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Assessing the impact of chemical fertilizers on soil acidification: A study on Jorhat district of Assam, India

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ABSTRACT

Soil pH is a measure of soil alkalinity or acidity. It is a significant indicator of soil health. The acidic soil (low pH value) constitutes much of the areas of Jorhat district with proportionally small areas of neutral soil. The '*r*' value of -0.538 with '*P*' value of 0.0365 express the existence of almost a strong negative as well as significant relationship between fertilizers consumption and pH value of soil. The dominance of highly acidic soil in the southern and central part of the Jorhat district portrays normally limited suitability (Low productivity) of soil for the cultivation of paddy (rice). Though most the areas in the northern part of Brahmaputra river (i.e. Majuli island) constitutes highly productive (production per ha) soil for paddy cultivation.

Key words: Chemical fertilizers, PH, Soil health, Soil characteristics.

INTRODUCTION

Fertilizers normally are applied to increase the yield of crop (Luo *et al*.2015). It has both positive and negative impact on soil characteristics. Long run application of NPK fertilizers in soil has negative impact, which implies normally unsuitable soil for future use (Simansky, 2015). Farmers increase the frequency of use of chemical fertilizers to increase crop yield. The practices are still continuous and caused serious environmental degradation (Rahman and Zhang, 2018). Over fertilization (excessive use of fertilizers) may have an adverse effect on crop quality and productivity. Excessive application of fertilizers can causes acidification of soil, algae concentration in water bodies, high emission of N_2O, and exhausts minimum organic ratio of soil (Manono, 2016). Nitrogen containing fertilizers are leading cause of environmental degradation when they use in excess quantity (Chan *et al*, 2005). Farmers of some developing nation apply fertilizers to the agricultural land in excess quantity due to lack of sufficient training (Tucker, 1979). The country also includes India where application of fertilizers in unsustainable way is practiced. However, intensive agriculture also leads to acidification of soil by means of excessive leaching, addition of fertilizers and removal of soil organic matter. The state of Assam is still dependent of agriculture (Bhuyan, 1998). About 90 % of populations are dependant of agriculture for their socio economic improvement and livelihood (Upadhyai and Nayak, 2017). Jorhat located in the flood plain of the Brahmaputra river has enough potentiality of agriculture. Although heavy population pressure and practice of intensive cultivation makes the farmers for application of chemical fertilizers even in excess quantity, which slowly leads to deterioration of soil quality of the area. Therefore, the study essentially focuses on possible impact of application of chemical fertilizers on soil acidity.

MATERIALS AND METHODS

The study incorporates average pH value data of Jorhat district for the period of 13 years (2001-2013) accessed from the Dept. of Horticulture, Assam Agricultural University, Jorhat, Assam. Similarly the data regarding fertilizers consumption (2001 to 2013) has been collected from the Directorate of Economics and Statistics, Jorhat. Though the required pH and soil productivity map has been accessed from the National Bureau of Soil Survey and Land Use Planning, Jorhat. The map has been georeferenced and projected in WGS 84 datum and UTM Zone 46 North projection using the software package of QGIS 2.18. The georeferenced/projected images have been further used for the preparation/extraction of vector layers of agricultural land use, soil productivity and soil acidity. Further classified map (acidic soil, productivity, agricultural land use) has been weighted based on level of productivity, acidification and land use. The vector base weighted data have been converted to raster base reclassified image individually for all the required datasets and final composite weighted raster has been prepared for the identification low productivity areas of rice cultivation. The co efficient of correlation and simple linear regression method has been employed to assess the meaningful relationship between average fertilizers consumption and acidity of soil. The p value with 5%

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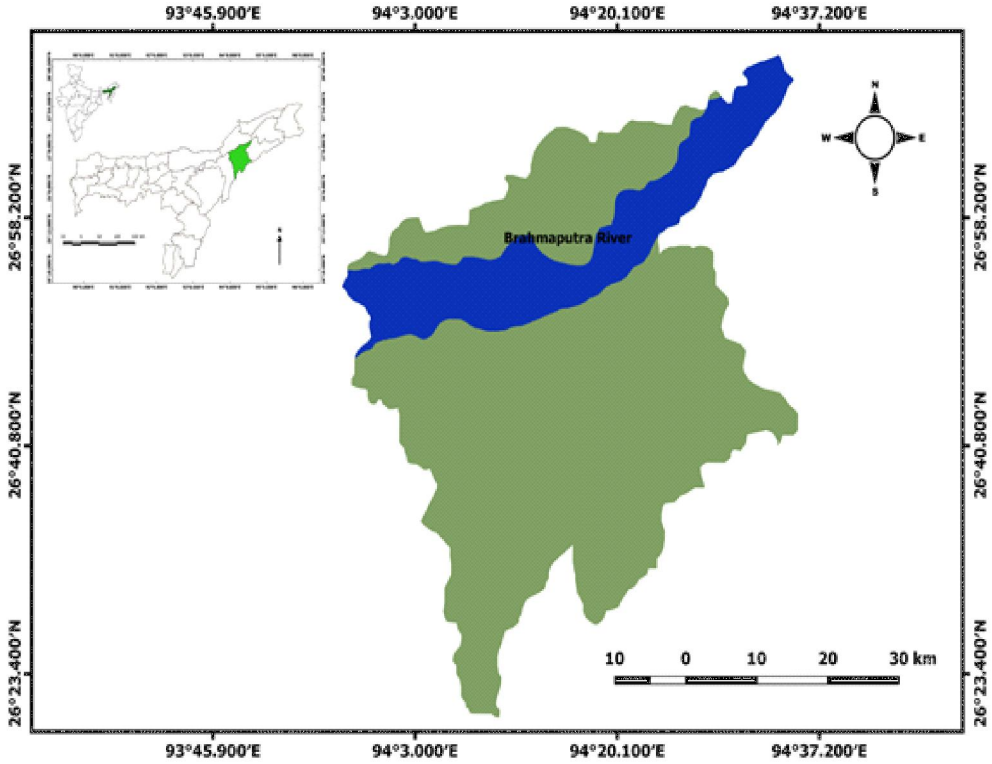


Fig 1: Study area.

significance level has been selected for assessing the strength of relationship between fertilizer consumption and acidification of soil.

Study area: The study was conducted in Jorhat district of Assam, located in the south bank of Brahmaputra river. The district is surrounded by Sivasagar and Golaghat in the eastern and western side where as the State of Nagaland in the south. The total geographical area of the district is about 2,8,52 sq km with average elevation of 90 meter from the MSL (mean sea level). Except the southern and south eastern foothill region, the rest of district covers relatively plain area. The area is under sub-tropical humid climatic condition with average annual rainfall of about 200-220 cm. the district lies between the longitude of 93° 57' E to 94° 37' E and latitude of 26° 20' N to 27° 10' N(Fig 1).

RESULTS AND DISCUSSION

The farmers normally apply NPK, urea, super phosphate fertilizers to the crop field to fulfill the various of dimension soil requirement. Since green revolution the production of consumption of fertilizers on crop filed has increased tremendously leading to unsustainable agriculture (Kumar and Indira, 2017). The Studies relating to application of chemical fertilizers on crop field, its trends and relationship with agricultural production in India has already been carried out by different researcher (Kumar and Indira, 2017; Hossain and Singh,2000; Singh, 2013, Mazid and Khan, 2015). However the studies relating to potential threat on soil pH by means of chemical fertilizers is still lacking.

The Jorhat district has the total geographical area of 2, 859, 38 sq km out of which gross cropped area accounts for 1,735,55.6 ha with net sown area is 1,253,90 ha. But there is a rapid change of both net sown area and gross cropped area. Based on the aforesaid statistics (Net sown area), the net consumption of chemical fertilizers has been estimated as 3,335,374 kg in the year 2010-2011. However the net consumption of chemical fertilizers during 2007-08 was 2,977,675 kg with net increase 357,699 kg in a short span 3 years. Thus evidences an average annual growth of 119,233 kg. Simultaneously the per ha consumption of chemical fertilizers increases from 18.9 kg in 2001 to 25.5 kg in 2008 and finally to 29.0 kg in 2013 (Table 1). During the Same period the pH value (cultivated land) seems to have declining trend. The average annual pH value of soil at Jorhat was found to be as 5.15 in 2001, which declines to 4.8 in the year 2008 and finally to 4.6 in 2013(Table 1). Thus a negative trend between fertilizers consumption and pH value has been noticed during the study period.

However the meaningful relationship between fertilizers consumption and pH value has been assessed by co-efficient of correlation and simple linear regression. The

Table 1: Trend of fertilizers consumption and pH value (**P^1**- Base year, **P^2**-Current year).

Year	Fertilizers consumption in kg/ha	pH value	Growth of Fertilizers consumption in kg/ha (p^2-p^1)	Growth of pH value (p^2-p^1)
2001	18.90	5.19	1.35	-0.29
2002	20.25	4.9	0.95	0.3
2003	21.20	5.2	0.3	-0.4
2004	21.5	4.8	-1	0
2005	20.5	4.8	5.2	-0.1
2006	25.7	4.7	-0.7	-0.1
2007	25.0	4.6	0.5	0.2
2008	25.5	4.8	1	0.2
2009	26.5	5	-0.3	-0.1
2010	26.2	4.9	1.8	-0.2
2011	28.0	4.7	0.6	0.1
2012	28.6	4.8	0.4	-0.2
2013	29.0	4.6	1.35	-0.29
Mean	**24.37**	**4.84**	**0.84**	**-0.04**
SD	**3.46**	**0.18**		

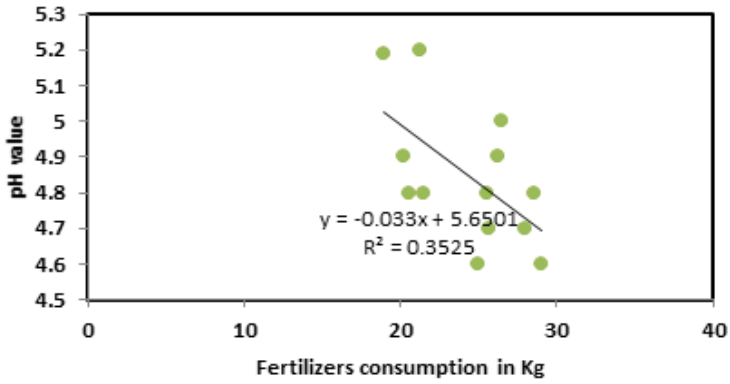


Fig 2: Relationship between fertilizers consumption and pH value.

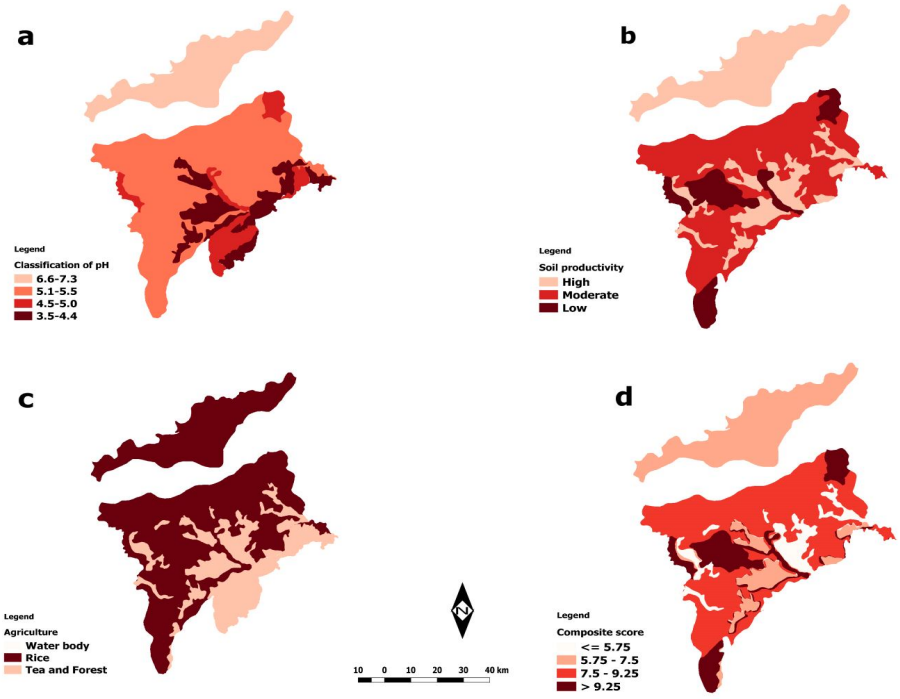


Fig 3: Spatial variations of pH (a), Productivity (b), land use (c), Rice suitability (d).

Coefficient of correlation between fertilizers consumption (in Kg/ha) and pH value indicated an almost strong negative relationship with 'r' value of -0.583 (Fig 2). However, the co efficient of determination detects that there is 33.98 % impact of fertilizers application on soil acidity. The 5% or 0.05 level of significance and 95% level of confidence have been assigned to obtain the required results. The p value of 0.0365 with 5% level of significance indicates significant negative relationship exist between the fertilizers application and pH value of soil. The mean deviation and standard deviation for consumption of fertilizers is calculated as 24.37 and 3.46 kg where as 4.84 and 0.18 for pH value respectively. Similarly the mean annual growth of fertilizer consumption is 0.84kg/ha and pH value is -0.04, indicating overall higher growth rate along with deviation of fertilizers consumption (Table 1).

$$y = a + bx$$

$$a = \frac{(\sum y)(\sum x^2) - (\sum x)(\sum xy)}{n(\sum x^2) - (\sum x)^2}$$

$$b = \frac{n(\sum xy)(\sum x^2) - (\sum x)(\sum y)}{n(\sum x^2) - (\sum x)^2}$$

The above mentioned regression equation portrays the *Y*= -0.033x+5.650, which indicates constant value of 'a=5.650' and dynamic 'bx=-0.033'. The following results are useful to compute the probable change of pH value in further years with changing value of consumption of fertilizers as pH is considered as dependant variable(y) while fertilizers consumption as independent variable (x).

Spatial variation of pH value: The pH refers to the power of hydrogen ion concentration of the soil (Wilson, 2013). Soil pH influences the crop in different ways. The nutrient availability to crops normally declines with decreasing pH value (Nduwumuremyi, 2013).The pH value of the study area vary from extremely acidic soil (3.5 to 4.4) to neutral soil (6.6 to 7.3) based on the map for National bureau of Soil survey and land use planning (NBSS & LUP, Jorhat). The detailed categorization of PH value of soil is demonstrated in the Fig 3a. The Figures display that a large part of the study covers strongly acidic soil (5.1-5.5) with some individual patches of very strongly acidic soil (4.5-5.0) in the central and southern part of the district. Similarly the productivity of soil (yield per ha of land) also varies regionally (Fig 3b). However the productivity of forest land (in the southern part of the district) is excluded in the study.

The study area dominantly covers tea and rice (paddy) cultivation (Fig 3c). Except for the tea areas (Fig 3c), the rest of the soil in the southern part of Brahmaputra River dominates low productivity region (paddy crop). However, an extensive area of productive soil for paddy cultivation is developed by river processes is available in the north bank of the district i.e. Majuli Island (Formerly sub-division of the district). However the composite score developed using the variability of pH, soil productivity and rice cultivation area significantly highlights the area of low pH value with low productivity dominated by rice cultivation (Fig 3d). The score of greater than 9.25 indicates that the area is not suitable for rice cultivation, while the score within 7.5 to 9.25 suggest moderate suitability of soil for rice. Though, the score below 7.5 demarcates the potentiality of soil for rice cultivation (Fig 3d).

Suggestions:

a. Consumption of natural soil enrichments, such as manures.
b. Control use of chemical fertilizers, pesticides and insecticides (permissible quantity per hectare).
c. Application of agrochemical as per the requirement of the soil (make appropriate study of the soil condition and its deficiencies).
d. Get up to date information about the use of agrochemicals through the krishak call centers.
e. Adaptation of the method of crop rotation, so that enrichment of the nitrogen can be maintained.
f. Liming of the crop land to reduce acidification (pH) of soil.

CONCLUSION

The study finally revealed a remarkable rise of application of chemical fertilizers on paddy field and simultaneous declines of pH value of the soil. Maximum growth with mean and standard deviation reveals finally greater temporal dynamics of fertilizers consumption. Low rice crop productivity with higher acidic soil demonstrates the active negative role of soil acidification (low pH) on agricultural development. The significant relationship between fertilizers consumption and pH value evidences the possible role of fertilizers on acidification (low pH) and overall deterioration of the agricultural field. However application of adequate lime prior to the cultivation of land with proper knowledge of quantity and quality of nutrients requirements/ deficiencies of soil can become an effective measure to deal with problem of acidification and low productivity of soil.

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