Arbuscular Mycorrhiza inoculation for Increasing the Tolerance Index and Productivity of Soybean on Marginal Soils

M.D Sukmasari*, Umar Dani and Acep Atma Wijaya
Faculty of Agriculture, Universitas Majalengka, Indonesia
Jl. KH. Abdul Halim No. 103 Majalengka, West Java, Indonesia.

Email : miftahdieni6@unma.ac.id

Abstract. An efforts to increase soybean crop productivity are highly related to of nutrients availability and crops management. This research was conducted to investigate the plant tolerance index (TI) and the mycorrhizae role to increase the availability of nutrients P and soybean productivity in a dry land. Factorial randomized block design that consists of mycorrhizal factors (0, 5, 10 and 15 g of inoculant per plant) and soybean cultivars (Anjasmoro, Dering 1 and Grobogan) and the repeated three times. The results showed that mycorrhizal inoculation with a dose of 10 g mycorrhizae per plant was able to increase the root length, root volume, dry weights, grain number and the weight of 100 grains. The highest number of grains was obtained by the Dering 1 cultivar. In addition the higher of 100 grains weigh was resulted by the Grobogan and anjasmoro cultivar. The cultivar adaptability was increased by mycorrhizal inoculation on marginal soils. Furthermore mycorrhizal inoculation gave a nonsignificant effect of tolerance index and the highest TI (1.97) was obtained by dering cultivars. These results confirms that the usage 10 g plant⁻¹ of mycorrhizal inoculants should be applied for increasing the growth and soybean productivity of marginal land.

Keywords : Arbuscular Mycorrhiza, Soybean, Tolerance Index, Marginal Soils

1. Introduction

Soybean is a strategic commodity in the world and specifically in Indonesia where its use is as important as rice and corn. Soybean is the main source of vegetable protein in Indonesian society and is considered the most economical compared to animal protein sources. The increased of public knowledge about nutritional value with daily protein consumption makes an increase of the soybean demand every year [1].

The decreasing soybean harvest area which is not balanced by efforts to increase productivity causes instability of soybean production in Indonesia which is only able to
meet around 65.61% of domestic consumption [2]. One of the Indonesian government programs to support agricultural development in the future is to optimize the use of agricultural resources, namely the use of marginal lands by improving the integrated agricultural business system [3]. The availability of vast dry land is one of the resources that can be utilized in efforts to increase soybean productivity. However, one of the main obstacles to dryland cultivation is low rainfall intensity and low soil fertility. The utilization of biological fertilizers in increasing soybean productivity has been widely used [4]. The advantages of using biological fertilizers are more environmentally friendly so that the sustainability of agriculture can be maintained [5].

Mycorrhiza with roots forms a symbiotic association with plants that aims to help the plant itself in improving the nutrition of the host plant [6, 7]. Other functions of this symbiotic form are as bioprotectants against root pathogen infections, increase plant resistance to drought stress, and act as plant growth promoting hormones [8]. In addition, mycorrhizal administration can assist in the formation of root nodules (mycorrhiza functions as a stimulant for absorption of P [9]. The results of the study stated that mycorrhizal administration significantly affected the number of leaves while ILD, LAN, and LTR had no significant effect. The results of [10] stated that administration of AMF significantly affected plant height, stem diameter, and degree of AMF infection. Mycorrhizal applications in plant cultivation also affect the chemical properties of the soil. The results of other studies state that mycorrhizal application in aquaculture can increase soil pH, P-availability, and C-Organic [11, 12].

Mycorrhiza has the ability to interact with the soil in supplying nutrient requirements, and will react more optimally to soils that are infertile [13]. Indigenous mycorrhiza and bokashi sago pulp can increase the number of fruit to 56% in Okra plants on dry land [14]. Environmental factors can influence the development of mycorrhizae in soil such factors include soil temperature, rainfall, and N content [15]. Liliskov et al. [16] mentioned that rainfall affects the presence of mycorrhizae in the soil. Mycorrhizae will be more active in low water conditions, so the use of mycorrhiza in dryland cultivation is very appropriate, due to the ability of mycorrhiza which has a broad range to expand the plant's root area to 100 times [17; 2;7]. The effectiveness of mycorrhizal infections can be seen from the morphology and physiology changes of soybean plants. So the purpose of this study was to investigate the tolerance index of three soybean cultivars in dryland cultivation and how each cultivar responded to the mycorrhizal infection.
Research on the use of mycorrhizae in increasing the growth and productivity of the soybean plants in dry land has not been much researched. One of the objectives of applying mycorrhiza inoculant on dryland is to increase the resilience of plants to drought stress. Moreover the research result is expected to support government programs for the cultivation of soybean on marginal soils in Indonesia.

2. Material and Method

2.1 Descriptions and Experimental Design

The study was conducted on dryland in the Experimental Farm of the Faculty of Agriculture, Universitas Majalengka from April to August 2018. Data analysis was carried out at the Laboratory of the Faculty of Agriculture, Universitas Padjadjaran, Bandung. The fungal mycorrhizal arbuscular (FMA) and identified as *Gygaspora sp*. The Arbuscular Mycorrhizal inoculant was obtained from CV. Bintang Asri Cimambo, West Java.

This experiment was carried out as factorialized randomized block design, consisted of two factors and repeated three times. The first factor was three Soybean cultivars $k_1=$Dering, $k_2=$Anjasmo and $k_3=$Grobogan and the second factor was dosage of arbuscular mycorrhizal inoculant ($m_0=0$ g plant$^{-1}$, $m_1=5$ g plant$^{-1}$, $m_2=10$ g plant$^{-1}$, and $m_3=15$ g plant$^{-1}$ for each plant) of mycorrhizal inoculant. Each factor uses a 40 x 40 cm polybag so that there are 72 polybags in total. Polybags were placed on land and watered periodically for two weeks until the vegetative period.

2.2 Observed Variables

The observed variables in this study are include: uptake of P at the age of 8 MST, percentage of mycorrhizal infected roots (%) by staining roots based on the Kormanik & Mc. Graw method, leaf nisbi, root length (cm) (measured from the root of the root to the longest root tip), root dry weight (g) (weighed root dry weight plus effective root nodule dry weight, total leaf chlorophyll (measured with chlorophyll meter : named the the type). Describe how the measurement was done, number of crop grains (counted all grain in one plant), seed weight per plant (g) (weighed dry seeds on each plant sample), and weight of 100 grain (g) (weighed 100 grains on each plant sample). Measurements were made at the using the following formula:

$$Nisbi \text{ Moisture level} = \frac{BS-BK}{BT-BK} \times 100\%$$  \hspace{1cm} (1)

where BS is fresh weight, BT is turgid weight, and BK is dry weight.
2.3 Statistic Analysis

All data were statistically analyzed using one-way analysis of variance (ANOVA) and the difference between treatments was tested by Duncan’s multiple range test at \( p \leq 0.05 \). All the statistical tests were performed using DSAASTAT program.

The tolerance level of each cultivar is calculated based on the following Stress Tolerance Index (STI) (Orcen, and Altinbas, 2014):

\[
\text{STI} = \frac{(Y_p)(Y_s)}{(Y_p)^2}
\]

(2)

Genotype criteria are tolerant according to STI parameters: If genotypes with STI > average STI, the genotype is tolerant, and genotypes with STI values > average STI are included in sensitive genotypes.

3. Results and Discussions

3.1 Root Growth Variables

The results of data analysis on the root character showed that the average of the observed root variables did not effect by cultivar treatment. Whereas the mycorrhizal treatment showed different results by administering various doses to the observed average root variables.

In the root length character, the best results were obtained with the treatment of mycorrhizal dosage of 10 g plant\(^{-1}\). It compared to other treatments that was equal to 32.54 cm, while the lowest results were obtained with the treatment without mycorrhizal administration. The similar result was also shown on root volume character, the highest results were resulted by the application of 10 g mycorrhizal inoculant and the lowest results were obtained in the control (without mycorrhiza). The infected with mycorrhizae gave better results than those that are not inoculated. Mycorrhizal inoculant is able to optimize the roots by extending the nutrient uptake zone intensively so that the plants with micoriza will be able to increase their capacity to absorb nutrients and water [18]. Therefore, the plant responses are experiencing drought stress tends to be more resistant to cortical damage than in plants without mycorrhizae. Disruption of roots due to drought stress will not be permanently effect on the roots which infected by mycorrhizae.
Mycorrhizal application showed the best results compared to the treatment without mycorrhizal (m₀) in the root dry weight variable on dryland. In a state of nutrient deficit, plants will optimize root growth [18] especially with mycorrhizal inoculation which will further enhance the root system, so that even though plants are planted in a dry state, mycorrhizae are still able to optimize nutrient uptake and water. Data in Table 2 showed that of cultivars was resulted the different of the root dry weight. The highest results was obtained by Dering 1 cultivar. This indicated that suspected due to the Dering cultivar that have a positive response to the environmental changes. Consequently, it can be used as characters for the most optimum symptoms of growth.

Table 1. The Results of Soil Analysis

| No | Parameter          | Satuan | Hasil   | Kriteria  |
|----|--------------------|--------|---------|-----------|
| 1  | pH : H₂O           | -      | 8,03    | Half Alkalis |
| 2  | pH : KCl 1 N       | -      | 4,11    | -         |
| 3  | C-Organik (%)      |        | 1,89    | Enough    |
| 4  | N-total (%)        |        | 1,56    | Low       |
| 5  | C/N                | -      | 8       | Low       |
| 6  | P₂O₅ HCl 25% (mg/100g) |     | 21,31   | Enough    |
| 7  | K₂O HCl (mg/100g)  |        | 32,59   | Enough    |
| 8  | P₂O₅ Olsen (ppm P) |        | 7,94    | Low       |

Source : Faculty of Agriculture Laboratory, UNPAD

Table 2. Characters of Root Length, Root Volume, and Dry Weights of Three Root Cultivars of Soybean due to Arbuscular Mycorrhizae Treatment

| Treatment                  | Root Length (cm) | Root Volume (ml) | Dry Weights of Root (g) |
|----------------------------|------------------|------------------|------------------------|
| Kultivar                   |                  |                  |                        |
| Dering (k₁)                | 26,80 a          | 4,50 a           | 1,17 b                 |
| Anjasmoro (k₂)             | 28,77 a          | 4,82 a           | 0,53 a                 |
| Grobogan (k₃)              | 25,61 a          | 3,76 a           | 1,05 ab                |

Doses of Mycorrhizal Biofertilizer

| Doses of Mycorrhizal Biofertilizer | Root Length (cm) | Root Volume (ml) | Dry Weights of Root (g) |
|-----------------------------------|------------------|------------------|------------------------|
| 0 g plant⁻¹ Mycorrhizal (m₀)      | 20,32 a          | 3,44 a           | 0,75 a                 |
| 5 g plant⁻¹ Mycorrhizal (m₁)      | 27,69 b          | 4,33 ab          | 0,99 b                 |
| 10 g plant⁻¹ Mycorrhizal (m₂)     | 32,54 c          | 5,56 b           | 0,89 b                 |
| 15 g plant⁻¹ Mycorrhizal (m₃)     | 27,70 b          | 4,44 ab          | 1,02 b                 |
3.2 Productivity Components

The different cultivars gave non significant differences on the observed productivity components, except the weight of 100 grains (Table 3). Anjasmoro and Grobogan showed the highest weight of 100 grains compared to the Dering cultivar. This was due to the seed morphology of the two cultivars which are belong in the large seed category. Whereas for the administration of arbuscular mycorrhizae on the character of the results showed that the application of arbuscular mycorrhizal biofertilizers gave the best results on the tested variables compared to without mycorrhizal administration. The best results of grain number or weight of 100 grains was obtained by application of 10 g plant\(^1\) of mycorrhizal inoculant. Rahmayanti et al [19] research results showed that inoculation of mycorrhizal fungi in cocoa plants generally produced better growth than plants that were not inoculated at all experimental stages. The improvement of water uptake by plants with the association of roots with fungi, will enlarge or prolong the cells of the mycorrhizal plants [20].

Mycorrhizal inoculation gave a non significant effect on grain yield per plant (Table 3). This is presumably because the development of inoculated mycorrhizae not optimal due to suboptimal environmental influences. Ritchie in Mapegau [21] suggested that the process of seed filling and photosynthate translocation is very sensitive to the water stress. In this condition, the process of filling seeds may be hampered due to the planting on the dryland, so that the weight of the obtained seeds is not optimal. In addition, the administration of arbuscular mycorrhizae produced the highest grain yield compared without mycorrhizae on the average of the observed variables, the overall productivity of the soybean decreased compared under optimum conditions. Plants that suffer from drought stress have smaller leaf sizes. This means reducing the ability to photosynthesize so that the formation of photosynthates decreases. As a result, the production of canopy dry matter decreases which results in assimilate translocation on yields also decreases. However, inoculation of 10 grams per plant still showed the highest value compared to other treatments.

| Treatment | Number of Grain | Weight of Grain (g) | Weight of 100 Grains (g) |
|-----------|----------------|---------------------|-------------------------|
|           |                |                     |                         |

Table 3. Character of Number and Weight of Seed per Plant also the Weight of 100 Grains of Three Cultivars of Soybean due to Arbuscular Mycorrhizal Treatment
Cultivars

| Cultivars     | Leaf Chlorophyll Number | Mycorrhizal Infection | Leaf Water Content (%) | Nutrient Uptake of P (mg tan⁻¹) |
|---------------|------------------------|-----------------------|------------------------|--------------------------------|
| Dering (k₁)   | 46.14 b                | 4.57 a                | 9.39 a                 |
| Anjasmoro (k₂) | 25.64 a                | 3.82 a                | 12.50 b                |
| Grobogan (k₃) | 28.67 a                | 4.43 a                | 12.83 b                |

Doses of Mycorrhizal Biofertilizer

| Doses of Mycorrhizal Biofertilizer | Leaf Chlorophyll Number | Mycorrhizal Infection | Leaf Water Content (%) | Nutrient Uptake of P (mg tan⁻¹) |
|------------------------------------|------------------------|-----------------------|------------------------|--------------------------------|
| 0 g plant⁻¹ Mycorrhizal (m₀)       | 31.30 a                | 3.89 a                | 9.35 a                 |
| 5 g plant⁻¹ Mycorrhizal (m₁)       | 27.56 a                | 3.38 a                | 10.61 a                |
| 10 g plant⁻¹ Mycorrhizal (m₂)      | 49.48 b                | 5.44 a                | 13.32 b                |
| 15 g plant⁻¹ Mycorrhizal (m₃)      | 25.59 a                | 4.38 a                | 11.69 a                |

3.3 Physiological Responds

The chlorophyll number in three soybean cultivars are varied (Table 4). This is an indicator that the physiological responses of the three soybean cultivars differ in the chlorophyll number of plants. There are several factors that can increase the chlorophyll number in plants, one of which is genetic. As Bilber [22], points out, differences in metabolism related to age, morphology and genetic factors of leaves in plants will produce variable chlorophyll number. In addition, environmental factors such as water stress also affect the concentration of chlorophyll in plants. In this study Anjasmoro cultivars showed the highest leaf chlorophyll number, this was related to the ability of each plant character to respond to the environment where it grew so that it also had an impact on its growth performance.

Table 4. Characteristics of Leaf Chlorophyll Number, Leaf Water Content and Nutrient Uptake of P Three Cultivars of Soybean due to Arbuscular Mycorrhizal Treatment
The administration of arbuscular microiza shows a tendency to increase the chlorophyll number, it is assumed that the performance of mycorrhiza which is able to provide plant nutrients so that the impact on chlorophyll concentration also increases even in drought stressful conditions. According to Asrar et al. [23] Under stress conditions, inoculation was positively effective in enhancing leaf-K+, P, and Ca2+ content in plants. This is also in line with the research of Khalid et al., [24], that mycorrhizal inoculation significantly increases chlorophyll number and water use efficiency under salinity stress.

The administration of inoculants was able to increase the degree of root infection by 22.37% compared with no inoculant FMA. By inserting mycorrhizal inoculants into the soil, more and more infected roots and infections in plants without inoculants may be caused by indigenous mycorrhizae [15]. The relative moisture level (RML) of leaves has a correlation with the proline composition in plants. Decreased of the RML value causes the production of certain amino acids such as proline to increase. The increased proline is beneficial in osmoregulation of plants and influences the potential value of water leaves, there by increasing the balance of the potential balance of ground water and plants [25]. Grobogan cultivar showed the highest RML compared to other cultivars (Table 4). It is assumed that these cultivars have the best tolerance level on soybean cultivation on the dry land. Whereas in the treatment of arbuscular mycorrhizae, the highest RML was demonstrated by the treatment with mycorrhiza compared to without mycorrhiza. Mycorrhiza helps plants expand the distribution of nutrient uptake especially water in the presence of external hyphae. The positive influence of mycorrhiza on nutrient absorption was revealed by Goswami et al., [26], that plants associated with mycorrhizae are more efficient in nutrient absorption, assimilate P elements faster, and increase absorption of elements N, S, Zn, and other essential elements.

The administration of mycorrhizal inoculants can increase P uptake in plants from the soil (Table 4). The effectiveness of mycorrhizae is obtain in its ability to grow and spread external mycelium widely in the soil, its capacity and efficiency of absorbing and flowing nutrients from the soil to the roots. Others researchers results showed that the level of root colonization was influenced by mycorrhizae. There is a positive correlation between root colonization with P. The FMA was able on infecting soybean roots, presumably because the soil used in the study is marginal dry land. Marginal soils have very low soil fertility rates, so plants respond to giving AMF at each treatment. According to Nicholas et al. [27], FMA produces carbonic acid from the respiration process, the presence of carbonic acid...
can increase the absorption capacity of nutrients by plants because by increasing the amount of carbonic acid in plant roots, the solubility of nutrients in the rhizosphere will also increase. As a result, plants get the ease of absorbing nutrients needed before they were fixed and not available.

3.4 Tolerance Index

Calculation of tolerance index is intended to determine the ability of a cultivar to tolerate changes in the environment in which it grows. This parameter is used for assembling cultivars that are adaptive to the environment gripped by biotic or abiotic. Based on Table 5, it can be seen that there are tolerant cultivars planted on the dry land, namely the Dering and Anjasmoro cultivars on the weight character of grain per plant. These cultivars can be taken into consideration as crossing elders in the assembly of adaptive soybean strains planted on the dry land [28]. The same letter in the same column in the Table 5 shows no significant difference based on the 95% LSI test: Sensitive is STI genotype < average STI; Tolerant is STI genotype > average STI.

| Cultivars   | Tolerance Index | Category     |
|-------------|-----------------|--------------|
| Dering 1    | 1.91 b          | Tolerant     |
| Anjasmoro   | 1.47 b          | Tolerant     |
| Grobogan    | 0.58 a          | Sensitive    |
| Average     | 0.99            |              |

4. Conclusion

Interaction between varieties and mycorrhizal inoculation (MI) gave a nonsignificant effect on all observed responds. Application of MI increased the root length, root volume, Leaf Chlorophyll Number, number of grain and weight of 100 grain and the the highest of was obtained by the usage of 10 g plant\(^{-1}\). In addition, the tolerance index (TI) was not affected by MI administration. The highest TI (1,91) was obtained Dering Cultivar. In Contrast, the lowest was obtained by Grobogan (0,58). This finding concluded that MI can be uased to improve the growth and the productivity of soybean on marginal soil with used Dering kultivar.
References

[1] Sacks FM, Lichtenstein A, Van Horn L, Harris W, Kris-Etherton P, Winston M. 2006. Soy Protein, Isoflavones, and Cardiovascular Health. An American Heart Association Science Advisory for Professionals from the Nutrition Committee. Circulation;113(7):1034–1044.

[2] Aldilah R 2015 Projection of Production and Consumption of Indonesian Soybean Journal of Applied Quantitative Economics Vol 8 (1) 9 – 23

[3] Eulenstein, F., Tauschke, M., Behrendt, A., Monk, J., Schindler, U., Lana, M. A. dan Monk,S. 2017. The Application of Mycottiza Fungi and Organic Fertilisers in Horticultural Potting Soil to Improve Water Use Efficiency of Crops. Horticulturae. 3(1): 1-8

[4] Pereira, S.I. and P. Castro. 2014. Phosphate-solubilizing rhizobacteria enhance Zea mays growth in agricultural P-deficient soils. Ecological Engineering 73: 526–535.

[5] Sanchez R.Y. 2016. Effect of Arbuscular Mycorrhizal Fungi in the Development of Cultivars of Chili 4 10–15.

[6] M. Aldino Rahman, Anne Nurbaiy dan Tualar Simarmata. 2019. Inoculation of Arbuscular Mycorrhizal Fungi (FMA) Increases Population of Phosphate Solubilizing Bacteria and P Nutrient Uptake of Chili (Capsicum Annuum L.) Plants in Inceptisol. Jurnal Agro Indonesia 4(1): 30-32 (2019).

[7] Haryantini, B.A, Yuwariah Y., Amien S., Fitriatin, B.N, Setiawati, M.R., Nurbaiy, A Kamaluddin, N.N and T. Simarmata. 2019. Community of Indigenous Arbuscular Mycorrhizal Fungi (Amf) of Chili Rhizosphere and Natural Forest Ecosystem. Malaysian Journal of Soil Science Vol. 23: 135-147 (2019). ISSN: 1394-7990.

[8] Noli Z A Netty W S E M Sari 2011 Exploration of Indigenous Arbuscular Mycorrhizal Fungi (CMA) Associated with Begonia resecta in the Forest of Biological Education and Research (HPPB) Proceedings of the National Biology Seminar Enhancing the Role of Biology in Realizing National Achievement with Global Reach Departemen Biologi FMIPA Universitas Sumatera Utara Medan 538-539.

[9] Al-Askar, A.A. and Y.M. Rashad. 2010. Arbuscular mycorrhizal fungi: A biocontrol agent against common bean Fusarium root rot disease. Plant Pathology Journal 9(1): 31-38.
[10] Oktaviani D Y Hasanah dan A Barus 2014 Soybean growth (Glycine max L.) with the application of arbuscular mycorrhizal fungi (FMA) and a microbial consortium. Jurnal Online Agroekoteknologi Vol 2 No 2 905-918

[11] Dai, O., R.K. Singh and G. Nimasow. 2011. Effect of arbuscular mycorrhizal (AM) inoculation on growth of chili plant in organic manure amended soil. African Journal of Microbiology Research 5(28): 5004-5012

[12] B I Nafiah dan B Prasetyo 2019 The Effect of Arbuscular and mikoriza Microbial Consortium on Corn Growth on Inceptisol Journal of Soil and Land Resources Vol 6 (2) 1325-1332

[13] Syamsiah J B H Sunarminto E Hanudin J Widada 2014 Effect of inoculation of arbuscular mycorrhizal fungi on glomalin growth and yield of rice J Ilmu Tanah dan Agroklmatologi 11:39:46

[14] Muis R., M. Ghulamahdi, M. Melati, Purwono, dan I. Mansur. 2016. Compatibility of arbuscular mycorrhizal fungi with soybean plants in water-saturated aquaculture. Penelitian Pertanian Tanaman Pangan, Vol. 35, No. 3: 229-238.

[15] Torres-Arias, Y., R. Ortega, F.C. Nobreb, E.E. Gómeza and R.L.L.Berbara. 2017. Production of native arbuscular mycorrhizal fungi inoculum under different environmental conditions. Brazilian Journal of Microbiology 48: 87–94.

[16] Lilieskov E. A., T. J. Fahey, T. R. Horton, and G. M. Lovett. 2002. Belowground ectomycorrhizal fungal community change over a Nitrogen deposition gradient ion Alaska. Ecology. 83(1): 104-115.

[17] Perdana Roy Oksems Purba, Nini Rahmawati, Emmy Harso Kardhinata. 2014. Effectiveness of Several Types of Arbuscular Mycorrhizal Fungi Against Rubber Plant Growth (Hevea Brassiliensis Muell. Arg.) at the nursery. Jurnal Online Agroekologi. Vol.2 (2) : 919 – 932

[18] Moelyohadi, Yopie. 2015. Response of root growth and canopy of some genotypes of corn (Zea mays L.) at low nutrient supply conditions by the water culture method. 10(1):36-42.

[19] Rahmayanti, A.Y., Maria Viva Rini, M.A. Syamsul Arif & Sri Yusnaini. 2013. Effects of Arbuscular Mycorrhizal Fungus and Cocoa Fruit Skin Compost on Cocoa Seedling Growth (Theobroma cacao L.). J. Agrotek Tropika. Vo. 1(2) hal. 121-127.
[20] Simarmata, T., T. Turmuktini, B.N. Fitriatin and M.R. Setiawati. 2017. Application of bioameliorants and biofertilizers to increase the soil health and rice productivity. Journal of Biosciences 23: 181–184.

[21] Mapegau, 2006. Effect of Water Stress on Soybean Growth and Yields (Glycine max [L] Merr.). Jurnal ilmiah pertanian Kultura 41 (1) : 43-49.

[22] Bilber, P.D. 2007. Evaluating a chlorophyll Content Meter on There Coastal Wetland Plant Species. Journal of Agricultural, Food and Environmental Sciences. 1(2): 1-11.

[23] Asrar, A.A., Abdel-Fattah, G.M., Elhindi, K.M., Abdel-Salam, A., 2014. The impact of arbuscular mychorrhizal fungi in improving growth, flower yield and tolerance of kalanchoe (Kalanchoe blossfeldiana Poelin) plants grown in NaCl-stress conditions. Food Agric. Environ. 12, 105–112.

[24] Khalid, E., M. Ahmed Sharaf El-Din, Abdallah M. Elgorban. 2017. The impact of arbuscular mycorrhizal fungi in mitigating salt-induced adverse effects in sweet basil (Ocimum basilicum L.). Saudi Journal of Biological Sciences (2017) 24, 170–179.

[25] Shamsul H., Q. Hayat, M. N. Alyemeni, A. S. Wani, J. Pichtel, and A. Ahmad. 2012. Role of proline under changing environments. Plant Signal Behav. 7(11): 1456–1466.

[26] Goswami, B.R., M.V.Parakhia, B.A. Golakiya and C.R.Kothari. 2018. Morphological and molecular identification of arbuscular mycorrhizal (AM) fungi, International Journal of Current Microbiology and Applied Sciences 7: 2336-2347.

[27] Nicholas, O., I. Olubukola and O.Babalola. 2017. Biofertilizers and sustainable agriculture: exploring arbuscular mycorrhizal fungi. Applied Microbiology and Biotechnology 101 : 4871-4881.

[28] Orcen, N., and M. Altinbas. 2014. Use of Some Stress Tolerance Indices For Late Drought In Spring Wheat. Fresenius Environmental Bulletin, Vol. 23 (9a).