Contribution of arbuscular mycorrhiza inoculation on the growth and phosphorus nutrition of jatropha (*Jatropha curcas*) in degraded upland soils of Samar, Philippines

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Abstract
Pot culture experiments were conducted to evaluate the effects of arbuscular mycorrhiza (AM) inoculation and NPK fertilization on the growth and phosphorus nutrition of *Jatropha curcas* in degraded upland soils from Samar, Philippines. Treatment combination of AM inoculation x P application, and AM inoculation x levels of NPK fertilization were evaluated. Results showed that arbuscular mycorrhiza and phosphorus application enhanced the growth and yield of jatropha and increased P uptake compared to those treatments without AM or P application. Plants treated with 15kg NPK/ha + AM, 30kg NPK/ha+ AM and 60kg NPK/ha were taller and have higher dry matter yield compared to the non-fertilized, non inoculated control. The P concentration and uptake was higher in AM inoculated plants than those without AM even at higher NPK application rates. Analyses of the rhizosphere soil contained higher water soluble P and 0.1M HCL extractable P in AM inoculated pots indicating higher P availability due to AM inoculation and higher microbial activity as estimated by acid phosphatase levels in soils compared with that of the bulk soil or the uninoculated control.

Key words
Acid upland soils, arbuscular mycorrhiza, *Jatropha curcas*, phosphorus nutrition, NPK fertilization

Introduction

In response to escalating concern on environmental pollution caused by the conventional fossil fuels and the realization that they are non-renewable have led to search for more environment friendly and renewable fuels, the Philippine Biodiesel Act was established and has allocated and prioritized the utilization of grasslands for jatropha production. These grasslands are usually marginal lands that are situated in the rolling topography. On top of that, there were no established fertilization and nutrient management schemes that would optimize the yield and productivity of *Jatropha curcas* under marginal grassland areas in the Philippines. Although jatropha is considered to be sturdy and can survived in marginal environments, proper agronomic practices such as fertilizer application and soil nutrient management strategies are still necessary in order to obtain optimum yield and economic returns. Therefore this study was being proposed to establish the most advantageous fertilization scheme and soil nutrient management strategies for improved growth and yield of *Jatropha curcas* in two major upland soil types in Samar, Philippines. Specifically, this study (i) determine the contribution of arbuscular mycorrhiza in combination of NPK fertilization on the growth and P nutrition of jatropha and (ii) to determine the optimum NPK fertilization rate for *Jatropha curcas* grown in degraded upland soils.

Materials and Methods

Experiment 1. Effect of AM inoculation and P application on the growth of jatropha

Surface soil (0-20 cm depth) representative of Libertad clay and Luisiana clay were collected from degraded grassland areas in Pinabacdao, Samar and Lavezares, Northern Samar, Philippines. Bulk soil samples were air-dried and sieved through 2 mm-diameter screen wire to remove undecomposed organic materials. Some of the chemical properties of the soil used in the experiment are presented in Table 1. A total of 24 pots (12 pots for each type of soil) containing 30 kg soil were prepared prior to plant establishment. Mature seeds were collected, dehusked and air dried were planted at the center of each pot. Prior to sowing of seeds, arbuscular mycorrhiza inoculation (10g/hill) was performed in treatments involving mycorrhiza. One week after germination, thinning of seedlings into one plant per pot was performed. The plants were maintained under screen house condition for 8 weeks The treatments combination include +AM+P, +AM-P, -AM+P, -AM-P. All plants were supplied with 50mg/kg N and K_2O. After the experiment, the roots were shaken vigorously to separate the soil not tightly adhering in the roots. The remaining soil adhering on the roots were considered as the rhizosphere soil.

Experiment 1. Effect of AM inoculation and NPK application on the growth of jatropha
Essentially, experiment 2 followed the same procedure with that of experiment1 and used the same soils collected from the same site as described previously. However the following treatments involving different levels of NPK application rates and mycorrhiza inoculation were employed. These are: T1 (no fertilizer application); T2 (15-15-15 kg NPK/ha/year + AM); T3 (30-30-30 kg NPK/ha/year + AM) and T4 (60-60-60 kg NPK/ha/year). All other experimental procedures followed with that of Experiment 1.

Table 1. Some chemical properties of Libertad clay and Luisiana clay used in the experiment.

Soil properties	Luisiana Clay	Libertad Clay
pH (1:1, soil, water)	4.6	5.2
OM (% odw)	0.15	4.25
Total N (% odw)	0.2	0.13
Avail P (Bray P2, mg/kg)	0.9	0.3
Exch K (1N NH_4COOH, pH 7; cmol+/kg)	0.37	0.62
CEC (cmol+/kg)	16.5	21.1

Results and Discussions

Effect of AM inoculation and P application on the growth of jatropha
Arbuscular mycorrhiza and phosphorus application have significantly affected the growth and dry matter yield of jatropha grown for 6 weeks in acidic upland soil. The total dry matter yield was significantly increased by both AM inoculation and P application and that the yield was enhanced by AM inoculation regardless of the P application (Table 2). Plants treated with P fertilizer have more phosphorus contents in shoots and in roots compared to the –P treatments. However, the P concentration in shoots and in roots were enhanced by AM inoculation as manifested by almost eight fold and 6-fold increase in shoot-P concentration due to +AM+P treatments and in –AM+P or +AM-P treatments compared to the –AM-P treatment, respectively. The roots P content was also enhanced by more than five-fold due to either AM inoculation or P application compared to the –AM-P control. Analyses of the rhizosphere soil contain higher water soluble P and 0.1M HCL extractable P in AM inoculated pots indicating higher P availability due to AM inoculation and higher microbial activity as estimated by acid phosphatase levels in soils compared with that of the bulk soil or the uninoculated control (data not shown). This result implied that the mycorrhiza inoculation helped the host plant in the absorption of phosphorus in soil by increasing P availability that resulted to higher concentration and uptake thereby improving the P nutrition of jatropha grown in P-deficient acid soil. Similarly, results would also indicate the favorable effect of AM inoculation on the overall NPK uptake of jatropha in acid soils which are characterized to be deficient in available P. This data would indicate that in acidic soil, P application could improve plant growth but its effect could be enhanced by the presence of AM colonization.

Table 2a. Dry matter yield, P concentration and P uptake of jatropha grown in Libertad clay for 6 weeks as affected by AM inoculation and P application.

	Dry Weight (gm)			P Concentration (g/100g)		P Uptake (mg/plant)	
TREATMENT	shoots	roots	Total	Shoots	Roots	Shoots	Roots
+AM+P	5.77 a	2.33 a	8.10 a	0.56 a	0.34 a	32.5 a	7.9 a
+AM-P	4.69 ab	1.85 b	6.53 b	0.41 b	0.24 b	19.1 b	4.5 b
-AM+P	3.77 b	1.50 c	5.27 b	0.41 b	0.28 b	15.4 c	4.2 b
-AM-P	2.40 c	0.87 d	3.27 c	0.07 c	0.05 c	1.7 d	0.4 c

Table 2b. Dry matter yield, P concentration and P uptake of jatropha grown in Luisiana clay for 6 weeks as affected by AM inoculation and P application.

TREATMENT	Dry Weight (gm)			P Concentration (g/100g)		P Uptake (mg/plant)	
	shoots	roots	Total	Shoots	Roots	Shoots	Roots
+AM+P	7.72 a	3.13 a	10.85 a	0.63 a	0.36 a	48.64 a	11.27 a
+AM-P	6.29 ab	2.21 b	8.50 b	0.48 b	0.22 b	30.19 b	4.86 b
-AM+P	5.73 b	1.98 c	7.71 b	0.52 b	0.28 b	29.8 b	5.54 b
-AM-P	3.60 c	1.12 d	4.72 c	0.09 c	0.06 c	3.24 c	0.67 c

Effect of AM inoculation and NPK application on the growth of jatropha

The growth and development of jatropha grown on Libertad and Luisiana clay has been affected by different levels of NPK fertilization and arbuscular mycorrhiza inoculation. Plant height, number of leaves, number of branches and stem diameter of jatropha were significantly affected by increasing levels of NPK fertilization (data not shown). The plants treated with 15kg NPK/ha + AM, 30kg NPK/ha+ AM and 60kg NPK/ha gave an overall increment of more than 6.5 to 7.8 fold for shoots and more than four-fold in roots over the control (T1). Overall increase in dry matter yield due to NPK fertilization and AM inoculation was more than six-fold over the control (Table 3).

The phosphorus contents in shoots were almost 32 fold higher in T2, 46-fold higher T3 and 15 times higher in T4 compared to the control. The overall P uptake showed significant differences among the different treatments with higher values on AM inoculated plants regardless of the P fertilization levels. This would imply that in acidic soil, increasing the P levels will not result to higher P concentration in plant tissues but its effect is rather small compared to the effect of mycorrhiza symbiosis.

Based on the growth performance and the nutritional status of jatropha grown for 12 weeks under pot culture conditions, a fertilization rate of 15 kg NPK/ha together with AM inoculation will improve significantly the growth and development of jatropha grown in Libertad clay. However, when comparison on the growth performance of the two upland soils would be made, it could be observed that the growth of jatropha in Libertad clay is much more inferior compared to those grown in Luisiana clay even if the plants in Libertad clay be fertilized with 60kg NPK per hectare (Figure 1). The difference in growth performance between the two-upland soils could be ascribed to the differing inherent fertility level in the soils most especially the levels of available phosphorus and the soil acidity.

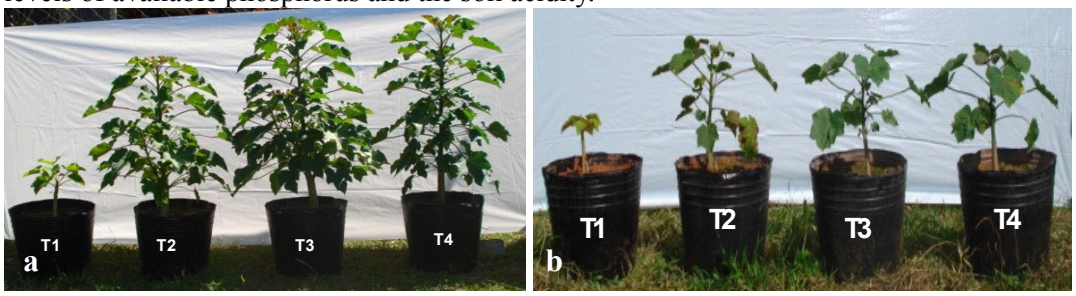

Figure 1. Photo showing the growth of jatropha as influenced by fertilizer application and mycorrhiza treatments grown for 12 weeks in (a) Libertad and (b) Luisiana clay.

Table 3a. Dry matter yield, P concentration and P uptake of jatropha grown in Libertad clay for 12 weeks as affected by AM inoculation and NPK application.

	Dry Weight (gm)			P Concentration (g/100g)		P Uptake (mg/plant)	
Treatment	**shoots**	**roots**	**Total**	**Shoots**	**Roots**	**Shoots**	**Roots**
T1	22.3 a	9.5 a	31.8 a	0.07 a	0.09 a	1.4 a	0.8 a
T2	145.7 b	45.0 b	190.6 b	0.30 b	0.27 b	44.6 c	12.1 c
T3	173.3 b	47.0 b	220.3 b	0.36 b	0.31 b	63.3 d	14.4 c
T4	169.7 b	46.0 b	215.7 b	0.12 a	0.11 a	20.2 b	4.9 b

Table 3b. Dry matter yield, P concentration and P uptake of jatropha grown in Luisiana clay for 12 weeks as affected by AM inoculation and NPK application.

	Dry Weight (gm)			P Concentration (g/100g)		P Uptake (mg/plant)	
Treatment	**shoots**	**roots**	**Total**	**Shoots**	**Roots**	**Shoots**	**Roots**
T1	5.1 a	3.0 a	8.1 a	0.07 a	0.05 a	0.4 a	0.1 a
T2	24.7 c	10.7 c	35.4 c	0.40 c	0.24 c	9.8 c	2.6 b
T3	41.7 d	7.6 bc	49.3 d	0.56 c	0.28 c	23.5 d	2.1 b
T4	14.7 b	5.2 b	19.9 b	0.12 b	0.10 b	1.8 b	0.5 a

Conclusion

The results implies that AM has a profound effect on P mobilization and uptake by the jatropha plant grown in acidic soils like the Luisiana and Libertad clay and that higher P application in acidic soils did not

necessary effected to high P availability and uptake due to the phenomenon of P fixation and immobilization by aluminum and iron oxides which are dominant in acidic soils.

References

Chachage B (2003) Jatropha oil as a renewable fuel for road transport. Policy implications for technology transfer in Tanzania. M.Sc. Thesis, International Institute for Industrial Environmental Economics, Lund University, Lund.

Openshaw K (2000) A review of Jatropha curcas: an oil plant of unfulfilled promise. *Biomass and Bioenergy* **19**, 1–15.