Title
Effect of submergence on alleviation of soil acidity and availability of nutrients in a rice-rice ecosystem

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Introduction

Soil acidity is one of the major constraints that retard production of rice in many parts of the world. The most common chemical constraints are Al toxicity, P fixation and deficiency, N, K, Ca, Mg, S, Zn deficiency and low cation exchange capacity. The optimum pH (measured in the solution of submerged soil) for rice (*Oryza sativa*) is about 6.6. Kerala, the southern most state of Indian peninsula, lies between $8^0$18' and $12^0$48' north latitudes and $74^0$52' and $77^0$22' east longitudes. It has a total geographical area of 38,864 km^2, which is about 1.2 % of total area of India and 98% of area is acidic in nature. Climate is typically humid tropical with clear wet and dry seasons. Have an isohyperthermic temperature regime and an ustic soil moisture regime in major part of the state

Materials and methods

The present study was conducted in the rainfed low land rice soils of Kerala to unveil the effect of submergence on the soil acidity and the kinetics of the availability of nutrients. Soil samples were collected from the 12 major rice growing tracts (3 each from each wet land tract) and invitro study was conducted by maintaining 5 cm water above soil for 12 weeks using CRD split plot design. The intial as well as fortnightly pH, available N, P, K, Ca, Mg, S, Na, K, Fe, Mn, Zn, Cu, Al and Si were determined by standard procedures outlined by Jackson (1973).

Results and discussion

All the soils studied were acidic except the black soils of Chittoor which are neutral to alkaline in reaction(Table1)

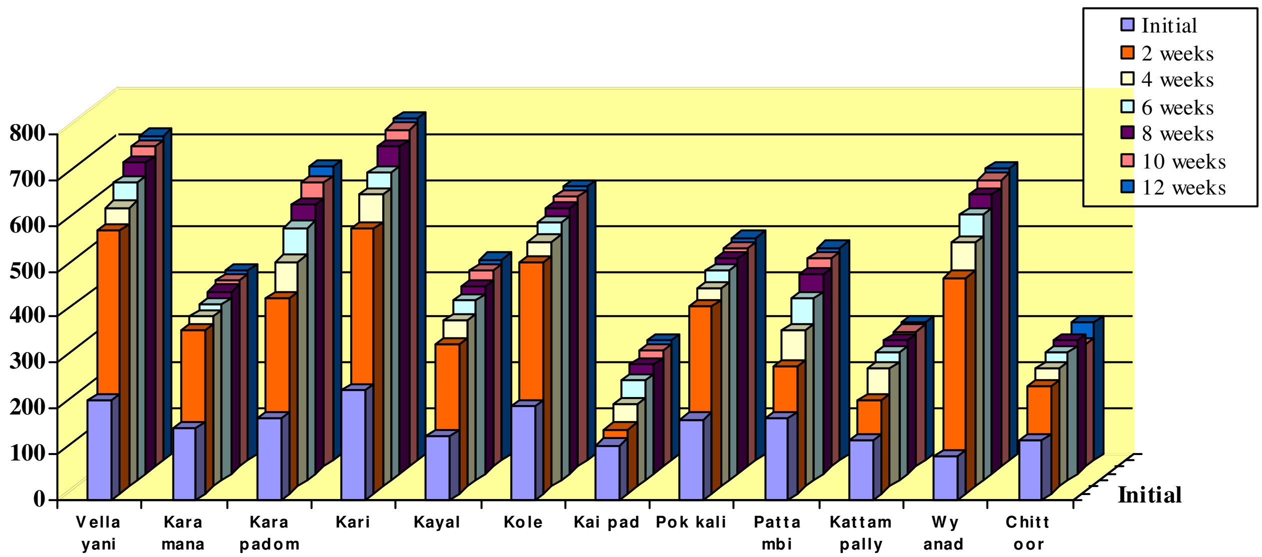
Table 1. Kinetics of pH due to submergence in wetland rice soils

Name of wetland	Initial	2 weeks	4 weeks	6 weeks	8 weeks	10 weeks	12 weeks	Mean
Vellayani-Typic Fluvaquent	4.33	5.53	6.20	6.28	6.34	6.44	6.46	5.71
Karamana- Typic Tropaquent	5.30	6.50	6.56	6.56	6.57	6.65	6.68	6.25
Karapadom-Aeric Tropaquept	4.56	5.26	5.90	6.10	6.30	6.25	6.26	5.62
Kari- Typic Sulfaquent	3.53	4.35	5.16	5.30	5.35	5.46	5.58	4.73
Kayal- Typic Hydraquent	4.26	4.43	4.58	4.91	5.00	5.01	5.04	4.6
Kole- Typic Tropaquept	4.50	4.60	5.86	5.90	5.92	6.13	6.21	5.39
Kaipad- Typic Fluvaquent	5.53	6.33	6.33	6.33	6.36	6.26	6.31	6.15
*Pokkali*_ Sulfic Tropaquept	3.36	3.26	4.16	4.13	4.10	4.30	4.31	3.85
Pattambi-Areic Kandiaqult	4.73	6.06	6.50	6.50	6.57	6.36	6.18	6.00
Kattampally-Typic Fluvaqent	5.20	6.23	6.16	6.20	6.30	6.13	6.02	5.96
Wyanad- Typic Trpaquent	4.70	6.40	6.80	6.86	6.96	6.83	6.76	6.3
Chittoor-Petrocalcic calciustert	6.63	7.20	7.15	7.18	7.26	7.26	7.26	6.98
Mean	4.72	5.51	5.97	6.02	6.09	6.09	6.09	

CD Soil x Period = 0.47 SE S x P = 0.17
CD Periods = 0.14 SE P = 0.05
CD Soils = 1.13 SE S = 0.39

All the wetlands reached above pH 5.5 within two weeks of submergence except *Pokkali, Kari, Kayal* and *Kole* lands. Since most soils contained more Fe (iii) oxide hydrates than any other oxidant, the increase in pH is largely due to the reduction of Fe. *Kari* and *Pokkali* soils are identified as Potential acid sulphate soils. The slow increase in pH in acid sulphate soils can be attributed to adverse conditions for microbial reduction, low contents of metabolisable organic matter and easily reducible Ferric Oxides (Ponnamperuma et al.1982). Hence for acid sulphate soils, keeping the soil under submergence, application of lime @ 1000 $kgha^{-1}$ and washing away of acidity is recommended. For the rest two weeks of submergence prior to transplanting rice seedlings can create the optimum pH for rice without addition of lime.

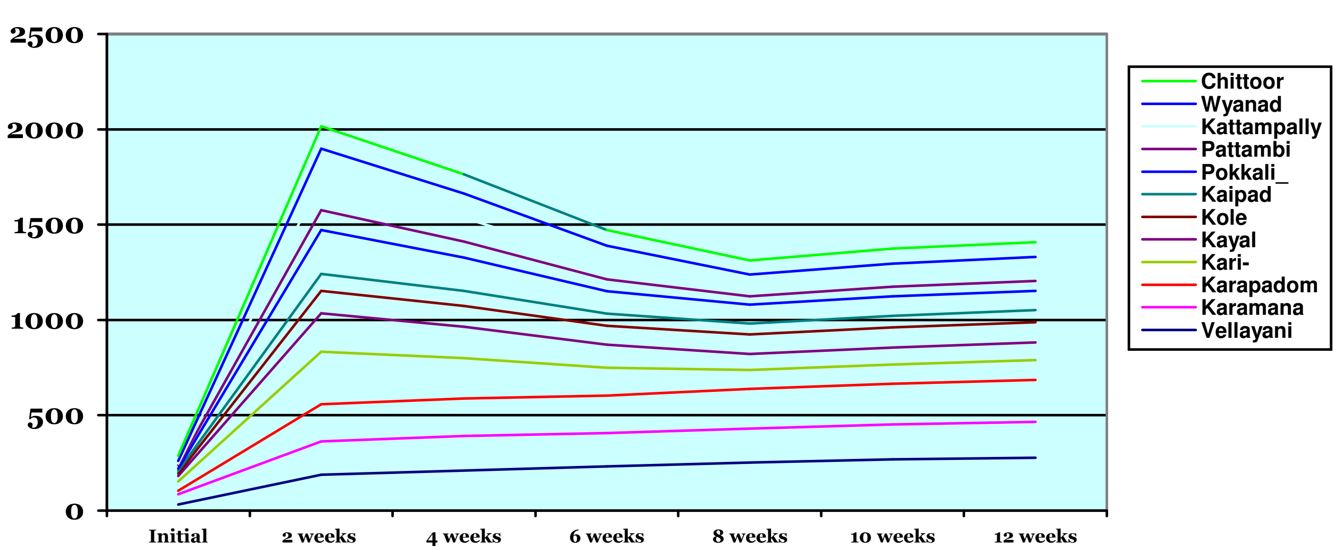
Fig. 1 Kinetics of available N due to submergence (mkg^{-1})



All the soils showed an increase in available nitrogen due to flooding (Fig1). The peak increase was noticed during the first two weeks and then a slow build up was noticed.

Phosphorus availability increased in all soils studied and the highest increase was noticed during first two weeks, a slow increase there after (Fig2). The increase in the solubility of phosphorus by flooding was caused by the reduction of Fe PO_4. 2 H_2O to Fe $(PO_4)_2$. 8 H_2O, desorption following reduction of Fe(iii) hydroxides to Fe (ii) ,hydrolysis of Fe PO_4 and Al PO_4, release of occluded P and anion exchange.

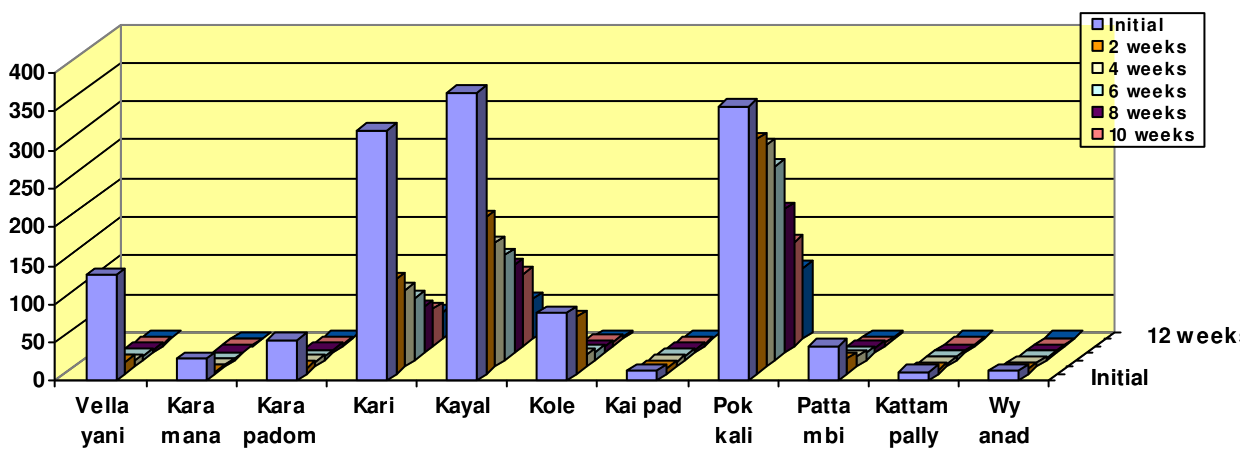
Fig. 2 Kinetics of available phosphorus due to submergence (mg kg^{-1})



Available potassium ,calcium, magnesium , sodium, iron and manganese were found to increase due to flooding in the soils studied. Submergence caused a decrease in the concentration of available Zinc and Copper. A simple remedy is to drain the soil and aerate it temporarily. All the soils registered an increase in available silica on flooding due to the release of silica following reduction of hydrous oxides of Fe(iii) sorbing silica and action of CO_2 on aluminosilicates. Almost all the relationships in all soils followed a quadratic pattern than linear model.

Available aluminium decreased to very low values in all soils except *kayal, Kari* and *Pokkali* soils due to flooding (Fig3). Al $^{3+}$ activity is directly related to pH, as pH rises due to flooding, aluminium is precipitated as hydroxides or sulphates. The toxicity can be minimized by liming@1000 kgha^{-1} followed by keeping the soil under flooded condition and leaching away of salts.

Fig. 3 Kinetics of available Al due to submergence mg kg^{-1}



Flooding a soil sets in motion chemical and electro chemical processes that affect the supply of nutrients and their uptake by rice. After 2 to 4 weeks period of rapid changes, the processes tend to stabilize. The stable milieu favors rice because the nutrient supply is adequate and the level of toxins is low. A yield increase of about one tone ha^{-1} can be obtained by merely delaying transplanting for 2 weeks after flooding. In Kerala all the wetland rice soils are acidic except Chittoor soils. *Kari* and *Pokkali* are classified as acid sulphate soils. Here the sulphidic materials are mainly concentrated in the surface layers i.e. <50 cm depth. Hence rice is the principal crop that can be grown here without much acidity development. In order to avoid oxidation of sulphidic materials these areas should be kept under flooding for major part of the year. Liming, flooding and leaching away of acidity and salts is the practice in such areas. Use of tolerant varieties and proper manuring can increase rice yields in these areas. Subsurface drainage can also be adopted for leaching away of acidity and salts. Rice-Fish farming systems, Rice-Duck farming systems are followed in *Kari*, *Kayal, Karapadom, Pokkali* and *Kaipad* soils. After addition of green manures and organic manures during land preparation, two weeks submergence is a must in the rice fields of Kerala to increase pH, availability of nutrients and to minimize toxic elements like Al.

References

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