Research article

Influence of PGPR, Bio-Phosphate Microorganism and Phosphate on Growth of Oil Palm Seedlings Under Drought Stress Conditions

Sri Suryanti[1]*, Arif Umami[1], Sri Gunawan[1]*, Idum Satia Santi[1], and Reza Hadi Maulana[2]

[1]Department of Agrotechnology, Faculty of Agriculture, Stiper Agricultural Institute, Indonesia
[2]Degree Program of Agricultural Science, Stiper Agricultural Institute Yogyakarta, Indonesia

ORCID
Sri Suryanti https://orcid.org/0000-0002-0230-0512

Abstract.
Drought is a major abiotic stress that threatens the production of agricultural oil palms. Drought interferes with plant uptake of phosphorus. The goal of this study was to investigate how plant growth-promoting rhizobacteria (PGPR), bio-phosphate microorganisms, and phosphate affected oil palm growth under drought stress. The study was conducted at the Tri Dharma Research Station INSTIPER in Yogyakarta from January to May 2020, and it used a factorial and completely randomized design with two factors and three replicates per treatment. The first factor was a fertilization treatment that included P1 (PGPR), P2 (bio-phosphate microorganisms), P3 (phosphate). The second factor was a drinking interval of L1 (once per day) and L2 (once per seven days). At 120 days after planting, data were collected. The results showed that the PGPR, bio-phosphate microorganisms and phosphate had no significant effect on plant height, number of leaves, leaf area, chlorophyll content, dry weight of plants, volume of root, dry weight of root and shoot, stem diameter, number of stomata, and root-shoot ratio. Root volume, root dry weight, and root-shoot ratio were significantly affected by one-day and seven-day watering intervals. Phosphate fertilization with watering once every seven days considerably increased the width of the stomata openingsl

Keywords: PGPR, Bio-Phosphate, Phosphate, Oil Palm, Drought

Corresponding Author: Sri Suryanti and Sri Gunawan.; email: ntie@instiperjogja.ac.id; sriegun@instiperjogja.ac.id

Published 07 June 2022

Publishing services provided by Knowledge E

© Sri Suryanti et al. This article is distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use and redistribution provided that the original author and source are credited.

Selection and Peer-review under the responsibility of the PGPR 2021 Conference Committee.

OPEN ACCESS

1. Introduction

Drought stress inhibits oil palm growth since seedlings. Drought affects a wide range of physiology and biochemistry processes, reducing plant growth. Drought response observations were first carried out on leaf morphology, leaf yellowing, lay, and necrosis, [1]. The effect of prolonged drought would be to reduce the growth and development of the oil palm, thereby reducing yield and directly inhibit the formation of fresh fruit clusters.

In the seeds there is a limit on dry stress conditions so as to reduce P translocation and P accumulation.. Phosphorus (P) fertilization increases moisture stress tolerance in many plants. PGPR biocontrol, bio-fertilization and biostimulation action mechanisms. Increasing phosphate solubilization, secretion of plant hormones (gibberellins, cytokinins, indole acetic acid and ethylene) as well as biological nitrogen fixation needed for growth and adaptation in stressful environments can be done by applying PGPR inoculant soil to seeds, [2]. application of dried oil palm leaves, rachis and inoculation of Bacillus sphaericus increased the N content in the media and significantly affected growth. application of organic N fertilizer and land inoculated with B gave good impact and yields in the young oil palm planting phase. then sphaericus UPMB-10 was able to replace the use of inorganic N fertilizer in the early phase of oil palm cultivation, [3] .In wheat, PGPR isolates showed a significant increase in root ramification and Bacillus sp. Root length increased relative to control. Root length, number of tips, and root area on control variables were significantly affected by PGPR isolate, [4]. administration of 20 g L-1 biophosphate was able to increase the weight of 100 grains of lower quality rice, which was 11.4% greater than without biophosphate administration. then the availability of N, P, K in Ultisol soil is influenced by the application of biophosphate. Furthermore, the length of the roots of paddy rice with the respective values being 36.8% and 13.3% was also influenced by the application of biophosphate 20 g L-1 and 10 g L-1. so that the application of biophosphate almost completely gives a good impact on growth, [5]. The purpose of this study was to evaluate the effect of rhizobacterium promoter plant growth (PGPR), from bio-phosphate and phosphate fertilization in overcoming the water deficit in oil palm seedlings.

2. Methodology

The research was conducted at the Tri dharma research station INSTIPER, at an altitude of 118 meters above sea level from January to May 2020. The materials used are main nursery of oil palm seedlings, regosol soil, fertilizer N, P, K, PGPR, SP18 and biophoshate. PGPR source inoculum was made from bamboo and *Mimosa pudica* rhizosphere (including their roots) as a source of Rhizobacteria inoculum. The cultivation condition was 27 oC in a sterilized growth medium. Two genera of bacteria were identified base on their morphological colony, namely Bacillus (5,6 x 106 CFU/ml) and Pseudomonas (5,1 x 107 CFU/ml). Total plate count was used for estimating microbes numbers. Biophosfat contains Pseudomonas and Aspergilus.

The factorial experiment was conducted entirely randomly with two factors and three repeats. The first factor was fertilization treatment: P1 (PGPR), P2 (bio phosphate microorganisms), P3 (phosphate). The second factor is the treatment of L1 (once a day) and L2 (once in 7 days) watering intervals. Plant height, number of leaves, leaf surface, chlorophyll content, plant dry weight, root volume, root and stem dry weight, stem diameter, number of stomata, stomata opening width and root-stem relationship were measured in this study.

3. Result and Discussion

The results showed that PGPR, biophosphate and phosphate microorganisms had no significant effect on the parameters of increasing plant height, number of leaves, leaf area, chlorophyll content, plant dry weight, root volume, root dry weight, stem dry weight, stem diameter. addition, number of stomata and ratio of roots to shoots. (Table 1).

PGPR inoculation in terms of leaf area under well-water and drought stress conditions, indicating that PGPR plants may produce more carbohydrates than non PGPR plants regardless of water levels. These effects could be proved by increasing above ground biomass, [6]. In this study, basic fertilizers such as N (urea), P (SP36), K (KCL) to provide the nutrients for plants until PGPR and bio phosphate microorganisms able to provide nutrients for the plants. PGPR at the beginning of colonization is parasitic so it has not provided nutrients for plants. PGPR need carbohydrates and root exudate for cell growth and division, as a result of which there is competition for nutrients in the rizhosfer region between plants and microbes.

Biophosphate is known to dissolve phosphate that is not available in the soil in a form that is easily absorbed by plants to promote plant growth. Phosphate solubilizing microbes combined with NPK increased plant height and weight of oil palm seed biomass. Therefore, the application of PGPR, biophosphate and P fertilizers gave the same effect on increasing the size of seedling height, number of plant leaves, leaf area, leaf chlorophyll content, seedling dry weight, seedling root volume, seedling root dry weight, shoot dry weight, increase in stem diameter, number of stomata, and root shoot ratio, [7]-[8].

Optimum irrigation is very important for hybrid oil palm (*Elaeis guineensis* Jacq.). In general, overwatering of nursery stock may cause a loss of growth. The oil palm stock was susceptible to a severe moisture deficiency (6-13% CFC). The wilting point of the nursery oil palm was defined as 20% CFC, under which the plants recovered by spraying, [9]. Significant differences in have been found volume of root, seedling root

Table 1: Varians analysis of PGPR, bio phosphate microorganisms, and phosphate fertilizer on addition of plant height (cm), number of leaves (unit), leaf area (cm2), chlorophyll content (mg/g tissue), dry weight of plant (g), volume of root (cm^3), dry weight of root (g), dry weight of shoot (g), diameter of stem (cm), number of stomata / mm^2, and ratio of root – shoot.

Parameters	Fertilizer		
	PGPR	Bio Phosfate Microorganisms	Phosfate
Plant height (cm)	59,4 p	56,7 p	56,3 p
Number of leaves (unit)	6,4 p	5,5 p	6,0 p
Leaf area (cm^3)	4591,86 p	4578,79 p	4263,34 p
Chlorophyll content (mg/g tissue)	48,380 p	42,290 p	46,280 p
Dry weight of plant (g)	141,55 p	143,05 p	130,79 p
Volume of root (cm^3)	151 p	148 p	147 p
Dry weight of root (g)	22,20 p	20,70 p	19,60 p
Dry weight of shoot (g)	119,35 p	122,37 p	111,19 p
Diameter of stem (cm)	3,97 p	3,89 p	3,72 p
Number of stomata / mm^2	71,50 p	70,8 p	74,7 p
Ratio of root-shoot	0,19 p	0,17 p	0,17 p

Note: The numbers in columns followed by the same letters indicate not significant based on the DMRT test (α=0.05).

dry weight, and root-shoot ratio among watering interval treatments, full-irrigation (once days watering interval) and once-in- 7-days withholding irrigation (20% SWC) (Table 2). An increased volume of root can increased dry weight of root (Figure 2.) and thus root growth increased root-shoot ratio in oil palm seedlings (Figure ??.).

Table 2: Varians analysis of watering interval treatment on addition of plant height (cm), number of leaves (unit), leaf area (cm2), chlorophyll content (mg/g tissue), dry weight of plant (g), volume of root (cm^3), dry weight of root (g), dry weight of shoot (g), diameter of stem (cm), number of stomata / mm^2, and ratio of root – shoot.

Parameters	Watering	
	Once a day	Once - in - 7 days
Plant height (cm)	60,93 a	54 a
Number of leaves (unit)	6,2 a	5,73 a
Leaf area (cm^3)	5020,93 a	3935,06 a
Chlorophyll content (mg/g tissue)	43,400 a	47,900 a
Dry weight of plant (g)	158,34 a	118,58 a
Volume of root (cm^3)	178 a	119,33 b
Dry weight of root (g)	25,59 a	16,06 b
Dry weight of shoot (g)	132,75 a	102,51 a
Diameter of stem (cm)	4,1 a	3,62 a
Number of stomata / mm^2	69,53 a	75,13 a
Ratio of root-shoot	0,20 a	0,16 b

Note: The numbers in columns followed by the same letters indicate not significant based on the DMRT test (α=0.05)

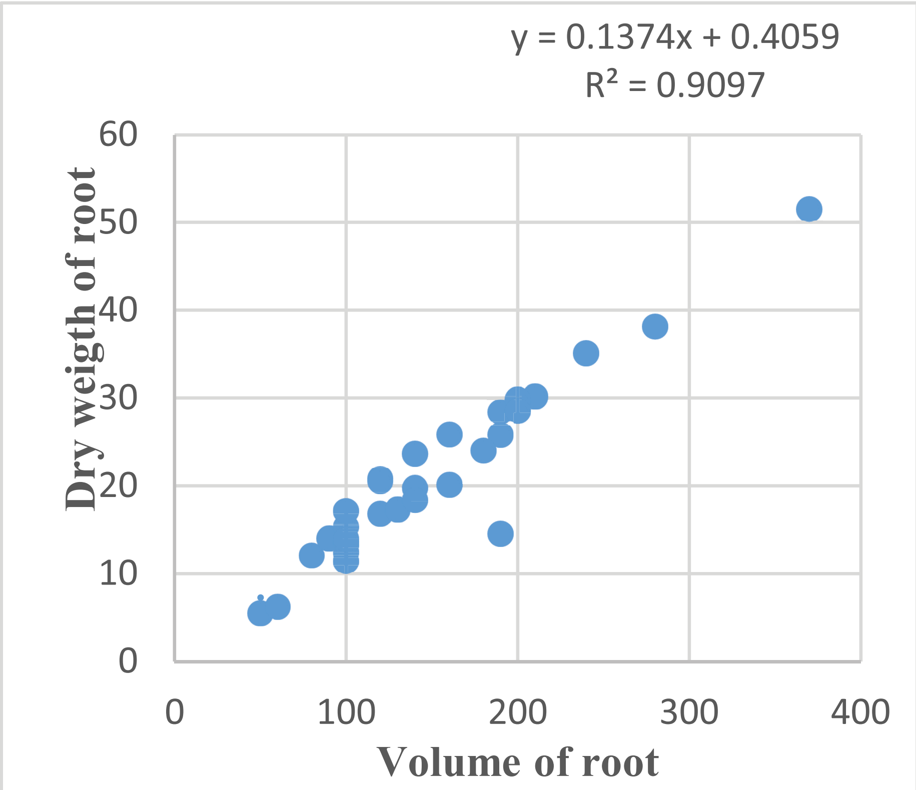

Figure 1: Relationship between volume of root and dry weight of root.

Table 3: The effect of PGPR, biophosphate microorganisms, and phosphate fertilizer and watering interval treatment on width of stomata opening.

Perlakuan	PGPR	Biophosfat	Phosphat	Rerata
Once a days	4,0920 a	3,7420 ab	3,2540 ab	3,7047
Once – in – 7 days	3,7680 ab	2,6640 b	4,2790 a	3,5520
Rerata	3,9170	3,2060	3,7620	+

Note: The numbers in rows and columns followed by the same letters indicate not significantbased on the DMRT test (α=0.05)

The results showed that the PGPR treatment with once a days watering interval and phosphate fertilization with watering once-in-7 days significantly had wider stomata openings than the biophosphate treatment with watering interval at once – in - 7 days (Table 3.). The soil moisture contents in this study with daily watering and watering interval once-in- 7 days were 24.78% and 20.29%. The permanent wilting point of oil palm seedlings was 20 %, so that the plants have experienced drought. The regulation of stomata pore aperture is a key determinant of plant productivity and drought resilience. The closure of stomata on biophosphate treatment with watering interval at a time – in - 7 days in response to drought stress mainly results in a lower rate of photosynthesis. The reduction in the width of the opening of the stomata is another morphological

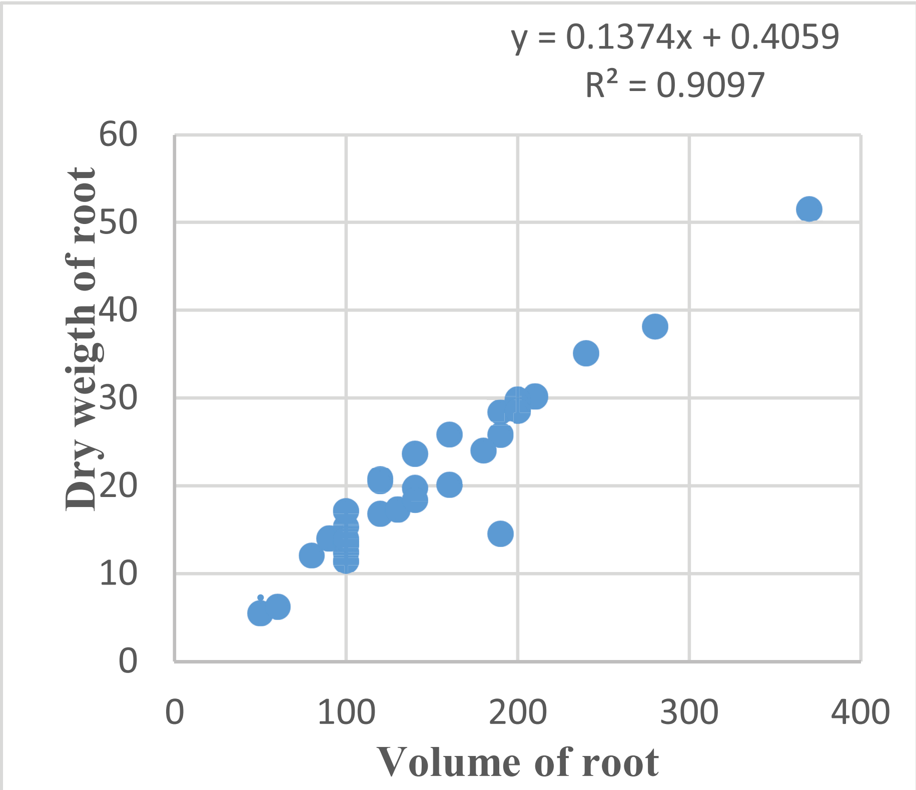

Figure 2: Relationship between dry weight and root shoot ratio .

change in response to the stress of dryness, [10]. Reducing transpiration by stomata closure is a good way for plants to survive under drought, however closure of stomata will reduce the rate of photosynthesis.

4. Conclusion

The application of PGPR, biophosphate microorganisms, and phosphate fertilization had no significant effect on seedling height, number of plant leaves, leaf area, leaf chlorophyll content, plant dry weight, root volume, root dry weight, plant dry weight. shoots, stem diameter, number of stomata, and plant root-shoot ratio. Watering intervals every seven days resulted in a decrease in root volume, root dry weight, and root-shoot ratio of oil palm seedlings. The PGPR treatment with a daily watering interval and phosphate fertilization with a once-in-seven-day watering expanded the breadth of stomata openings considerably.

References

[1] Wang L, Lee M, Ye B, Yue GH. Genes, pathways and networks responding to drought stress in oil palm roots. Scientific Reports. 2020;10(1):1–13. https://doi.org/10.1038/s41598-020-78297-z

[2] Kenneth OC, Nwadibe EC, Kalu AU, Unah UV. Plant growth promoting rhizobacteria (PGPR): A novel agent for sustainable food production. American Journal of Agricultural & Biological Sciences. 2019;14(1):35–54. https://doi.org/10.3844/ajabssp.2019.35.54

[3] Zakry FAA, Shamsuddin ZH, Khairuddin AR, Zin ZZ, Anuar AR. Inoculation of *Bacillus sphaericus* UPMB-10 to young oil palm and measurement of its uptake of fixed nitrogen using the 15n isotope dilution technique. Microbes Environments. 2012;27(3):257–262. https://doi.org/10.1264/jsme2.ME11309

[4] Jochum MD, McWilliams KL, Borrego EJ, Kolomiets MV, Niu G, Pierson EA, Jo YK. Bioprospecting plant growth-promoting rhizobacteria that mitigate drought stress in grasses. Frontiers in Microbiology. 2019;10(Sep):1–9. https://doi.org/10.3389/fmicb.2019.02106

[5] Yafizham, Abubakar M. Effect of bio-phosphate on increasing the phosphorus availability, the growth and the yield of lowland rice in ultisol. Journal of Tropical Soils.2010 ;15 : 133–138. https://doi.org/10.5400/jts.2010.15.2.133

[6] Zhu Y, Wang Z, Wang J, Wang Z, Zhou J. Plant growth-promoting rhizobacteria improve shoot morphology and photosynthesis in dryland spring wheat. WIT Transactions on Built Environment. 2014;145(Dec):343–350. https://doi.org/10.2495/ICBEEE20130431

[7] Backer R, Rokem JS, Ilangumaran G et al. Plant growth-promoting rhizobacteria: Context, mechanisms of action, and roadmap to commercialization of biostimulants for sustainable agriculture. Frontiers in Plant Science. 2018;871(Oct):1–17. https://doi.org/10.3389/fpls.2018.01473

[8] Khajeeyan R, Salehi A, Dehnavi MM, Farajee H, Kohanmoo MA. Growth parameters, water productivity and aloin content of aloe vera affected by mycorrhiza and PGPR application under different irrigation regimes. South African Journal of Botany. 2021. https://doi.org/10.1016/j.sajb.2021.02.026

[9] Cha-um S, Yamada N, Takabe T, Kirdmanee C. Physiological features and growth characters of oil palm (*Elaeis guineensis jacq.*) in response to reduced water-deficit and rewatering. Australian Journal of Crop Science. 2013;7(3):432–439.

[10] Yang J, Liang T, Liu L, Pan T, Zou Z. Stomatal opening and growth in tomato seedlings treated with different proportions of red and blue light. Canadian Journal of Plant Science. 2019;99(5):688–700. https://doi.org/10.1139/cjps-2018-0241