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RESEARCH ARTICLE

ON-FARM VERIFICATION OF DOLOMITE LIME AND SOIL TEST BASED FERTILIZER ON TUBER YIELD OF POTATO (*Solanum tuberosum*) IN ACIDIC SOILS UNDER SURMA-KUSHIYARA FLOODPLAIN OF BANGLADESH

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ABSTRACT

On-farm verification trial was conducted with lime and soil test based fertilizer application for improving the yield of potato in acidic soils under the Surma-Kushiyara Floodplain soil of Bangladesh. The trials were laid out in a factorial randomized complete block design with six dispersed replications. The treatments were, M_1: soil test based (STB) recommended fertilizer and M_2: farmers practice (FP) and dolomite levels (L_0: 0 t ha^{-1}, L_1: 1 t ha^{-1} and L_2: 2 t ha^{-1}). The result showed that average yield of tuber (24.04t ha^{-1}) was higher in STB fertilizer (M_1). Lime application gave significantly superior tuber yields of potato in all three years. The average tuber yield of potato increased in treatments L_1 and L_2 by 6.73 and 19.75%, respectively over non- lime control. The STB fertilizer dose (N_{151} P_{29} K_{116} S_{14} Zn_1 kg ha^{-1}) along with 2 t ha^{-1} of dolomite (M_1L_2) performed better and produced the highest average tuber yield (25.46 t ha^{-1}) of potato. Economic analysis revealed that maximum gross return (Tk. 305520 ha^{-1}) and gross margin (Tk.170852 ha^{-1}) was obtained from treatment combination M_1L_2 followed by M_2L_1 (N_{160} P_{50} K_{130} S_0 Zn_0 kg ha^{-1} and 1 t ha^{-1} of dolomite lime). The maximum marginal benefit cost ratio (MBCR) 9.06 over non-lime control was also observed in treatment combination M_2L_1. Considering the results, the fertilizer nutrients practice by farmers (N_{160} P_{50} K_{130} S_0 Zn_0 Kg ha^{-1}) with 1 t ha^{-1} of dolomite lime was found more profitable and viable among the treatments for cultivating potato under strongly acidic soil of Sylhet in Bangladesh.

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INTRODUCTION

Potato (*Solanum tuberosum* L.) is the third most important crops in the country followed by rice and wheat. Potato is commonly use as vegetables; which contributes to about 55% of the total annual vegetable production in Bangladesh (BBS, 2009). However; the climate of Sylhet region is suitable for potato, tomato, cabbage, aroids and other vegetable production (Nazrul and Shaheb, 2014; Sarker *et al*., 2012). At present, the potato is being cultivated by farmers and it becoming a commercial crop in this area. To enhance potato production, potato-rice based improved cropping pattern is an economically viable and improved cropping pattern for utilization of fallow land in Sylhet region instead of existing Fallow-T. aus-T. aman rice cropping pattern (Nazrul *et at*, 2013). The problem of acidic soils is an important challenge for Bangladesh because of their adverse effect on soil fertility, crop production and food security (FRG, 2012). At present, more than 30 % lands of this country comprises of very strongly acidic (pH < 4.5, strongly acidic (pH 4.5-5.5) and slightly acidic (pH 5.5-6.5). The soils of Sylhet regions are strongly acidic. In this regard, strong soil acidity could be considered as an important factor that adversely affecting crop production in Sylhet. Use of liming materials to reduce the soil acidity is an important soil management practice as well as improve crop yields with proper nutrient availability (Nazrul and Shaheb, 2016; Nazrul and Khan, 2016; Shaheb *et al*., 2014; Rahman *et al*., 2013). Liming raises soil pH and reduces the toxic effect of Al, Fe and Mn, and increases the availability of P, Mo, Ca, and Mg (Bodruzzaman, 2010; FRG, 2012). Adding lime increases soil pH, reduces acidity, adds Ca and/or Mg, and reduces the solubility of Al and Mn in the soil (Anderson *et al*., 2013). Numerous researches have confirmed positive effect of liming on vegetables crops (Nazrul *et al.,* 2016). Dolomite is one of the commercial limes and could increase pH level of soils. Plants need a constant supply of Ca for vigorous leaf and root development and canopy growth (Del-Amor *et al*., 2003). Magnesium is a major constituent of cell wall (Jones, 1999). Thus, there is a need to demonstrate and verify the importance of lime and soil test based fertilizer

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application in improving the yield of potato under farmers' field condition.

MATERIALS AND METHODS

An experiment was conducted under farmer's fields located at farming system research and development (FSRD) site, Jalalpur, Sylhet during 2013-2016 to study the effect of dolomite lime under fertilizer nutrient management practices on the yield of potato. The study area lays $24^0$89' N latitude and $91^0$87' E longitude under the Surma-Kushiyara Floodplain soil of Bangladesh. The type of experimental soil is non-calcareous gray with low organic matter content (1.29%), low soil pH (4.2-5.1), very low total N (0.06%), low content of P (8.59), K (0.13) and S (9.14) where as Zn (1.22) and Boron (0.48) medium and optimum, respectively. The experiment was laid out in a factorial randomized complete block design with six dispersed replications where fertilizer nutrient managements M_1: soil test based (STB) recommended fertilizer and M_2: farmers practice (FP) and levels of dolomite lime (L_0: 0 t ha^{-1}, L_1: 1 t ha^{-1} and L_2: 2 t ha^{-1}) were the treatment variables. The dolomite lime (CaO: 30 %, MgO: 22% and CO_2: 48%) was applied 15-20 days before sowting of seed potato tubers with spread method on the top of the soil and then incorporated at soil depth of 25 cm. The fertilizers nutrients packages M_1: $N_{151}P_{29}K_{116}S_{14}Zn_1$ was calculated as per the initial nutrient status of the experimental soil and M_2: $N_{160}P_{50}K_{130}S_0Zn_0$ Kg ha^{-1} based on average fertilizer doses of 25 farmers. The potato tubers (var. Diamant) were sown in between 25-28 November in three consecutive years. Seeds were sown at the rate of 1500 kg ha^{-1} with spacing 60 cm *x* 25 cm. Entire amount of TSP, gypsum, zinc sulphate and one half of MoP and urea was applied at final land preparation. The remaining urea and MoP was top dressed at 25-30 days after seeding (DAS) before earthing up. Two irrigations were given at 25-30 and 45-50 DAS. The fungicides Indofil and Rovral were applied at 3`5 and 45 DAS, respectively for late blight control. The tuber was harvested in between 22-25 February in each year. The tuber yield was recorded properly for statistical analyze and means were separated by least significant difference (LSD) test at 5% level of significance. Cost benefit analysis was done based on the market price of the inputs and outputs.

RESULTS AND DISCUSSION

The effect of fertilizer management practices and different levels of dolomite lime and their interactions on the tuber yield of potato are presented in Table 1. Considering fertilizer nutrients management packages showed highest tuber yield (24.04 t ha^{-1}) of potato in soil test based (STB) fertilizer (M_1) while lowest (21.48 t ha^{-1}) in farmers practice (M_2) as control. The STB recommended fertilizer treated plots (M_1) increased the average tuber yield by 11.91 % over non-limed control (M_2). In the case of dolomite lime, the highest tuber yield (25.04 t ha^{-1}) of potato was found with dolomite 2 t ha^{-1} (L_2) in three consecutive years while non liming treatment produced the lowest average tuber yield (20.91 t ha^{-1}) of potato. Similarly, lime treated plots increased the tuber yield of potato by 6.73 t ha^{-1} and 19.75 % over the control. There was increase of tuber yields with increasing of dolomite levels.

Table 1. Effect of fertilizer management and level of dolomite liming on the tuber yield of potato in acidic soil of Sylhet (2013-2016)

Treatments	Tuber yield of potato (tha^{-1})			Average yield of tuber (tha^{-1})
	2013-14	2014-15	2015-16	
Fertilizer managements				
M_1	21.15	23.51	27.46	24.04
M_2	20.04	20.83	23.56	21.48
Level of liming				
L_0	18.64	20.20	23.89	20.91
L_1	20.00	21.71	25.26	22.32
L_2	23.15	24.60	27.38	25.04
CV (%)	8.58	16.22	8.60	11.13
$LSD_{(0.05)}$	NS	NS	NS	8.58
Fertilizer managements × Level of dolomite lime				
M_1L_0	19.64	22.33	26.64	22.87
M_1L_1	20.80	23.27	27.29	23.79
M_1L_2	23.02	24.93	28.44	25.46
M_2L_0	17.65	18.07	21.13	18.95
M_2L_1	23.27	24.27	26.31	24.61
M_2L_2	19.20	20.16	23.23	20.86
CV (%)	8.58	16.22	8.60	11.13
$LSD_{(0.05)}$	2.67	6.54	3.99	4.40

M_1: soil test based (STB) recommended fertilizer and M_2: farmers practice (FP) and Level of limes L_0: 0 tha^{-1}, L_1: 1 tha^{-1} and L_2: 2 tha^{-1}

Table 2. Cost and return analysis of fertilizer management with levels of dolomite limes on the tuber yield of potato in acidic soil of Sylhet (2013-16)

Treatments	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk.ha^{-1})	MGR (Over control)	Marginal TVC (Over control)	MBCR (Over control)
M_1L_0 (control)	274440	119668	154772	0	0	0
M_1L_1	285480	127168	158312	11040	7500	1.47
M_1L_2	305520	134668	170852	31080	15000	2.07
M_2L_0 (control)	227400	122072	105328	0	0	0
M_2L_1	295320	129572	165748	67920	7500	9.06
M_2L_2	250320	137072	113248	22920	15000	1.53

MGR: Marginal gross return; MBCR: Marginal benefit cost ratio; Price of input and output (Tk.Kg^{-1}): Dolomite lime or $CaMg(CO_3)_2$ - 7.50, Urea-16.00, TSP-22.00, MoP-15.00, Gypsum-10.00, Zinc- 120.00, Cowdung-1.50, potato-12.00

It might be the application of dolomite lime may improve the pH of the acidic soils and its higher content of available nitrogen and phosphorus helps to increase the yield of crops.
The research findings of consecutive years revealed that liming with dolomite under STB fertilizer nutrient management practices played significant role in increasing the tuber yield of potato. The individual effect of fertilizer nutrient managements and doses of dolomite showed that significantly higher tuber yield of potato was produced by M_1 and L_2. However, the combined application of fertilizer nutrient management (M_1) and dolomite lime (L_2) resulted in higher tuber yield (25.46 t ha^{-1}) while the lowest average tuber yield (18.95 t ha^{-1}) of potato was gained from M_2L_0. These results are also in agreement with the findings of other researchers (Khandakhar *et al*., 2004; Haile and Boke, 2011) who reported that agricultural limes (2-4 t ha^{-1}) can be effective in increasing Irish potato yield in acidic soils. Lee and MacDonald (1977) also reported that the application of dolomite limestone in acidic soils increased tuber yield and improved tuber quality. The application of calcium carbonate (1.0 t ha^{-1}) with phosphorus in soil produced maximum tuber yield over control as reported by Rahman *et al*., (2014). Liming improved overall soil properties like soil pH, available P and total nitrogen and reduced exchangeable Al.

Cost benefit analysis of dolomite application under STB fertilizer nutrient management on tuber yield of potato revealed that maximum gross return (Tk.305520 ha^{-1}) and gross margin (Tk. 170852 ha^{-1}) was obtained from treatment combination M_1L_2 (N_{151} P_{29} K_{116} S_{14} Zn_1 and 2 t $ha^{-1}$of dolomite lime) followed by M_2 L_1 (N_{160} P_{50} K_{130} S_0 Zn_0 kg ha^{-1} and 1 t $ha^{-1}$of dolomite lime). On the contrary, the treatment combinations with non-limed controls (M_1L_0 and M_2L_0) provided the lowest gross return Tk. 274440 and Tk. 227400 and gross margin Tk. 154772 and Tk. 105328 ha^{-1}, respectively (Table 2). Though the highest gross return and gross margin was obtained from STB fertilizers nutrients packages with 2 t ha^{-1} of dolomite lime (M_1L_2) but the maximum marginal benefit cost ratio (MBCR) 9.06 over non-limed control was observed in treatment combination M_2L_1 (N_{160} P_{50} K_{130} S_0 Zn_0 kg ha^{-1} and 1 t ha^{-1} of dolomite lime). It was due to lower dose of lime and variable cost compared to treatment combination M_1L_2 ($N_{151}P_{29}$ K_{116} S_{14} Zn_1 kg ha^{-1} and 2 t $ha^{-1}$of dolomite lime).

Conclusion

Results revealed that the tuber yields of potato were varied significantly where M_1L_2 ($N_{151}P_{29}$ K_{116} S_{14} Zn_1 kg ha^{-1} and 2 t $ha^{-1}$of dolomite lime) produced the highest average tuber yields of potato. It might be due to the application of lime which improves the pH of the acidic soils and its higher content of available nitrogen and phosphorus helps to increase the tuber yield. As per monetary advantage, the maximum marginal benefit cost ratio (MBCR) 9.06 over non-limed control was found in treatment combination M_2L_1 (N_{160} P_{50} K_{130} S_0 Zn_0 kg ha^{-1} and 1 t $ha^{-1}$of dolomite lime); which is found more profitable and viable among the treatments combination for growing potato under strongly acidic soil of Sylhet in Bangladesh.

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