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Short Communication

Effect of calcium salts application on soil properties of *pokkali* soils

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Abstract
A field study was conducted in Thathapilli padasekharam (10º12'N, 76º26' E) in Ernakulam district, during June 2017-April 2018 to study the effect of calcium salts application on soil properties of *pokkali* soils. The treatments comprised of absolute control (T_1), application of calcium nitrate (T_2), calcium chloride (T_3), calcium sulphate (T_4), rock phosphate (T_5) and dolomite (T_6) at the rate of 45, 30, 34, 27 and 25 kg per 100 m^2 respectively, so as to adjust the ratio of Na: Ca to 1: 5 on the exchange complex of the soils. Significant increment in the soil pH and microbial biomass carbon were noticed in all the treatments over control. Exchangeable Na, Al and available Fe contents in soil were reduced significantly by calcium salts application after the harvest of rice. Exchangeable Na content remained high in control after the harvest of prawn, whereas it was lower in calcium salt treatments except in the case of rock phosphate.

Keywords: Calcium salts, *Pokkali*, Prawn, Rice, Soil properties

Pokkali is a unique rice cultivation system in the water-logged coastal saline acid soils of Kerala. These tidal wetlands are characterized by multi stressed conditions such as acidity, salinity and waterlogging. Plant growth is affected by salinity at all stages of development resulting in reduced grain yield, dry matter content and productivity. Excess sodium present in the saline environment modifies nutritional status in soil and plant and creates adverse conditions for plant growth. As a soil amendment, calcium helps to maintain chemical balance in the soil and ameliorate adverse effects of salinity on plants. It preserves structural and functional integrity of plant cell membranes (Tuna et al., 2007). Soil structure can be improved by application of Ca^{2+}, which prevents clay dispersion and inhibits aggregate disruption by its exchangeable nature with Na and Mg (David and Dimitrios, 2002). Calcium compounds can also control the impact of soil acidification. Hence the present investigation was carried out to study the effect of calcium salts on soil properties of rice-prawn system of *pokkali* lands using five different calcium salts.

The experiment was conducted in the Thathapilli padasekharam (10º12'N, 76º26' E) of Kottuvally panchayath in Ernakulam district, during June 2017– April 2018. Rice cultivation was carried out from June to October, followed by prawn farming from December to April. The experiment was laid out in Randomised Block Design with six treatments and four replications having plot size of 100 m^2 each. Rice variety Vyttila 6 was raised in the first crop season. Initial soil testing was carried out in order to find out the ratio of exchangeable Na : Ca in the soil. Quantity of Ca salts required to maintain the Na : Ca ratio was found out separately for each treatment.

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The treatments comprised of absolute control (T_1), application of calcium nitrate (T_2), calcium chloride (T_3), calcium sulphate (T_4), rock phosphate (T_5) and dolomite (T_6) at the rate of 45, 30, 34, 27 and 25 kg per 100 m^2 respectively, so as to adjust the ratio of Na : Ca to 1:5 in the exchange complex of the soil. The land preparation for rice cultivation was started in the month of April 2017. Bunds were strengthened and sluices repaired for regulating water level. Fields were then drained during low tides and allowed to dry. Mounds were prepared along the field, which facilitated washing down of salts during rains. Each treatment plot was separated by small bunds along the experimental field. With the onset of monsoon, sprouted seeds were sown at the rate of 100 kg ha^{-1} on the mounds. Mounds were dismantled after 30 days of sowing and the rice seedlings were uniformly spread over the field. One hand weeding was carried out one month after transplanting. Since the *pokkali* cultivation is organic no other external input was applied. The rice panicles alone were harvested on the 3rd week of October 2017. By the end of November 2017, the field was prepared for prawn culture, by strengthening bunds and sluices, removing weeds and floating vegetation from the area and fixing net in order to prevent the entry of non-insect pests. Stocking of tiger prawn (*Penaeus monodon*) seeds were carried out on 28th of December in the same field two months after rice harvest. Prawn seeds at the rate of 40,000 ha^{-1} were released. In the initial one month, feeding was done with company feed "Higashi". After that prawns were fed with 1 kg of wheat, twice a day. Prawns were harvested after 107 days of culture by pumping out the water from entire field and netting and also by hand picking.

Soil samples were collected from the treatment plots during three stages; before the sowing of crop, after the harvest of rice and after the harvest of prawn, and analysed for various physical (soil texture, bulk density), chemical (pH, EC, organic carbon, available N, P, K, Ca, Mg, S, Fe, Cu, Mn, Zn, B and exchangeable Na and Al) and biological parameters (microbial biomass carbon). Statistical analysis was done by using SPSS statistical software and data were compared according to Duncan's Multiple Range Test (DMRT).

Initial soil analysis revealed that texture of soil was sandy loam with a bulk density of 1.25 Mg m^{-3}. Soil was deficient in available N, Ca, Mg and Cu and all other nutrients were in sufficiency level (Table 1). Temporal variation in soil properties in the treatments after the harvest of rice and prawn revealed that all the treatments showed superiority over control without any significant difference (Table 2). Significant reduction in soil pH was observed in control after the harvest of rice, while all the other five calcium treatments were on par. Significant difference was absent in the case of soil electrical conductivity, organic carbon, available P, Ca, Mg, S, Cu and Mn after the harvest of rice. But variation in the organic carbon status after prawn cultivation was noticed in T_2 as result of higher dry matter content addition during rice cultivation in the treatments and slower decomposition of plant residues in submerged soil. Available N which was categorized as low in the initial analysis increased to high in treatments like T_2 and T_4 after the harvest of rice. Higher content of available phosphorus was observed in all treatments. Significant change was

Table 1. Initial soil properties of the experimental site

Soil parameters	Value
pH	6.74
EC (dS m^{-1})	1.51
OC (%)	2.16
Avail. N (kg ha^{-1})	174.5
Avail. P (kg ha^{-1})	71.32
Avail. K (kg ha^{-1})	281.1
Avail. Ca (mg kg^{-1})	218.6
Avail. Mg (mg kg^{-1})	10.69
Avail. S (mg kg^{-1})	232.2
Avail. Fe (mg kg^{-1})	122.5
Avail. Cu (mg kg^{-1})	0.199
Avail. Zn (mg kg^{-1})	12.76
Avail. Mn (mg kg^{-1})	5.668
Avail. B (mg kg^{-1})	0.604
Exchangeable Na (mg kg^{-1})	164.3
Exchangeable Al (mg kg^{-1})	10.68
Microbial biomass carbon (µg g^{-1} soil)	235.7

Table 2. Temporal variations in soil properties after the harvest of rice and prawn in different treatments

Soil property	T1 (absolute control)		T2 (calcium nitrate)		T3 (calcium chloride)		T4 (calcium sulphate)		T5 (rock phosphate)		T6 (dolomite)	
	ARH	APH	ARH	APH	ARH	APH	ARH	APH	ARH	APH	ARH	APH
pH	4.14^{b}	5.94^{a}	5.11^{a}	5.64^{a}	5.14^{a}	5.75^{a}	4.36^{ab}	5.21^{a}	4.67^{ab}	5.92^{a}	5.14^{a}	5.63^{a}
EC (dSm^{-1})	1.60^{a}	8.15^{a}	1.75^{a}	7.40^{a}	1.65^{a}	7.27^{a}	1.59^{a}	7.27^{a}	1.71^{a}	8.32^{a}	1.75^{a}	7.47^{a}
OC (%)	2.32^{a}	2.37^{ab}	2.33^{a}	2.54^{a}	2.28^{a}	2.33^{b}	2.33^{a}	2.32^{b}	2.23^{a}	2.39^{ab}	2.32^{a}	2.46^{ab}
N (kg ha^{-1})	554.8^{ab}	533.1^{a}	609.1^{a}	658.5^{a}	534.7^{ab}	564.4^{a}	601.0^{a}	564.4^{a}	500.5^{b}	564.4^{a}	538.7^{ab}	595.8^{a}
P kg ha^{-1})	61.02^{a}	82.72^{a}	62.65^{a}	83.62^{a}	62.25^{a}	80.05^{a}	65.18^{a}	66.90^{a}	68.61^{a}	85.65^{a}	58.25^{a}	82.73^{a}
K (kg ha^{-1})	375.6^{bc}	988.9^{a}	593.7^{a}	1109^{a}	582.2^{a}	967.4^{a}	465.6^{ab}	1101^{a}	376.3^{bc}	1189^{a}	303.1^{c}	988.3^{a}
Ca (mg kg^{-1})	169.9^{a}	401.7^{a}	219.8^{a}	406.9^{a}	209.4^{a}	429.2^{a}	227.7^{a}	436.1^{a}	193.7^{a}	436.5^{a}	223.0^{a}	422.5^{a}
Mg (mg kg^{-1})	14.15^{a}	22.98^{c}	14.24^{a}	23.84^{abc}	14.26^{a}	23.48^{abc}	14.12^{a}	24.24^{a}	14.09^{a}	23.93^{ab}	14.37^{a}	23.22^{bc}
S (mg kg^{-1})	1156^{a}	1594^{b}	1177^{a}	1636^{ab}	1121^{a}	1825^{ab}	1362^{a}	1995^{a}	1249^{a}	1902^{ab}	1466^{a}	1999^{a}
Fe (mg kg^{-1})	306.5^{a}	582.9^{a}	201.6^{c}	467.2^{bc}	202.9^{c}	361.5^{b}	286.9^{ab}	499.3^{ab}	272.7^{ab}	478.6^{ab}	241.8^{bc}	470.9^{ab}
Cu (mg kg^{-1})	1.073^{a}	0.311^{a}	1.112^{a}	0.199^{a}	1.105^{a}	0.361^{a}	1.134^{a}	0.268^{a}	1.148^{a}	0.333^{a}	1.157^{a}	0.301^{a}
Zn (mg kg^{-1})	8.271^{ab}	20.41^{ab}	8.559^{ab}	15.73^{ab}	9.453^{a}	15.08^{b}	9.163^{a}	21.59^{a}	8.360^{ab}	20.73^{ab}	7.001^{b}	19.95^{ab}
Mn (mg kg^{-1})	4.192^{a}	11.15^{a}	5.211^{a}	5.744^{b}	5.882^{a}	6.323^{b}	5.481^{a}	8.509^{a}	6.308^{a}	6.083^{b}	6.427^{a}	7.659^{b}
B (mg kg^{-1})	0.912^{ab}	1.130^{a}	0.486^{b}	1.065^{a}	0.702^{ab}	1.138^{a}	1.085^{ab}	1.044^{a}	0.977^{ab}	1.167^{a}	1.206^{a}	0.935^{a}
Exchangeable Na (mg kg^{-1})	95.15^{a}	201.6^{ab}	90.85^{ab}	176.3^{b}	71.55^{c}	164.8^{b}	81.60^{bc}	164.9^{b}	77.30^{c}	217.9^{a}	81.27^{bc}	163.2^{b}
Exchangeable Al (mg kg^{-1})	42.73^{a}	4.434^{a}	29.02^{b}	7.452^{a}	29.15^{b}	7.067^{a}	28.88^{b}	5.750^{a}	28.04^{b}	3.819^{a}	27.58^{b}	4.764^{a}
MBC (µg g^{-1} soil)	268.9^{a}	315.3^{a}	320.4^{b}	344.8^{b}	327.2^{b}	336.3^{b}	334.0^{b}	338.6^{b}	329.8^{b}	349.8^{b}	345.9^{b}	357.1^{b}

*ARH- After Rice Harvest, APH- After Prawn Harvest

absent as regards to available P even after the application of rock phosphate as one of the treatments. This was because of the slow release nature of rock phosphate in the soil. Highest available K was observed in T_2 , T_3 and T_4 treatments and there was no effect on treatments on soil available K after the cultivation of prawn. Sasidharan (2004) reported that tidal action significantly increased the available K content. Amount of available Ca almost doubled after the harvest of prawn. This may be due to deposition of calcium rich exuvia of prawns (Tacon, 1987). In *pokkali* lands Ca is found in water soluble form and in organic complexed form so that available Ca content is directly influenced by tidal action and organic matter content (Bhindu, 2017). Available sulphur content was extremely high in all the treatments after rice as well as prawn harvest. High content of S was reported in *pokkali* lands due to the acid sulphate nature (Santhosh, 2013).

Available Fe, Mn, Zn and B content in *pokkali* soil were found to be high at both rice harvesting and prawn harvesting stages. Available Fe content was comparatively lower in treatments with calcium salts than control. Calcium compounds can increase the soil pH which consecutively reduces Fe^{2+} , Al^{3+} , Mn^{2+} and SO_4^{2-}in the soil solution. The direct marine influences along with high organic matter content resulted in the high content of available boron in organically complexed form in lowlands of *pokkali* tract (Santhosh, 2013). Available Cu showed higher value in all the treatments at rice harvest stage but its content was reduced at the time of prawn harvest. This might be due to chelation of Cu by organic colloids. Exchangeable Na at rice harvesting stage varied significantly in all the calcium treated plots. Higher content of exchangeable Na was recorded in control and it was comparatively low in calcium chloride and rock phosphate treatments. Rock phosphate being a less soluble fertilizer, satisfactory utilization of rock phosphate takes place under pH 6 (Ellis et al., 1955). Its dissolution rate varies and there may be a chance of displacement of between Ca and Na ions in the soil exchange complex. Reduction in exchangeable Al content was observed in all calcium treatments, except control after the rice harvest, but there was no significant difference after the prawn harvest. According to Sanchez (1976), Al toxicity can be reduced to some extent by addition of calcium. Sasidharan (2004) found that removal of Al toxicity is very difficult in *pokkali* soil because of tidal action. Calcium treatments increased microbial biomass carbon in all the treatments except control after the harvest of rice as well as prawn. Haynes and Naidu (1998) pointed out that liming caused a temporary flush in soil microbial activity.

Effect of calcium salt application on soil properties of *pokkali* soil varied according to season. Effects were more pronounced after the harvest of rice than the harvest of prawn in the case of soil pH, available K, Fe, exchangeable Na and Al. Addition of calcium salts invariably increased the soil pH and microbial biomass carbon and inactivated Fe, Mn, and Al in soil solution. These effects of calcium salts addition were maintained after the harvest of prawn also.

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