Effect of mycorrhizae, NPK and compost on vegetative and reproductive parameters of soybean (Glycine max L)

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Abstract- Soybean (*Glycine max* L: Fabaceae) is a mycotrophic (mycorrhizal) legume grown commercially for human consumption. It is a major grain legume cultivated in Sri Lanka. The greenhouse experiment was conducted to determine the influence of mycorrhizae as a substitute for inorganic fertilizer on growth and yield of Soybean (*Glycine max*) and observe how mycorrhizae inoculation affect to yield of soybean and soil microbial activity in drought condition.

Five different fertilizer mixtures; mycorrhizae, sterilized field soil with compost, Mycorrhizae, Sterilized field soil with standard dose of NPK, Sterilized field soil and compost and Strilized field soil and standard dose of NPK, non sterilized soil (control) were used. Each treatment was irrigated with three different water levels; 50ml, 100ml and 200ml per day. Experiment conducted in a Factorial Complete Randomized Design with three replicates. Statistical analysis was carried out using the Student Newman-Kuells Means Separation Test of SAS program (9.1.3).

Results indicated that significantly highest number of pods per plant was recorded in potting mixtures; mycorrhizae+sterilized soil+compost (22 pods/ plant) and sterilized field soil+compost (20 pods/ plant) comparing to other all treatments. There is no any interaction between water levels with application of mycorrhizae for all measured growth and yield parameters of soybean. However significantly different growth and yield parameters were observed in various potting mixtures and as well as 3 types of water levels. Mycorrhizae increase the soil microbial activity significantly comparing with field soil and potting mixture with inorganic fertilizer.

Index Terms- Mycorrhizae, Inorganic fertilizer, Soybean

I. Introduction

Inorganic fertilizer application enhances plant growth and yield because it absorbs quickly to soil and plants. Therefore farmers applied maximum amount of inorganic fertilizer to their crops to achieve higher yield. As a result of the excess inorganic fertilizer leaches to the ground water table it has to pollute. To avoid this situation, combination of inorganic fertilizer with biological ingredients is better to use in crop cultivation (Urban Creeks Council, 2001). Mycorrhiza (family: Endogone) is a type of organic fertilizer/bio fertilizer that creates mutuality symbiosis between mycorrhizal fungi and higher plants. Mycorrhizae improves crop yield and increases the use of inorganic fertilizer by forming a bridge between the roots and the soil (University of Washington, 2006). It is indirectly enhancing the structure of the soil and improves air and water infiltration.

Soybean (*Glycine max* L: Fabaceae) is a mycotrophic (mycorrhizal) plant native to East Asia. It is much depended on mycorrhizal symbiosis, classified as mycotropic plant. Soybean being a profitable crop that grown commercially for human consumption. At present soybean is one of the five major grain legumes cultivated in Sri Lanka. It is recognized as a potential food crop that can bridge the gap between the national needs and the availability of protein, as well as edible oil requirement in Sri Lanka (Arulandy, 1995).

Virtually all plant taxa have well-established symbioses with a large variety of microorganisms. Mycorrhizae are known to stimulate plant growth and nutrient absorption and enhance the drought tolerance. Plants colonizing mycorrhizae might improve soil quality and natural interactions in the soil (Auge, 2001). Therefore the hypothesis of the present study was mycorrhizae inoculation to the Soybean grown soils will alleviate the water stress of Soybean.

II. Materials and Method

Study was conducted at Faculty of Agriculture, University of Ruhuna, Mapalana, Kamburupitiya (low country ,16m from sea level) wet zone (WL_2) where the annual rainfall is greater than 1,900 mm. The mean monthly temperature is 27.5^0C and relative humidity is around 72%.

Soybean (variety PM 25) seeds were obtained by Department of Agriculture. Pots were filled with potting media and sterilized using Dimethyl [(1,2-phenylene)bis-(iminocarbonothioyl) fungicide (400g/l EC) . After sterilization, pots were kept wet for seven days. Seeds were covered by thin soil layer and watering was done daily. After twenty one days of nursery period, healthy same size (5cm) seedlings were kept in the pots and maintained three plants per pot. Thinned out weaker plant after 10-12 days and remained two plants in each pot.

Five different fertilizer mixtures; mycorrhizae andsterilized field soil with compost (M+C), Mycorrhizae andstrilized field soil with standard dose of NPK (M+NPK), Sterilized field soil withcompost (SS+C) and Strilized field soil with standard dose of NPK (SS+NPK), non sterilized soil (control) were used. Standard dose of mycorrhizae and NPK (2g mycorrhizae/5L water, NPK- 35:130:35 respectively) was used. Each treatment was irrigated with three different water levels; 50ml, 100ml and 200ml per day.

All management practices were conducted according to recommendations of the Department of Agriculture from seed germination to harvesting. Soil microbial activity was measured according to the CO_2 evolution method.

After 8 weeks plants were harvested. Number of leaves per plant at 25 days, number of leaves per plant at 45 days, shoot length, number of pods per plant, wet weight of pod per plant, , plant wet weight, and were measured. Treatments were undertaken in Factorial Complete Randomized Design to avoid any biases and make better estimation of treatment effect. Each treatment was replicated five times. Data were analyzed using SAS program (9.1.3).

III. Results and Discussion

There is no any interaction between water levels with application of mycorrhizae for all measured growth parameters of soybean. However significantly different growth and yield parameters were observed in various potting mixtures and 3 types of water levels (Fig 1 and 2, Table 1). When consider all treatments which we practiced; at the lower water levels in soil significantly decreased all growth parameters of soybean (Table 2 and Fig 3).

When consider average values of leaf number per plant at 25 days (beginning of vegetative stage) and after 45 days (end of the vegetative stage) in all water levels significantly higher number was observed in potting mixtures; mycorrhizae+sterilized soil+compost and mycorrhizae+compost+inorganic fertilizer where mycorrhizae was applied.

The significantly highest plant wet/fresh weight was observed at the potting mixture Sterilized field soil+ compost (19.4g) and 200ml water level (12.6g).

More root nodules were observed in potting mixture mycorrhizae+sterilized soil+compost comparing to the other all treatments. The adding of compost could increase the soil porosity and decrease the mechanical soil resistance to the growth of mycorrhizae. In the potting mixture mycorrhizae+compost+inorganic fertilizer didn't observe nodules due to inorganic fertilizer may inhibit the growth of mycorrhizae. Same results also reported Smith *et al*, 2010 when synthetic fertilizer was present reduced the arbuscular mycorrizal colonization. Addition of compost would increase the soluble organic matter content in the soil. This would be the result of increased mycorrhizae growth and initiate root nodules.

Shoot length of the plant also affected positively with increasing the water levels but it was not significant In the treatments with mycorrhizae inoculums, addition mycorrhizal hyphae might improve nutrient and water absorption to the plants through roots.

As indicated in Table 1 highest number of pods per plant was recorded in potting mixtures; mycorrhizae+sterilized soil+compost (22 pods/ plant) and Sterilized field soil+compost (20 pods/ plant). The lowest mean number of pods was recorded in (11 pods/soybean plant) when used non sterile field soil as the potting medium.

Highest wet weight of pods/plant was recorded in sterilized field soil+compost potting medium (11g/ plant) comparing to other all treatments. Lowest wet weight was recorded in non sterilized field soil (5.2g/ plant) and it was not significantly different from potting medium Strilized field soil + standard dose of NPK (5.6g/ plant).

Highest microbial activity (emitted CO_2 mg/kg of soil) was observed in potting medium mycorrhizae+sterilized soil+compost (600 CO_2 mg/kg soil) and it was significantly different from all other treatments (Fig. 4). Rod, R (2005) was observed mycorrhizal fungi constitute the dominant micro-organisms in most undisturbed soils estimated at about 70% of microbial biomass. However potting medium, mycorrhizae+ compost+inorganic fertilizer was reduced (300 CO_2 mg/kg soil) microbial activity by 50% comparing to mycorrhizae+sterilized soil+compost. The same results were observed by Seran *et al* 2010 soil micro and macro organisms are reduced with the presence of inorganic fertilizers as compared to organic fertilizers.

Table 2. Effects of different water levels on the growth and yield of Soybean

Treatment	Shoot length (cm)	Number of pods/plant	Pod wet weight (g)	Plant wet weight (g)
W_1	78.3 a	12.8 c	5.8 b	9.7 b
W_2	78.1 a	15.4 b	6.6 b	10.7 b
W_3	84.5 a	21.7 a	9.2 a	12.6 a

Column values followed by the same letter are not significantly different as determined by Duncan's multiple range test (P=0.05).Values in same column with same letter denoted non- significant difference

IV. Conclusion

Highest number of pods per plant was recorded in potting mixtures; mycorrhizae+sterilized soil+compost (22 pods/ plant) and sterilized field soil+compost (20 pods/ plant) comparing to other all treatments.

Addition of mycorrhizae increases the soil microbial activity significantly comparing with potting mixtures with inorganic fertilizer, sterilized soil with compost and field soil

References

[1] Arulandy, V (1995), Breeding soybean varieties for Sri Lankan conditions, Retrieved November o6, 2012, From agrilearning.goviya.lk/Pulses/Pulses research/soya/So4.pdf

[2] Auge, R. M.(2004). Arbuscular mycorrhizae and soil/plant water relations. Can. J. Soil Sci. 84, 373-381.

[3] Rod, R (2005), Understanding mycorrhizalfungi , Retrieved August 07, 2012, from www.carbonlink.com.au/data/files/downloads/understanding mycorrhizal fungi.pdf

[4] Seran, TH, Srikrishnah, S, Ahamed, MMZ 2010, Effect of different levels of inorganic fertilizers and compost as basal application on the growth and yield of onion (Allium cepa L.) , The Journal of Agricultural Sciences, vol. 5, no 2

[5] Smith SE, Smith FA (2010) Roles of arbuscular mycorrhizas in plant nutrition and growth: new paradigms from cellular to ecosystems scales. Annu Rev Plant Biol 63: 227–250

[6] University of Washington (2006), Retrieved August 07, 2012, from http://green-diamond-biological.com/wp-content/uploads/2012/03/Mycorrhiza-article.pdf5

[7] Urban Creeks Council n.d., Bio fertilizers and Mycorrhizae, Retrieved August 24, 2012, from http://www.urbancreeks.org/Biofertilizers.pdf

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Table 1. Growth parameters of Soybean in different treatments. [mycorrhizae, sterilized soil with compost (T1), Mycorrhizae, strilized field soil with standard dose of NPK (T2), Sterilized field soil and compost (T3) and Strilized field soil and standard dose of NPK (T4), non sterilized soil (control-T5) were used. Standard dose of mycorrhizae (2g mycorrhizae/5L water) was used. Each treatment was irrigated with three different water levels; 50ml (W1), 100ml (W2) and 200ml (W3) per day].

Treatment	Shoot length (cm)	Number of pods/plant	Pod wet weight (g)	Plant wet weight (g)
$T_{1\ (M+C)}$	93.4 a	22 a	7.7 b	11.7 b
$T_{2(M+NPK)}$	77.5 b	16b	6.6 bc	8.9 c
$T_{3(SS+C)}$	93.7 a	20a	11.0 a	19.4 a
$T_{4(SS+NPK)}$	73.4 b	15 b	5.6 c	7.5 c
$T_{5(NS)}$	63.6 c	11 c	5.2 c	6.7 c

Column values followed by the same letter are not significantly different as determined by Duncan's multiple range test (P=0.05).Values in same column with same letter denoted non- significant difference

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Fig 1. Effects of mycorrhizae inoculation to the potting mixture on the growth and development of soybean plant at same water level (100ml/ day).

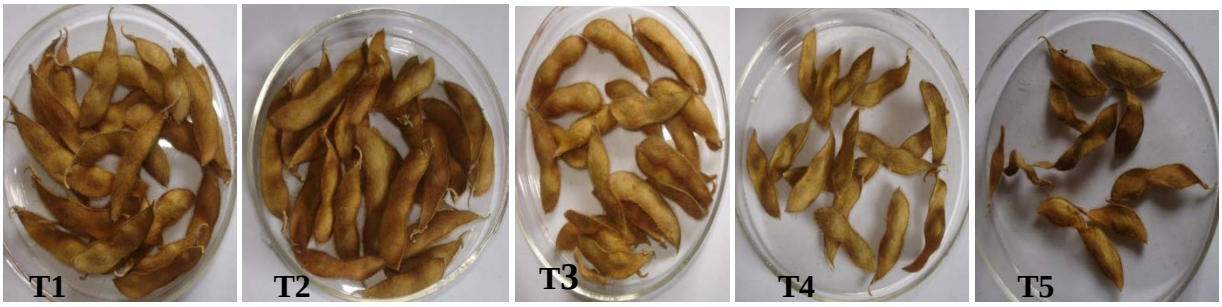


Fig 2. Effects of mycorrhizae inoculation to the potting mixture on the growth and development of soybean pods at same water level (100ml/ day)

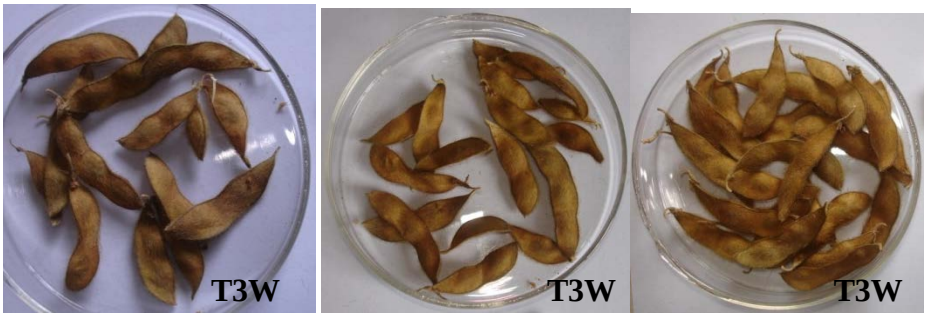
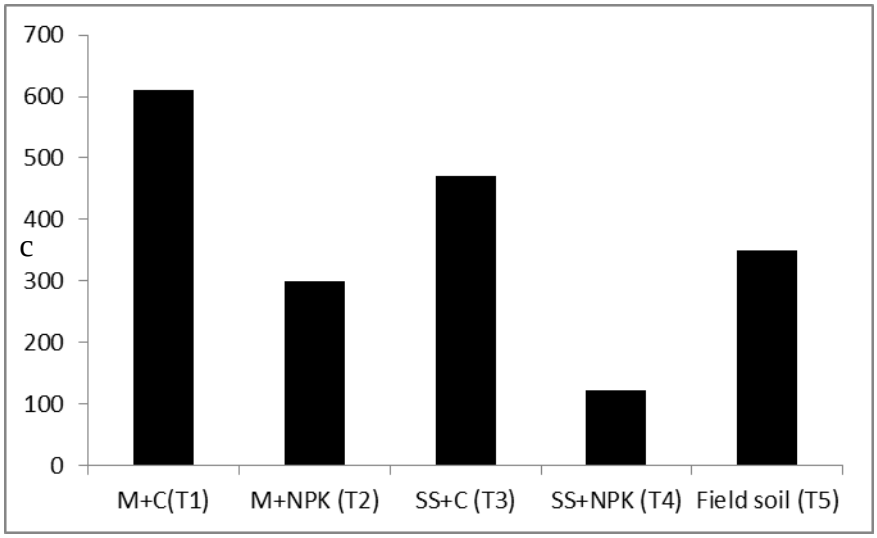


Fig 3. Effects water content to growth and development of soybean pods at T3.

Fig 4. Effect of potting mixtures on soil Microbial activity. (Omitted CO2 concentration mg/kg)

a



c

Column values followed by the same letter are not significantly different as determined by Duncan's multiple range test (P=0.05).Values in same column with same letter denoted non- significant difference