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IMPROVING THE PRODUCTIVITY POTENTIAL OF SOYBEAN IN THE LAHAR-LADEN AREA USING DRIP IRRIGATION SYSTEM AND MYCORRHIZAE SP.

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Abstract

This study aimed to assess the effect of the soil moisture allowable depletion and Mycorrhizae sp. on improving the productivity potential of soybean in the lahar-laden area using the drip irrigation system and furrow irrigation method. Results revealed that the plant height was significantly influenced by 40 % of soil moisture allowable depletion (MAD), with plants significantly taller when the soil was treated with Mycorrhizae sp. at 30 days after sowing (DAS). The drip irrigation method significantly affected the soybean plant height, leaf area index, and root length at 46 DAS. No significant increase was observed in the number of branches and stem diameter. The spore development of the beneficial fungus Mycorrhizae sp. was not affected by the supplementation of various irrigation systems. The highest increment of Vesicular Arbuscular Mycorrhizae (VAM) fungal spore development was observed in inoculated soils using the furrow irrigation method with 312.93 spores (30 days after inoculation (DAI)). Production of spores in the drip irrigation system rapidly increased from 31-96 DAI, giving the spore population count 356.84.

Key Words: Spore Population; Mycorrhizae Sp.; Allowable Moisture Depletion; Drip Irrigation; Soybean

INTRODUCTION

Volcanic eruptions are highly destructive; this natural phenomenon is beneficial in the long term. Rapid restoration of vegetation and soil environment occurs on volcanic ash (lahar) deposits soon after the ash deposition event. The periodic additions of volcanic ash generally improve the soil's physical and chemical properties and renew its productivity. With proper management, volcanic ash soils can produce high productivity and long-term agricultural and environmental sustainability (Sadao et al., 2014). Promoting water-efficient technologies to utilize available water resources better to increase the productivity and acceptance of horticultural crops in these areas was a significant challenge. In providing sustainable solutions, tools are necessary to optimize water application using a drip irrigation system and application of Mycorrhizae sp.

Mycorrhizal fungi are a remarkable group of organisms that have been benefiting plants. In effect, the fungus provides a secondary root system, a considerably more efficient and

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extensive system than its own root system. Mycorrhizal symbiosis plays a crucial role in nutrient cycling in the ecosystem and protects plants against environmental and cultivation stress (Carvalho and Silva, 2004). Mycorrhizal fungi colonize the plant's root system; they create a network that increases the plant's capacity to absorb more water and phosphorus. This process, in turn, enhances growth and favors the rapid development of roots and plants. This study aimed to improve the productivity potential of soybean in lahar-laden areas using a drip irrigation system and Mycorrhizae sp. application. Specifically, the study aims to: assess the effect of irrigation regimes on the growth of soybean grown in Mycorrhizae sp. inoculated soils, evaluate the effects of Mycorrhizae sp. on soil moisture depletion; and determine the spore development and production potential of Mycorrhizae sp. affected by the irrigation regime.

Scope and Limitation of the Study

The study focused on measuring the soil moisture depletion of lahar soil and the effect of Mycorrhizae sp. on the growth of soybean. Soil moisture content was measured using a soil moisture meter. A critical consideration in a drip irrigation system is the installation costs since costs generally determine a project's feasibility and viability. The water savings was also an essential aspect since there is a demand to determine the best percentage of Management Allowable Depletion (MAD) to irrigate the crops.

Thus, the system must operate with optimized consistency to fully attain the above objectives. The system was tested for soybean production (CLSOY seeds variety of CLSU) in a drip irrigation system with different irrigation regimes and Mycorrhizae sp. application. The study was conducted at the lahar-laden area at Carael, Botolan, Zambales, from January 2020 to May 2020, with simultaneous data gathering of parameters.

REVIEW OF LITERATURE

Water Productivity

Water productivity is a valuable concept when comparing the productivity of water in different parts of the same system or river basin and comparing the productivity of water in agriculture with other possible uses of water. Improving physical water productivity in agriculture reduces the need for additional water and land in irrigated and rain-fed systems and is a critical response to increasing water scarcity. Water-saving is achieved from improved water productivity in agriculture sustain ecosystems (Jha, Mali, Naik & Sengupta, 2017).

Drip Irrigation

Drip irrigation is sometimes called trickle irrigation and involves dripping water onto the soil at low rates (2-20 liters/hour) from a system of small-diameter plastic pipes fitted with outlets called emitters or drippers. Water is applied close to plants so that only part of the soil in which the roots grow gets wet, unlike surface and sprinkler irrigation, which involves wetting the whole soil profile. With drip irrigation water, applications are more frequent (usually every 1-3 days) than with other methods. This provides an excellent high moisture level in the soil in

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which plants can flourish (Brouwer, 2001). Adopting drip irrigation improved the yields in the range of 38.2-65.8% over furrow irrigation, with the highest yield increase in peas (65.8%) and tomatoes (58.7%). Drip irrigation consistently recorded higher water productivity (W.P.) with more than five folds increase in potato and cauliflower cases. The average W.P. was higher under drip irrigation (6.89 kg/m3) as compared to the furrow method (1.31 kg/m3) (Jha et al., 2017).

Yonts (2018) emphasized that reducing irrigation water by 25% increased irrigation water use efficiency by 26% and only caused a 6% yield reduction relative to the complete irrigation treatment scenario. The harvest index showed less and more irregular variation among irrigation treatments. Both leaf areas per plant and leaf area index significantly reduced at all growth stages as the amount of irrigation water was decreased (Sincik, Candogan, Demirtas, Buyukcangaz & Yazgan, 2008).

Importance of Mycorrhizae sp.

Mycorrhizal fungi are a remarkable group of organisms benefiting plants. In effect, the fungus provides a secondary root system, a considerably more efficient and extensive system than its own root system. Arbuscular Mycorrhizae sp. (AM) is one of the most common symbioses worldwide and is formed by about 80% of the known plant species (Mandyam & Jumpponen, 2008). Arbuscular Mycorrhizal (AM) fungi biotrophically colonize the root cortex and develop an extra-matrical mycelium that helps the plant to acquire mineral nutrients from the soil (Fuzy, Biro, Toth, Hildebrantt & Bothe 2008). These are present in most agronomic and vegetable crops and fruits.

Mycorrhizal symbiosis plays a crucial role in nutrient cycling in the ecosystem and protects plants against environmental and cultivation stress (Carvalho & Silva, 2004). Mycorrhizal fungi colonize the plant's root system; they create a network that increases the plant's capacity to absorb more water and phosphorus. This process, in turn, enhances growth and favors the rapid development of roots and plants.

AM fungi may also have been associated with enhanced chlorophyll levels in leaves and improved plant tolerance of diseases, parasites, water stress, salinity, and heavy metal toxicity (Bethlenfalvay, 1992). Moreover, there is increasing evidence that fungi's hyphal networks contribute significantly to the development of soil aggregates, hence to soil conservation (Miller & Jastrow, 1992).

Soybean

Soybean (Glycine max (L.) Merrill) or soya bean is a legume crop belonging to the family Leguminosae or Fabaceae and sub-family Papilionaceae. The plant grows up to 1.5 meters tall, depending on the variety. Erect stems are covered with thick brown hair. Leaves are compound, with three leaflets. These are alternate, trifoliate with ovate leaflets and short peduncles.

The inconspicuous, stalkless white to purple flowers are borne singly or in small clusters in the axils (where the leaf meets the stem). The fruit is a broad, hairy, flattened legume or pod,

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around 10 cm (3 in) long, yellow to brown when fully mature and dried. The fruits are called pods measuring up to 7 cm long, containing one to four seeds that are colored yellow, black, or green.

Soybeans occur in various sizes and many hulls or seed coat colors, including black, brown, blue, yellow, green, and mottled. The mature bean's hull is hard and water-resistant and protects the cotyledon and hypocotyl (or "germ") from damage. If the seed coat is cracked, the seed does not germinate. The scar, visible on the seed coat, is called the hilum (colors include black, brown, buff, gray, and yellow), and at one end of the hilum is the micropyle or small opening in the seed coat, which can allow the absorption of water for sprouting (Bureau of Plant Industry, 2016).

Soybeans contain significant amounts of phytic acid, dietary minerals, and B vitamins. Soy vegetable oil, used in food and industrial applications, is another product of processing the soybean crop. Soybean is an essential protein source for feed farm animals (that yields animal protein for human consumption).

Traditional unfermented food uses of soybeans include soy milk, from which tofu and tofu skin are made. Fermented soy foods include soy sauce, fermented bean paste, nattō, and tempeh. Fat-free (defatted) soybean meal is a significant and cheap protein source for animal feeds and many packaged meals. For example, soybean products, such as textured vegetable protein (TVP), are ingredients in many meats and dairy substitutes. In the Philippines, it is known as "Utaw" while in other Asian countries, it is known as "Wonder bean," "Great treasure," "gift from God" and the "source of liquid gold."

CLSOY 1

Variety of soybean that is recommended for Luzon post-rice areas developed by CLSU. It contains a high soymilk yield, small seed, and brown hilum in color.

Lahar Description

A lahar is a volcanic mudflow or debris flow. Lahars have the consistency, viscosity, and approximate density of wet concrete: fluid when moving and solid at rest. Lahars can be massive. The Osceola Lahar produced by Mount Rainier (Washington) some 5600 years ago resulted in a wall of mud 140 meters (460 ft.) deep in the White River canyon, which covered an area of over 330 square kilometers (130 sq mi) for a total volume of 2.3 cubic kilometers (0.55 cu mi).

A lahar of sufficient size and intensity can erase virtually any structure in its path and can carve its pathway, making the prediction of its course difficult. Conversely, a lahar quickly loses force when it leaves the channel of its flow: even frail huts may remain standing while at the same time being buried to the roofline in the mud. A lahar's viscosity decreases with time and can be further thinned by rain, but it nevertheless solidifies quickly when coming to a stop (Gerrard, 1990).

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Natural regeneration of soil productivity is a long process (100- 500 years), as observed in Japanese volcanic soils. An accelerated rehabilitation program would be more suitable to provide a more significant impact on food production. In Zambales, Tarlac, and Pampanga, rehabilitation program initiated by the government, like the Department of Agriculture, includes scraping volcanic debris in shallow mudflow areas and introducing new crops after rice. Twenty-five (25) years later, with so many interventions programs implemented by the government and other concerned sectors and groups, much improvement has taken place in the mudflow-struck rice farms, and farming practices may have normalized already (Yoshinaga, Henmi, Nakai, and Nakata, 1994).

MATERIALS AND METHODS

Experimental Treatment and Design

This experiment was laid-out under field conditions following a 2 x 4 split-plot design using Mycorrhizae sp. application as the main plot and moisture allowable depletion (MAD) levels as sub-plots. Each treatment was replicated thrice.

The main plot – Application of Mycorrhizae sp.

A1 = with Mycorrhizae sp.

A2 = without Mycorrhizae sp.

Subplot – Moisture Allowable Depletion (MAD)

T1 – 75% MAD, Drip Irrigation

T2 – 60% MAD, Drip Irrigation

T3 – 40% MAD, Drip Irrigation

T4 – Furrow Irrigation

Land Preparation

Plowing and harrowing the field 2-3 times at an interval of seven days. Each harrowing consists of 2 passing to attain the correct soil tilt. Twenty-four (24) plots were prepared with 2 m x 10 m dimensions and a distance of 1m in between plots. The land area was fenced by hog wire to avoid the destruction of animals.

The land area used is 800 m2. The replicated plots have three rows 30cm wide and 10m long located approximately evenly space to complete every treatment replication.

Test Plant

Four thousand eight hundred sixty (4,860) soybean "CLSOY" seeds were used in the experiment. The soybean seeds were sandwiched in a wet cheesecloth for 24 hours to break their dormancy, and the damp cloth was approximately 80% moist. The seeds were sown 30 cm in a row with 30 cm between the rows space. Three to four seeds were sown, and thinning was done to maintain two plants per hole after germination. The planting depth of the seeds was 3 to 5 cm deep in the soil.

Mycorrhizae sp. Inoculation of Soil Samples

Before planting, about 2.50 grams of pre-counted fungal inoculants provided by the Mycorrhizae sp. laboratory of DENR were spread evenly on every hill. Treatment had Three (3) plots with 99 hills per plot. The weight of Mycorrhizae sp. used per plot was 247.5 grams, and 123.75kg (2.5 bags) was used for one hectare. Application of Mycorrhizae sp. was done by measuring five (5) cm depth in the soil before placing the seeds, then covering it again with soil.

Irrigation

Irrigation was applied using a drip method. Each row has its irrigation line position near the plants. Lateral drip lines and emitters spaced 30 cm x 30 cm were installed, having an emitter discharge of 1 Lph. Lateral lines were connected to a 32 mm ϕ sub-mainline, which was also connected to a 32 mm ϕ mainline (Appendix figure 4). In every block, a water meter was installed to monitor the amount of water delivered in every plot. Three (3) lateral lines were installed in each plot per block. Each plot had a sub-mainline installed with control valves to start and stop irrigation flows.

Data Gathered

Soil Moisture

Before planting, uniform water was applied to all the beds to bring them to Field capacity (F.C.) 19% (177 mm) for uniform germination, wilting point of the plant was 6% (55.8 mm), and the available water of the soil is 13% (120.9 mm). The soil moisture for all beds was maintained at F.C. until 15 DAS. After 15 DAS, the irrigation treatments were initiated. Soil moisture was maintained uniformly at field capacity from planting until maturity of soybean pod and allowed to reduce gradually until they reached predetermined moisture allowable depletion levels for 75% MAD (9.25%), 60% MAD (11.2%), and 40% MAD (13.8%).

Mycorrhizae sp. Growth and Development

Mycorrhizae sp. spore count in each soil sample was conducted by modified wet-sieving and decanting techniques (Gerdemann and Nicolson, 1963). This was obtained at every growing stage of the soybean plant. The collection of soil samples was done through the destructive sampling of five (5) plants that were uprooted for every replicate. Weigh 50 grams of soil into every soil plant to count the spores; this was done in the laboratory of DENR.

Irrigation

Irrigation was applied using a drip method. Each row has its irrigation line position near the plants. Lateral drip lines and emitters spaced 30 cm x 30 cm were installed, having an emitter discharge of 1 lph. Lateral lines were connected to a 32 mm ϕ sub-mainline, which was also connected to a 32 mm ϕ mainline (Appendix Figure 4).

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In every block, a water meter was installed to monitor the amount of water delivered in every plot. Three (3) lateral lines were installed in each plot per block. Each plot had a sub-mainline installed with control valves to start and stop irrigation flows. After sowing, drip irrigation was used to enhance the seed germination of soybean. The irrigation was applied after reaching the allowable moisture depletion of 75% MAD (T_1), 60% MAD (T_2), and 40% MAD (T_3) to maintain the available moisture of the soil.

Growth and Yield Parameters

1. Plant height (cm) was measured using a meter stick every week from the base (before the root system) up to the tip of the longest leaf.
2. Stem diameter (mm) was measured using a caliper; the entire plant sample in every plot will be determined from the topsoil up to 10 cm height of the stem.
3. Number of branches (pieces) was determined every week. This was gathered by counting branches in every plant sample per treatment.
4. Leaf area index (cm2) was measured using graphing paper to trace the small, medium, and the largest leaf of each treatment collected.
5. Root length (cm) was determined using a ruler for every growing stage of the plant to harvest. The length of the longest roots of sample plants was measured.

Statistical Analysis

Data collected during the growing stage of the soybean plant was statistically analyzed following the Analysis of Variance (ANOVA) for a 2 x 4 Split Plot Design. Differences among and between treatment means were determined using the Least Significant Difference Test (LSD).

RESULTS AND DISCUSSION

Growth and development of soybean

Plant height

The effect of Mycorrhizae sp. application, allowable moisture depletion and their interaction on soybean plant height are presented in Figure 1. A significant increase in plant height was obtained from Mycorrhizae sp. inoculated soil. An increase was extensively observed at the plant's early development (15 DAS) and continuing growth for its vegetative period before flowering (30 DAS). The height of plants was positively affected by the method of application of Mycorrhizae sp. at 5%.

Results revealed that the plant height was significantly influenced by different allowable soil moisture depletion, with plants significantly taller when treated in the soil with Mycorrhizae sp. At 30 DAS, soybean maintained inoculated with Mycorrhizae sp. grew fastest at 40% MAD at 27.92 cm tall, followed by 60% MAD at 27.43 cm, 75% MAD at 27.40 cm tall, and the smallest plant height was grown on furrow irrigation obtained 24.60 cm. In contrast, plants

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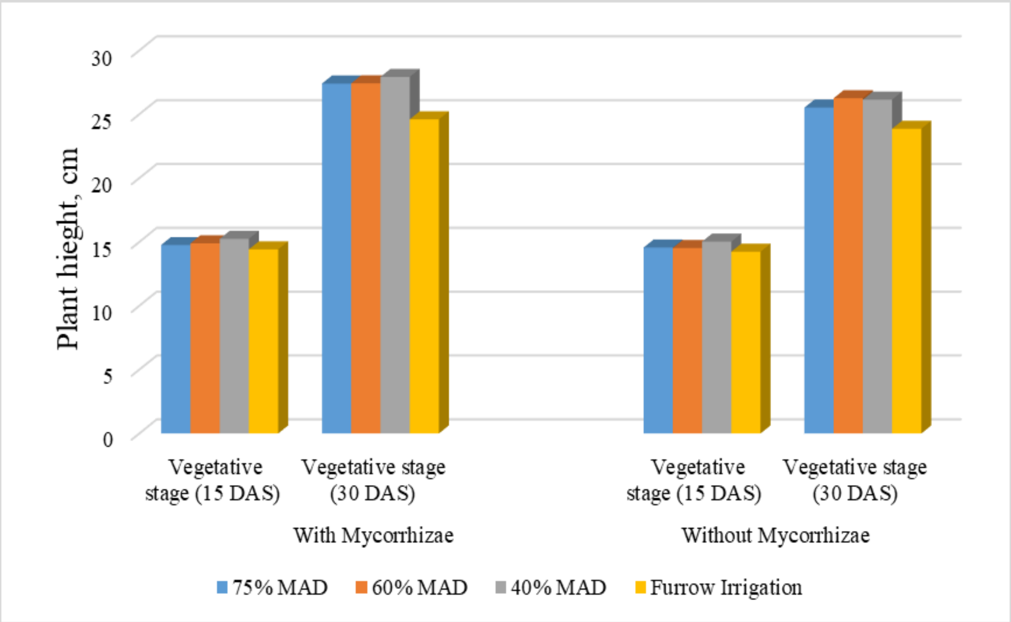
grew without Mycorrhizae sp. the tallest plant height was grown at 60% MAD at 26.26 cm, followed by 40% MAD at 26.14 cm followed by 75% MAD and furrow irrigation with 25.52 cm and 23.86 cm, respectively. The interaction effect with the combination of treated and non-treated Mycorrhizae sp. and specific moisture allowable depletion (MAD) did not manifest a significant advantage in developing soybean plants in height. Plants grew similarly across Mycorrhizae sp. application and allowable moisture depletion (MAD).

This observation conforms to Atala and his co-worker's (2012) study that watering quality affected plant survival only, and watering frequency increased seedling survival but reduced plant size of Pinus radiate. Further, mycorrhizal inoculation, together with soil moisture allowable depletion, affected plant growth and development. The soil moisture characteristics depend on the size and distribution of spores or void space (Hamblin, 1985). Wang (2000) emphasized drip irrigation conserved water and maintained the soil profile at a higher temperature more favorable for plant emergence and seedling development. The potential high yield of the soybean plant depends on the growth performance of the plant.

Figure 1: Average plant height of soybean during the vegetative stage



Stem Diameter

The effect of soil moisture allowable depletion was not significantly influenced by the soybean plant's stem diameter development. The biggest stem diameter was grown without Mycorrhizae sp. at 60% MAD, obtained at 5.96 mm, followed by 5.39 mm at 50% available moisture, 5.37 mm at 40% available moisture, and 5.21 mm at furrow irrigation. On the other hand, in soybean plants grown with Mycorrhizae sp., the biggest stem was obtained at 5.86 mm with 40% available moisture of soil, followed by 75% MAD with 5.77 mm, furrow irrigation with 5.63 mm, and the smallest stem developed was 60% MAD with 5.08 mm showed in Figure 2.

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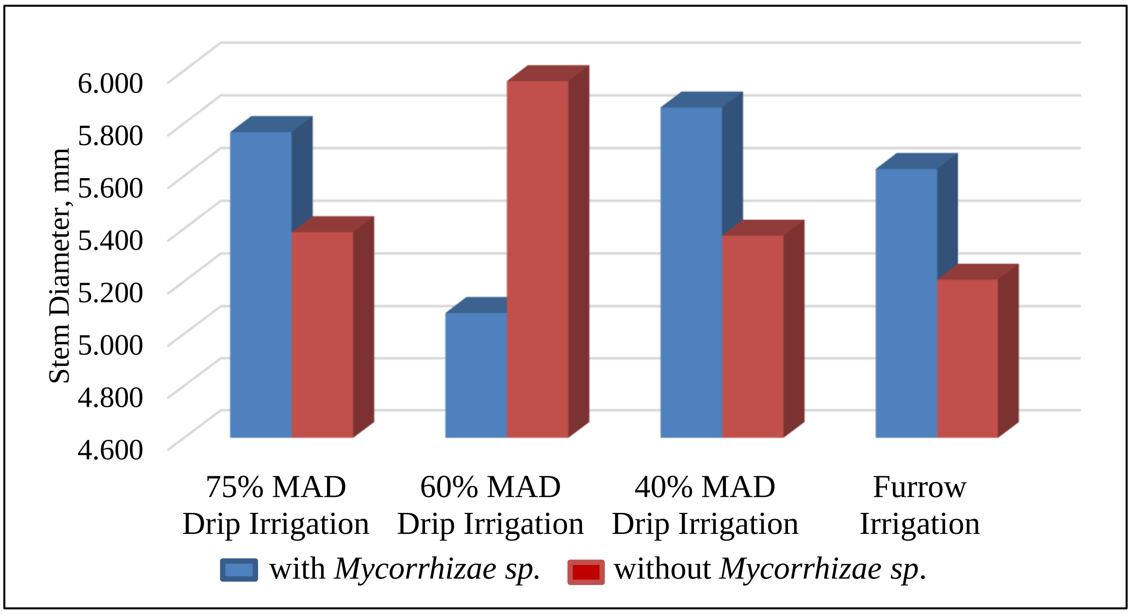
Figure 2: Stem diameter (millimeter) of soybean grown in the application of Mycorrhizae sp. and allowable moisture depletion



Number of Branches

The effect of soil moisture allowable depletion was not significantly influenced the development of branches of the soybean plant. The result shows that the most produced branches of soybean plant were grown in 40% MAD treated with Mycorrhizae sp. 2.98 branches followed by 75% MAD 2.71 branches, furrow irrigation 2.56 branches, and the least produced was grown in 60% MAD 2.33 branches. On the other hand, soybean plants grown without Mycorrhizae sp. were grown in both 60% and 40% MAD and obtained 2.76 branches. The least produced branches were grown at 75% available moisture (MAD) 2.67 branches.

Leaf Area Index

The leaf area index of the soybean plant was significantly affected by soil moisture allowable depletion but not significantly influenced by Mycorrhizae sp. The largest leaf developed was grown with and without Mycorrhizae sp. in 60% soil moisture allowable depletion with 61.70 cm2 and 61.27cm2, respectively. Followed by 40% soil moisture allowable depletion obtained 59.53 cm2 without Mycorrhizae sp., 57.54 cm2 treated with Mycorrhizae sp. At 75% soil moisture allowable depletion with 56.46 cm2 grown with Mycorrhizae sp. and 56.31cm2 without Mycorrhizae sp. The least leaf developed soybean plant was grown in traditional irrigation with and without Mycorrhizae sp. application, obtained 53.38 cm2 and 49.91 cm2, respectively.

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Table 1: Leaf area index (cm2) of soybean plant grown in Mycorrhizae sp. application and moisture allowable depletion

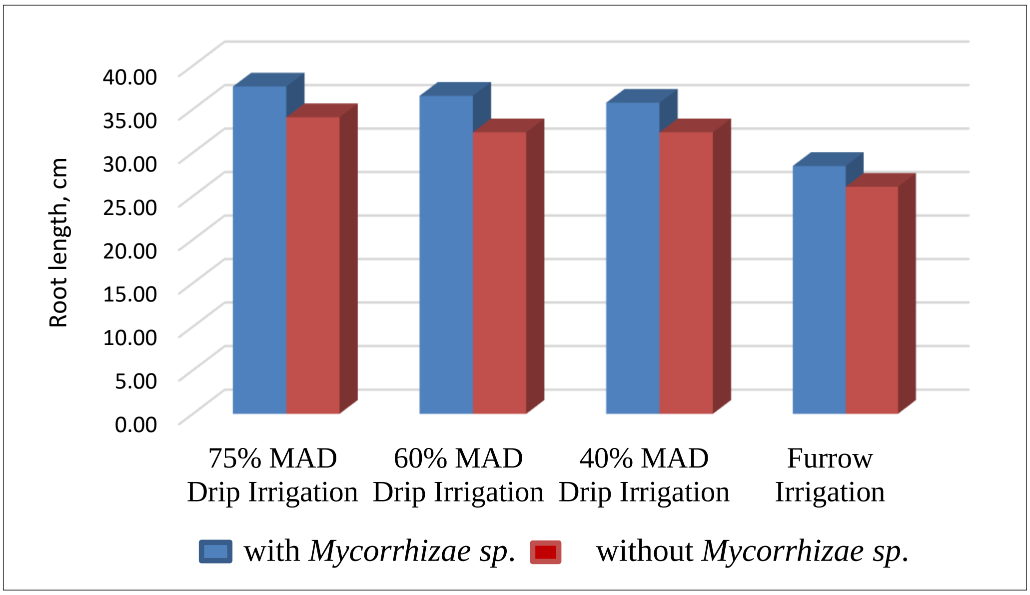
Moisture Allowable Depletion	Mycorrhizae sp. Application		B-Mean
	With Mycorrhizae sp.	Without Mycorrhizae sp.	
75% MAD	56.46	56.31	56.38 **b**
60% MAD	61.70	61.27	61.48 **a**
40% MAD	57.54	59.53	58.53 **b**
Furrow Irrigation	53.38	49.91	51.64
A-Mean	57.27	56.75	

Note: Means followed by the same letter are not significantly different at 5% LSD. cv (a)[1] = 1.17%, cv (b)[1] = 4.68%, (a)ns = not significant and (b)* = significant at 5% level.

Root Length

Plant roots' length is essential in absorbing and transporting nutrients from the soil to the plants. Application of Mycorrhizae sp. significantly influenced the root length of soybean at 5%. Results on root length are reflected in Figure 3, the effect of with and without applying Mycorrhizae sp. with different percentage of soil moisture allowable depletion on the root length of soybean plants during the flowering stage was significantly affected. Plants treated with Mycorrhizae sp. showed the longest root ranging from 28.47 cm to 37.60 cm. Without Mycorrhizae sp., the longest root ranged from 26.07cm to 34.07 cm.

Figure 3: Root length (cm) of soybean grown in the application of Mycorrhizae sp. and Moisture allowable depletion



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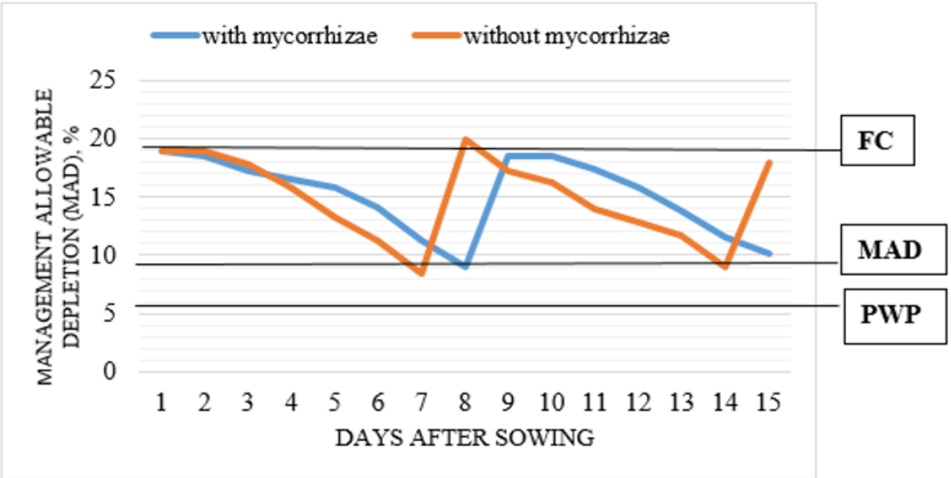
Effect of Mycorrhizae sp. on the soil moisture depletion

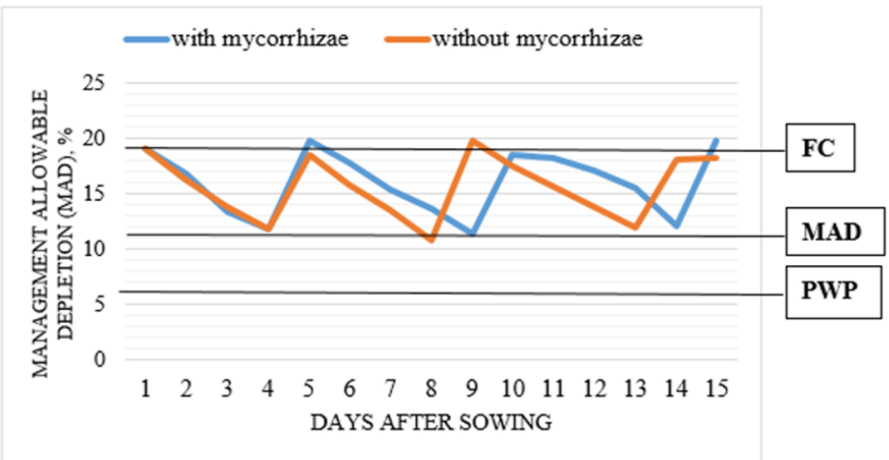
Figures 4 to 6 show that the soil inoculated with Mycorrhizae sp. during the vegetative stage of soybean has a higher water holding capacity, retained the optimum moisture, and MAD was slowed down. Compared to non-inoculated soil, the irrigation interval was much longer. According to Baslam (2011), Mycorrhizal fungi enhance the plant's tolerance by serving as a sponge that absorbs more water and nutrients. Assist in drought tolerance, and create ideal garden soil structure: soil that drains, breaths, and retains optimum moisture. The functional relationships between soil moisture stress and yield components will help farm managers schedule irrigation and improve soybean crop function under varying soil moisture conditions, Wijewardana (2018).

Figure 4: Drip irrigation at 75% MAD scheduling scheme



FC- Field capacity MAD-Management allowed deficit PWP-Permanent wilting point

Figure 5: Drip irrigation at 60% MAD scheduling scheme



FC- Field capacity MAD-Management allowed deficit PWP-Permanent wilting point

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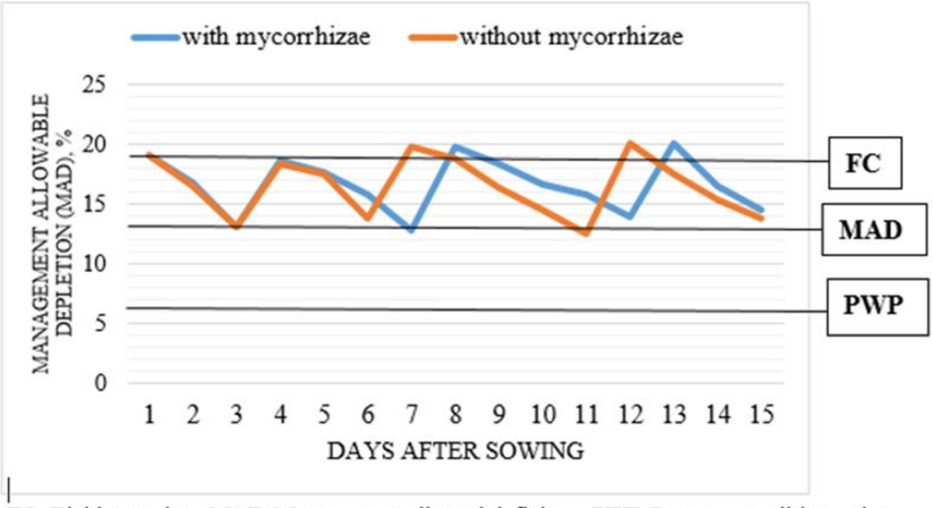
Figure 6: Drip irrigation at 40% MAD scheduling scheme

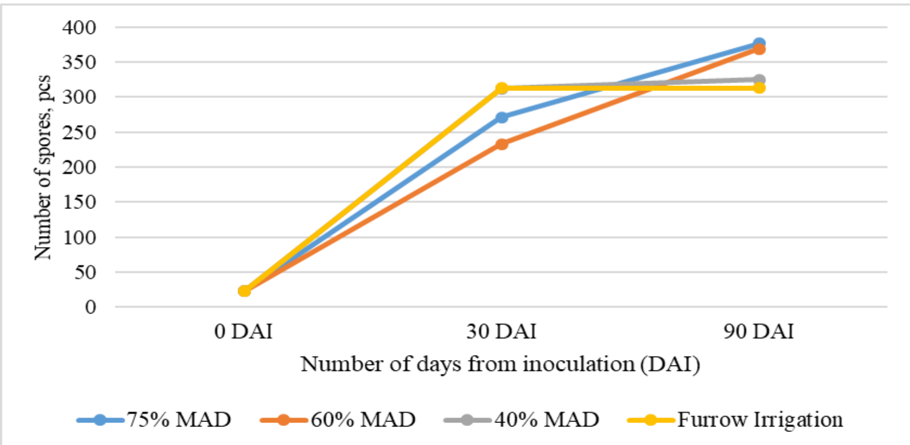


FC- Field capacity MAD-Management allowed deficit PWP-Permanent wilting point

Spore development and production potential of Mycorrhizae sp.

Figure 7 illustrates the trend of spore development of VAM fungus inoculated in various acceptable soil moisture. Initially, 22.25 spore counts per 2.5 grams of Mycorrhizae sp. were inoculated into the soil. At 30 DAI, the highest increment of VAM fungal spore development was observed in inoculated soils irrigated through furrow irrigation with 312.93 spores, followed by 40% MAD with 312.13 spores, followed by 75% MAD and 60% MAD with 271.27 spores and 233.13 spores, respectively. Production of spores in 75% MAD, 60% MAD, and 40% MAD rapidly increased from 31-96 DAI, giving the spore population count 376.53 spores, 368.74 spores, and 325.26 spores, those inoculated in soils receiving drip irrigation. VAM spores developed in furrow irrigation on the first 30 days from inoculation and became gradually stable when approaching 90 DAI.

Figure 7: Spore development of Mycorrhizae sp. spp. in various allowable soil moisture depletion



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SUMMARY, CONCLUSION, AND RECOMMENDATION

This study was conducted to determine soybean plants' performance in different allowable soil moisture depletion grown with and without Mycorrhizae sp. The experiment was conducted in the Lahar-laden area at Carael, Botolan, Zambales, from February to May 2020. A two-factor experiment was conducted utilizing a split-plot experimental design. The study treatments comprised two applications of Mycorrhizae sp. (main plot) and four allowable soil moisture depletions (subplot). Treatments were replicated thrice with ten plant samples per replicate. Soybean plants were grown in experimental beds, irrigated with the drip irrigation method, and raised for 90 days for evaluation. Spore population, soil moisture allowable depletion, growth performance, and yield parameters were collected and analyzed.

Results revealed that the plant height was significantly influenced by different allowable soil moisture depletions, with plants significantly taller when the soil was inoculated with Mycorrhizae sp. At 30 DAS, soybean maintained inoculated with Mycorrhizae sp. grew fastest in 40% MAD at 27.92 cm tall, followed by 60% MAD at 27.43 cm, 75% MAD at 27.40 cm tall, and the smallest plant height was grown on furrow irrigation obtained 24.60 cm. In contrast, plants grew without Mycorrhizae sp. the tallest plant height was grown at 60% MAD at 26.26 cm, 40% MAD at 26.14 cm, followed by 75% MAD and furrow irrigation with 25.52 cm and 23.86 cm, respectively. Using soil treated with and without Mycorrhizae sp. as planting media and different percentages of allowable soil moisture depletion did not significantly influence the plants' stem diameter. Soybean is grown in different percentages of available soil moisture and treated with Mycorrhizae sp. from the vegetative state (30 DAS), resulting in the biggest stem than those without Mycorrhizae sp. with stem diameter increments ranging from 2.90-3.38 mm and 1.80-2.47 mm, respectively.

The effect of soil moisture allowable depletion treated with Mycorrhizae sp. was not significantly influenced the development of branches of the soybean plant. The most produced soybean plant branches were grown in 40% MAD treated with Mycorrhizae sp. 2.98 branches, followed by 75% MAD 2.71 branches, traditional irrigation 2.56 branches, and the least produced was grown in 60% MAD 2.33 branches. On the other hand, soybean plants grown without Mycorrhizae sp. were grown in both 60% and 40% MAD and obtained 2.76 branches. The least produced branches were grown at 75% available moisture (MAD) 2.67 branches.

The leaf area index of the soybean plant was significantly affected by soil moisture allowable depletion but not significantly influenced by Mycorrhizae sp. The largest leaf developed was grown with and without Mycorrhizae sp. in 60% soil moisture allowable depletion with 61.70 cm^2 and 61.27cm^2, respectively. Followed by 40% soil moisture allowable depletion obtained 59.53 cm^2 without Mycorrhizae sp., 57.54 cm^2 treated with Mycorrhizae sp. At 75% soil moisture allowable depletion with 56.46 cm^2 grown with Mycorrhizae sp. and 56.31cm^2 without Mycorrhizae sp. The least leaf developed soybean plant was grown in traditional irrigation with and without Mycorrhizae sp. application, obtained 53.38 cm^2 and 49.91 cm^2, respectively.

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Different percentages of allowable moisture depletion and Mycorrhizae sp. applications significantly affected the root length of the soybean plant. The longest root length was grown in a drip irrigation system inoculated with Mycorrhizae sp. at 75% moisture allowable depletion obtained 43.92 cm long. Treatments without Mycorrhizae sp. recorded the longest root length in the drip irrigation system at 60% MAD, obtained 39 cm long.

The spore development of the beneficial fungus Mycorrhizae sp. was not affected by supplementing various irrigation systems to the soil medium. At 30 DAI, the highest VAM fungal spore development increment was observed in inoculated soils irrigated through furrow irrigation with 312.93 spores. In contrast, spore development was obtained with 272.18 stores in drip irrigation. Production of spores in the drip irrigation system rapidly increased from 31-90 DAI, giving the spore population count 356.84. VAM spores developed in furrow irrigation on the first 30 days from inoculation and became gradually stable when approaching 90 DAI.

Based on the objectives and supported by the results of the study, the following conclusions were drawn:

1. The use of 40% available MAD treated with Mycorrhizae sp. affected the plant height during the vegetative stage;
2. The effect of soil inoculated with Mycorrhizae sp. and irrigated with drip irrigation significantly affected the root length; and,
3. Soil inoculated with Mycorrhizae sp. enhanced the water-holding capacity of lahar-laden soil.

Based on the study's results, the following recommendations there made: trial of the study with an automated operation of drip irrigation, reading and data recording of MAD every day.

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