EFFECTS OF DIFFERENT RATES OF LIME (*Dolochun*) ON SOME SOIL NUTRIENTS AND YIELD OF POTATO

A Thesis

By

PAPIYA DAS

Examination Roll No.1202020202
Reg. No. 0508
Session: 2007-2008

MASTER OF SCIENCE (MS)
IN
SOIL SCIENCE

Department of Soil Science
Faculty of Agriculture
Sylhet Agricultural University, Sylhet-3100.

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The Authoress

ABSTRACT

A field experiment was conducted at the field of Soil Resource Development Institute (SRDI), Sylhet during the period from October 2012 to March 2013 with a view to evaluate the effect of different rates of lime application on soil nutrients and tuber yield of potato. The experiment consisted of four treatments viz. no lime application (control), 0.988 t lime ha^{-1}, 1.976 t lime ha^{-1}, and 2.964 t lime ha^{-1}. Liming was done with dolomitic limestone ($CaCO_3.MgCO_3$). The experiment was laid out in a randomized complete block design with four replications. Yield and yield components of potato were recorded. The pre- and post-harvest soils were analyzed for pH, total N, exchangeable K, available P, S, Ca and Mg contents. The results indicated that liming had significant influence on yield of potato tuber. The days required for 80 % emergence, foliage coverage, plant height, root length, number of tubers $hill^{-1}$, weight of tubers $hill^{-1}$ and yield of tuber (t ha^{-1}) were the highest when lime was added at 0.988 t ha^{-1}. The highest yield of tuber was recorded 19.69 t ha^{-1} due to application of 0.988 t lime ha^{-1} and the lowest yield was found 14.38 t ha^{-1} in control treatment. Pre- and post-harvest soils analyses indicated that the application of different rates of lime to soil progressively increased soil pH and increased total N, availability of P, S, Ca and Mg in soils. The exchangeable K tended to decrease with increasing level of lime application.

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CHAPTER I

INTRODUCTION

In Bangladesh, there are different types of problem soils like acid sulphate soil, peat soil, phosphate fixing soil, saline soil, etc. These soils restrict the growth of plants and make crop production difficult and sometimes impossible. Acid sulphate soils occur near the coast on the Chittagong coastal plains and in the southwest of the Ganges Tidal Floodplains areas. Peat soil occurs in the Gopalganj-Khulna Beels and in the Sylhet Basin. Phosphate fixing soils include some terrace soils developed on the Madhupur and Barind Tracts. All these soils are strongly acidic in nature. The potential of acid soil for crop production is limited due to less availability of phosphate and toxicity of aluminum. Aluminium toxicity is responsible for poor yields in acid soils (Lierop *et al.,* 1982). For example, most of the topsoils of the hills, terraces and floodplains are acidified to variable extents (Shaheed, 1995). Intensive acidification is also identified in the heavy clays in the Sylhet Basin areas and in some broad valleys within the Madhupur, Barind and Chittagong Hill Tracts. Northern and Eastern hills have also undergone strong acidification to a considerable depth. Soils become acidified rapidly as a consequence of intensive cultivation of cereals with application of ammonium based N fertilizer (Mahler and Macdole, 1985) and heavy rain in the monsoon. Soil P^H of these regions ranges from 4.5-6.5. Acid soils possess high concentration of Al^{3+}, Fe^{3+}, Mn^{2+}, deficient concentration of P and Mo and low availability of bases which together causes reduction in crop yield. The maximum availability of N, P, K, S, Ca and Mg is in the near neutral pH range of 6.6 to 7.3. The micronutrients like Fe, Mn, B, Cu and Zn are more available in acid range. Special management practices need to be applied in such soils for economic crop production for instance liming that increases the availability of P, Ca, Mg and Mo and reduces toxicity of Fe and Mn, increase fertilizer effectiveness and decrease plant diseases (Sahai, 1990; Bodruzzaman, 2009). Liming makes K more efficient and improves physical condition of soil by decreasing its bulk density, increasing its infiltration capacity and the rate of water percolation. Lime works nicely in acid soils for cultivation of all dry land crops e.g. wheat, potato, maize, etc.

Potato is the edible tuber of the cultivated plant *Solanum tuberosum* of the family Solanaceae. The probable place of origin of potato as a cultivated crop is Peru and Bolivia (Ahmed, 1977). Potato was domesticated and has been grown by indigenous farming communities for over 4000 years. Introduced into Europe in the sixteenth century, the crop subsequently was distributed throughout the world, including Asia. It is assumed that at the beginning of the 17th century the Portuguese navigators first brought potato to Indian subcontinent. Potatoes have been grown in Bangladesh since at least the 19th century. By the 1920s, the first commercial production of the crop was established in the country (Islam, 1983).

Potato is one of the most important food crops grown in more than 100 countries in the world. Over one billion people consume potato worldwide and it is the staple diet of half a billion people in developing countries. Potato ranks fourth in the world (325.30 million tons) (Hossain, 2009) and third in Bangladesh (8.2 million tons) after rice and wheat with respect to food production (BBS, 2012). The greatest potato producing counties are the United States (mostly in Maine and Idaho), Germany, Russia, Holland, and Poland. Potato has emerged as a major food crop in Bangladesh and is being cultivated throughout the country. The total area under potato cultivation has been estimated at 4,30,255 hectares and production 82,05,470 metric tons in 2011-2012 (BBS, 2012).

There are several reasons for such a low yield of potato in Bangladesh, which include use of poor quality seed, application of improper amount of manures and fertilizer and use of traditional cultivation techniques. Along with the stated problems of potato production soil acidity is another one. The area under potato production in Bangladesh began to increase rapidly with the introduction of modern potato varieties in the 1960s. More than 40 high yielding varieties of potato have been recommended for cultivation under Bangladesh condition. But the optimum dose of lime for the production of potatoes in acidic soil has not yet been defined.

In respect of the eastern part of Bangladesh, farmers are applying a large amount of fertilizer for potato production but they do not get good yields. Unless the soil pH is raised to around neutrality, the availability of nutrient elements will limit the growth of plants. So it's a need to mitigate the yield gap of potato production. Lime application is one of the ways for better soil fertility management of acidic soil. In these regard, a study in acidic soil using optimum level of lime is necessary. It's a future challenge for Bangladesh to better exploit the potential of the production of potato crop to meet the country's food requirement without endangering the environment. Through the application of lime, soil pH might be increased and yield gap of potato can be minimized.

Therefore, the above point in view, the present study has been designed in the acidic soils of AEZ-20, Eastern Surma-Kusiyara Floodplain with the following objectives:

i. To evaluate the growth and yield of potato tubers under different levels of lime application.

ii. To examine the effects of lime application on soil pH, N, P, K, S, Ca and Mg contents.

CHAPTER II
REVIEW OF LITERATURE

Liming is important for the management of acid soils, for its good crop yield and healthy soil environment. The direct and residual beneficial effects of lime were reported by many workers in many countries. But limited works have been reported in Bangladesh with respect to management of acid soils for higher yield of crops by application of lime. In this chapter literatures related to management of acid soils and crop production by application of lime are cited.

2.1 Effect of lime on soil pH

Lalljee *et al*., (2002) conducted an experiment to study the effects of lime application on micronutrient content of soil and yield and nutrient content of two varieties of potato (*Solanum tuberosum*). Lime was added at various rates, 0, 4, 8 and 12 t ha^{-1}. They found that pH of soil was increased from 5.12 to 7.22 over a period of 12 weeks.

Lierop *et al.,* (1982) studied the effect of liming on potato (*Solanum tuberosum* L.) yields as related to soil pH, Al, Mn, and Ca. The crop was grown in unlimed and limed soils, with initial pH values ranging from 4.62 to 5.02 (H_2O) and 4.32 to 4.76 (0.01 M $CaCl_2$), in a greenhouse experiment. They found the pH values higher than 4.6 (0.01 M $CaCl_2$) or 4.9 (H_2O) due to the lime treatments.

Maier *et al.,* (1997) studied the effects of application of calcitic lime on soil pH, yield and cadmium concentration in potato (*Solanum tuberosum* L.) tubers. They found that liming increased soil pH values up to 2 units.

Waliyar *et al*., (1992) initiated a trial on the effect of lime and carbofuran on soil pH. Al toxicity, nematode population and groundnut yield were studied in relation to crop growth variability during two years. In the first, year lime application could not change the pH in soil. In the second year, rainy and dry seasons, however, the application of 10 t ha^{-1} of lime increased pH.

Jibrin *et al.,* (2002) conducted a field trial between 1996-1997 to assess the responses of six tropical cover crops and maize to lime and applied rock phosphate. They found that liming with 1.35 t CaO ha^{-1} in 1997 raised the soil pH value by 0.2.

Jasmin and Heeney (1962) reported that increments in lime application increased soil pH when they conducted a 2-year study in a few vegetables grown on acid peat soils.

Maier *et al.,* (2002) conducted three glasshouse experiments, using light textured soils to investigate the effect of nitrogen source and calcitic lime on soil pH and potato yield, leaf chemical composition, and tuber cadmium concentrations. The N sources applied were calcium nitrate, ammonium nitrate, urea, and ammonium sulphate. Rates of calcitic lime ranged from 0 to 20 t ha^{-1}. Liming increased soil pH values up to 2.8 units, and depending on sampling time, differences in soil pH of up to 1.8 units occurred between the N sources.

Sultana *et al.,* (2009) carried out an experiment to evaluate the effects of liming on chemical properties of wheat field soils and yield of wheat in Ranisankail soil series of Bangladesh. There were eight treatments of liming material applied from dolomite ($CaCO_3.MgCO_3$) as T_1 (Control); T_2, 0.5 t ha^{-1} lime; T_3, 1.0 t ha^{-1} lime; T_4, 1.5 t ha^{-1} lime; T_5, 2.0 t ha^{-1} lime; T_6, 2.5 t ha^{-1} lime; T_7, 3.0 t ha^{-1} lime and T_8, 3.5 t ha^{-1} lime. They found that the application of different rates of lime to soil progressively increased soil pH from 4.85 to 6.64. They reported that the increased in soil pH was due to available of Ca and Mg in soils due to the dissolution of dolomite ($CaCO_3.MgCO_3$) to Ca and Mg. The pH of the post harvest soils was positively correlated with available Ca and Mg status in soils.

Adeoye and Singh (1985) investigated the effects of lime rates on soil pH at two tillage depths. They found mean increases in soil pH after the first cropping season ranged from 0.85 to 2.11 for the lowest (2 t ha^{-1}) and the highest (20 t ha^{-1}) lime levels respectively. The mean top-soil pH was 0.25 units higher in shallow cultivated (5 cm) than in deep cultivated (20 cm) plots.

Sharifuddin *et al.,* (1995) conducted a field trial to evaluate the effects of dolomitic limestone (DLS) on the yield of corn. A sweet corn-groundnut rotation was grown for 3 years with 2 crops per year. DLS was applied at rates of 0.0, 0.5, 1.0, 2.0, 4.0 and 8.0 t ha^{-1}. They showed that application of 8.0 t DLS ha^{-1} increased soil pH from 3.8 to 5.7 in 1 month, and to 6.5 after 1 year, but it then decreased to 5.8 and 4.8 after 3 and 4 years, respectively.

Rahman *et al.,* (2000) tested 4 levels of lime (0, 1, 2 and 3 t ha^{-1}) and 5 levels of phosphorus (0, 40, 60, 80 and 100 kg P_2O_5 ha^{-1} from TSP) to see the effect on soil pH, phosphorus availability and yield of wheat. They found that liming increased the soil pH both at surface and subsurface soil. Soil pH raised from 5.2 to 6.5 in surface and from 5.4 to 6.4 in sub-surface soil due to application of lime at the rate of 2 t ha^{-1}.

2.2 Effect of lime on available phosphorus content of soil

Rahman *et al.,* (2000) tested 4 levels of lime (0, 1, 2 and 3 t ha^{-1}) and 5 levels of phosphorus (0, 40, 60, 80 and 100 kg P_2O_5 ha^{-1} from TSP) on soil pH, phosphorus availability and yield of wheat. They observed that available phosphorus of soil tended to increase with each increment of lime and applied phosphorus levels. The maximum average values of available phosphorus were recorded at different depths of soil due to liming at the rate of 2 t ha^{-1}.

Herman *et al.,* (1973) conducted an experiment to study the effect of lime on some chemical characteristics, nutrient availability, and crop response of a newly broken organic soil. They reported that liming caused a considerable decrease in the native water-soluble phosphorus of the soil as well as a decrease in the manganese content of potato leaf tissue.

Kamaruzzaman *et al*., (2013) studied the effect of lime on wheat. They used Dololime as liming materials with six treatments viz. control, 0.5, 1.0, 1.5, 2.0, and 2.5 t lime ha^{-1} with three replications. They found that available P was significantly increased due to application of lime which was mainly associated with increased wheat yields.

Jasmin and Heeney (1962) conducted a 2-year study on the effect of lime on the status of nitrogen, phosphorus, potassium, calcium and magnesium in a few vegetables grown acid peat soils. They found that increments in lime application increased the available phosphorus.

Sultana *et al.,* (2009) studied the effects of liming on chemical properties of wheat field soils. They stated that the status of available P of soils was positively correlated with the rates of lime application. The phosphorus value of post-harvest soil increased from 43.35 μg g^{-1} to 53.27 μg g^{-1} when lime was applied at the rate of 3 t ha^{-1}.

2.3 Effect of lime on exchangeable potassium in soil

Jasmin and Heeney (1962) conducted a 2-year study on the effect of lime on the status of nitrogen, phosphorus, potassium, calcium and magnesium in a few vegetables grown in acid peat soils. They found that increments in lime application decreased the exchangeable potassium.

2.4 Effect of lime on available sulphur content in of soil

Haynes and Naidu (1991) conducted a study to know the effects of lime additions on the availability of phosphorus and sulphur in some temperate and tropical acid soils. They found that addition of both lime and phosphate reduced the sulphate adsorption capacity of all the soils and therefore their ability to retain sulphate against leaching. Additions of lime and phosphate, however, also resulted in net mineralization of soil organic S and the accumulation of sulphate in the soil.

2.5 Effect of lime on available calcium content in of soil

Kamaruzzaman *et al*. (2013) carried out an experiment on the effect of lime on yield contributing characters of wheat in Barind Tract of Bangladesh. They used Dololime as liming materials and found that available Ca was significantly increased due to application of lime.

Sultana *et al.*, (2009) carried out an experiment to evaluate the effects of liming on chemical properties of wheat field soils and yield of wheat with eight treatments. They found that the application of different rates of lime to soil progressively increased the Ca content in soil from 1.21 meq 100 g $soil^{-1}$ to 2.55 meq 100 g $soil^{-1}$.

2.6 Effect of lime on available magnesium content in soil

Kamaruzzaman *et al*., (2013) carried out an experiment on the effect of lime on yield contributing characters of wheat in Barind Tract of Bangladesh. They used Dololime as liming materials with six treatments viz. Control, 0.5, 1.0, 1.5, 2.0 and 2.5 t lime ha^{-1} with three replications. They found that available Mg was significantly increased due to application of lime.

Sultana *et al.*, (2009) carried out an experiment to evaluate the effects of liming on chemical properties of wheat field soils. There were eight treatments of liming material applied from dolomite ($CaCO_3.MgCO_3$) as Control, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, and 3.5 t ha^{-1} lime. They found that the application of different rates of lime to soil progressively increased the Mg content in soils from 0.39 meq 100 g $soil^{-1}$ to 1.41 meq 100 g $soil^{-1}$.

2.7 Effect of lime on the yield of potato

Mathur and Levesque (1983) carried out a study to observe the effect of liming on the yield, nutrition and copper status of potatoes, carrots and onions grown sequentially in two peat soils. They stated that the highest yields of potatoes were obtained at 4-6 t calcitic lime ha^{-1} rates. The Cu concentration of potato leaves and tubers did not exceed 16 ppm.

Lierop *et al.,* (1982) studied the effect of liming on potato (*Solanum tuberosum* L.) yields as related to soil pH, Al, Mn, and Ca. The crop was grown in unlimed and limed soils, with initial pH values ranging from 4.62 to 5.02 (H_2O) and 4.32 to 4.76 (0.01 M $CaCl_2$), in a greenhouse experiment. They viewed that liming at 8 g $CaCO_3$/8 liter soil ($\simeq$ 2,000 kg/ha) increased the average tuber yield on an average by 40%.

Lalljee *et al*., (2002) conducted an experiment to study the effects of lime application on micronutrient content of soil and yield and nutrient of potato (*Solanum tuberosum*). Lime was added at various rates e.g., 0, 4, 8 and 12 t ha^{-1}. Application of 4 t ha^{-1} showed the highest increase in yield in comparison to the control. Application of 12 t ha^{-1} in fact depressed yields as compared to control. They found that the protein content of the crop increased with application of lime. The highest increase was observed with 4 t ha^{-1} lime application. The highest value of starch was found for the 4 t ha^{-1} treatment as compared to control. They also found the highest ash percentage with 12 t ha^{-1} lime.

Khandakhar *et al.*, (2004) conducted a study in strongly acidic sandy loam soil to investigate the effect of lime and potassium on tuber yield of potato. The tested factors were application rates of lime (0, 0.5, 1.0 and 2.0 t ha^{-1}) and potassium (0, 60, 80 and 100 kg K ha^{-1}). Lime and potassium significantly increased the tuber yield. The highest increase in yield was recorded about 86% over control. They recommended the optimum rate of lime and potassium in acidic sandy-loam soils for potato cultivation as 2 t ha^{-1} and 100 kg ha^{-1}, respectively.

MacLean *et al.*, (1967) studied the effect of lime on potato crops and on properties of a sphagnum peat soil. Limestone applied at the rate of 6.7 metric t ha^{-1} to a raw peat soil (pH 3.7) increased the tuber yield in a field experiment by 5.5 t ha^{-1}. Higher rates of lime gave no further increase.

Maier *et al.*, (1997) studied the effect of application of calcitic lime on soil pH, yield and Cd concentration in potato (*Solanum tuberosum* L.) tubers. They found that the yields of potato tubers were generally unaffected by liming. They also found significant reductions in tuber Cd concentrations after liming of soils.

Minhas *et al.*, (1994) conducted a field experiment to study the effect of P, lime and animal manure on crop yields, in a potato-maize-potato-wheat cropping sequence. Phosphorus was applied as single superphosphate @ 0, 26, 52 and 78 kg P ha^{-1}; lime as $CaCO_3$ at 0 and 5 t ha^{-1}; and well decomposed animal manure at 0 and 10 t ha^{-1}. The direct P application, up to 78 kg P ha^{-1} to spring potato and, up to 52 kg P ha^{-1} to autumn polato, increased the potato yield significantly. The direct application of animal manure and lime to spring potato crop was not significant.

Jasmin and Heeney (1962) conducted a 2-year study on the effect of lime on the status of nitrogen, phosphorus, potassium, calcium and magnesium in a few vegetables grown in acid peat soils. They found that yields of potatoes were not increased with lime applications at above 3 t acre^{-1} under the conditions of the study.

2.8 Effects of lime on the yield and nutrient content of other crops

Mathur and Levesque (1983) carried out a study to observe the effect of liming on the yield, nutrition and copper status of potatoes, carrots and onions grown sequentially in two peat soils. They found that carrots produced the highest yields at 30 t ha^{-1} rate. Copper concentrations in carrot tops and roots were below 16 ppm. Onions gave the highest yield, particularly of bulbs, at the 30 t lime ha^{-1} rate. But Cu concentration in bulbs exceeded 16 ppm at 6 t ha^{-1} rate of liming. In all crops, Cu concentrations generally decreased sharply as soil pH increased to above 4.0. The Ca:Mg ratio in plants usually increased with liming but, within the observed , there was no increases in yield. Plant concentrations of N, P and K generally decreased with liming at the higher rates (20 or 30 t ha^{-1}).

A trial on the effect of lime and carbofuran on soil pH, Al toxicity, nematode population and yield in groundnut was initiated to study crop growth variability by Waliyar *et al*. (1992). Groundnut was sown in the 1989 rainy season, followed by pearl millet (*Pennisatum glaucum*) in the 1989–90 dry season and again groundnut in the 1990–91 rainy, and dry seasons. In 1989, the carbofuran treatment increased the pod yield. Lime application did not increase groundnut yield. In the 1990–91 rainy and dry seasons, however, improved crop growth and increased the yield of groundnut to the same level as was achieved by the carbofuran treatment.

Subash *et al.,* (2012) conducted an experiment to investigate the effect of lime and farmyard manure on the concentration of cadmium in water spinach. Water spinach (*Ipomoea aquatic* cv. Kankon) was grown in sandy loam soil spiked with 5 mg Cd kg^{-1} with lime and farmyard manure amendments. Growth parameters of water spinach increased significantly with the addition of lime and farmyard manure in the soil. Lime addition to soil decreased Cd concentration in both shoot and root of water spinach. In control (0+0), Cd concentration was 62.67 mg kg^{-1} in shoot and 135.5 mg kg^{-1} in root. Cd concentration decreased by 72, 15, and 66% over the control in shoot and 82, 28, and 76% in the roots correspondingly with the highest rate of lime (20 t ha^{-1}), manure (20 t ha^{-1}), and lime plus manure combinations (20 t ha^{-1} + 20 t ha^{-1}). The result imply that 5 to 10 t ha^{-1} lime could be used in Cd-contaminated soils to reduce Cd uptake by agricultural crops.

Jibrin *et al.*, (2002) conducted a field trial between 1996-1997 to assess the responses of six tropical cover crops and maize to lime and applied rock phosphate and evaluated the effect of these treatments on the performance and P nutrition of succeeding maize. Application of phosphate rock at 30 kg ha^{-1} to cover crops produced very significant improvement in the yields of succeeding maize. While liming with 1.35 t CaO ha^{-1} in 1997 raised the soil pH value by 0.2 and significantly improved total P uptake by maize.

Kamaruzzaman *et al*. (2013) carried out an experiment on the effect of lime on yield contributing characters of wheat in Barind Tract of Bangladesh. They used Dololime as liming materials with six treatments viz. Control, 0.5, 1.0, 1.5, 2.0, 2.5 t lime ha^{-1} with three replications. The different characters of wheat viz. plant height, tillers $plant^{-1}$, spike length, grains $spike^{-1}$ and grain yield were significantly increased by the application of lime. The 0.5 t ha^{-1} lime application significantly increased most of the growth parameters of wheat compared to control (no lime application). Application of lime had significant effect on the grain yield of wheat. The highest grain yield was found in 1.5 t lime ha^{-1} application (4.73 t ha^{-1}), which was statistically identical with the grain yields obtained in 2.0 t ha^{-1} and 2.5 t ha^{-1} lime application but superior to those found in control, 0.5 t ha^{-1} and 1.0 t ha^{-1} lime application. Thus, the application of 1.50 t lime ha^{-1} is enough for satisfactory yield wheat.

Hossain *et al*. (2011) carried out a study to know the effect of lime, magnesium (Mg) and boron (B) on yield and yield components of wheat and also their residual effect on mungbean. Treatments for wheat were (I) recommended fertilizer + Mg + B, (II) recommended fertilizer + lime + B + Mg, (III) recommended fertilizer + lime + Mg, (IV) recommended fertilizer + lime + B and (V) control (Only recommended fertilizer) and for mungbean were (I) recommended fertilizer + Mg + B, (II) 75% of recommended dose, (III) recommended fertilizer + B, (IV) recommended fertilizer + Mg and (V) control (without fertilizers). Results showed that the highest yield and yield components of wheat were recorded from recommended fertilizers + lime + B + Mg treated plot and the second highest were recorded from recommended fertilizers + lime + Mg treated plot. The lowest was recorded in control plot (only recommended fertilized). In case of mungbean the highest yield was found from recommended fertilizers + B treated plot, this treatment was limed in previously cultivated wheat crop and the lowest was recorded from control plot (without fertilizer).

Cutcliffe *et al*., (1974) reported that the application of 2,240 kg Dolomitic limestone ha^{-1} $year^{-1}$ for 2 yr resulted in greater yields of field beans (*Phaseolus vulgaris* L.) than a single application of 4,480 kg lime ha^{-1} in fine sandy loam soil as they have worked to determine the effects of applications of lime and soil pH on the yield of field beans. The highest yields of field beans were recorded about 2,300 kg ha^{-1}. They reported that liming will be a very important cultural practice if commercial production of field beans is to become established in the soil with an initial pH of 5.0 to 5.2.

Sultana *et al.*, (2009) carried out an experiment to evaluate the effects of liming on chemical properties of wheat field soils and yield of wheat in Ranisankail soil series of Bangladesh. There were eight treatments of liming material applied from dolomite ($CaCO_3.MgCO_3$) as control, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0 and 3.5 t ha^{-1} lime. The treatment 2.0 t lime ha^{-1} produced grain yield of 4659 kg ha^{-1} which was statistically identical to those found in 2.5, 3.0 and 3.5 t ha^{-1} lime application. Liming markedly increased S and Mg concentrations of wheat grain but the concentrations of P and Ca remained unaffected.

Adeoye and Singh (1985) investigated the effects of lime rates at two tillage depths on soil pH and yield of maize, sorghum and groundnut in an acid sandy soil. They reported that optimum rate of lime application for crop yield was 2 t ha^{-1} under deep tillage; higher lime rate was needed under shallow tillage to achieve similar yields.

Sharifuddin *et al.,* (1995) studied the effects of dolomitic limestone (DLS) on the yield of corn grown on strongly acid soils. A sweet corn-groundnut rotation was followed for 3 years. DLS was applied at rates of 0.0, 0.5, 1.0, 2.0, 4.0 and 8.0 t ha^{-1}. They showed, in year 1, highest yield of corn was obtained from 1.0 t DLS ha^{-1}, whereas 2.0 and 4.0 t DLS ha^{-1}

were required in the first and second residual year, respectively. They stated that the liming with dolomitic limestone at 2.0 t ha^{-1} is recommended for sweet corn. Further liming is not required for next 2 years when 2.0 t ha^{-1} is applied. If annual applications of DLS are preferred, then use of 1.0 t ha^{-1} is recommended.

Rahman *et al.*, (2000) studied the effect of lime and phosphorus on soil pH, available phosphorus in soil and yield of wheat in acid soils of Dinajpur. They tested 4 levels of lime (0, 1, 2 and 3 t ha^{-1}) and 5 levels of phosphorus (0, 40, 60, 80 and 100 kg P_2O_5 ha^{-1} from TSP). They reported that when lime was applied at the rate of 2 t ha^{-1}, higher yield was obtained with application of 60 kg P_2O_5 ha^{-1}.

Gupta *et al.,* (1989) carried out some field experiments to observe the direct and residual effects of lime at ICAR research farm in Sikkim on soybean, results showed that the increase in grain yield of soybean resulted in the system. They observed that addition of 1 t to 2.5 t/ha increased yield 27% and 48% during 1982 and 1983, respectively. They found a significant residual effect on yield.

Subbaiah and Mittra (1997) conducted a field experiment during rainy seasons of Kharif 1989 and 1990 to find out the effects of liming and P application on the growth and yield of rice in west Bengal. They reported that the highest grain yields of 5001 and 4928 kg/ha were obtained with 4 t/ha of lime in the first and second years, respectively.

Going through the above reviews, it is realized that the use of lime in soil increases the availability of P, Ca, and Mg content, K also become more efficient in soil. Lime application improves physical condition of soil. It is also observed that the yield of potato increases with the application of lime in acid soil.

CHAPTER III
MATERIALS AND METHODS

The field experiment was carried out during the period from October 2012 to March 2013 at Soil Resource Development Institute (SRDI) field, Sylhet. The experiment was designed to study the changes on soil pH, available P, Ca and Mg and performance of potato under different levels of lime

This chapter presents a brief description on the experimental site, soil, climate, crop, experimental design, treatments under investigation, cultural operations, land preparation, collection of plant materials, sowing of seed, collection of soil samples, analytical methods involved in estimating concentration of nutrients in the soil samples, harvesting of the crop, data collection and statistical analysis of the data.

3.1 Experimental site

The experimental site belongs to the field laboratory of Soil Resources Development Institute, Sylhet. Geographically, the experimental site is located at 24°52´2.0″ N latitude and 91°51´ 29.4″E longitude. The site falls under the Agro-ecological Zone-20, Eastern Surma-Kusiyara Floodplain.

3.2 Soil

The soil of the experimental site belongs to Goyainghat soil series of the Surma-Kusiyara Floodplain. General soil type is non-calcareous grey floodplain soil with organic matter content of 2.27%. The morphological characteristics, physical properties and chemical composition of the soil are presented in Appendix-1.

3.3 Collection of soil samples

Composites soil samples were collected from plough layer of the experimental field before liming and from individual plot after harvesting of crops.

3.4 Climate

The experimental site enjoys the subtropical monsoon climate characterized by an average temperature over 10-day intervals ranging from 20.07 ^{0}C to 27.52 ^{0}C and heavy rainfall during kharif season (April to September) and scanty rainfall associated with moderately low temperature and plenty of sunshine in rabi season (October to March). High temperature prevails in the kharif season with occasional gloomy weather. The experiment covered a period from October 2012 to March 2013. The winter climatic condition of Bangladesh (Rabi season) is favorable for potato cultivation.

3.5 Treatments

In the experiment different levels of lime were applied viz. 0, 4, 8 and 12 kg decimal^{-1} (0, 0.988, 1.976 and 2.964 t ha^{-1}). Other fertilizer application remains the same for all treatments.

3.6 Experimental design and layout

The experiment was laid out in a randomized complete block design (RCBD) with four treatments and four replications. The size of each unit plot was 2 m^2 (2.0 m × 1.0 m). The total number of plots were 16. The blocks were treated as replications. The unit plots were randomly selected for four treatments. The spaces between blocks and between plots were 0.50 m. One meter guard area was kept around the entire experimental plot.

3.7 Collection of seeds

Potato variety used in the experiment was Diamant. The B-Grade seeds of potato were collected from Bangladesh Agricultural Development Corporation (BADC), seed marketing section, Sylhet.

3.8 Collection of fertilizer

The fertilizers e.g., urea, triple super phosphates (TSP), muriate of potash (MoP), gypsum, zinc sulphate and solubor (boron) were collected from local market in Sylhet.

3.9 Land preparation

The experimental land was first opened on 31 October 2012 and ploughed using a power tiller and subsequently four ploughing with country plough were done followed by laddering to obtain the desirable tilth. The land was prepared by removing weeds, stubbles and crop residues and trimming ails. The layout was done as per experimental design.

3.10 Liming

After land preparation, different rates of lime (dololime) were applied as per experimental treatments (3.5). Lime was applied directly to dry soil followed by cross ploughing and laddering to make well incorporation of lime with soil. After that light irrigation was done.

3.11 Fertilizer application

The experimental plots were fertilized with urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and solubor at the rate of 245, 130, 226, 72, 16 and 3 kg ha^{-1}, respectively after 17 days of liming. One half of urea and MoP and all of the other fertilizers were applied during the final land preparation. Rest of urea and MoP were applied 32 days after tuber planting.

3.12 Preparation of seed materials

The seeds were taken out of the cold storage 10 days before planting and kept in a ventilated room and allowed to sprout in diffused light for obtaining healthy and sturdy sprouts prior to planting. Damaged tubers were removed. The average weight of well sprouted whole tubers was 20 g and sprouted large sized tubers of 40 g or above weight were cut longitudinally into two equal pieces each having more than two eyes. The cut tubers were hardened by mixing of ash so as after planting the tubers were not attacked by ant or any other soil pests. The seed rate was 1.5 t ha^{-1}.

3.13 Planting of seed tubers

The whole sprouted seed tubers were planted at a spacing of 60 cm × 25 cm on 24 November 2012 at a depth of 5 cm. The unit plot size was 2 m × 1 m. Thus, each plot accommodates 16 seed tubers in 2 rows, each row having 8 tubers.

3.14 Intercultural operations

The intercultural operations undertaken on different dates are presented in Appendix -2.

3.14.1 Earthing up

Earthing up around the plant was done at 32 and 50 days after planting in the selected plots for ridging which was preceded by top dressing of the remaining half of urea and MoP, by taking the soil from the space between the rows into plots by a small spade.

3.14.2 Weeding and mulching

The crop was infested with bathua (*Chenopodium album* L.), durba (*Cynodon dactylon* L.), chapra (*Eleusine indica*), mutha (*Cyperus rotundus* L), and obnoxious weeds. Weeding was done manually using *niri* as and when required to keep the plots free from weeds. The soil was mulched by breaking the crust for easy aeration. These two operations were done carefully without hampering roots and shoots for the luxurious crop growth.

3.14.3 Top dressing of fertilizer

Top dressing of urea and MoP was done 32 days after sowing.

3.14.4 Irrigation

Pre-emergence irrigation was done 7 days after planting as because moisture was not optimum for germination before emergence, light irrigation was done for even germination of seed tuber. After emergence, three times moderate irrigations were given throughout the growing period on 30, 50 and 70 days after planting.

3.14.5 Plant protection measures

Dithane M-45 @ 2.25 kg ha^{-1} was applied 3 times at 15-day intervals during vegetative growth as preventive measures against late blight disease. First application was done at 45 days after planting. The remaining was done at 15-day intervals.

3.15 Harvesting

The crop was harvested at full maturity at 96 days after planting on 2nd March 2013. Maturity was determined by the appearance of yellowish color of most leaves, falling of stems on the ground and finally drying of few leaves. Harvesting was done manually with the help of country plough. Enough care was taken to avoid injury of potatoes during harvesting. Initially 6 sample plants were harvested randomly from each plot to collect data, and then the tubers of rest of the plants were harvested.

3.16 Data collection

The observations pertaining to the following characters were recorded during the plant growth and after harvest from the randomly selected 6 tagged plants of each unit plot.

3.16.1 Days required for 80% emergence of the crop

This was achieved by recording the time taken to reach emergence of 12 tubers out of 16 tubers planted in each crop.

3.16.2 Plant height

The plant height was measured in centimeters from the ground level to the tip of the longest shoot in unit plots after 75 days of planting. Results of 6 sample plants were averaged, calculated and presented.

3.16.3 Foliage coverage

The foliage coverage was determined in percentage (%) by visual observation at 75 days after planting.

3.16.4 Number of main stems hill^{-1}

The number of stem per hill was calculated from 6 plants selected at random from each unit plot and mean was calculated.

3.16.5 Root length

Root length was measured in centimeters from the selected 6 tagged plants of each unit plot after harvesting and mean was calculated.

3.16.6 Number of tubers hill^{-1} at harvest

The number of tubers per plant was counted from the average of 6 selected plants from each unit plots at the time of harvesting.

3.16.7 Weight of tubers hill^{-1} at harvest

The weight of tubers per plant was determined from the average of 6 selected plants from each unit plots at the time of harvesting.

3.16.8 Yield of tuber

Yield of tuber per plot was recorded at the time of harvesting from all plants of each plot and it was recorded in kilograms. The yield of tuber per plot was converted into yield per hectare, expressed as t ha^{-1}.

3.17 Chemical analysis of soil

3.17.1 Soil pH

Soil pH was determined by glass electrode pH meter in 1:2.5 soil water suspensions. The suspension was allowed to stand for one hour with occasional shaking before pH was determined (Jackson, 1958).

3.17.2 Total nitrogen

Kjeldahl method (wet oxidation procedure) was used to determine total N from soil sample. Digestion of soil sample was made with concentrated H_2SO_4 to promote the oxidation of organic matter and also to organic-N to NH_4-N and catalyst mixture (K_2SO_4.$CuSO_4$.5H_2.Se = 100:10:1) to increase the boiling temperature of digestion. Se increases the rate of oxidation of organic matter by H_2SO_4. NH_4-N in the digest was determined by the collection of NH_3 liberated by distillation of the digest with 33% NaOH. Distillate is collected in 0.05M HCl solution and finally titrated against 0.05M NaOH to know accurately because ammonium chloride formed by the reaction of NH_3/NH_4OH with HCl is titrated back to NaOH.

3.17.3 Exchangeable potassium

Exchangeable K was determined by flame photometer after extraction with 1N NH_4OAC, pH 7.0 (Page *et al.*, 1982).

3.17.4 Available Phosphorus

Available P was extracted by shaking with 0.5M $NaHCO_3$ solution having pH 8.5 following the method described by Olsen *et al.* (1954). The extractable P was then determined colorimetrically by $SnCl_2$ reduction method at 660 nm wavelength.

3.17.5 Available sulphur

Available S was determined by extracting the soil samples with $CaCl_2$ (0.15%) extraction method as described by Page *et al.* (1982). The sulphur content in the extract was determined turbidimetrically and the turbid was measured by spectrophotometer at 420 nm wavelength.

3.17.6 Available calcium

Available Ca was determined by Atomic Absorption Spectrophotometer (AAS). An amount of 2.5 g of soil was mixed with 25ml 1M NH_4OAC solution (pH 7.0) and shake for 30 minutes and left overnight. Then 5ml of soil extract was taken into a 50ml volumetric flask and 5 ml $LaCl_3$-solution was added to it. The volume was made by adding water. The Ca content was then measured by Atomic Absorption Spectrometer (AAS) (Page *et al.*, 1982).

3.17.7 Available magnesium

To determine Available Mg 2.5 g of soil was mixed with 25 ml 1M NH_4OAC solution (pH 7.0) and shake for 30 minutes and left overnight. Then 5 ml of soil extract was taken into a 50 ml volumetric flask and 5 ml $LaCl_3$-solution was added to it. The volume was made by adding water. The Mg content was then measured by Atomic Absorption Spectrometer (AAS) (Page *et al.,* 1982).

3.18 Statistical analysis

The calculated data on various parameters under study were statistically analyzed using MSTAT-C, a statistical package programme. The mean for all the treatments was calculated and analysis of variance for all the characters was performed by F-variance test. The significance of differences between pairs of treatment means was evaluated by the least significant difference (LSD) test at 5 % level of probability (Gomez and Gomez, 1984).

CHAPTER IV
RESULTS AND DISCUSSION

The experiment was conducted to evaluate the effect of different levels of lime on some soil properties and yield of potato. The parameters studied were days required for 80% emergence of the crop, plant height at 75 days after planting (DAP), foliage coverage at 75 DAP, number of main stems hill^{-1}, average tap root length, number and weight of tubers hill^{-1} at harvest and yield of tuber plot^{-1}. Soil pH, total nitrogen (%), exchangeable potassium, available phosphorus, sulphur, calcium and magnesium of initial and post-harvest soils were also studied to investigate changes, if any due to lime application. Results of the experiment have been presented in Tables 4.1, 4.2 and 4.3.

4.1 Effect of different levels of lime application on the yield components of potato plant

4.1.1 Days required for 80% emergence of the crop

The effect of lime on days required for 80% emergence of the crop indicated that it was significantly influenced by different levels of lime (Table 4.1 and Appendix-4). It was found that the highest number days (18 days) required for 80% emergence of the crop was observed with the plots treated with no lime (control). The second highest time (15.5 days) was required for 80% emergence of the crop due to lime application at 1.976 t ha^{-1}, 14.3 days for completing 80% emergence of the crop was recorded with the treatment of 2.964 t ha^{-1} liming. The lowest time (13.3 days) required for 80% emergence of the crop was recorded with 0.988 t ha^{-1} lime application. The range of variation between the highest and the lowest days required for 80% emergence was 4.8 days. Under Bangladesh condition where the crop period is relatively short this variation

Table 4.1. Effects of different rates of lime application on the yield and yield components of potato

Treatments (Lime rate)	Days required for 80% emergence of crop	Plant height at 75 DAP (cm)	Foliage coverage at 75 DAP (%)	Number of stems hill^{-1}	Average tap root length (cm)	Number of tubers hill^{-1}	Weight of tubers hill^{-1} (g)	Yield of tuber plot^{-1} (kg)
0 t ha^{-1}	18.0	27.3	61.3	2.50	19.8	7.07	179.7	2.88
0.988 t ha^{-1}	13.3	29.5	82.3	3.00	28.5	10.8	266.4	4.26
1.976 t ha^{-1}	15.5	29.5	68.1	3.25	24.3	10.6	225.3	3.61
2.964 t ha^{-1}	14.3	29.3	71.5	3.75	21.0	9.8	232.8	3.73
$LSD_{(0.05)}$	2.38	NS	9.64	NS	4.21	1.53	52.69	0.85
CV (%)	9.78	18.81	8.52	26.67	11.25	10.00	14.57	14.62
$S_{\bar{x}}$	0.75	1.96	3.02	0.42	1.32	0.48	16.47	0.27

NS: Not significant

of days required to complete 80% emergence may have significant influence on the ultimate yield of tubers ha^{-1}.

4.1.2 Plant height at 75 DAP

Plant height was recorded at 75 days after planting (DAP). Different levels of lime did not show any significant variation in plant height (Table 4.1 and Appendix-4). At 75 DAP, the longest plant height (29.5 cm) was recorded from the plots treated with lime rate of 0.988 t ha^{-1} and 1.976 t ha^{-1} and the shortest plant height (27.3 cm) was recorded from the control plots.

4.1.3 Foliage coverage at 75 DAP

In the present study, foliage coverage was recorded at 75 days after planting which was significantly affected by different rates of lime (Table 4.1 and Appendix-4). At 75 DAP, the highest foliage coverage (82.3%) was observed due to the application of 0.988 t ha^{-1}lime and the lowest (61.1%) was found in the treatment having no lime application. The foliage coverage was recorded 71.5% and 68.1% due to application of lime at the rate of 1.976 and 2.964 t ha^{-1}, respectively. Good foliage indicates higher growth, development and productivity of a potato plant. This character is related to the yield of tubers. Higher foliage coverage produces higher photosynthetic assimilates and thus increases tuber yield. Tran and Giroux (1991) observed the full foliage coverage at 65 to 75 days after planting when nitrogen was applied to the potato plant.

4.1.4 Number of main stems $hill^{-1}$

The number of main stems $hill^{-1}$ did not significantly differ due to the different levels of lime application and it ranged between 2.50 and 3.75 (Table 4.1 and Appendix-4). Although the differences were insignificant, the number of main stems $hill^{-1}$ increased with increasing rates of lime application. The number of main stems produced in the field was recorded as 2.50, 3.00, 3.25 and 3.75 for the treatments 0, 0.988, 1.976 and 2.964 t ha^{-1} lime applications, respectively. This character is mainly dependent on cultivars and physiological state of seed

Photograph-1

Photograph-2

Photograph-3

Photograph-4

Plate 1. Photographs 1-4 showing the effects on potato plant due to application of 0, 0.988, 1.976 and 2.964 t lime ha^{-1}, respectively

rather than the fertility of the soil (Anand and Krishnappa, 1988). Kushwah (1989) also gave similar opinion.

4.1.5 Root length (cm)

The potato plants produced numerous fibrous roots in addition to tap roots. The length of tap root significantly varied with different rates of lime treatments (Table 4.1 and Appendix-4). The highest length (28.5 cm) was produced by the plants due to application of 0.988 t ha^{-1} and the lowest length (19.3 cm) was recorded in the control plots. The root length was recorded 24.3 cm and 21 cm due to lime application at the rate of 1.976 and 2.964 t ha^{-1}, respectively. Measurement of tap root length of potato plant during harvest is shown in the plates 1-4.

4.1.6 Number of tubers $hill^{-1}$

The number of tubers $hill^{-1}$ varied significantly due to different rates of lime treatments (Table 4.1 and Appendix-4). Lime applied at the rate 0.988 t ha^{-1} produced the highest number of tubers $hill^{-1}$ (10.8) which was statistically similar with the treatment of 1.976 t ha^{-1} and 2.964 t ha^{-1} that produced 10.6 and 9.8 number of tubers $hill^{-1}$, respectively. The control treatment produced the lowest number of tubers $hill^{-1}$ (7.07). The results revealed that application of lime had positive effect on the tuber production. The increase in number of tubers per hill might be due to increased photosynthetic activity and translocation of photosynthates to auxiliary shoots which might have helped in the initiation of more stolons (Anand and Krishnappa, 1988).

4.1.7 Weight of tubers $hill^{-1}$

The weight of tubers $hill^{-1}$ was significantly affected by the different levels of lime which has been presented in Table 4.1 and Appendix-4. The heaviest weight of tubers $hill^{-1}$ (266.4g) was recorded with the application of lime at 0.988 t ha^{-1} which was statistically similar with the plants treated with 2.964 t ha^{-1}. The lightest weight of tubers $hill^{-1}$ (179.7 g) was produced by the control plots.

4.1.8 Yield of potato tuber

Yield of tubers $plot^{-1}$ (2 m^2) was significantly varied with the different levels of lime (Table 4.1 and Appendix-4). The plot treated with 0.988 t ha^{-1} produced the highest yield of tuber $plot^{-1}$ (4.26 kg). The lowest yield of tuber $plot^{-1}$ (2.88 kg) was recorded in the control plot. It was observed that, the lowest days for 80% emergence, the highest plant height, the highest foliage coverage and the highest number of tubers per hill which contributed to the highest yield of tubers $plot^{-1}$ treated with 0.988 t ha^{-1} lime applications.

The tuber yield $plot^{-1}$was converted to the yield ha^{-1} (Table 4.2). The highest yield of tuber (19.69 t ha^{-1}) was obtained when lime was applied at the rate of 0.988 t ha^{-1} and the lowest yield of tubers (14.38 t ha^{-1}) was observed from the plots where no lime was applied. Yield of potato tuber with the application of 0.988 t lime ha^{-1} increased by 36.93 % over control. However, there was no significant variation between the yield of tubers from the plants treated with 1.976 t lime ha^{-1} and 2.964 t lime ha^{-1}. Nazrul and Shaheb (2013), found the highest yield of potato tuber as 17.78 t ha^{-1} with the application of 2 t $CaCO_3$ ha^{-1} and 17.90 t ha^{-1} with the application of 2 t $CaCO_3.MgCO_3$ ha^{-1}.

Table 4.2. Effect of different rates of lime on the yield of potato tuber

Treatments (Lime rate)	Yield of tuber potato(t ha^{-1})	Increase in yield over control (%)
0 t ha^{-1}	14.38	--
0.988 t ha^{-1}	19.69	36.93
1.976 t ha^{-1}	18.63	29.55
2.964 t ha^{-1}	18.06	25.59
$LSD_{(0.05)}$	2.59	
CV (%)	10.59	
$S_{\bar{x}}$	0.9363	

4.2 Effects of different levels of lime application on changes in soil properties

4.2.1 Soil pH

Lime application increased the soil pH significantly (Table 4.3). Soil pH raised from 5.72 to 6.0 due to application of lime at the rate of 0.988 t ha^{-1}. Application of 1.976 t lime ha^{-1} lime increased initial soil pH up to 6.37. The treatment 2.964 t lime ha^{-1} increased soil pH up to 6.63. An increase in soil pH by liming is known under many soil - crop lime situations (Rahman *et al.* 2000; Dixit and Sharma, 1993; Jesmin and Heeney, 1962; Bishnoi *et al.* 1988). The increase in soil pH and decrease in soil acidity with liming might be due to the neutralization of exchangeable Al^{3+} and H^{+} by Ca^{2+} (Dixit and Sharma, 1993) and increased base saturation (Haldar and Mandal, 1987).

4.2.2 Total nitrogen

There was a significant change in total N content (%) in the post-harvest soils due to lime treatments (Table 4.3). The initial value of total N was 0.05 %. In the post-harvest soils there was no change of total N in the control plots. Due to the lime treatment of 0.988, 1.976 and 2.964 ton ha^{-1} total N (%) of post-harvest soil was 0.07%, 0.07% and 0.07% respectively. Edmeades (1981) reported that an increase in the rate of N mineralization is a major effect of lime.

4.2.3 Exchangeable Potassium

The effect of different rates of lime application on exchangeable K was significant in this study (Table 4.3). The initial value of exchangeable K was 0.14 meq $100g^{-1}$ soil which decreased to 0.10, 0.09, 0.08 and 0.09 meq $100g^{-1}$ soil in the post-harvest soils treated with 0, 0.988, 1.976 and 2.964 ton ha^{-1} lime, respectively. The result is in agreement with Jasmin and Heeney (1961). They reported that exchangeable K decreased with the addition of lime.

Table 4.3. Effects of different rates of lime applications on changes in soil properties of potato field

Treatment (Lime rate)	Soil pH	Total N (%)	Exchangeable K (meq 100^{-1} g soil)	Available P (µg g^{-1} soil)	Available S (µg g^{-1} soil)	Available Ca (meq 100^{-1} g soil)	Available Mg (meq 100^{-1} g soil)
Initial soil	5.72	0.05	0.14	4.69	6.39	4.53	3.67
0 t ha^{-1}	5.72	0.06	0.10	5.14	7.79	4.71	3.67
0.988 t ha^{-1}	6.00	0.07	0.09	6.29	9.28	4.84	4.27
1.976 t ha^{-1}	6.37	0.07	0.08	7.73	8.18	5.07	4.52
2.964 t ha^{-1}	6.63	0.07	0.09	7.08	7.60	6.12	5.68
$LSD_{(0.05)}$	0.34	0.014	NS	2.91	3.78	0.81	0.73
CV (%)	3.45	11.98	7.14	29.20	28.75	9.91	10.03

NS: Not significant

4.2.4 Available phosphorus

The initial value of available P in experimental soil was 4.69 µg g^{-1} soils. The post-harvest soils had the values of 5.14, 6.29, 7.73 and 7.08 µg g^{-1} soil in the plots treated with lime of 0, 0.988, 1.976, 2.964 t ha^{-1}, respectively (Table 4.3). Due to liming the highest value of available P was recorded from 2.964 t ha^{-1} lime application. Lime application increased the soil pH which helped the release of fixed P from the oxides and hydroxides of Fe and Al and thus increased the P availability in soil (Sultana *et al.,* 2009). Prasad (1992) reported that the value of available soil P significantly increased with higher dose of liming due to lowering down the precipitation of P with other elements (Al, Mn and Fe) and increasing level of base saturation in soil. Increase in available P after harvest of crop was also reported by Sood and Bhardwaj (1992) under application of lime.

4.2.5 Available sulphur

There was a considerable change in the soil available S due to application of different rates of lime (Table 4.3). Initial value of available S was 6.39 µg g^{-1} soil. The available S content of soil changed to 7.79 µg g^{-1}, 9.28 µg g^{-1}, 8.18 µg g^{-1} and 7.6 µg g^{-1} with 0, 0.988, 1.976 and 2.964 t ha^{-1} lime applications. The highest content of available S was found after the application of 1.976 t lime ha^{-1} and it decreased with the application of the other two lime treatments. Addition of lime reduced the sulphate adsorption capacity of soils and, therefore, their ability to retain sulphate against leaching could act (Haynes and Naidu, 1991).

4.2.6 Available calcium

Liming affected the available Ca status in soil markedly (Table 4.3). The initial value of available Calcium in the soil was 4.53 meq 100^{-1} g soil. Calcium value of the post-harvest soil was 4.71 meq $100g^{-1}$ soil, 4.84 meq $100g^{-1}$ soil, 5.07 meq $100g^{-1}$ soil and 6.12 meq $100g^{-1}$ soil as per treatment, respectively. It is observed that the Ca value of the post-harvest soil was increased with the increasing rate of lime. The liming material used as dolomite ($CaCO_3.MgCO_3$), which on dissolution released a large amount of Ca and thus the availability of Ca in post-harvest soil increased (Sultana *et al.,* 2009).

4.2.7 Available magnesium

Available Mg in post-harvest soil was affected by different lime treatments (Table 4.3). The initial value of available Mg was 3.67 meq 100^{-1} g soil and in post-harvest soil it was 3.67, 4.27, 4.52 and 5.68 meq 100^{-1} g soil, respectively. It was found that the available Mg status of post-harvest soil increased with the increasing level of lime application. As the liming material used as dolomite ($CaCO_3.MgCO_3$) which released a large amount of Ca as well as Mg in soil on dissolution and thus causing increasing availability of Mg in post-harvest soils (Sultana *et al.,* 2009).

CHAPTER V
SUMMARY

A field experiment was conducted on Eastern Surma-Kushiara Floodplain soil at SRDI Sylhet field during the period from October 2012 to March 2013 to see the effect of different rates of lime application on soil pH, N, P, K, S, Ca, Mg as well as on the growth and yield of potato.

The treatment of the experiment consisted of four different rates of lime (dololime) viz., 0, 0.988, 1.976 and 2.964 t ha^{-1}. The experiment was laid out in a randomized complete block design with four replications. The size of unit plot was 2 m × 1 m. Potato seed tubers were planted on 24th November 2012 at the rate of 1.5 t ha^{-1} in a spacing of 60 cm × 25 cm. Fertilizers were applied to each plot at the rate of 245 kg ha^{-1} urea, 130 kg ha^{-1} TSP, 226 kg ha^{-1} MoP, 72 kg ha^{-1}gypsum, 16 kg ha^{-1} zinc sulphate and 3 kg ha^{-1} solubor. The crop was harvested on 2nd March, 2013. Data on soil nutrients, yield components and yield of potato were recorded and statistically analyzed for evaluation of the treatment effects.

The results showed that the different dose of lime had marked influence on all the parameters related to growth and yield except plant height and number of stems $hill^{-1}$. On the other hand, there were also significant effect of lime on soil characters like soil pH, total N, available P, S, Ca and Mg.

The lowest time (13.3 days) required for 80% emergence of the crop was taken by the plants treated with 0.988 ton ha^{-1} and the highest time (18 days) required for 80% emergence of the crop was taken by the plants treated with no lime.

The treatment 0.988 t lime ha^{-1} recorded the highest foliage coverage (82.3%) and the lowest (61.1%) was found in the control plots.

The longest tap root length (28.5 cm) was observed in the plants treated with 0.988 t lime ha^{-1} and the shortest length (19.3 cm) was found in the control plots which was statistically similar with the plants receiving the treatments 1.976 t lime ha^{-1} and 2.964 t lime ha^{-1}.

The highest number of tubers (10.8) and weight of tubers (266.4g) $hill^{-1}$ was produced by 0.988 t lime ha^{-1} which was statistically superior to control plots. The control plants showed the lowest results in these aspects.

Tuber yields per plot as well as per hectare were significantly influenced by different levels of lime application. The highest yield of tuber (19.69 t ha^{-1}) was obtained when the crop was supplied with 0.988 t lime ha^{-1} and the lowest (14.38 t ha^{-1}) was found with the control.

The application of different rates of lime to soil progressively increased soil pH. Soil pH increased from 5.72 to 6.63 in the post-harvest soil as a response of increasing rates of lime application.

The total N (%) varied markedly due to application of lime. The highest value of total N (%) was recorded as 0.07% from the treatment of 0.988, 1.976 and 2.964 t lime ha^{-1} and the lowest value was 0.06 from the treatment of 0 t lime ha^{-1}.

The exchangeable K did not vary significantly due to application of lime.

On the other hand, the highest value (7.73 μg g^{-1} soil) of available P of post harvest soils was recorded from the treatment 1.976 t lime ha^{-1} and the lowest value (5.14 μg g^{-1} soil) from the control.

The S content was also appreciably changed in the post-harvest soil. The highest sulphur content was found with the treatment 0.988 t lime ha^{-1} and the lowest result was with the 2.964 t lime ha^{-1} treatment.

Application of 2.964 t lime ha^{-1} recorded the highest value of both available Ca and available Mg contents of post-harvest soils which were 6.12 meq 100^{-1} g soil and 5.68 meq 100^{-1} g soil, respectively.

CHAPTER VI
CONCLUSIONS AND RECOMMENDATION

A field experiment was carried out in Goyainghat soil series of the Eastern Surma-Kusiyara Floodplain soil at SRDI (Soil Resource Development Institute), Sylhet with a view to study the effects of different rates of lime application on changes of soil pH, total N, exchangeable K, available P, S, Ca and Mg contents and also on the yield of potato.

The result revealed that the application of lime showed positive effect on the growth, yield and yield components of potato. It was also observed that the nutrient availability increased due to lime application. Among the treatments 0.988 t lime ha^{-1} showed the better performance in respect of yield and quality of soil.

The experiment needs to be conducted in different soil series especially in Sylhet region considering the level of acidity of soil for a wider acceptability of the findings.

For identification of liming dose in acid soils further location specific study is needed.

Potato is emerging as a major food crop in Bangladesh and is being cultivated throughout the country. A major part of medium high land of Goyainghat soil series in Sylhet region that remains fallow in rabi season where potato can be cultivated by adding 0.988 t lime ha^{-1} followed by other fertilizers. The potential cropping pattern may be as

i) Potato/ Rabi crops- T. Aus rice/jute- T. Aman rice

ii) Potato/Rabi crops- Fallow- T. Aman rice

CHAPTER VI

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APPENDICES

Appendix-1. Morphological and chemical characteristics of the soil (0-15cm)

A. Morphological characteristics:

Locality	:	Soil Resource Development Institute, Pirojpor, Sylhet, Bangladesh.
Physiographic unit	:	Surma Kusiyara Floodplain
Soil tract	:	Surma-Kusiyara Alluvium
Soil series	:	Goyainghat
Order	:	Inceptisols
Suborders	:	Aquepts
Greatgroup	:	Endoaquepts
Subgroup	:	Typic Endoaquepts
Family code	:	Loamy, mixed, nonacid, hyperthermic
Drainage	:	Adequate
Topography	:	Medium high land
Flood level	:	Above flood level
Locality	:	Soil Resource Development Institute, Pirojpor, Sylhet, Bangladesh.
Physiographic unit	:	Surma Kusiyara Floodplain
Soil tract	:	Surma-Kusiyara Alluvium
Soil series	:	Goyainghat
Order	:	Inceptisols

B. Chemical characteristics:

pH	:	5.7
Organic matter (%)	:	1.95
Total N (%)	:	0.06
Exchangeable K (meq $100g^{-1}$ soil)	:	0.14
Available P (µg g^{-1} soil)	:	4.69
Available S (µg g^{-1} soil)	:	6.39
Available Ca (meq $100g^{-1}$ soil)	:	4.53
Available Mg (meq $100g^{-1}$ soil)	:	3.67

Appendix-2. Cultural operations made in the experimental plots:

Name of operation	Dates of the operations
Land preparation	31-10-2012 to 01-11-2012
Initial soil sample collection	03-11-2012
Liming	03-11-2012
Layout of the Experiment	20-11-2012
Application of basal dose of fertilizer	20-11-2012
Preparation of planting materials	23-11-2012
Planting of tubers	24-11-2012
Pre-emergence irrigation	02-12-2012
2nd Irrigation	25-12-2012
1st Weeding	25-12-2012
1st Earthing up	27-12-2012
Top dressing of fertilizer	27-12-2012
2nd Earthing up	14-01-2013
3rd Irrigation	14-01-2013
1st Pesticide application	24-01-2013
Weeding	24-01-2013
4th Irrigation	02-02-2013
2nd Pesticide application	02-02-2013
Data collection (Plant height and foliage coverage)	08-02-2013
3rd Pesticide application	13-02-2013
Data collection (main stems per hill)	13-02-2013
Harvesting	02-03-2013
Post-harvest soil collection	03-03-2013

Appendix-3. Analysis of variance of data on the yield components and yield of potato

Sources of variation	Degrees of freedom	Mean squares								
		Days required for 80% emergence of crop	Plant height (cm) at 75 DAP	Foliage coverage (%) at 75 DAP	Number of main stems $hill^{-1}$	Tap root length (cm)	Number of tubers $hill^{-1}$	Weight of tubers $hill^{-1}$ (g)	Yield of tuber $plot^{-1}$ (kg)	Yield of tuber (t ha^{-1})
Replication	3	2.167	26.917	44.362	1.417	0.083	5.541	2363.565	0.598	7.010
Treatment	3	16.833**	0.3081	306.550**	1.083	61.083**	11.840**	5099.109*	1.305*	21.323**
Error	9	2.222	15.417	36.348	0.694	6.917	0.915	1084.962	0.280	3.507

** Significant at 1% level of probability; * Significant at 5% level of probability

Appendix-4. Analysis of variance of data on the pH and nutrients value of post harvest soil of potato field

Sources of variation	Degrees of freedom	Mean squares						
		Soil pH	Total N (%)	Exchangeable K (meq $100g^{-1}$ soil)	Available P (µg g^{-1} soil)	Available S (µg g^{-1} soil)	Available Ca (meq $100g^{-1}$ soil)	Available Mg (meq $100g^{-1}$ soil)
Replication	3	0.085	0.0001	0.0001	3.477	0.257	0.235	1.111
Treatment	3	0.629**	0.0006**	0.0003	4.912*	2.240*	1.898**	2.836**
Error	9	0.045	0.00008	0.00001	3.312	5.573	0.259	0.206

** Significant at 1% level of probability; * Significant at 5% level of probability