena, D. Elumalai, M. P. Srikumaran, and V. N. Maheswari, “Effects of vermicompost and plant growth enhancers on the exo-morphological features of Capsicum annum (Linn.) Hepper,” Int. J. Recycl. Org. Waste Agric., vol. 7, no. 1, pp. 83–88, 2018.
[8] J. Pathma and N. Sakhthivel, “Microbial diversity of vermicompost bacteria that exhibit useful agricultural traits and waste management potential,” Springerplus, vol. 1, no. 1, pp. 1–19, 2012.
[9] W. S. Wong, S. N. Tan, L. Ge, X. Chen, and J. W. H. Yong, The Importance of Phytohormones and Microbes in Biofertilizers. 2015.
[10] W. A. S. N. Ulina, A. Sahar, A. Rauf, M. Sembiring, E. Munir, and T. Sabrina, “Microbe population in biofertilizer with vermicompost as a carrier during the process and storage,” IOP Conf. Ser. Earth Environ. Sci., vol. 393, no. 1, 2019.
[11] G. Soil and D. Programme, Soil testing methods manual. 2020.
[12] P. Carvalho and M. J. Foulkes, “Roots and Uptake of Water and Nutrients,” in Encyclopedia of Sustainability Science and Technology, R. A. Meyers, Ed. New York, NY: Springer New York, 2018, pp. 1–24.
[13] D. Saidi, “Relationship between cation exchange capacity and the saline phase of Cheliff sol,” Agric. Sci., vol. 03, no. 03, pp. 434–443, 2012.
[14] C. Jones and K. Olson-Rutz, “Plant Nutrition and Soil Fertility,” Mont. State Univ. Ext., vol. Module 2, no. (Sept.), pp. 4449–8, 2016.
[15] I. K. Haririhan, D. B. Wake, and M. H. Wake, “Indeterminate growth: Could it represent the ancestral condition?,” Cold Spring Harb. Perspect. Biol., vol. 8, no. 2, pp. 1–17, 2016.
[16] S. M. Weraduwage, J. Chen, F. C. Anozie, A. Morales, S. E. Weise, and T. D. Sharkey, “The relationship between leaf area growth and biomass accumulation in Arabidopsis thaliana,” Front. Plant Sci., vol. 6, no. APR, pp. 1–21, 2015.
[17] M. Razaq, P. Zhang, H. L. Shen, and Salahuddin, “Influence of nitrogen and phosphorus on the growth and root morphology of Acer mono,” PLoS One, vol. 12, no. 2, pp. 1–13, 2017.
[18] G. FISCHER, P. J. ALMANZA-MERCHÁN, and F. RAMÍREZ, “Revista Colombiana de Ciencias Hortícolas,” Revista Colombiana de Ciencias Hortícolas, vol. 6, no. 2. pp. 238–253, 2012.
[19] T. Balemi and K. Negisho, “Management of soil phosphorus and plant adaptation mechanisms to phosphorus stress for sustainable crop production: A review,” J. Soil Sci. Plant Nutr., vol. 12, no. 3, pp. 547–561, 2012.