Feasibility of using phosphate solubilizing microorganisms native to Sri Lankan soils to improve phosphorus nutrition of some selected crop plants

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Abstract

Management of soil fertility and plant nutrition by the application of biofertilizers has been in the practice worldwide, their commercial application is a novel concept to Sri Lanka. Hence, this research was focused on introducing a native phosphate biofertilizer for Sri Lanka agriculture.

Soil samples, collected from rhizosphere and bulk soils of organically cultivated eight cinnamon species, one cocoa species and three pepper species were screened using Pikovskaya (PVK) medium to isolate phosphate solubilizing microorganisms (PSMs). A total of 53 PSMs: 12 fungi and 41 bacteria were obtained and coded for convenience. A secondary screening to detect the persistence of the solubilization ability in the presence of soluble P yielded 12 fungi and 26 bacteria from the above total. Efficiencies to solubilize insoluble tri calcium phosphate and ERP were assessed on liquid PVK and ERP-PVK media. Three fungal: MPsRF1, MCvRF1, TCvgRF5, and one bacterial isolate: MPlRB2, were identified as efficient solubilizers and identified as *Aspergillus niger*, *Trichoderma virens*, *Penicillium oxalicum* and *Klebsiella variicola*. A possible synergism between four species towards phosphate dissolution was detected using the PVK and ERP-PVK broth cultures. *A. niger* in combination with *P. oxalicum* recorded the highest significant dissolved phosphate levels of 893.43 (±56.768) mg P/L and 309.42 (±42.52) mg P/L, respectively, within 72 h post inoculation ($P \leq 0.05$).

A total of 13 different substrates were evaluated for finding a suitable and easily available substrate for effective mass propagation of *A. niger* and *P. oxalicum* and identified refuse tea as a suitable substrate. *A. niger* and *P. oxalicum* combination was tested for their performance in increasing P nutrition of rice, cinnamon and pepper in pot and field studies. Pot experiments were conducted according to the complete randomized design while field experiments were laid out according to the randomized complete block design. In all experiments, plant growth, and yield parameters, soil available and plant P & soil microbial parameters were taken into account. The data gathered were subjected to one way ANOVA, two way ANOVA and multiple mean comparison test using the Minitab 16.1.1 statistical software.

Rice pot experiment had two factors: (1) microbial inoculation (2) applied phosphorus amount. A total of fourteen different treatments with five replicates were used. Rice pot experiment was carried out at RRDI, Bathalagoda. Both the growth and yield parameters showed significant variability of ($p \leq 0.05$) among the treatments. The highest grain weight per pot (15.21 ±1.69 g) was given by the treatment containing only the inoculum of two fungi without applied chemical fertilizers. In almost all the parameters measured, significant increments were observed in treatments containing the inoculum over treatments with chemical fertilizer.

Rice field experiment consisted of six different treatments: zero input control (T_0), recommended level of fertilizers only (T_3), half recommended level of TSP + inoculum + recommended level of urea and MOP (T_8), half recommended level of TSP + half recommended level of P_2O_5 replaced by ERP + Inoculum + recommended level of urea and MOP (T_{12}), sterilized mass cultivation medium only (T_{13}) and inoculum only (T_{14}) and same parameters used in pot experiment were measured and analyzed. It was carried out in Kurunegala, in a field which was not fertilized for more than 10 years. Inoculum showed significantly positive effects on mean plant height, mean number of panicles per plant, mean number of filled and total grains per plant, mean grain weight and soil available P ($p \leq 0.05$). Most of the parameters measured in the treatment containing inoculum + 50 % TSP showed significantly high or significantly not different results with that of with the standard control. The highest mean grain weight per plant (17.76 ± 1.92 g) was recorded in the treatment containing inoculum + 50% TSP while second highest mean grain weight per plant of 15.71 ± 2.55 g was shown by the standard control. Overall results confirmed the possibility of

replacing 50% of TSP from rice cultivation by the phosphate biofertilizer contained *A. niger* and *P. oxalicum*.

Cinnamon pot experiment was conducted at the premises of Department of Plant Sciences and it contained six treatments: recommended level urea and MOP only (T_1), recommended level urea, MOP and half recommended level ERP only (T_2), recommended level urea, MOP and ERP only (T_3), recommended level urea and MOP + inoculum (T_4), recommended level urea, MOP and half recommended level ERP + inoculum (T_5) recommended level urea, MOP and ERP + inoculum (T_6). Each treatment had 12 replicates and data were gathered by three destructive samplings carried out at three months intervals. Among the growth, soil and microbial parameters measured, treatments which had inoculum failed to show positive effect on cinnamon plants ($p \geq 0.05$). Hence, same treatments were repeated in cinnamon field experiment which was done at Dodamgaslanda Estate, Kurunegala. Non-destructive sampling was carried out twice at six months intervals. Here also *A. niger* and *P. oxalicum* could not exhibit a positive effect on cinnamon growth and soil available P.

Pepper pot experiment was done at plant house of Department of Plant Sciences. It contained 21 different treatments having two factors: (1) microbial inoculation and mass cultivation medium and (2) phosphorus level. First factor consisted with seven levels while second factor contained three levels. Each treatment contained five replicates. Among the growth, soil, plant and microbial parameters measured, none of the treatments containing the inoculum showed significant effect ($p \geq 0.05$). Pepper field experiment was carried out at Dodamgaslanda Estate with eight treatments: without ERP (T_1), half recommended ERP only (T_2), ¾ recommended ERP only (T_3), recommended ERP only (T_4),without ERP + inoculum (T_5), half recommended ERP +inoculum (T_6), ¾ recommended ERP + inoculum (T_7), recommended ERP + inoculum (T_8). Each treatment had three replicates for each block. Similarly to pot experiment, inoculum did not show any significant effect on any of the growth, microbial and soil parameters measured. Hence, further experiments are recommending to finding out the suitability and applicability of the phosphate biofertilizer for perennial plants.