INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 17, No. 2, p. 185-193, 2020

RESEARCH PAPER OPEN ACCESS

Effect of lime on the yield performance cabbage, cauliflower, tomato, chili and brinjal in the Hill Valley soil of Bangladesh

Md. Zonayet*[1], Mostak Ahmed[2]

[1]*CRP-1: Hill Agriculture, Sustainable Land Management (Component-II), Krishi Gobeshona Foundation (KGF), Bandarban, Bangladesh*

[2]*On-Farm Research Division (OFRD), Bangladesh Agricultural Research Institute, Bandarban, Bangladesh*

Key words: Lime, Hill Valley soil, Soil fertility, Yield of vegetables

http://dx.doi.org/10.12692/ijb/17.2.185-193 Article published on August 30, 2020

Abstract

The experiments were conducted in three hill district of Bangladesh (CHTs) i.e Bandarban, Khagrachari and Rangamati under the AEZ 29 (Northern and Eastern Hills Tract) during November 2017 to March 2019 to study the Effect of lime on the yield performance Cabbage, Cauliflower, Tomato, Chili and Brinjal in the hill valley soil. The experiment was designed on Randomized Completely Block Design (RCBD) with two treatments and three replication. The treatments consider as Lime 2t/ha instead of farmers practice. In valley acidic soil cabbage, tomato, chilli, brinjal and cauliflower were grown with lime application @ 2t/ha. Yield of cabbage varied from 49.36-57.23t/ha. Highest yield of cabbage (57.23t/ha) was found at Bandarban site instead of farmer practice. Yield of chili was ranged from 9.93 to 18.21ton/ha. Highest chilli yield (18.21t/ha) was recorded from Bandarban Site. Yield of brinjal was ranged from 54.43 to 56.67ton/ha. The highest brinjal yield 56.67t/ha at Khagrachari and tomato yield 55.39t/ha was found at Bandarban Site. Yield of cauliflower was ranged from 44.55 to 52.65ton/ha, where highest yield (52.65t/ha) of cauliflower was recorded from the field of Khagrachari site and lowest yield of cauliflower was recorded 44.55 ton/ha in Bandarban site instead of farmer practice.

* **Corresponding Author:** Md. Zonayet ✉ zonayetamin@gmail.com

Introduction

Chattogram Hill Tracts (CHT) covers 13,295km² which is around 9% of the total land area of Bangladesh. In the undulating terrain in hilly districts of Bandarban, Khagrachari and Rangamati agriculture occupies only 6% of land area. Nearly 70% of the total households in the hill districts depend primarily on agriculture of which 71% represents marginal and small farmers (BBS, 2008). Despite of expansive green valleys and hills, low population density and favorable environment for growing wide varieties of crops, most people are extremely poor than the average poor segment in the plains. The reasons for poverties of the farming communities in CHT can be attributed principally to relatively low productivity of hill soils and farmers' limited access to developed land management technologies. If managed properly, the exposed area of elevated hills being much more than the covered land area of 9% can play a vital role in total food production of the country (Khandakhar *et al.*, 2004)

Hilly area is potential for growing variety of crops throughout the year. Because, hill slopes are always free from flood. The hilly areas are also have high potentiality for fruits and vegetable production due to favorable prevailing weather condition, easily available hardy labour, high demand and market price, create year round employment opportunity for the people (both male and female) in different aspects like production system, packaging, processing, marketing etc., utilization of the fallow land through sustainable cropping system, increased food production and developed better livelihood of the hilly people and create environment friendly green belt in the hilly areas (Sultana *et al.*, 2009) . Most of the cultivable land (62%) is single cropped (Uddin *et al.*, 2010). For this the cropping intensity of hill area is much lower than that of plain area. Agriculture is the major source of income and livelihoods of CHT farmers. Majority household heads are involved in agricultural production (UNDP 2009).

Acidification of soils is an important challenge for some areas of Bangladesh because of their adverse effects on soil fertility, crop production and food security. At present more than 30 per cent lands of this country have acidity constraint for crop production which is either very strongly acidic (pH < 4.5), strongly acidic (pH 4.5-5.5) or slightly acidic (pH 5.5-6.5) (FRG, 2012). Among them hill valley of Bangladesh is most important factor. Most of the hill valley soil (Bandarban, Khagrachari and Rangamati) contain strongly acidic pH<4.5. Hill valley is most suitable for vegetable cultivation by minimizing of soil pH. 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). Several other reports (Mongia *et al.*, 1998; Rahman *et al.*, 2000; Rahman *et al.*, 2002, and Rahman *et al.*, 2004) also suggest that liming eliminated the toxic effect of aluminum and manganese and increased the availability of several plant nutrients, such as Ca, Mg, P, N, and Mo. Numerous researches have confirmed the positive impact of liming on yield of some crops (Rastija *et al.*, 2010; Shaheb *et al.*, 2014; Rahman *et al.*, 2013; Rahman *et al.*, 2005).

The climate of this region is suitable for potato, tomato, cabbage, aroids and other vegetable production (Nazrul and Shaheb. 2014; Nazrul *et al.*, 2013a; Nazrul *et al.*, 2013b; Shaheb *et al.*, 2012; Sarker *et al.*, 2012). In addition, agriculture is the only economic activity of most small farmers in this region. But strong soil acidity is an important factor that adversely affecting crop production. Use of liming materials to correct the soil acidity is an important aspect of soil management practice. Thus, lime application improved crop yields by eliminating the production constraints and favoring the production factors related to nutrient availability (Shaheb *et al.*, 2014; Rahman *et al.*, 2013; Rahman *et al.*, 2005). Cabbage (Brassica oleracea var. capitata) and Cauliflower (Brassica oleracea var. botrytis) are cole vegetables crops which are grown better in pH 6.0- 6.8 (Knott 1962).

Most of the soils of CHT are moderate to strongly acidic in nature. In acid soil, concentration of Al, Fe and Mn is generally increased due to their solubility in acid medium. This high concentration of Al, Mn &

Fe may become toxic to plant, hamper root growth and thus adversely affect the plant growth and yield. High concentration of Al and Fe reacts with available phosphorus to form insoluble Al and Fe phosphate and thus render P unavailable to plants. As a result, the available phosphorus status in hilly soils is low to very low and high dose of phosphate fertilizer is required for satisfactory crop production in hill soils. Moreover, a large number of microorganisms, which is responsible for organic matter decomposition and mineralization process, become in active in very acid soil. Consequently, organic matter decomposition and mineralization process become slowly and plant do not get their nutrient in required amount from the soil. Considering the facts as stated, a judicious liming program need to be initiated for increasing the availability of phosphorus to plants and increasing microbial activity and to reduce the solubility and toxicity of Al, Mn and Fe that adversely affect the plant growth and yield. For that reason, this detailed study was under taken to evaluate the yield performance of cabbage, cauliflower, tomato, brinjal snd chili as affected by liming and to restore/maintain and enhance soil fertility for sustainable agriculture in the uplands and hill valley.

Materials and method

Experimental site

All experiments were conducted under farmer's fields located at hill valley of Bandarban, Khagrachari and Rangamati site of Chattagram under the AEZ 29 (Northern and Eastern Hills Tract) 2017-2019 to study the effect of lime on the yield performance Cabbage, Cauliflower, Tomato, Chili and Brinjal in the hill valley soil.

Research collaborating organization

Laboratory experiments and farmers participatory trials have been done to develop sustainable land management technologies for on-station, on-farm and hill valley of CHT in order to improve the productive capacity of the soil and crop yield. As an Institutional support, researchers and field/laboratory staffs of HARS, BARI Khagrachari, Hartazari and OFRD, BARI Bhandarban, Cotton Development Board (CDB), Bandarban and BSMRAU, Gazipur and SAU, Dhaka along with recruited project officers, and other scientific staffs are engaged for setting the trials, data collection and processing.

Experimental method and materials

In this experiments liming materials were used as agricultural lime ($CaCO_3$) or dolomite-Ca Mg $(CO_3)_2$. In valley soil crops were selected as a experimental view i.e Cabbage, Cauliflower, Tomatoes, Brinjal and Chilli. Variety/Cultivar: Cabbage: Atlas 72, 70 and music, Cauliflower: Snowbox, Silver star, Quite excel, Tomatoes: Heroplus, Surokkha, Brinjal: Lacal, Chilli: NS 1701. The experiments were laid out in a Randomized Completely Block Design (RCBD) with three replications. Fertilizer dose: Cabbage: N_{150} P_{55} K_{63} S_{20} $Zn_{2.3kg/ha}$; CD 5t/ha, Lime 2t/ha, Cauliflower: N_{150} P_{75} K_{135} S_{27} $Zn_{3.4}$ $B_{0.75kg/ha}$; CD 5t/ha, Lime 2t/ha, Tomato: N_{150} P_{75} K_{135} S_{27} $Zn_{3.4}$ $B_{0.75kg/ha}$; CD 5t/ha, Lime 2t/ha, Brinjal: N_{170} P_{72} K_{150} S_{20} $Zn_{3.4}$ $B_{0.75kg/ha}$; CD 5t/ha, Lime 2t/ha, Chilli: N_{100} P_{158} K_{120} S_{27} $Zn_{3.4}$ $B_{0.75kg/ha}$; CD 5t/ha, Lime 2t/ha.

Pre-harvest soil collection

During land preparation the initial soil samples were collected from 0-15 cm soil depth. An auger was used for drowning the samples by means from different location covering the whole experimental plot and mixed thoroughly to make a composite sample. The plant roots, leaves etc. were picked up and removed after collection of soil samples, then the samples were air-dried.

Application of lime and fertilizers

Agricultural lime or dolomite was used before final land preparation. Before 10-15 days ago lime was mixed with soil in hill valley simultaneously. When a land used lime in one year its effects stay in field almost two-three years. Fertilizers were applied in the form of Urea, TSP, MoP, Gypsum and Zinc sulphate, respectively. Half of urea and all other fertilizers were applied and mixed with soil at the time of final land preparation. Rest urea was top dressed at 25 days after transplanting. Seedlings of cabbage (var. Atlas-70) and cauliflower (var. Canditcharm), tomato (hero plus), brinjal (local) and chili (NS 1701) at the age of 30 days were planted on a plot size of 5 m x 4 m with

plant spacing of 60 cm x 40 cm. The crops were harvested 80-95 days after planting (DAP).

Twice irrigations one of each at 25 days interval from the transplant of seedlings; one weeding at 20 DAP; two sprayings of secure fungicide @ 1.5mL-1 of water for controlling blight of crops.

Intercultural operation and collection of yield contributing data

The field was observed time to time to identify visual difference among the treatment and any kind of infestation by weeds, insects and diseases so that considerable damages by pest should be minimized. The field appearence nice with normal green color plants. All intercultural operations were done as when necessary. The head and curd yield of cabbage and cauliflower and fruit yield tomato, brinjal, chili were recorded from 10 randomly selected plants from each plot and yield of crops were recorded from whole plot basis at harvest.

Statistical analysis

Different characters of vegetables yield and N, P, K, S content in post-harvest soil of vegetable cultivation were done following the ANOVA technique and the mean results in case of significant F-values were adjusted by the Least Significant Difference (LSD) (Gomez *et. al.,* 1984).

Results and discussion

Results revealed that significant response was found on fertilizer management and application of lime and their interactions on the head yields of cabbage, curd yields cauliflower, fruit yields of tomato, brinjal and chilli respectively.

Effect of lime on the yield performance of tomato in the hill valley soil

Addition of fertilizer did not affect soil pH due to the buffering capacity of the soil. This result agrees with the findings of Ayoola (2006), who found that the different levels of fertilizer did not significantly affect the soil pH. Electrical conductivity (EC) of the soil saturation extract significantly increased after fertilizer application; however, this increase was not high enough to affect the plants growth or yield. According to Richards (1954), ECe values of 0-2 dS. m-1 are considered safe for all crops and yields, while sensitive crops are affected when those values are between 2 to 4 dS.m-1. EC values between 4 - 8 dS. m-1 are harmful to most crops. There was a significant difference in Ca, P content in the soil after the addition of lime due to increase in the amounts of soluble organic matter (mainly organic acids), which increased the rate of desorption of phosphate and thus improved the available P content in the soil and increase the fruit yield of tomato.

Tomato var. Hero Plus was used as the test material for the experiment conducted at Bandarban, Rangamati and Khagrachari in selected watershed. The fertilizers were applied @: N_{150} P_{75} K_{135} S_{27} $Zn_{3.4}$ $B_{0.75kg/ha}$; CD 5t/ha, Lime 2t/h. By upscaling effect of lime on the yield performance of tomato in the hill valley soil, data showed that the yield of tomato with the application of lime. The yield of tomato varied from 47.32-55.39t/ha instead of farmers practice. Highest yield (55.39t/ha) was found at Bandarban site. The increase in nitrogen supply resulted in an increase in concentrations of N and Ca and a decrease in P in tomato fruits (Christo *et al.*, 1994).

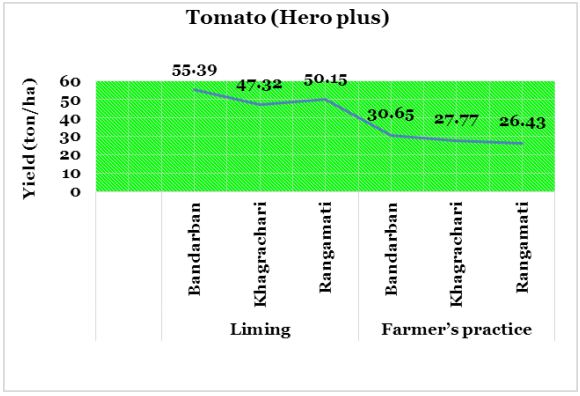

Fig. 1. Effect of lime on the yield performance of tomato in the hill valley soil

Effect of lime on the yield performance of cabbage in the hill valley soil.

In Bangladesh winter vegetable cabbage (*Brassica oleracea* L. var. capitata L.) is the most widely cultivated. There are 0.75 million hectares of land under cabbage cultivation in Bangladesh with the production of 217 thousand metric tons fresh cabbage

(BBS, 2014).It is an excellent source of vitamins, minerals and dietary fibers. The crop demands higher amount of plant nutrients particularly nitrogen for head (edible part of cabbage) production.

Field experiments were conducted at Bandarban, Rangamati and Khagrachari to determine the optimum doses of lime to improve the quality and yield of cabbage of var. Atlas 72. Fertilizers were applied@ N_{150} P_{55} K_{63} S_{20} $Zn_{2.3kg/ha}$; CD 5t/ha, Lime 2t/ha. By up scaling effect of lime on the yield performance of cabbage in the hill valley soil, data showed that the yield of cabbage with the application of lime. The yield of cabbage varied from 49.36-57.23t/ha instead of farmers practice. Highest yield (61.45t/ha) was found at Khagrachari site. Khandakhar *et al.* (2004) also reported that @2 t ha-1 of Ca $(OH)_2$ along with 100 kg K ha-1 is recommended for potato cultivation under strongly acidic soil. Whole non-liming treatment produced the lowest yield (56.04 t ha-1) of cabbage.

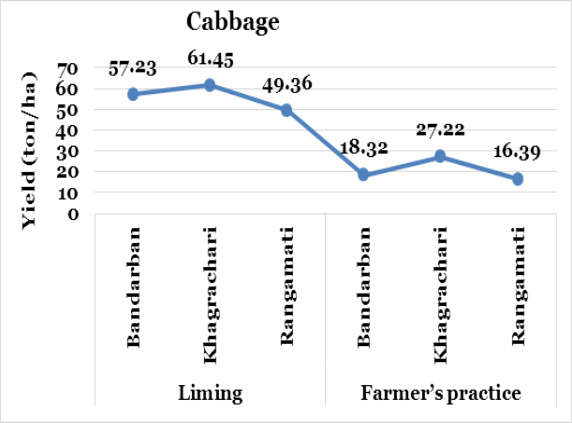

Fig. 2. Effect of lime on the yield performance of cabbage in the hill valley soil.

Effect of lime on the yield performance of cauliflower in the hill valley soil

Calcium (Ca) and Phosphorus (P) is an essential nutrient for the growth and production of cauliflower. Inadequate application of Ca and P in soil have led to severe Ca and P deficiency in our country. Low soil pH reduces the availability and uptake of P to plants. Increased soil application with lime can be an effective way to increase the curd yield in cauliflower. It was observed that the effect of lime and fertilizer management on the curd yield of cauliflower was significant. Field experiments were conducted at Bandarban, Rangamati and Khagrachari to determine the optimum doses of lime to improve the quality and yield of cauliflower in Chittagong hill tracts. Cauliflower var. Snow Box was used with fertilizers were applied @: N_{150} P_{75} K_{135} S_{27} $Zn_{3.4}$ $B_{0.75}$kg/ha; CD 5t/ha, Lime 2t/ha.

By up scaling effect of lime on the yield performance of cauliflower in the hill valley soil, data showed that the yield of cauliflower with the application of lime. The yield of cauliflower varied from 44.45-52.65t/ha instead of farmers practice. Highest yield (52.65t/ha) was found at Khagrachari site. Calcium (Ca) and Phosphorus (P) is one of the most essential plant nutrients that influence the growth and productivity of cauliflower. In dry basis, it occurs in concentration of 0.1 - 0.5% lesser than N in Plants. Although, it is absorbed in small amounts by plants (Sharma SK., *et al.*, 2002), it is a key element in many physiological and (Islam MH., *et al.*, 2010) biochemical process.

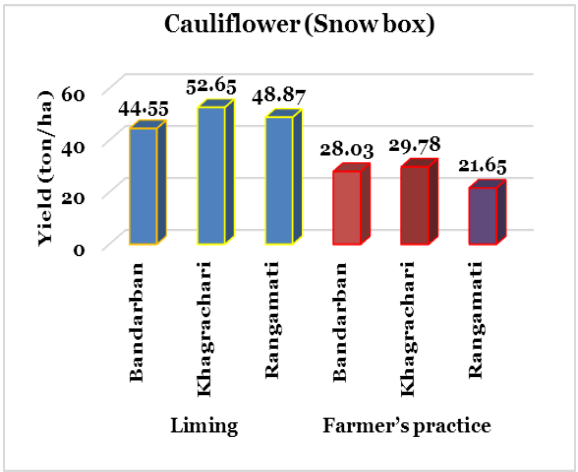

Fig. 3. Effect of lime on the yield performance of cauliflower in the hill valley soil.

Effect of lime on the yield performance of chilli in the hill valley soil.

Chili (*Capsicum annuum* L.) is the world's most important vegetable after tomato and used as fresh, dried or processed products, as vegetables and as spices or condiments (Acquaah, 2004). It is commonly grown crop worldwide as hot and sweet pepper. The crop is usually grown as herbaceous

annual in temperate areas while it is a perennial shrub in the tropics and in hill valley soil.

Integrated approach for the maintenance of soil productivity with the complementary use of both dololime and organic fertilizers offers a good opportunity to small scale farmers to maintain yields at reasonable and sustainable levels. So as a general, the supply of nutrients improves the exchange capacity of nutrients due to the increase of organic matter content of the soil. It increases soil water retention, slow release of nutrients and contribute to the residual pool of organic nitrogen and phosphorus in the soil. It enhances soil biological activity, which improves nutrient mobilization from organic and chemical sources and decomposition of toxic substances.

Field experiments were conducted at Bandarban, Rangamati and Khagrachari to determine the optimum doses of lime to improve the quality and yield of chilli in Chittagong hill tracts. NS 1701 variety of chilli was used as the material for the experiment. Fertilizers were applied as follows: N_{100} P_{158} K_{120} S_{27} $Zn_{3.4}$ $B_{0.75kg/ha}$; CD 5t/ha, Lime 2t/ha. Ofori *et al.* (2005) reported that integrated approach for the maintenance of soil productivity with the complementary use of both mineral and organic fertilizers offers a good opportunity to small scale farmers to maintain yields at reasonable and sustainable levels.

By up scaling effect of lime on the yield performance of chilli in the hill valley soil, data showed that the yield of chilli with the application of lime. The yield of chilli varied from 9.93-18.21t/ha instead of farmers practice. Highest yield (18.21t/ha) was found at Bandarban site. Vegetable crops put tremendous pressure on soil for nutrient demand because of their high productive ability. As such, generous application of lime and fertilizers are needed to meet their nutritional requirements (Gopinath *et al.*, 2009).

Effect of lime on the yield performance of brinjal in the hill valley soil

Solanum species (eggplants) belong to the family of Solanaceae and genus Solanum, with over 1,000 species worldwide (Agoreyo *et al.*, 2012). Eggplant or Brinjal (Solanum melongina) is a well-known vegetable in local market as well as world market. It is originated in India (Simmon, 1979). The present study was observed that the application of lime and chemical fertilizers solely or combined application had a great influence at all the growth stages of the crop. Significant differences in all parameters like, plant height, number of leaves, leaf area and number of branches due to the combined application of agricultural lime and chemical fertilizer. Field experiments were conducted at Bandarban, Rangamati and Khagrachari to determine the optimum doses of lime to increase and yield of brinjal in Chittagong hill tracts. Local variety of brinjal was used. Different fertilizers were applied @ N_{170} P_{72} K_{150} S_{20} $Zn_{3.4}$ $B_{0.75kg/ha}$; CD 5t/ha, Lime 2t/ha.

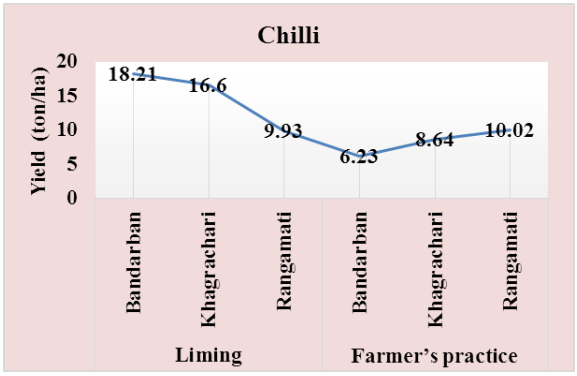

Fig. 4. Effect of lime on the yield performance of chilli in the hill valley soil

By up scaling effect of lime on the yield performance of brinjal in the hill valley soil, data showed that the yield of brinjal with the application of lime. The yield of brinjal varied from 54.43-56.67t/ha instead of farmers practice.

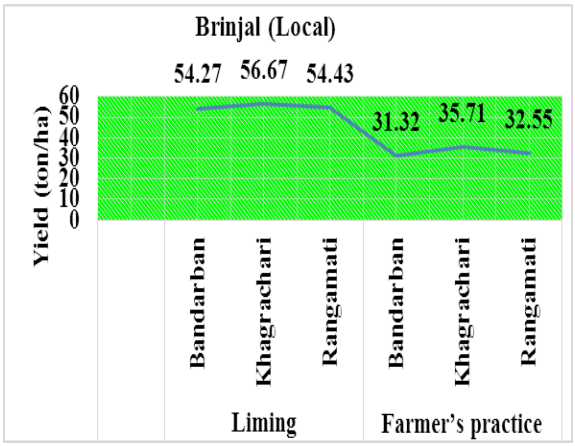

Fig. 5. Effect of lime on the yield performance of brinjal in the hill valley soil

Highest yield (56.67t/ha) was found at Khagrachari site. Similar results were also reported by Naidu *et al.* (1999) revealed that the morphological parameters were affected significantly due to the application of different combination of organics, chemicals and bio fertilizers. Nitrogen fertilizer use has played a significant role in increase of crop yield (Modhej *et al.*, 2008). Significant increase in plant height, number of leaves, number of branches and number of fruits due to influenced by environmental conditions and management practices. Prabhu *et al.* (2003) their studies indicated that plant height is increased by the application of agricultural lime and bio fertilizers, attributed to the increased uptake of nutrients in the plants.

Table 1. Effect of lime on the yield performance of cabbage, cauliflower, chilli, brinjal and tomato in the hill valley soil.

Treatment	Location	Cabbage (atlas 72) ton/ha	Cauliflower (snow box) ton/ha	Chilli (NS 1701) ton/ha	Brinjal (Local) ton/ha	Tomato (hero plus) ton/ha
Liming	Bandarban	57.23	44.55	18.21	54.27	55.39
	Khagrachari	61.45	52.65	16.60	56.67	47.32
	Rangamati	49.36	48.87	9.93	54.43	50.15
Farmer's practice	Bandarban	18.32	28.03	6.23	31.32	30.65
	Khagrachari	27.22	29.78	8.64	35.71	27.77
	Rangamati	16.39	21.65	10.02	32.55	26.43
Grand Mean		38.32	37.58	11.60	44.15	36.61
CV (%)		5.77	14.53	15.41	11.5	4.91
LSD (0.05%)		7.77	19.19	6.28	2.47	6.83

Acknowledgment

I would like to express my deepest thanks and boundless gratitude of CRP-1, Hill Agriculture Project, Component II, and Sustainable Land Management, Bandarban for organizing the research work and Krishi Gobeshona Foundation (KGF) for their economic help to get the opportunity as a Scientific Officer during research period.

Conclusion

To study the influence of effect of lime on the yield performance of cabbage, cauliflower, chilli, brinjal and tomato in the hill valley soil to boost the productivity potential combined application microbial and chemical fertilizers had a great influence at all the growth stages of the crop. Addition of lime in valley soil increase the supply of nutrients improves the exchange capacity of nutrients due to the increase of organic matter content of the soil. It increases soil water retention, slow release of nutrients and contribute to the residual pool of organic nitrogen and phosphorus in the soil. It enhances soil biological activity, which improves nutrient mobilization from organic and chemical sources and decomposition of toxic substances. Considering the importance of the crop in the hill area of Bangladesh hill valley soil fertility needs to be improved by using lime before final land preparation which increase all of the vegetables yields. The depletion of soil nutrient, the availability of nutrients facility, and absence of recommendation about the combined application of organic and inorganic blended fertilizers on vegetables, therefore, it is necessary to conduct research that leads to make recommendation of economically feasible by lime and fertilizer application.

As to recommendation vegetables production put tremendous pressure on soil for nutrient demand because of their high productive ability. The results revealed that, in valley acidic soil cabbage, tomato, chilli, brinjal and cauliflower were grown with lime application @ 2t/ha. Yield of cabbage varied from 49.36-57.23t/ha. Highest yield of cabbage (57.23t/ha) was found at Bandarban site instead of farmer practice. Yield of chili was ranged from 9.93 to 18.21 ton/ha. Highest chilli yield (18.21t/ha) was recorded from Bandarban Site. Yield of brinjal was ranged from 54.43 to 56.67 ton/ha. The highest brinjal yield 56.67t/ha at Khagrachari and tomato yield 55.39t/ha was found at Bandarban Site. Yield of cauliflower was

ranged from 44.55 to 52.65 ton/ha, where highest yield (52.65t/ha) of cauliflower was recorded from the field of Khagrachari site and lowest yield of cauliflower was recorded 44.55 ton/ha in Bandarban site instead of farmer practice. By conducting such kind of study in hilly area of Bangladesh, Most of the farmers of hill valley areas cannot cultivate their field due to high P_H but now days they properly cultivate their field by using to minimize the acidity of hill valley soil, Those kinds of technology were successfully completed in the hill valley of Bandarban district, Production of vegetables (cabbage, cauliflower, tomatoes, brinjal and chilli) was more from previous year cultivation beside another without experimental plot, Quality of vegetables also improved, Farmers got more price by selling of vegetables from previous year, Percentage of loss of vegetables were decreased by using lime.

References

Acquaah G. 2004. Horticulture Principles and Practices. 2nd edition, Prentice Hall of India Private Ltd. New Delhi, India.

Agoreyo BO, Obansa ES, Obanor EO. 2012. Comparative nutritional and phytochemical analyses of two varieties of *Solanum melongena*. Science World Journal **7(1),** 16-17.

Ayoola OT. 2006. Effects of Fertilizer Treatments on Soil Chemical Properties and Crop Yields in a Cassava-based Cropping System. Journal of Apply Science. Res **2,** 1112-1116.

BBS. 2014. Yearbook of Agricultural Statistics of Bangladesh, Dhaka.

BBS. 2008. Statistical Year Book of Bangladesh. Bangladesh Bureau of Statistics, Planning Division, Ministry of Planning, Dhaka, Bangladesh.

Bodruzzaman M. 2010. Lime requirement of acid soils for sustainable crop production. Ph. D. Thesis. BAU, Mymensingh, Bangladesh p. 310.

Christo M, Leoni S, Cornillon P, Gainze A, Dumas Y, Rodriguez A, Dimirkou A. 1994. Influence of Water and Nitrogen Availability on Elemental Composition of Processing Tomato Fruit in EU. Countries. Agriculture and Horticulture **376,** 279-284.

FRG. 2012. Fertilizer Recommendation Guide, Bangladesh Agriculture Research Council (BARC), Farmgate, Dhaka 1215 p. 274.

Gopinath K, Saha S, Mina B, Pande H, Kumar N, Srivastava A, Gupta H. 2009. Yield potential of garden Pea (*Pisum sativum* L.) varieties and soil properties under organic and integrated nutrient management systems. Arch Argon Soil Science **55,** 157-167.

Heady EO, Dillon JL. 1988. Agricultural Production Functions. Kalyani Publishers. New Delhi, India.

Islam MH, Karim AJ. 2010. "Curd yield and profitability of broccoli as affected by phosphorus and potassium". International Journal of Sustainable Crop Production **5(2),** 1-7.

Khandakhar SMAT, Rahman MM, Uddin MJ, Khan SAKU, Quddus KG. 2004. Effect of Lime and Potassium on Potato Yield in Acid Soil. Pakistan Journal of Biological Science **7(3),** 380383.

Kisic I, Ferdo B, Mesic M, Butaroc A, Vadic Z. 2004b. The effect of fertilization and liming on some soil chemical properties of eutric gleysol. Agricultural. Science **69(2-3),** 43-49.

Knott JE. 1962. Hand book for vegetable grower. John Wiley & Sons, Inc. New York.

Meda AR, Pavan MA, Cassiolato ME, Miyazawa M. 2002. Dolomite lime's reaction applied on the surface of a sandy soil of the Northwest Parana, Brazil. Braz. Agricultural Biology and Technology **45(2),** 219-222.

Modhej A, Naderi A, Emam Y, Aynehband A, Normohamadi GH. 2008. Effects of post-anthesis heat stress and nitrogen levels on grain yield in wheat (*T. durum* and *T. aestivum*) genotypes. International Journal of Plant Production **2,** 257-267.

Mongia AD, Singh NT, Mandal LN, Guha A. 1998. Effect of liming, superphosphate and rock phosphate application to rice on the yield and uptake

of nutrients on acid sulphate soils. Journal of Indian Soil Science **46,** 61-66.

Naidu AK, Kushwah SS, Dwivedi YC. 1999. Performance of organic manures, bio and chemical fertilizers and their combinations on microbial population of soil and growth of okra. Jawaharalal Neharu Krishi Vishwa Vidhyalaya Research Journal **33(1-2),** 34-38.

Nazrul MI, Shaheb MR, Sarker JU. 2013a. Performance of BARI released aroid varieties in Surma Kushiyara Flood Plain Soil. Bangladesh Agronomy Journal **16 (1),** 39-44.

Nazrul MI, Shaheb MR. 2014. Performance of sweet gourd as relay with transplanted aman rice under rainfed ecosystem in Sylhet region. Bangladesh Agronomy Journal **17(2),** 47-53.

Nazrul MI, Shaheb MR, Khan MAH, Khan ASMMR. 2013b. On-farm evaluation of production potential and economic returns of potato-rice based improved cropping system. Bangladesh Agronomy Journal **16(2),** 41-50.

Ofori J, Masunaga T, Kamidouzono A, Wakatsuki T. 2005. Rice growth and yield in waste-amended West African Lowland soils. Journal of Plant Nutrition **28,** 12011214.

Oliveira PPA, Boaretto AE, Trivelin PCO, de Oliveira WS, Corsi M. 2003. Liming and fertilization to restore degraded Brachiaria decumbens pastures grown on an entisol. Agricultural Science **60(1),** 125-131.

Prabhu M, Veeraraghavathatham D, Srinivasan K. 2003. Effect of nitrogen and phosphorus on growth and yield of brinjal hybrid COBH-1. South Indian Horticulture **51(1-6),** 152-156.

Rahman MA, Meisner CA, Duxbury JM, Lauren J, Hossain ABS. 2002. Integrated approach of liming and nutrient management to improve the productivity of acidic soil within a rice-wheat cropping system. Poster no. 773, Symposium no. 05, 17th World Congress of Soil Science. 14-21 August 2002. Bangkok, Thailand.

Rahman MA, Chikushi J, Lauren JG, Duxbury JM, Meisner CA. 2004. Liming and nutrient management for sustainable productivity of acidic alluvial soils under rice-wheat cropping system in Bangladesh. Proc. 6th International symposium on plant-soil interaction at low pH. pp. 304-305.

Rahman MA, Chikushi J, Lauren JG, Duxbury JM, Meisner CA, Yasunaga E. 2005. Chemical control of soil environment by lime and nutrients to improve the productivity of Integrated Approach for Liming and Fertilizer Application on Yield of Cabbage and Cauliflower.

Richards LA. 1965. Physical Condition of Water in Soil. In: Methods of Soil Analysis .Part 1. Agronomy Series #9, American Society of Agronomy, Inc., Madison.

Sarker MMR, Shaheb MR, Nazrul MI. 2012. Urea Super Granule: A good source of nitrogen on growth yield and profitability of cabbage in Sylhet. Journal of Environmental Science and Natural Resources **5(1),** 295-299.

Shaheb MR, Nazrul MI, Rahman MA. 2014. Production potential and economics of wheat as influenced by liming in north eastern region of Bangladesh. Asian Journal of Agriculture and Biology **2(2),** 152-160.

Shaheb MR, Nazrul MI, Sarker MH. 2012. Performance of Tomato varieties as affected by different planting dates in the north-eastern region of Bangladesh. Bangladesh Agronomy Journal **15(2),** 53-58.

Sharma SK, Zahir MN. 2002. "Effect of nitrogen and phosphorus on the growth and seed yield of sprouting broccoli cv. Green head". Horticulture Journal **15(2),** 87-90.

Sultana BS, Mian MM, Islam MR, Rahman MM, Sarker BC, Zoha MS. 2009. Effect of liming on soil properties, yield and nutrient uptake by wheat. World Environment **4(1),** 39-47.

Uddin MJ, Hasan MM, Ahmed S, Hasan MM. 2010. Effect of spacing on morpho-physiological response of different T.aman rice cultivars under coastal high land ecosystem. Indian Journal of Agriculture. Res **44,** 251-258.