The roles of FMA in increasing growth and effectiveness of soybean roots on dry land supporting sustainable agriculture in Deli Serdang District

L Z Nasution1*, C Hanum2 and Delvian3

1Department of Natural Resources and Environmental Management, Universitas Sumatera Utara, Medan, Sumatera Utara, Indonesia.
2Faculty of Agriculture, Universitas Sumatera Utara, Medan, Sumatera Utara, Indonesia.
3Department of Forestry, Universitas Sumatera Utara, Medan, Sumatera Utara, Indonesia.

E-mail: *lellyzulhaida@yahoo.co.id

Abstract. Soybean cultivation in dry land is an agricultural intensification effort to increasing soybean production. The application of biological fertilizer like FMA contributes to increase growth and plant development, also supporting eco-friendly agriculture. The purpose of this research is to determine the role of FMA in the improving the growth and effectiveness of soybean rooting on dry land to support sustainable agriculture in Deli Serdang district. This research was conducted at BBI Tj. Selamat, Deli Serdang district in June-August 2019. Parameters observed were plant height, FMA colonization percentage, and soybean root volume. The results showed that the treatments of M0 (control), M1 (4 gr FMA), M2 (8 gr FMA), and M3 (12 gr FMA) did not significantly affect plant height and root volume, but significantly affected the FMA colonization percentage in the roots of soybean. The lowest FMA colonization percentage was obtained at M0 treatment (2.33%), while the highest was shown in M2 treatment (2.67%).

1. Introduction
Dry land has potency to be developed as a productive agricultural land if managed with the right technology. The dry land development that has been applied is food crops and horticulture cultivation to fulfil the people’s food. Deli Serdang is one of the districts in North Sumatra that has wide dry land. Dry land area in Deli Serdang district is about 65,345 Ha consist of shifting cultivation area, unirrigated field, and temporarily unused garden [1].

Soybean is a potential food crop to be developed in dry land and its needs always increase along with the population growth in Indonesia. The increase in soybean needs can be seen from the rate of soybean imports until 2011. Indonesia has experienced soybean imports increasing in 2007 - 2011 of 3.28% was caused tofu and tempeh processing industries that using imported soybeans that have lower prices, but the quality is not better than local soybeans [2]. The high soybean import was indicated the failure of soybean self-sufficiency in Indonesia and encourages the government to take policy steps through the Ministry of Agriculture. The government set a target of soybean production from 2015 - 2019 should
increase to reach 3 million tons [3]. An effort to achieve the government's goal is an agriculture intensification effort that can improve agricultural land sustainability.

Agriculture intensification efforts on dry land are the principal capital in integrated crop technology management, especially soybean plants and can provide optimal results for soybean farmers if done sustainably. Agriculture intensification and extensification effort can be applied in an area to increase soybean crop production [4]. Dry land has the potency to develop but has several problems in its development for crop management. Nutrient limitations are one of the issues of dry land that will inhibit the growth and development of soybean plants if it is not managed correctly. The weakness of organic matter resulted in soil fertility reduction and deficiency of available water that affected the difficulty of annual crops cultivating on dry land [5].

Agriculture intensification efforts carried out must support eco-friendly agriculture program. The manifestation of eco-friendly agriculture is done using fertilizers using based on recommendations of soil analysis result, minimizing inorganic fertilizer application with the substitution of organic and biological fertilizer application. FMA is an alternative technology of soybean cultivation development in dry land. It acts as natural agents that have an extraordinary role for plants to help nutrients absorption that is available or not available in the soil for plant growth and development. Soil microbes as beneficial fertilizers are very useful and have an essential role in increasing soil fertility and fertilization efficiency and reducing environmental pollution [6].

FMA sources from the endomycorrhizal group measuring 40-90 mm in sporocarp, which is found in nature and symbiotic in the deep roots of host plants, through the spread of hypha that will be able to increase plant growth and soil fertility [7]. FMA has a functional role such as bio processor, bio protector, bio activator, and bio aggregator; hence it can be utilized to increase the plants quantity and quality, reduction the need of fertilizers and pesticides, fertilize the soil, reduce CO2 emissions, and reduce soil erosion [8]. The purpose of this research is to observe the role of FMA in increasing the growth and effectiveness of soybean roots on dry land supporting sustainable agriculture in Deli Serdang district.

2. Methodology
This research was conducted in BBI Tj. Selamat, Deli Serdang District, Tanjung Anom village from June until August 2019. The materials used in this research were Anjasmoro soybean variety, FMA, urea, TSP, KCI fertilizer, growth regulator, insecticide, plastic rope, bamboo, plastic. The tools used were Upland Soil Tes Kit, soil drill, analytical scales, hoe, spoon, and stationery.

The results of the soil analysis using Upland Soil Test Kit showed that the soil pH was slightly acidic, high P and low organic C. Based on that soil condition, the fertilizer recommendations were SP 36 (100 kg/Ha), KCl (50 kg/Ha), and urea (80 kg/Ha). Fertilizers applied is only 50% of the recommendations to observe the effectiveness of FMA and reduce the application of the inorganic fertilizers.

The research activities begin with land preparation and the treatment plot was made with 2x2 m size as much as 36 treatment plots. Soybean seeds are planted two seeds/hole. The FMA was weighed according to the established treatment, which was 0, 4, 8, and 12 gr/plant. Each treatment plot was applied 20 gr SP36 fertilizer, 15.65 gr TSP, 10 gr KCl, and 16 gr urea per treatment plot.

The parameter observed were plant height, percentage of FMA colonization, and root volume at eight weeks after planting. Plant height measurements were carried out from soil surface to the highest leaf. The analysis of FMA colonization percentage used staining technique in roots with Tryphan blue and observed under a microscope, then calculated the root infection percentage with the formula [9]:

\[
Infection \ Percentage \ (%) = \frac{\sum \text{infection roots}}{\sum \text{total observation}} \times 100 \%
\]  

(1)

While root volume was measured with the formula:

\[
Root \ volume \ (ml) = (Volume \ water + \ root) - (Volume \ water)
\]  

(2)
The research method used a Randomized Group Design and the data analysis used was Two Way Anova and further tests using DMRT 5%.

3. Result and discussion

3.1. Plant height (cm)
The FMA biofertilizer treatment did not significantly affect soybean plant height (Table 1). FMA biofertilizer treatment that did not significantly affect the plant height was assumed because of the 50% reduction of recommended fertilizer. High Phosphor with acidic soil pH resulted in Phosphor being not available to plants because it was bound to both Al and Fe. Although the result was not significantly different from Table 1, it was shown that there is an increase in soybean plant height in each additional dose of FMA biofertilizer compared to plant height without FMA.

Application of FMA promotes the root infection by FMA that helps Phosphor absorption, which contributes to increasing plant height. The fungus hyphae produce enzyme phosphatase, which can release Phosphor from specific bonds so that it will be available to plants [10]. The FMA application can help nutrients and water absorption in the soil because the specific process of FMA hyphae help water absorption in the soil and produce plant growth-stimulating hormones such as auxin, cytokinins, and gibberellins [11].

Table 1. Effect of FMA biofertilizer on plant height, FMA percentage, and root volume of soybean plants

| Treatment/Parameters | Plant Height (cm) | FMA coloniz. Percentage (%) | Roots Volume (ml) |
|----------------------|-------------------|-----------------------------|-------------------|
| M₀ (Control)         | 85.83 a           | 2.33 a                      | 5.77 a            |
| M₁ (4 gram of FMA)   | 88.16 a           | 28.11 b                     | 5.44 a            |
| M₂ (8 gram of FMA)   | 92.50 a           | 32.67 b                     | 6.33 a            |
| M₃ (12 gram of FMA)  | 94.76 a           | 31.11 b                     | 6.77 a            |

Notes: Numbers followed by the same letters in the same column show results not significantly different at the 5% level.

3.2. FMA colonization percentage (%)
The FMA biofertilizer treatment significantly affected the FMA colonization percentage in the roots of soybean plants (Table 1) with category class 1-class 3 [12] or low to high [13]. The FMA colonization percentage in control treatment without FMA (M₀) was significantly different from other treatments (M₁, M₂, and M₃), but the FMA colonization percentage between the three treatments was not significantly different. The lowest FMA colonization percentage was obtained in the M₀ treatment was 2.33% while the highest (32.67%) was shown in the M₂ treatment. The increase of FMA colonization percentage on FMA addition compared to control was influenced by the FMA ability in infecting or symbiotic with the roots of soybean plants as host plants. FMA that applied containing Gigaspora margarita spores, Glomus manihotis spore, Glomus etunikatum spora and Acaulospoea tuberculata spore which are indigenous FMA and proven ability to infect plant roots well. The indigenous FMA has the potential to form broad and adaptive colonization of its host plants, as well as tolerance to environmental stress [14].

3.3. The volume of roots (ml)
As with plant height, the treatment of FMA biofertilizers on the root volume of soybean plants also had no significant effect (Table 1). The average value of the root volume of soybean plants showed that the lowest root volume obtained by M₁ treatment (5.44 ml) while the highest root volume value was found in the M₃ treatment (6.77 ml). Unsupportive research environment conditions (high Phosphor) resulted
in FMA treatment having no significant effect on the root volume. Root volume has no significant effect due to high Phosphor resulting in the FMA development is not optimal in infecting plant roots [15].

4. Conclusion
The treatment of FMA did not significantly affect plant height and root volume, but it did have a significant effect on the percentage of AMF colonization. The category of FMA colonization in the soybean roots in the control treatment was very low (2.33%) while the FMA treatment was classified to medium category with values ranging from 28.11 to 32.67%.

Reference
[1] BPS Deli Serdang [Central Bureaue Statistic of Deli Serdang Regency] 2018 Deli Serdang Dalam Angka [Deli Serdang Regency in Figures] (Deli Serdang, Central Bureaue Statistic) p 623
[2] Hadi A 2013 Analisis Produksi Dan Konsumsi Kedelai Domestik Dalam Rangka Mencapai Swasembada Kedelai di Indonesia [Analysis of Domestic Soybean Production and Consumption in the Framework of Reaching Soy Self-Sufficiency in Indonesia] (Bogor: Departement of Economic Resources and Environmental Management IPB) p 101
[3] Kementerian Pertanian [Ministry of Agriculture] 2015 Rencana Strategis Kementerian Pertanian 2015-2019 [Ministry of Agriculture’s Strategic Plan 2015 – 2019] (Indonesia: Kementerian Pertanian [Ministry of Agriculture]) p 364
[4] Marwoto and Hilman 2005 Teknologi Kacang-Kacangan dan Umbi-Umbian Mendukung Ketahanan Pangan [Legumes and Tuber Crops Technology Supports Food Security] Indonesian legumes and tuber crops research institute In Working of ILETRI 2003 – 2004 Malang
[5] Abdurachman A, Dariah A and Mulyani A 2008 Strategi dan teknologi pengelolaan lahan kering mendukung pengadaan pangan nasional [Strategy and technology of dryland management to support national food production] J. Littbang Pertanian 27 (2) pp 43–9
[6] Purwaningsih S 2001 Pengaruh mikroba tanah terhadap pertumbuhan dan hasil panen kedelai (Glycine max L.) [Effect of soil microorganism on the growth and yield of soybean (Glycine max L.)] Berita Biologi 54 (4) pp 373–8
[7] Anissah L 2014 Kajian Pustaka Aplikasi Fungi Mikoriza Arbuskula (FMA) Pada Tanaman Kehutanan Jenis Non Dipterocarpaceae [Literature Study of Application Fungi Mycorrhizal Arbuscular (FMA) of Forest Trees Species Non Dipterocarpaceae] (Bogor: Departement of Forestry IPB) p 53
[8] Nusantara A D, Bertham Y H and Mansur I 2012 Bekerja dengan Fungi Mikoriza Arbuskula [Working with Fungi Mikoriza Arbuscula] Seameo Biotrop, First Edition (Bogor: Seameo Biotrop) p 78
[9] Giovannetti M and Mosse B 1980 An evaluation of technique for measuring vesicular arbuscular mychorrhizal infection in roots New Phytologist 84 pp 489–500
[10] Subiksa I G M 2002 Pemanfaatan Mikoriza Untuk Penanggulangan Lahan Kritis [Utilization of Mycorrhizae for Critical Land Management] Undergraduate Thesis Institut Pertanian Bogor, Indonesia
[11] Daras U, Trisilawati O and Sobari I 2013 Pengaruh mikoriza dan amelioran terhadap pertumbuhan benih kopi (Effects of mycorrhizas fungi and ameliorants on the growth of coffee seedlings) Bulletin of RISTRI 4 (2) pp 145–56
[12] Rajapakse S and Miller Jr JC 1992 Methods for studying vesicular–arbuscular mycorrhizal root colonization and related root physical properties Methods Microbiol 24 pp 302–16
[13] O’Connor P J, Smith S E and Smith F A 2001 Arbuscular mycorrhizal associations in the southern Simpson desert Aust J Bot 49 pp 493–9
[14] Delvian 2006 Dinamika Sporulasi Cendawan Mikoriza Arbuskula [The Dynamics of Sporulation of Fungi Mycorrhizal Arbuscular] Science Paper (Medan: Department of Forestry Universitas Sumatera Utara) p 25
[15] Muis A, Indradewa D and Widada J 2013 Pengaruh inokulasi mikoriza arbuskula terhadap pertumbuhan dan hasil kedelai (Glycine max (L) Merrill) pada berbagai interval penyiraman [The effect of arbuscula mycorhizal inoculation on the growth and yield of soybean (Glycine max (L) Merrill) at Various Watering Intervals] *Vegetalika* 2 (2) pp 7-20