Effect of Long Term Phosphorus Fertilizer Application on Phosphorus Availability and Cd Accumulation in Rice Soils (*Oryza sativa* L.)

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Introduction

Rice occupies approximately 33 % of the total cultivated area in Sri Lanka accounting to 0.78 million hectares (Central Bank of Sri Lanka, 2010). Plant nutrients are essential for the production of crops and in term of healthy food for the world's increasing population. In that context, phosphorus (P) is an important nutrient in rice cultivation. P is directly absorbed form soil and makes up 0.1% - 0.4% of the dry matter in plants. It involves in carbohydrate breakdown for energy release, cell division and transfer of inherited characters. P stimulates early root growth and development, hastens maturity of plant, improves seed production and involves in energy transformation. Since supply of P from soil is not enough to obtain higher grain yields, farmers are advised to apply P fertilizer into soil. These synthetic fertilizers carry lot of heavy metals such as Cd as contaminants. Scientists are of great interest at the moment of the contamination of heavy metals to paddy fields through P fertilizer especially super phosphate (TSP). Cadmium (Cd) is a toxic heavy metal and is also known as one of the major environmental pollutants. Cd is dissolved in water, taken by crops, transferred to human body by ingestion causing health problems. This research was conducted to study the effect of P fertilizer application in the long term basis on soil fertility status and grain yield of paddy.

Methodology

The study was conducted at Rice Research and Development Institute Batalagoda situated in the low country intermediate zone IL1 agro ecological region of Sri Lanka (longitudes of 800 and 810 and latitude of 70 and 80 at an elevation of 65 meters above sea level). Soils of the experimental site belong to Kurunagala soil series and great soil group of Psummentichupludult. Treatments namely: no P fertilizer (T1); seasonal P fertilizer application (T2); alternative seasonal P application (T3) were used and arranged in Randomized Complete Block Design (RCBD) with four replicates. P fertilizer rates added to the above experiment were based on the recommendation given by the Department of Agriculture (Department of Agriculture, 2001). Urea, triple super phosphate (TSP) and Murate of Potash (MOP) were added at the rate of 120 kg N ha^{-1}, 35 kg P_2O_5 ha^{-1} and 30 kg K_2O ha^{-1} respectively. Soil samples were analyzed for available P and total P contents. Plant samples were analyzed for plant P contents. To determine Cd accumulation in soil, straw, seeds, plant and soil samples were analyzed. Having air dried and passed through 2 mm sieve, each sample was thoroughly ground into fine powder and total P, available P and Cd were measured.

Results and Discussion

According to the results of the analysis the Plots treated with P fertilizer had the highest level of soil P and plant P whereas the control plots had the lowest level of soil P and plant P (Table 1). Over time, available P concentration increased and that may be attributed to submergence and decomposition of straw and stubbles. According to the results given in the table 1, the available soil P has reduced drastically from 4WAP to 8WAP and that is mainly due to crop uptake. The available P amount has not changed after 8 weeks until the harvesting time. The changes in total P levels in different treatments followed the same pattern (Table 1). There was a fluctuation in

total P levels with time. It is speculated that there may be different sources of P fertilizers, which provide the P to the soil during the growing time. According to the plant P (Table 1) rice plant absorbed most of its phosphorous at 8 WAP. After that age there was a very limited amount of P in rice plants.

Table 1. Mean values of available P in soil, total soil P and P in plants (mg/kg).

	Treatments	Before transplanting	4 WAP*	8 WAP	12 WAP
Soil available P	T1	7.24	13.79	7.37	7.04
	T2	8.54	23.87	11.32	12.17
	T3	9.27	15.58	9.28	7.64
Total soil P	T1	95.68	56.30	89.11	61.67
	T2	98.06	74.19	102.12	86.56
	T3	96.95	56.98	91.10	65.53
Plant P	T1	-	1280.03	1285.61	1226.43
	T2	-	1352.79	1313.80	1245.41
	T3	-	1291.23	1296.91	1215.13

*Weeks After Planting

The analysis for Cd revealed that there was no significant ($P<0.005$) difference in soil Cd concentration with the application of P fertilizer (Table 2). It was appear that even without application of P fertilizer there was a considerable amount of Cd in the paddy soil. Cd concentration in plant parts decreased with the application of P fertilizer. This may be due to higher biomass production with the application of P fertilizer. No significant difference ($P<0.005$)in seed Cd concentration with the application of P fertilizer could be observed.

Table 2. Mean values of soil Cd, plant Cd and seed Cd levels (mg/kg).

Treatments	Soil Cd	Plant Cd	Seed Cd
T1	0.235	0.756	0.390
T2	0.198	0.631	0.430
T3	0.285	0.531	0.473

As the results showed (Table 3) that there was no significant difference ($p<0.005$) among the treatments for the filled grain percentage, 1000 grain weight and number of panicles per m^2. However, the grain yield was significantly higher ($p<0.005$) with application of P fertilizer. The factors that contribute to a significantly higher yield were number of panicles per m^2 and integration of the other yield components with it. The higher biomass production with increased availability of phosphorus may be the result for significant higher yield in T2.

Table 3. Grain yield and yield components.

Treatments	Filled grains (%)	1000 grain Weight(g)	Number of panicles (m^{-2})	Yield (kg)
T1	81.404	25.363	181.500	6.510
T2	82.420	25.598	209.550	7.525
T3	81.587	25.143	186.450	6.900

Conclusions

There was a positive relationship between grain yield and application of P fertilizer. With increasing P fertilizer application, increase in yield could be observed. No significant difference between alternative seasonal P application and no P application for a long time indicate that the alternative P application was not enough to maintain soil P levels as well as grain yield of rice. There was a positive relationship between total P and Available P levels as well. With

decreasing total P levels the available P levels increased. Higher yields reduction in Cd in grains was observed. Though Cd is supplied with P fertilizer, the reduction in soil Cd could be observed with the application of P fertilizers due to higher biomass production. Therefore it can be suggested that high yielding rice varieties having a little Cd content in seeds.

Reference

Department of Census and Statistics: Agriculture and Environment Statistics Division. [Online]. Available at: http://www.statistics.gov.lk/agriculture/index.htm