Adoption on Cassava Technology Package to Improve the Plant Growth in Kalasan, Yogyakarta, Indonesia

Agung Astuti[1]* *and Mulyono[1]*

[1] Agrotechnology Department, 55183 Universitas Muhammadiyah Yogyakarta, Indonesia

Abstract. Production of cassava in Kalasan is still low. The problem faced is to improve cassava growth, thereby increasing cassava yields. The aim of this study was to determine the effect of mycorrhizal inoculation, stem wounding soaked in PGPR, and spraying nano EPOFB ash fertilizer on the growth of cassava plants. The demonstration plot for planting cassava in Kalasan field was arranged in a completely randomized block design (CRBD), with single factor treatments, namely: A = stem without wounding (control), B = stem with wounding and soaked in PGPR, C = stem without wounding and inoculated with mycorrhiza, D = stem without wounding and sprayed with nano EPOFB ash fertilizer, E = stem with wounding + soaked in PGPR + inoculated with mycorrhiza + sprayed with nano EPOFB ash fertilizer. The results showed that the application of the innovative technology package (stem with wounding + soaked in PGPR + inoculated with mycorrhiza + sprayed with nano EPOFB ash fertilizer) to cassava cultivation in Kalasan had an effect on the percentage of mycorrhizal colonization, increased the dry weight of the roots, and accelerated the emergence of large numbers of shoots, thereby producing the highest number of leaves despite the shortest plant height.

1 Introduction

Since farmer groups in Kalasan are not cultivating cassava intensively, the production is still low between 5 and 10 tons per hectare. Meanwhile, according to the Indonesian Ministry of Agriculture, cassava productivity in Indonesia is around 24.65 tons/ha [1]. The average number of cassava plants produced is generally 6–9 tubers per plant because farmers typically use too-old stem, which limits their ability to grow, and the planting method used still lacks innovative techniques. A study conducted in 2022 by Astuti, Mulyono, and Meitasari showed that adding cow dung to cassava cultivation could yield up to 38.63 tons/ha [3].

Cassava stem that are too old will have difficulty developing a root system, which is a major factor in determining cassava production because these roots will grow into tubers and serve to absorb nutrients for plant growth and development. For this reason, cassava roots need to be stimulated using wounding techniques and PGPR soaking to produce lots of roots. The success of the wounding technique is influenced by the number and frequency of

* Corresponding author : agung_astuti@umy.ac.id

woundings. According to Rusbadila, Samidjo et al., three or four woundings on stem before planting cassava produced a yield of 51 tonnes/ha [4]. Meanwhile, according to Lopes et al., giving PGPR and mycorrhizal inoculation provided good growth for the propagation of cassava woundings [5].

Apart from that, the soil in Kalasan has been treated with inorganic (synthetic) fertilizers for too long, resulting in hard soil texture due to the chemical bonds between elements and soil particles and the deposition of residues. Such soil conditions will inhibit plant growth, thereby decreasing yields. Meanwhile, cassava farmers also have difficulty getting inorganic fertilizer, so in this case, they have to apply sustainable biological fertilizer. Mycorrhizae are fungi that have a symbiotic relationship with plants that can increase root proliferation, uptake of water and nutrients, especially phosphate, and resistance to extreme conditions, such as drought stress, soil acidity, nutrient concentration, and temperature [6, 7]. The results of research from Ilyas showed that giving mycorrhizal inoculum to cassava plants could increase the yield of cassava tubers by more than double compared to cassava plants that were not given mycorrhizal inoculum (control) [8]. Research by Astuti, Mulyono & Meitasari also reported that inoculation of indigenous Gunung Kidul mycorrhizae at a dose of 25 g/plant produced the highest yield of cassava (38.76 tonnes/ha) [3].

Spot fertilization of KCl on cassava plants shows that not all of the K element can be absorbed by the plants, which is proven by the delay in cassava filling on some roots. For this reason, it is necessary to spray potassium fertilizer, especially in nano formula, which is applied through the leaves to be absorbed through the stomata more easily. The advantages of nano particles include their flexibility to be combined with different technologies and their capacity to penetrate intercellular spaces that are accessible to colloidal particles [9]. Nano EPOFB fertilizer contains 0.05% N, 54.79% P_2O, 36.48% K_2O, 2.63% MgO, 5.46% CaO, 1,230 ppm Mn, 3450 ppm Fe, 183 ppm Cu, and 28 ppm Zn [10]. The application of 0.4% nano potassium fertilizer from Empty Palm Oil Fruit Bunches (EPOFB) ash is the most effective in opening stomata and making the photosynthesis process more active in potato plants [11].

According to the research by Agung, Mulyono & Pramesti, the application of innovative technology, namely mycorrhizal inoculation, stem wounding, and spraying nano EPOFB ash fertilizer could produce 35.92 tonnes/ha of cassava [12]. Thus, further study on the innovative technology package implemented in Kalasan is suggested. The research aimed to determine the effect of mycorrhizal inoculation, stem woundings soaked in PGPR, and spraying nano EPOFB ash fertilizer on the growth of cassava plants in Kalasan.

2 Methodology

The study was conducted in Kalasan district, Sleman Regency, Yogyakarta. The study utilized cassava stem, crude mycorrhizal inoculum, PGPR, NPK fertilizer (Urea, SP-36, and KCl), nano empty oil palm fruit bunches (EPOFB), KOH 10%, sterile Aquades, Acid Fuchsin, HCl. The instruments employed are decantation filter for filtering mycorrhizal spores, deglass, slides, microscopes for mycorrhizal infections observation, muffle furnace, and Ballmill for making nano EPOFB ash fertilizer. The utilized research methodology was experimental research was arranged in a completely randomized block design (CRBD), with single-factor treatments of the cassava cultivation innovative technology package, consisting of A) stem without wounding (control), B) stem with wounding and soaked in PGPR, C) stem without wounding and inoculated with mycorrhiza, D) stem without wounding and sprayed with nano EPOFB ash fertilizer, E) stem wounding + soaked in PGPR + inoculated with mycorrhiza + sprayed with nano EPOFB ash fertilizer. Each treatment consisted of three replications, resulting in 15 treatment units. Each unit consisted of three sample plants, three plants for destructive sampling, and two reserve plants.

2.1. Trapping mycorrhiza

Propagation of mycorrhiza with trapping method was done by using pot culture of corn for 2 months followed by applying stress on the corn to induce the spore production.

2.2. Cassava stem cutting

Cassava was wounded by making 3 (three) cuttings at the end of the cassava stem graft.

2.3. EPOFB nano-fertilizer

Nano-fertilizer from EPOFB was prepared by through the ashing process and ball milling that grinds nano particle.

2.4. Planting cassava

Cassava was planted with planting distance of 1m x 1m, inoculated with 20 g/plant of mycorrhizae and fertilized with cow manure with the dose of 500 g/plant. Plant maintenance was performed by irrigation, supplemented with Urea(40 g/plant), SP-36 (20 g/plant), KCl (30 g/plant), and foliar spraying with EPOFB nano-fertilizer (0.40%) at 2 weeks period after the plant reach 6 weeks of age. Observations on root development, growth development, yield and production effectiveness.

The stages of the research were as follows: Fig.1.

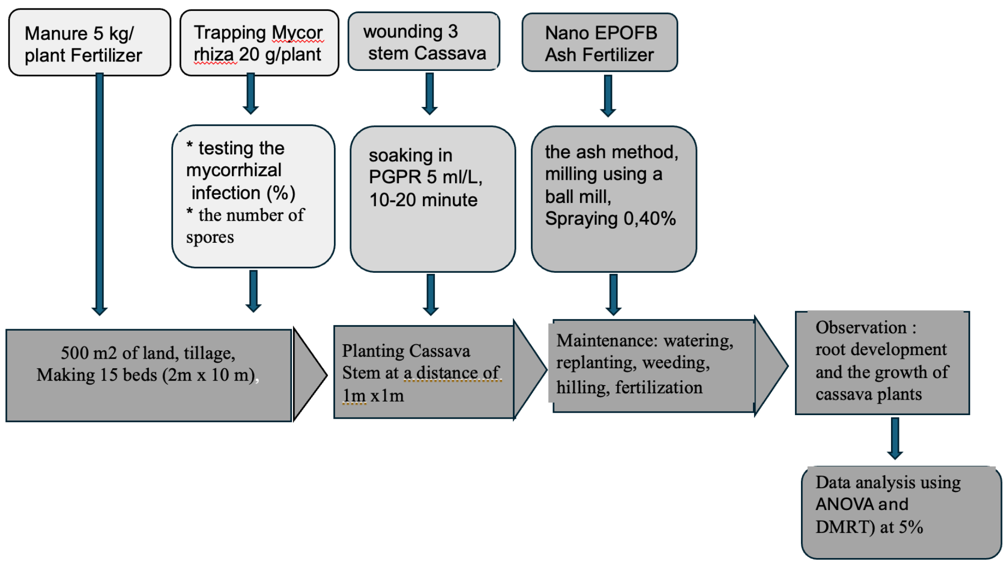

Fig. 1. The stages of the research

2.5. Parameters Observed and Data Analysis

The parameters observed include the mycorrhizal infection, the roots dry weight, and the development of plants (Shoot Emergence Time, number of shoots, number of leaves, cassava plant height). The data obtained were analyzed using analysis of variance and DMRT test with an alpha level 5%.

3 Results and Discussion

3.1. Mycorrhizal colonization on cassava plants and root development

To determine the effect of mycorrhizal application, infection was observed on the roots of cassava plants. A plant root is declared to be infected with mycorrhiza if external hyphae, internal hyphae, vesicles, and arbuscules are found on the root [13]. In this research, mycorrhiza colonized almost 100% of the roots in the treatment of stem without wounding + mycorrhizal inoculation and the treatment of stem with wounding + soaking PGPR + mycorrhizal inoculation + spraying nano EPOFB ash fertilizer (Fig. 2). This is due to the compatibility of mycorrhiza with cassava plants, and it develops to form external hyphae, internal hyphae, vesicles, and arbuscules and stimulates root branching. This correlates with an increase in the dry weight of the roots, thereby helping the absorption of water and nutrients, especially phosphate, and improving resistance to extreme conditions. This was explained by Brundrett et al. [14] that mycorrhizal inoculation could stimulate roots, thereby increasing their proliferation. Astuti and Putri added that the indigenous mycorrhiza of Gunung Kidul, which was compatible with cassava, could increase the number of roots [15]. However, mycorrhizal colonization also occurred in cassava plants that were not inoculated with mycorrhiza. This might be because the land was once planted with corn, a host for mycorrhizal symbionts. In addition, Adiaty et al. reported that the growth and development of mycorrhiza were greatly influenced by environmental factors [16]. The spread of mycorrhiza is also influenced by plant type [17].

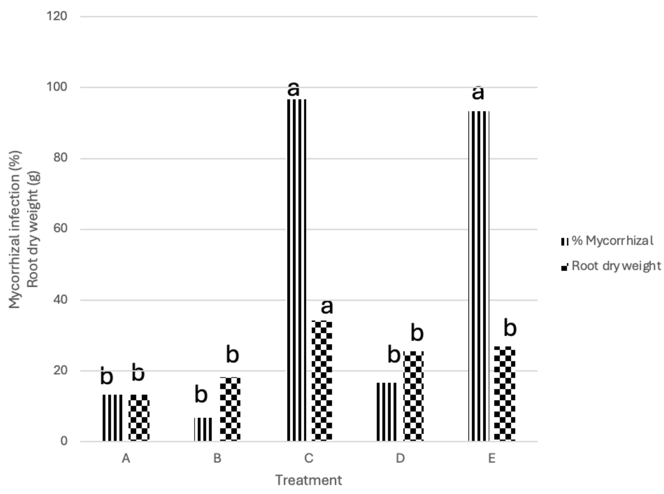

Fig. 2. Mycorrhizal Infection and Root Weight of Cassava Plant

Remarks:
A) stem without wounding (control)
B) stem with wounding and soaked in PGPR
C) stem without wounding and inoculated with mycorrhiza
D) stem without wounding and sprayed with nano EPOFB ash fertilizer
E) stem with wounding + soaked in PGPR + inoculated with mycorrhiza + sprayed with nano EPOFB ash fertilizer

The application of the innovative technology package in the treatment of stem with woundings + soaked in PGPR + inoculated with mycorrhiza + sprayed with nano EPOFB ash fertilizer most stimulate cassava roots (Fig.2). This is because by wounding the stem, roots will appear, and their growth can be accelerated by wounding [18]. Meanwhile, PGPR can provide good growth for the propagation of cassava woundings [19]. The results of research by Astuti, Mulyono, and Ma'rifah showed that the application of indigenous mycorrhiza from Gunung Kidul and three woundings on cassava stem could increase the number of roots and yield of cassava, reaching 54.32 tonnes/Ha [18].

3.2. Development of Cassava Plants

The first plant tissue development that appeared was shoot, with different numbers and emergence times, which then regenerated into complete plants [20]. Based on the variations in shoot growth, there was a significant difference, in which the shoots that appeared faster were in the treatment of stem with wounding and soaked in PGPR and the treatment of stem with wounding + soaked in PGPR + inoculated with mycorrhiza + sprayed with nano EPOFB ash fertilizer. Likewise, the number of shoots was also higher (Table 1). The number of cassava leaves in this work was found higher than the previous results (12) when nano EPOFB was used as fertilizer. This is because the PGPR content produced by microbes in PGPR can stimulate faster shoot growth and the number of shoots [22]. Manurung et al. also mentioned that giving PGPR to several planting media compositions had an effect on the growth of pepper woundings [20]. It has been commonly understood that photosynthesis takes place in the leaves, therefore the more leaves, the higher the photosynthetic activity that results in the increase of CO_s assimilation during plant growth and development. The increase in photosynthate would, therefore, affects the cassava yield. In addition, the increase in photosynthesis also increases the plant dry weight. Biosaka is known to fulfill the nutrients requirement by the plant to increase its photosynthesis. The rate of phosynthesis is directly related to photosynthate which in turn also affects the shoot dry weight.

The number of leaves was significantly higher in the treatment of stem with wounding + soaked in PGPR and the treatment of stem with wounding + soaked in PGPR + inoculated with mycorrhiza + sprayed with nano EPOFB ash fertilizer (Table 1). Because the shoots will develop into leaves, the treatment with the highest number of shoots correlates with the highest number of leaves. The application of the innovative technology package stimulates the fastest emergence of shoots with the highest number of shoots and leaves.

Table 1. Shoots and Leaves of Cassava Plants

Treatment	Shoot Emergence Time (days)	Number of Shoots	Number of Leaves
A	2.1 a	2.5 b	56.88 b
B	1.9 b	3.3 a	64,55 a
C	2.1 a	2.6 b	57.33 b
D	2.4 a	3.1 a	53.66 b
E	1.9 b	3.2 a	66.22 a

Remarks:
A) stem without wounding (control)
B) stem with wounding and soaked in PGPR
C) stem without wounding and inoculated with mycorrhiza
D) stem without wounding and sprayed with nano EPOFB ash fertilizer
E) stem with wounding + soaked in PGPR + inoculated with mycorrhiza + sprayed with nano EPOFB ash fertilizer

The vegetative growth of a plant can be seen from the increase in height, which is in line with cell division, especially at the tip of the apical meristem cells for the formation of stem and leaves, as well as the addition of root length to strengthen the plant, thereby increasing plant height rapidly [23]. Treatment of stem without wounding and sprayed with nano EPOFB ash fertilizer tended to produce the highest plant height (Fig. 3). This is because the nano formula form of fertilizer is applied through the leaves, making it more easily absorbed through the stomata, thereby accelerating the metabolic process of cell division, especially at the tip of the apical meristem cells for the formation of stem and leaves, so that plant height increases rapidly [23].

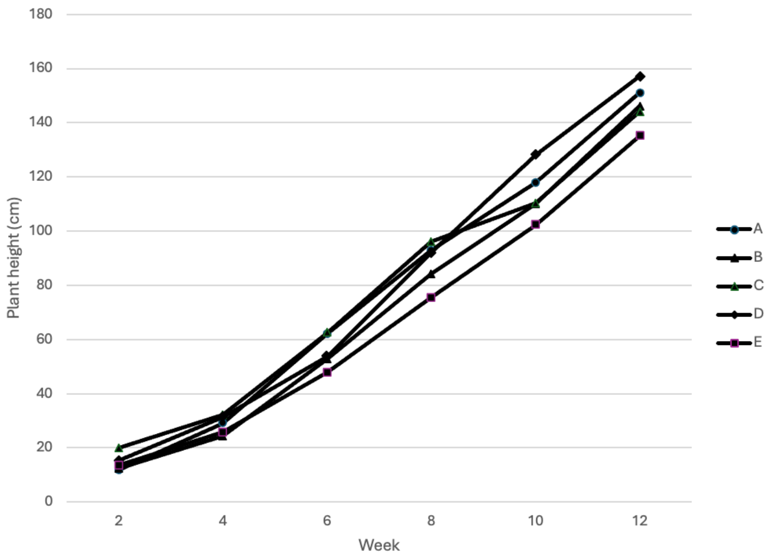

Fig. 3. Development of Cassava Plant Height

Remarks:
A) stem without wounding (control)
B) stem with wounding and soaked in PGPR
C) stem without wounding and inoculated with mycorrhiza
D) stem without wounding and sprayed with nano EPOFB ash fertilizer
E) stem with wounding + soaked in PGPR + inoculated with mycorrhiza + sprayed with nano EPOFB ash fertilizer

Meanwhile, the application of the innovative technology package in the treatment of stem with wounding + soaked in PGPR + inoculated with mycorrhiza + sprayed with nano EPOFB ash fertilizer resulted in the lowest plant height but produced the highest number of leaves. Leaves are plant organs where the photosynthesis process takes place, which synthesizes food for the plant's needs and food reserves, such as in fruit and tuber [20]. The more leaves there are, the higher the photosynthesis rate, resulting in increased yield. The results of research by Astuti, Mulyono, and Pramesti showed that cassava stem with wounding, inoculated with mycorrhiza, and sprayed with nano EPOFB ash fertilizer showed an increased yield of 30.90% compared to the control [12].

3 Conclusion

The results of the research show that the application of the innovative technology package (stem with wounding + soaked in PGPR + inoculated with mycorrhiza + sprayed with nano EPOFB ash fertilizer) to cassava cultivation in Kalasan has an effect on the percentage of mycorrhizal colonization, increases the dry weight of the roots, accelerates the emergence of large numbers of shoots, so that the number of leaves is the highest, even though the plant height tends to be the lowest.

Acknowledgments

The authors would like to thank the LPM UMY for providing a grant for the Tri Dharma Improvement Program for Higher Education of Universitas Muhammadiyah Yogyakarta under Decree No. 7/A.3-III/SK-LPM/I/2024.

References

[1] KementanRI.. https://www.pertanian.go.id/Data5tahun/TPATAP-2017(pdf)/37-ProdtvUbikayu.pdf (2020)
[3] Astuti, A., Mulyono & Meitasari. PLANTA TROPIKA **10**(2): 186-193 (2022)
[4] Rusbadila, H., et al. Prosiding UMY Grace **1**(1): 235-243 (2020).
[5] Lopes, E. A. P., Silva, A. D. A. D., Mergulhão, A. C. D. E. S., Silva, E. V. N. D., Santiago, A. D., & Figueiredo, M. D. V. B. *Revista Caatinga*, *32*, 152-166 (2019).
[6] Barbosa, M. V. & Pedroso. Ciência e Agrotecnologia **43** (2019)
[7] Zhang, S., et al. New Phytologist **222**(1): 543-555 (2019).
[8] Ilyas, Y. N. http ://repository.umy.ac.id (2020).
[9[Buzea, C., et al. Biointerphases **2**(4): MR17-MR71(2007).
[10] Efendi, A., Diana, P. & Akhir, N. Ziraa'Ah Majalah Ilmiah 45 : 69-79 (2020).
[11] Mulyono, M., Febriana, E. R., & Hidayat, T. PLANTA TROPIKA **10**(2): 177-185 (2022).
[12] Astuti, A., Mulyono & Pramesti, N. N. S. P. *IOP Conference Series: Earth and Environmental Science* (Vol. 1287, No. 1, p. 012013). IOP Publishing. https://iopscience.iop.org/article/10.1088/1755-1315/1287/1/012013/meta (2023)
[13] Kusumastuti, L., Astuti, A., & Sarjiyah. *Planta Tropika: Jurnal Agrosains*, *5*(1), 7–14 (2017).
[14] Brundrett M, Bougher N, Dell B, Grove T and Malajczuk N. Australian Centre for International Agricultural Research Canberra (1996).
[15] Astuti, A. and A. Putri. IOP Conference Series: Earth and Environmental Science, IOP Publishing (2020)
[16] Adiaty, T. O., Linda, R., & Mukarlina. *Protobiont*, *7*(3), 83 –89 (2018).
[17] Widyaningrum, N., Rakhmawati, A., & Aminatun, T. *Biologi*, *5*(8), 28–37 (2016).
[18] Astuti, A., Mulyono & Ma'rifah, F. *IOP Conference Series: Earth and Environmental Science* (Vol. 1172, No. 1, p. 012025). IOP Publishing. https://iopscience.iop.org/article/10.1088/1755-1315/1172/1/012025/meta (2023)
[19] Manurung, L., Asnawati, & Purwaningsih. *Sains Pertanian Equator* (2023).

[20] Hendaryono, D. P. S., & Wijayani, A. *Kanisius* (2012).
[21] Frank P. Gardner, Brent Pearce, Roger Mitchell. First Edition. Iowa State Pr. 328 p (2 017)
[22] Khalimi, K., & Wirya, G. N. A. S. *Khalimi, 4*(2), 131-135 (2009).
[23] Noviana, L., & Raharjo, B. *Bioma*, *11*(1), 30–39 (2009)