

Plant growth analysis

by turnitin turnitin

Submission date: 14-Oct-2024 06:20PM (UTC+0600)

Submission ID: 2484930358

File name: 2022_1_b_2_k_Muh._Akhsan_Akib_et_al.pdf (512.01K)

Word count: 4151

Character count: 22201



Original Research Article

doi: <https://doi.org/10.20546/ijcrbp.2022.907.001>

Plant growth analysis and arbuscular mycorrhizal colonization in *Amaranthus tricolor* L.

Muh. Akhsan Akib^{1*}, Syatrawati², Retno Prayudyaningsih³

¹Universitas Muhammadiyah Parepare, Jl. Jend Ahmad Yani km 6, Parepare, Sulawesi Selatan, Indonesia 91131

²Politeknik Pertanian Negeri, Jl. Poros Makassar - Parepare Km. 83, Mandalle, Pangkajene Dan Kepulauan, Sulawesi Selatan, Indonesia 90761

³Pusat Riset Mikrobiologi Terapan, BRIN, Jl. Raya Jakarta-Bogor km 46, Cibinong, Jawa barat, Indonesia 16911

*Corresponding author; e-mail: akhsanbagus@yahoo.co.id

Article Info

Keywords:

Assimilation
Dosage form
Leaf area
Photosynthesis
Sachet

Abstract

Red spinach (*Amaranthus tricolor* L) is a horticultural vegetable that contains anthocyanins, protein, calcium, phosphorous, iron, vitamin A, vitamin C, and B vitamin. However, this plant has not become a major commodity, so it is generally grown in lands with a low level of soil fertility. Application of arbuscular mycorrhizal (AM) fungi in powder dosage form can help plant growth with a positive effect. However, this dosage form has several weaknesses, so a study aimed at knowing the effectiveness of AM fungi in different dosage forms is needed in physiological studies to analyze plant growth and the level of colonization of red spinach roots in the vegetative stage. This research was carried out using the model of the Latin square design (LSD) with three treatments for AM dosage forms of fungi: tablets, sachets, and powders, and without mycorrhizal application (control). The results showed that AM fungi in sachet dosage form could colonize the roots of spinach plants with the highest percentage, although physiological studies have not given consistent results. The sachet dosage form of AM fungi is the novelty of this study. AM fungi in a sachet dosage form can be recommended as the dosage form the most attractive, efficient, and effective to be applied and mobilized to farmers' fields.

• Received: 12 May 2022 • Revised: 20 June 2022 • Accepted: 26 June 2022 • Published Online: 6 July 2022

Introduction

Spinach is a horticultural plant that has many types and discovered in 60 families that can grow on various types of land and in different ecosystems (Ribera et al., 2021; Ulianych et al., 2020). One type of spinach is red spinach (*Amaranthus tricolor* L.) originating from tropical America (Sumarmi et al., 2020). Red spinach

contains high anthocyanins and functions to prevent the formation of free radicals (Shafura et al., 2022). The results showed that red spinach contained 6350 ppm anthocyanins in the leaves and 2480 ppm in the stems (Pebriantiet al., 2015).

In addition to antioxidants, red spinach also contains protein, calcium, phosphorus, iron, vitamin A, vitamin

B, and vitamin C. In addition to the benefits of the leaves (Febriyani et al., 2019; Fevriat et al., 2021), spinach root can be used as an antipyretic, diuretic, anti-toxic, diarrhea medicine, and to clean the blood (Ganjare and Raut, 2019; Peter and Gandhi, 2017).

Cultivation of red spinach is still limited due to the condition of agricultural land with low nutrient content. According to Fajeriana et al., (2022) and Nawaz et al., (2017), red spinach productivity can be increased if it is planted in land conditions with high organic matter content and sufficient nutrient availability, pH 6-7, and the use of biological agents.

The application of mycorrhizae as a biological agent technology has been widely studied and has given positive results for plant growth. However, the application of mycorrhizae is still in the powder dosage form. This dosage form has several disadvantages, including having a non-uniform application dose and allowing spore loss due to wind and being washed away by rainwater. The unavailability of technology for MA fungi dosage forms packaged in sachets and tablets is important in this study, as a solution to improve the performance of MA fungi which is efficient, effective, and environmentally friendly. so a study is needed that objectives to determine the effectiveness of AM fungi in various dosage forms in physiological studies. (analysis of spinach plant growth in the vegetative phase). Plant growth analysis is a way to follow the dynamics of photosynthesis by measuring dry matter production.

The accumulation of dry matter reflects the ability of plants to bind sunlight energy through the process of photosynthesis, as well as its interaction with other environmental factors. The components of growth analysis include Leaf Area (LA), Leaf Area Index (LAI), Relative Growth Rate (RGR), and Net Assimilation Rate (NAR).

Research methods

The research was carried out at the Agropastid farm in Parepare city, Indonesia, at the coordinates of 3°59'30,204" S; 119°38'42,936" E in an experimental form based on the Latin Square Design with three treatments of dosage form AM fungi, namely: tablets, sachets, powders and without mycorrhizal application (control).

Plant growth analysis was implemented by observing

the Leaf Area (LA), Leaf Area Index (LAI), Relative Growth Rate (RGR) variables, and net assimilation rate (NAR). The formula for each growth analysis variable is shown in table 1.

Preparation of red spinach roots infected with AM Fungi was carried out at the Biotechnology Laboratory of the Makassar Environmental and Forestry Research and Development Center (BP2LHK Makassar). The colonization of AM Fungi in roots could be calculated based on the number of all roots observed with using the formula from Brundrett et al., (1996).

$$\% \text{ AM Fungi colonization} = \frac{\sum \text{infected root area}}{\sum \text{total area of the roots observed}} \times 100\%$$

The Institute of Mycorrhizal Research and Development, USDA Forest Service, Athens, Georgia has classified the number of root infections into 5 classes: grade 1, very low (if infection was 0% - 5%), grade 2, low (if infection was 6% - 25%), grade 3, moderate (if infection was 26% - 50%), grade 4, high (if infection is 51% - 75%), grade 5, very high (if infection was 76%-100%) (Rai et al., 2019). Data of plant growth analysis and the percentage of infected roots, were analyzed with the F test and Middle-value test which are shown in graphical.

Results and discussion

Analysis of variance showed that the dosage form of AM fungi an effect was not significant until significant effects on the observed components of the red spinach. Variance analysis for variables of LA and LAI showed that the application of biological agents in different dosage forms had a non-significant effect, but average values obtained were very diverse. Plant growth spinach at 30-40 DAP, LA and LAI phenomena appear the same in all treatments. However, when the plants reached the age of 50 to 60 DAP, a high LA value was also followed by a high LAI value. The phenomenon provided information that the plant leaves had shaded each other (Figures 1A and 1B). Campbell, (2022) stated that an LAI >1 indicates the occurrence of shading between leaves, the shaded leaves will cause the rate of photosynthesis to be not optimal because the shaded leaves will be parasitic (Pignon et al., 2017; Wang et al., 2021; Wijeratne et al., 2008).

The treatment of MA fungi in tablet dosage forms

stimulated the growth of red spinach with very high LA and LAI values at the age of 60 DAP. Allegedly, AM fungi in tablet dosage form have AM fungi spores that have adapted and symbiosis with plant roots to help absorb water and nutrients to meet plant needs.

The absorption of water and nutrients can be increased by the formation of internal and external hyphae (Irmawati and Gofar, 2020; Prameswari et al., 2021). External hyphae are an important part of AM fungi that are outside the roots and function to absorb phosphorus in polyphosphate, these compounds are then transferred into the internal and arbuscular hyphae where they are broken down into organic phosphates which are released into the host plant cells (Madrid-Delgado et al., 2021; Smith et al., 2003). AM fungi can help plants absorb water and nutrients needed for photosynthesis, while plants provide assimilation for the survival of AM fungi (Bahram and Netherway, 2022; Elliott et al., 2021).

A high LAI value does not always provide benefits for plants, depending on the morphology and leaf sitting position (Khairunisa, 2015; Parker, 2020). Red spinach plants given AM fungi in different dosage forms had a negative impact, namely a decrease in the net assimilation rate (NAR) and relative growth rate (RGR) (Figure 2A and 2B). The ANOVA results showed that NAR and RGR were not affected by the treatment of AM fungi in different dosage forms. The net assimilation rate (NAR) is produced from the net-assimilation process per unit leaf area and time (Díaz-López et al., 2020; Hilty et al., 2021). The rate of assimilation is not constant with time but decreases with increases in plant age and is linearly related to leaf area and plant dry weight (Aslani et al., 2020; Hilty et al.,

2021). The inhibition of leaf development will impact to leaves' reduced capacity to absorb light (Bielczynski et al., 2017; Cioć and Pawłowska, 2020; Yavari et al., 2021). The NAR has an opposite relationship with the increase in LAI, where the higher the LAI value as at the age of 50-60, the lower the NAR value because the plant leaves shade each other so that it affects the production of assimilation. Net assimilation rate according to Aslani et al., (2020) and Li et al., (2016) is strongly influenced by the spread of sunlight on the plant canopy, the existence of leaves that shade each other will reduce the NAR value. This opinion is in accordance with the statement of Orzech et al., (2022) and Samidjo, (2021) that the net assimilation rate depends on the level of sunlight to plants. The spread of solar radiation on the canopy determines the dry matter production rate per unit leaf area during vegetative growth. Likewise, Raffo et al., (2020) and Yang et al., (2021) states that the production of plant dry matter depends on the acceptance of sunlight on plants and the availability of water. Relative growth rate (RGR) is rate of increase in plant dry weight per unit of dry weight (Sun et al., 2021; Zulkarnaini et al., 2019). The decrease in NAR affects reduced in RGR of plant. As explained by Francescangeli et al., (2006) and Osone et al., (2008) that decrease in RGR was caused by increase in LA which caused LAI to increase, so that reducing photosynthesis rate and increasing respiration rate, which caused that use more assimilate.

According to Villar et al., (2005) and Almodares et al., (2007), the older age of plant, so the lower of RGR. The RGR is also closely related to the use efficiency of light by leaves, in this case, LA and NAR will affect RGR. An increase in LA followed by a high NAR can increase RGR.

Table 1. Formulation of plant growth analysis.

Variable	Unit	Formula	Source
LA	cm ²	Wr/Wt x LK	(He et al., 2020; Musa et al., 2020; Schrader et al., 2021)
LAI	No Dimension	(LA ₂ + LA ₁ /2).1/G	(Aschonitset al., 2014; Chenet al., 1997; R. Yang et al., 2022)
RGR	g.g ⁻¹ .day ⁻¹	ln W ₂ - ln W ₁ / T ₂ - T ₁	(Kumar & Kaliyaperumal, 2015; Pommerening & Muszta, 2015)
NAR	g.cm ⁻² .day ⁻¹	(W ₂ -W ₁ /T ₂ -T ₁) . (ln LA ₂ -ln LA ₁ /LA ₂ -LA ₁)	(Díaz-López et al., 2020; Li et al., 2016)

Note : LA = Leaf area (cm²), Wr = Leaf replica paper weight (g), Wt = total paper weight (g), LK = Total paper area (cm²), G = Ground area, W=dry weight, T=time.

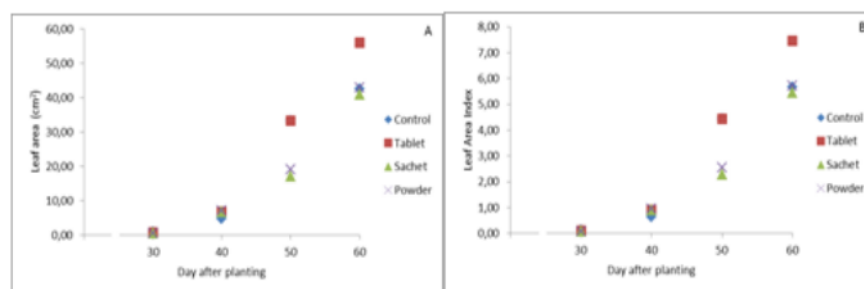


Fig. 1: The average LA and LAI of red spinach at treating different AM fungi dosage forms.

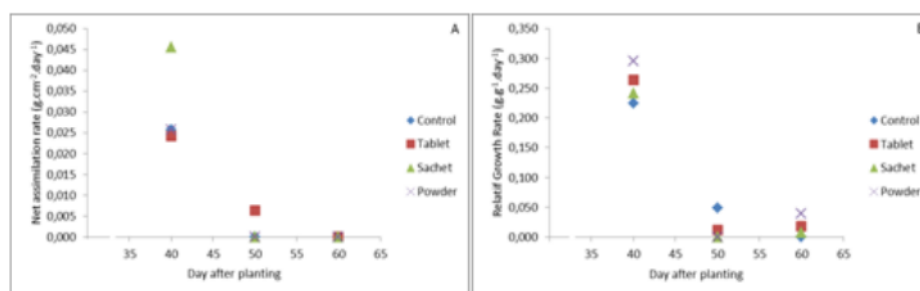


Fig. 2: The average NAR and RGR of red spinach at treating different AM fungi dosage forms.

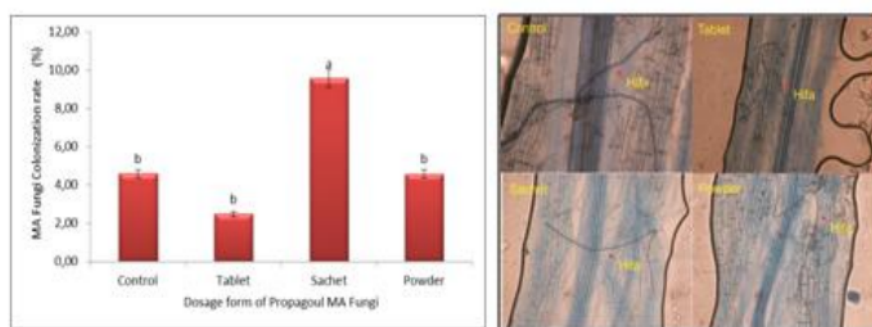


Fig. 3: The average root colonization level of red spinach at treating different AM fungi dosage forms.

AM fungi propagule dosage form had a positive effect on the colonization rate of AM fungi on plant roots, the highest colonization rate was obtained in the sachet dosage form compared to other dosage forms, but based on the classification of number of root infections by Institute of Mycorrhizal Research and Development, USDA Forest Service, Athens, Georgia, then the percentage of colonization rates in all propagule dosage forms is still classified as very low grade (0% - 5% infection) to low grade (6% - 25% infection), this is presumably because apart from the MA fungus, it is still

in the process adaptation to the host plant is also possible that the supply of assimilating for MA fungi is very low so the performance of AM fungal infection in plant roots classified as low, as can be show in Fig. 3.

The AM fungi in a sachets dosage form can colonize the roots of red spinach with the highest percentage, so that can be recommended as a dosage form of AM fungi that is more attractive, efficient, and effective to be applied and mobilized to farmers' land. Although physiological studies it has not given consistent results.

5

Conflict of interest statement

The authors declare that there is no conflict of interest regarding the publication of this article.

Acknowledgment

Authors thanks to Ministry of Education, Culture, Research, and Technology which has provided support through the competition of Penelitian Dasar Unggulan Perguruan Tinggi (PDUPT) in 2022-2024.

References

- Almodares, A., Taheri, R., & Adeli, S. (2007). Inter-relationship between growth analysis and carbohydrate contents of sweet sorghum cultivars and lines. *Journal of Environmental Biology*, 28(3), 527–531.
- Aschonitis, V. G., Papamichail, D. M., Lithourgidis, A., & Fano, E. A. (2014). Estimation of Leaf Area Index and Foliage Area Index of Rice using an Indirect Gravimetric Method. *Communications in Soil Science and Plant Analysis*, 45(13), 1726–1740.
- Aslani, L., Gholami, M., Mobli, M., & Sabzalian, M. R. (2020). The influence of altered sink-source balance on the plant growth and yield of greenhouse tomato. *Physiology and Molecular Biology of Plants*, 26(11), 2109–2123. <https://doi.org/10.1007/s12298-020-00891-2>
- Bahram, M., & Netherway, T. (2022). Fungi as mediators linking organisms and ecosystems. *FEMS Microbiology Reviews*, 46(2), 1–16.
- Bielczynski, L. W., Łański, M. K., Hoefnagels, I., Gambin, A., & Croce, R. (2017). Leaf and plant age affects photosynthetic performance and photoprotective capacity. *Plant Physiology*, 175(4), 1634–1648.
- Brundrett, M., Bougher, N., Dell, B., Grove, T., & Malajczuk, N. (1996). *Working with Mycorrhizas in Forestry and Agriculture Mycorrhizas of Australian Plants View project Banksia Woodland Restoration Project View project* (P. Lynch (ed.); Issue June 1982). The Australian Centre for International Agricultural Research (ACIAR). <https://www.researchgate.net/publication/227365112>
- Campbell, G. S. (2022). *Leaf Area Index is A Single Number-A Statistical Snapshot of A Canopy Taken At One Paretucular Time*. Meter Environment. <https://www.metergroup.com/en/meter-environment/education-guides/researchers-complete-guide-leaf-area-index-lai>
- Chen, J. M., Rich, P. M., Gower, S. T., Norman, J. M., & Plummer, S. (1997). Leaf area index of boreal forests: Theory, techniques, and measurements. *Journal of Geophysical Research Atmospheres*, 102(24), 29429–29443.
- Cioć, M., & Pawłowska, B. (2020). Leaf response to different light spectrum compositions during micropropagation of gerbera axillary shoots. *Agronomy*, 10(11). <https://doi.org/10.3390/agronomy10111832>
- Díaz-López, E., Aguilar-Luna, J. M. E., & Loeza-Corte, J. M. (2020). Net Assimilation Rate and Agronomic Efficiency of Nitrogen in Tartago (*Ricinus communis* L.) (Euphorbiaceae) in Dry Climate. *Scientifica*, 2020. <https://doi.org/10.1155/2020/7064745>
- Elliott, A. J., Daniell, T. J., Cameron, D. D., & Field, K. J. (2021). A commercial arbuscular mycorrhizal inoculum increases root colonization across wheat cultivars but does not increase assimilation of mycorrhiza-acquired nutrients. *Plants People Planet*, 3(5), 588–599.
- Fajeriana, N., Ali, A., Sangadji, Z., & Setyawati, A. (2022). Application of Cow Manure Bokashi Fertilizer to Nutrients of Top Soil Oxisol Planting Media with the Growth and Yield of Red Spinach (*Amaranthus tricolor* L.). 18(03), 909–915.
- Febriyani, V., Rahman, N., & Ratman. (2019). Determine Calcium Level (Ca) and Iron (Fe) on Red and Green Spinaches at Parigi Moutong. *Jurnal Akademika Kimia*, 8(4), 230–235.
- Fevria, R., Aliciafarma, S., Vauzia, & Edwin. (2021). Comparison of Nutritional Content of Water Spinach (*Ipomoea aquatica*) Cultivated Hydroponically and Non-Hydroponically. *Journal of Physics: Conference Series*, 1940(1), 012049.
- Francescangeli, N., Sangiacomo, M. A., & Martí, H. (2006). Effects of plant density in broccoli on yield and radiation use efficiency. *Scientia Horticulturae*, 110(2), 135–143.
- Ganjare, A., & Raut, Ni. (2019). Nutritional and medicinal potential of *Amaranthus spinosus*. *Journal of Pharmacognosy and Phytochemistry*, 8(3), 3149–3156.
- He, J., Reddy, G. V. P., Liu, M., & Shi, P. (2020). A general formula for calculating surface area of

- the similarly shaped leaves: Evidence from six Magnoliaceae species. *Global Ecology and Conservation*, 23, e01129.
- Hilty, J., Muller, B., Pantin, F., & Leuzinger, S. (2021). Plant growth: the What, the How, and the Why. *New Phytologist*, 232(1), 25–41.
- Irmawati, W., & Gofar, N. (2020). The Effectiveness of Mycorrhizal and Nitrogen Fertilizer on the Production of Chili (*Capsicum annum*) in Tidal Land. *Jurnal Lahan Suboptimal : Journal of Suboptimal Lands*, 9(2), 175–183.
- Khairunisa. (2015). Pengaruh Pemberian Pupuk Organik, Anorganik Dan Kombinasinya Terhadap Pertumbuhan Dan Hasil Sawi Hijau (*Brassica juncea* L. Var. Kumala). Undergraduate thesis, Universitas Islam Negeri Maulana Malik Ibrahim.
- Kumar, R. S., & Kaliyaperumal, K. (2015). Scientometric analysis of global publication output in mobile technology. *DESIDOC Journal of Library and Information Technology*, 35(4), 287–292.
- Li, X., Schmid, B., Wang, F., & Paine, C. E. T. (2016). Net assimilation rate determines the growth rates of 14 species of subtropical forest trees. *PLoS ONE*, 11(3), 1–13.
- Madrid-Delgado, G., Orozco-Miranda, M., Cruz-Osorio, M., Adriana Herndez-Rodruvez, O., Rodr  uez-Heredia, R., Roa-Huerta, M., & Dolores Avila-Quezada, G. (2021). Pathways of Phosphorus Absorption and Early Signaling between the Mycorrhizal Fungi and Plants. *Phyton*, 90(5), 1321–1338.
- Musa, U. T., Yusuf, M., & Ojo, S. O. (2020). Leaf Area Determination for Sesame (*Sesamum indicum*), Wheat (*Triticum aestivum*), Groundnut (*Arachis hypogaea*) and Bambaranut (*Vigna subterranea*) Crops Using Linear Measurements. *Journal of Biology, Agriculture and Healthcare*, 10(12), 20–26.
- Nawaz, S., Khan, J., Zaman, M., Shaheen, S., Niamatullah, M., Rehman, A., & Javaria, S. (2017). Effect of Combine Application of Urea, Urease, Nitrification Inhibitors and Plant Growth Regulators on Spinach Productivity. *Asian Journal of Agricultural Extension, Economics & Sociology*, 17(4), 1–7.
- Orzech, K., Wanic, M., & Załuski, D. (2022). Gas Exchanges in the Leaves of Silage Maize Depending on the Forecrop and Maize Development Stage. *Agronomy*, 12(2), 1–17.
- Osone, Y., Ishida, A., & Tatenno, M. (2008). *Correlation between relative growth rate and specific leaf area requires associations of specific leaf area with nitrogen absorption rate of roots*. *PubMed Commons*. 179(2), 417–427.
- Parker, G. G. (2020). Leaf Area Index (LAI) is Both a Determinant and a Consequence of Important Processes in Vegetation Canopies. *Forest Ecology and Management*, 477, 118496.
- Pebrianti, C., Ainurrasyid, R. B., & Purnamaningsih, L. (2015). Uji Kadar Antosianin dan Hasil Enam Varietas Tanaman Bayam Merah (*Alternanthera amoena* Voss) pada Musim Hujan Test Anthocyanin Content and Yield of Six Varieties Red Spinach (*Alternanthera amoena* Voss) In The Rainy Season. *Jurnal Produksi Tanaman*, 3(1), 27–33.
- Peter, K., & Gandhi, P. (2017). Rediscovering the therapeutic potential of *Amaranthus* species : A review. *Egyptian Journal of Basic and Applied Sciences*, 4(3), 196–205.
- Pignon, C. P., Jaiswal, D., McGrath, J. M., & Long, S. P. (2017). Loss of photosynthetic efficiency in the shade. An Achilles heel for the dense modern stands of our most productive C4 crops? *Journal of Experimental Botany*, 68(2), 335–345.
- Pommerening, A., & Muszta, A. (2015). Methods of modelling relative growth rate. *Forest Ecosystems*, 2(1). <https://doi.org/10.1186/s40663-015-0029-4>
- Prameswari, D., Irianto, R. S. B., Tuheteru, F. D., & Kalima, T. (2021). Effect of arbuscular mycorrhizal fungi and planting media on seedlings growth of *Helicteres isora* L. In the nursery. *IOP Conference Series: Earth and Environmental Science*, 914(1), 1–9.
- Raffo, A., Mozzanini, E., Ferrari Nicoli, S., Lupotto, E., & Cervelli, C. (2020). Effect of light intensity and water availability on plant growth, essential oil production and composition in *Rosmarinus officinalis* L. *European Food Research and Technology*, 246(1), 167–177.
- Rai, I. N., Suada, I. K., Proborini, M. W., Wiraatmaja, I. W., Semenov, M., & Krasnov, G. (2019). Indigenous endomycorrhizal fungi at salak (*Salacca zalacca*) plantations in Bali, Indonesia and their colonization of the roots. *Biodiversitas*, 20(8), 2410–2416.
- Ribera, A., van Treuren, R., Kik, C., Bai, Y., & Wolters, A. M. A. (2021). On the origin and dispersal of

- cultivated spinach (*Spinacia oleracea* L.). *Genetic Resources and Crop Evolution*, 68(3), 1023–1032.
- Samidjo, G. S. (2021). Growth Pattern of Sunflower on Some Light Intensity in the Coastal Land. *IOP Conference Series: Earth and Environmental Science*, 752(1), 012019.
- Schrader, J., Shi, P., Royer, D. L., Peppe, D. J., Gallagher, R. V., Li, Y., Wang, R., & Wright, I. J. (2021). Leaf size estimation based on leaf length, width and shape. *Annals of Botany*, 128(4), 395–406.
- Shafura, N., Janah, L. N., Huda, M. S., & Daryono, B. S. (2022). Effectiveness of Bio-Catharantin Induction to Increase Red Spinach (*Alternanthera amoena* Voss.) Production. *Proceedings of the 7th International Conference on Biological Science (ICBS 2021)*, 22(Icbs 2021), 528–532.
- Smith, S. E., Smith, F. A., & Jakobsen, I. (2003). Mycorrhizal fungi can dominate phosphate supply to plants irrespective of growth responses. *Plant Physiology*, 133(1), 16–20.
- Sumarmi, S., Arlinda, M., & Sukirno, S. (2020). The Effectiveness of Red Spinach (*Amaranthus tricolor* L.) and Green Spinach (*Amaranthus hybridus* L.) Extracts for *Bacillus thuringiensis* var. *kurstaki* Protectant against UVB Radiation for the Control of Armyworm (*Spodoptera litura* Fab.). *Journal of Tropical Biodiversity and Biotechnology*, 5(2), 143–148.
- Sun, W., Shi, F., Chen, H., Zhang, Y., Guo, Y., & Mao, R. (2021). Relationship between relative growth rate and C:N:P stoichiometry for the marsh herbaceous plants under water-level stress conditions. *Global Ecology and Conservation*, 25(1101), e01416.
- Ulianych, O., Kostetska, K., Vorobiova, N., Shchetyna, S., Slobodyanyk, G., & Shevchuk, K. (2020). Growth and yield of spinach depending on absorbents' action. *Agronomy Research*, 18(2), 619–627.
- Villar, R., Marañón, T., Quero, J. L., Panadero, P., Arenas, F., & Lambers, H. (2005). Variation in relative growth rate of 20 *Aegilops* species (Poaceae) in the field: The importance of net assimilation rate or specific leaf area depends on the time scale. *Plant and Soil*, 272(1–2), 11–27.
- Wang, Y. bo, Huang, R. Dong, & Zhou, Y. Fei. (2021). Effects of shading stress during the reproductive stages on photosynthetic physiology and yield characteristics of peanut (*Arachis hypogaea* Linn.). *Journal of Integrative Agriculture*, 20(5), 1250–1265.
- Wijeratne, T. L., Mohotti, A. J., & Nissanka, S. P. (2008). Impact of long term shade on physiological, anatomical and biochemical changes in tea (*Camellia sinensis* (L.) O. Kuntz). *Tropical Agricultural Research*, 20(January), 376–387.
- Yang, R., Liu, L., Liu, Q., Li, X., Yin, L., Hao, X., Ma, Y., & Song, Q. (2022). Validation of leaf area index measurement system based on wireless sensor network. *Scientific Reports*, 12(1), 1–13.
- Yang, Y., Guo, X., Liu, G., Liu, W., Xue, J., Ming, B., Xie, R., Wang, K., Hou, P., & Li, S. (2021). Solar Radiation Effects on Dry Matter Accumulations and Transfer in Maize. *Frontiers in Plant Science*, 12(September), 1–13.
- Yavari, N., Tripathi, R., Wu, B. Sen, MacPherson, S., Singh, J., & Lefsrud, M. (2021). The effect of light quality on plant physiology, photosynthetic, and stress response in *Arabidopsis thaliana* leaves. *PLoS ONE*, 16(3 March), 1–19.
- Zulkarnaini, Z. M., Sakimin, S. Z., Mohamed, M. T. M., & Jaafar, H. Z. E. (2019). Changes in leaf area index, leaf mass ratio, net assimilation rate, relative growth rate and specific leaf area two cultivars of fig (*Ficus carica* L.) treated under different concentrations of brassinolide. *Agrivita*, 41(1), 158–165.

How to cite this article:

Akib, M.A., Syatrawati, Prayudyaningsih, R., 2022. Plant growth analysis and arbuscular mycorrhizal colonization in *Amaranthus tricolor* L. *Int. J. Curr. Res. Biosci. Plant Biol.*, 9(7): 1-7.

doi: <https://doi.org/10.20546/ijcrbp.2022.907.001>

Plant growth analysis

ORIGINALITY REPORT

16%

SIMILARITY INDEX

13%

INTERNET SOURCES

11%

PUBLICATIONS

4%

STUDENT PAPERS

PRIMARY SOURCES

1	healthdocbox.com Internet Source	1 %
2	jopr.mpob.gov.my Internet Source	1 %
3	www.isisn.org Internet Source	1 %
4	rngr.net Internet Source	1 %
5	dspace.emu.ee Internet Source	1 %
6	Submitted to Kenyatta University Student Paper	1 %
7	media.neliti.com Internet Source	1 %
8	S Sundari. "Comparison of dissolved organic carbon and nutrients content in Papua peatland", IOP Conference Series: Earth and Environmental Science, 2022 Publication	1 %

9	ejurnal.seminar-id.com Internet Source	1 %
10	eprints.utm.my Internet Source	1 %
11	www.biorxiv.org Internet Source	1 %
12	H Y S H Nugroho, M K Sallata, W Isnan, M Saad, A Hermawan. "Effectiveness of soil and water conservation structures in increasing community perception and controlling erosion and sedimentation", IOP Conference Series: Earth and Environmental Science, 2021 Publication	1 %
13	assets.researchsquare.com Internet Source	1 %
14	idalamat.com Internet Source	1 %
15	www.rroij.com Internet Source	<1 %
16	bioresources.cnr.ncsu.edu Internet Source	<1 %
17	krishikosh.egranth.ac.in Internet Source	<1 %
18	www2.llu.lv Internet Source	<1 %

- | | | |
|----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 19 | Silvia Kharismaya Putri. "Substitution of Eco Enzyme in AB Mix on Growth and Weight of Red Spinach", Symposium on Biology Education (Symbion), 2023
Publication | <1 % |
| 20 | Xingming Wang, Miao Zhang, Xinyi Wang, Dongyan Yang, Xueyan Zhang. "Synergistic regulation of the growth and fruit quality of cherry tomato by remaining fruit spikes and number of interspike leaves after pruning", Scientia Horticulturae, 2023
Publication | <1 % |
| 21 | dergipark.org.tr
Internet Source | <1 % |
| 22 | ijctpms.com
Internet Source | <1 % |
| 23 | Hans Lambers, Rafael S. Oliveira. "Plant Physiological Ecology", Springer Science and Business Media LLC, 2019
Publication | <1 % |
| 24 | Lifang Hao, Junling Zhang, Peter Christie, Xiaolin Li. "Response of Two Maize Inbred Lines with Contrasting Phosphorus Efficiency and Root Morphology to Mycorrhizal Colonization at Different Soil Phosphorus Supply Levels", Journal of Plant Nutrition, 2008
Publication | <1 % |

25	edepot.wur.nl Internet Source	<1 %
26	www.newsdirectory3.com Internet Source	<1 %
27	www.researchgate.net Internet Source	<1 %
28	Andres Felipe León-Burgos, Gina Yuret Beltrán Cortes, Andrea Liliana Barragán Pérez, Helber Enrique Balaguera-López. "Distribución de fotoasimilados en los órganos vertederos de plantas Solanaceas, caso tomate y papa. Una revisión", Ciencia y Agricultura, 2021 Publication	<1 %
29	Submitted to Universitas Brawijaya Student Paper	<1 %
30	D Prameswari, R S B Irianto, F D Tuheteru, T Kalima. "Effect of arbuscular mycorrhizal fungi and planting media on seedlings growth of Helicteres isora L. in the nursery", IOP Conference Series: Earth and Environmental Science, 2021 Publication	<1 %

Exclude bibliography ☒ On