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INTEGRATED APPROACH FOR LIMING AND FERTILIZER APPLICATION ON YIELD OF CABBAGE AND CAULIFLOWER IN ACIDIC SOIL OF SYLHET

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Abstract

An experiment was conducted at farming system research and development (FSRD) site, Jalalpur and multi location testing (MLT) sites, Moulvibazar and Zokigonj during 2013-2015 to study the effect of liming and fertilizers levels on the yield of cabbage and cauliflower in acidic soil of Sylhet. Trials were laid out in a factorial randomized block design with six dispersed replications. The treatments of fertilizer managements were M_1: soil test based (STB) recommended fertilizer and M_2: fertilizer dose practiced by the farmers (FP) and the level of limes were L_1:0 t ha^{-1}; L_2: 1 t ha^{-1} and L_3: 2 t ha^{-1}. Results revealed that yields of cabbage and cauliflower responded significantly to fertilizer doses, levels of lime, and their combinations in all the locations. Soil test based fertilizer rate (M_1-N_{201}, P_{63}, K_{65}, S_{23}, $Zn_{0.5}$ for cabbage and M_1-N_{157}, P_{57}, K_{116}, S_{20}, $Zn_{0.5}$ Kg ha^{-1} for cauliflower) gave the maximum head and curd yields of cabbage and cauliflower, respectively. The levels of lime at the rate 2 t ha^{-1} (L_3) provided the highest yields of cabbage and cauliflower in all locations. Dolomite lime @ 2 t ha^{-1} in combination with recommended fertilizer (M_1L_3) gave the highest yields and maximum economic returns of cabbage and cauliflower in all locations. However, it was identical with 1 t ha^{-1} of dolomite lime of similar dose of fertilizer nutrients. Therefore, application of lime at the rate 1 t ha^{-1} with STB recommended fertilizer management (M_1) could be enough for profitable economic returns for cultivating cabbage and cauliflower in strongly acidic soil in Sylhet.

Introduction

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). The Sylhet regions are mostly under the agro-ecological zone 20 (Eastern Surma Kushiyara Floodplain) and the soils of this region are strongly acidic. 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), but Eastern Surma Kushiyara

Floodplain soil is non-calcareous grey which have low pH (<5) so, liming is needed to increase pH for better performance of the crops. 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). At present, farmers in this area use agricultural lime or dolomite in different quantities to correct the soil acidity. But, initial high cost involvement in liming practice makes exploring the benefit of liming difficult for the marginal growers. The experiments were therefore, designed to find out the suitable levels of dolomite lime and fertilizer management options for better yield of cabbage and cauliflower in acidic soils under the AEZ 20 of Sylhet region.

Materials and Methods

An experiment was conducted under farmer's fields located at FSRD site, Jalalpur and MLT sites, Moulvibazar and Zokigonj during 2013-2015 to study the effect of lime and fertilizer on the yield of cabbage and cauliflower in acidic soil of Sylhet. The study area lays $24^0$70' N latitude and $91^0$67' E longitude under the Surma-Kusiyara Floodplain of Bangladesh. Before starting the experiment, initial soil samples were collected from each farmer's field and analyzed in the laboratory of Soil Resource and Development Institute, Sylhet.

Type of experimental soil is non-calcareous grey with low organic matter content (1.29%), low soil pH (4.2-5.1), very low total N (0.06%), low content of P (8.59µg/g soil), K (0.13meq/100g soil) and S (9.14 µg/g soil) where as Zn (1.22 µg/g soil) and B (0.48 µg/g soil) medium and optimum, respectively. Trials were laid out in a factorial randomized block design with six dispersed replications where 2 fertilizer managements levels were M_{1}- soil test based (STB) recommended fertilizer and M_{2}- Fertilizer dose practiced by the farmers (FP) and 3 level of limes viz., L_{1}- 0 t ha^{-1}, L_{2}- 1 t ha^{-1} and L_{3}- 2 t ha^{-1} as treatment variables. The dolomite lime (CaO = 30 %, MgO = 22% and CO_2= 48%) was applied 15-20 days before planting with spread method on the top of the soil and then incorporate with the soil depth at 25 cm by plough. The crops wise fertilizers nutrients N P K S Zn (cabbage - M_1: 201-63-65-23-0.5, M_2: 220-70-70-40-0 and cauliflower - M_1: 157-57-116-20-0.5, M_2: 170-43-136-0-0 Kg ha^{-1}) were calculated as per the initial nutrient status of the experimental soil and average fertilizer doses practiced by 25 farmers. 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) 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. All intercultural operations were done as when necessary. The head and curd yield of cabbage and cauliflower were recorded from 10 randomly selected plants from each plot and yield of crops were recorded from whole plot basis at harvest. The recorded data were statistically analyzed and mean values were separated by least significant difference test (LSD). All types of variable costs of production were recorded and cost-benefit analysis was carried out (Heady and Dhillon, 1988).

Results and Discussions

Location: Jalalpur

Head yield of cabbage: Results revealed that significant response was found on fertilizer management and application of lime and their interactions on the head and curd yields of cabbage and cauliflower respectively. The average maximum head yield of cabbage (65.01 t ha^{-1}) was recorded in soil test based (STB) (M_1) compared to fertilizer dose of the farmers (M_2). the maximum head yield (66.22 t ha^{-1}) of cabbage was found in 2 t ha^{-1} of dolomite (L_3) that was followed by 1 t ha^{-1} (L_2) of dolomite lime. 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. The results revealed that combined effect of STB and 2 t ha^{-1} of dolomite lime (M_1L_3) provided the maximum average head yield of cabbage (70.90 tha^{-1}) that was statistically followed by M_1L_2 with yield of 66.49 t ha^{-1}(Table 1).

Table 1. Effect of fertilizer management and levels of liming on the head and curd yield of cabbage and cauliflowerat Jalalpur, Sylhet (2013-2015)

Treatments	Head yield (t ha^{-1})			Curd yield (t ha^{-1})		
	2013-2014	2014-2015	Average	2013-2014	2014-2015	Average
A. Fertilizer management						
M_1	67.71	62.30	65.01	44.39	60.40	52.4
M_2	62.24	54.69	58.47	43.88	49.08	46.48
CV (%)	2.53	8.87	5.70	4.33	12.97	8.65
B. Level of liming						
L_1	58.46	53.61	56.04	40.90	53.93	47.42
L_2	67.16	58.75	62.96	43.59	53.71	48.65
L_3	69.31	63.12	66.22	47.92	56.57	52.25
CV (%)	2.53	8.87	5.7	4.33	12.97	8.65
$LSD_{(0.05)}$	2.48	7.82	5.15	5.81	NS	5.81
Fertilizer management × Level of liming						
M_1L_1	59.55	55.67	57.61	40.25	59.26	49.76
M_1L_2	70.50	62.48	66.49	43.25	58.32	50.79
M_1L_3	73.07	68.73	70.9	49.66	63.61	56.64
M_2L_1	57.37	51.55	54.46	41.55	48.61	45.08
M_2L_2	63.83	55.02	59.43	43.93	49.10	46.52
M_2L_3	65.54	57.50	61.52	46.17	49.52	47.85
CV (%)	2.53	8.87	5.7	4.33	12.97	8.65
$LSD_{(0.05)}$	2.48	7.82	5.15	2.88	10.70	6.79

M_1: Soil test based (STB) recommended fertilizer and M_2: Fertilizer dose practiced by farmers (FP) and Level of limes L_1: 0 t ha^{-1}, L_2: 1 t ha^{-1} and L_3: 2 t ha^{-1}

Curd yield of cauliflower: The STB fertilizer dose (M_1) provided higher curd yield of cauliflower (52.40 tha^{-1}) as compared to yield of the farmers (M_2). Considering the application of lime doses, the highest average curd yield (52.25 t ha^{-1}) of cauliflower was found in 2 t ha^{-1} of dolomite lime (L_3) that was followed by L_2 (48.65 t ha^{-1}). But, the lowest

yield (47.42 t ha^{-1}) was observed in L_1 (zero liming). Application of dolomite could increase soil pH from 4.9 to 5.4 with increase Ca and Mg stock in the soil (Oliveira *et al*., 2003; Thompson and Kelly 1957). The situation made cauliflower to perform good vegetative growth because it is sensitive on pH level and high dose of Mg reported by Thompson and Kelly (1957). The combined application of STBand 2 t ha^{-1} of dolomite lime (M_1L_3) gave the maximum curd yield of cauliflower (56.64 t ha^{-1}) which was statistically identical to M_1L_2 (50.79 t ha^{-1}). However, the lowest curd yield (45.08 t ha^{-1}) of cauliflower was produced by the treatment combination of M_2L_1 (Table 1).

Cost and return analysis: The gross return, total cost and net return of different combinations are presented in Table 2. From the cost benefit analysis, it was exhibited that maximum gross return (Tk. 567200 and Tk. 566400 ha^{-1}) and net return (Tk. 385777 and Tk. 401067 ha^{-1}) was obtained from the combination of M_1L_3 for cabbage and cauliflower, respectively. The lowest values of the same economic parameters were observed in combination of M_2L_1 (Table 2). The economic analysis also revealed that the highest values (3.13 and 3.43) of benefit cost ratio (BCR) were obtained in case of both vegetables under the same treatment (M_1L_3).

Table 2. Cost and return analysis of fertilizer management with levels of limes on the yield of cabbage and cauliflower at Jalalpur in Sylhet (2013-2015)

Treatments	Cabbage				Cauliflower			
	GR (Tk.ha^{-1})	TC (Tk.ha^{-1}) (	GM (Tk.ha^{-1})	BCR	GR (Tk.ha^{-1})	TC (Tk.ha^{-1})	GM (Tk.ha^{-1})	BCR
M_1L_1	460880	172123	288757	2.68	497600	156033	341567	3.19
M_1L_2	531920	177023	354897	3.00	507900	160933	346967	3.16
M_1L_3	567200	181423	385777	3.13	566400	165333	401067	3.43
M_2L_1	435680	166268	269412	2.62	450800	153638	297162	2.93
M_2L_2	475440	171168	304272	2.78	465200	158538	306662	2.93
M_2L_3	492160	175568	316592	2.80	478500	162938	315562	2.94

GR: Gross return (Tk.ha^{-1}), TC: Total cost (Tk.ha^{-1}) and GR: Gross margin (Tk.ha^{-1})
Price of input and output (Tk.Kg^{-1}): Dolomite lime- 5.00, Urea-20.00, TSP-22.00, MoP-15.00, Cowdung-1.00, Cabbage-8.00, Cauliflower-10.00

Location: Zokigonj

It was observed that the doses of fertilizer management and dolomite levels and their interactions on the head and curd yield of cabbage and cauliflower were influenced significantly.(Table 3).

***Head yield of cabbage*:** The average head yield (66.58 t ha^{-1}) of cabbage with STB fertilizer dose t was higher than cabbage fertilized with farmer's practices. Among the dolomite levels, 2 tha^{-1} (L_3) contributed the maximum head yield (68.05 t ha^{-1}) of cabbage which was statistically identical to 1 t ha^{-1} (L_2) of dolomite. Non liming treatment (L_1) produced the lowest average head yield of cabbage (60.84 t ha^{-1}). It was found that combination of STB recommended fertilizer management and 2 t ha^{-1} of dolomite limes (M_1L_3) gave the maximum head yield of cabbage (71.25 tha^{-1}) that was statistically followed by M_1L_2 with yield of 65.92 t ha^{-1}.It was reported that liming material increases the cation exchange

capacity of soil and also increase nutrient content such as P and K (Kisic *et al.,* 2004b). It was assumed that application of dolomite lime increase soil pH; which helps to improve nutrients for the vegetables resulted increased the growth and yield of cabbage.

***Curd yield of cauliflower*:** The average higher curd yield of cauliflower (49.42 t ha^{-1}) was recorded in STB recommended fertilizer (M_1) compared to farmers practice (M_2). On the contrary, significantly higher curd yield (50.83 t ha^{-1}) of cauliflower was produced by L_3 compared to L_2 and without lime. Results of combined application of STB recommended fertilizer management and 2 t ha^{-1} of dolomite showed that the highest curd yield of cauliflower (54.90 t ha^{-1}) was recorded that was statistically followed by M_1L_2 (47.93 t ha^{-1}). However, the treatment combination (M_2L_1) was provided the lowest curd yield (40.69 t ha^{-1}) of cauliflower (Table 3).

Table 3. Effect of fertilizer management and level of liming on the head and curd yield of cabbage and cauliflower, respectively at Zokigonj in acidic soil of Sylhet (2013-2015)

Treatments	Head yield			Curd yield		
	2013-2014	2014-2015	Average	2013-2014	2014-2015	Average
A. Fertilizer management						
M_1	63.72	69.44	66.58	50.03	48.81	49.42
M_2	60.61	62.44	61.525	43.64	43.14	43.39
CV (%)	1.80	8.24	5.02	8.91	2.67	5.79
B. Level of liming						
L_1	60.00	61.67	60.84	43.90	42.22	43.06
L_2	62.58	64.00	63.29	46.33	44.33	45.33
L_3	63.92	72.17	68.05	50.28	51.38	50.83
CV (%)	1.80	8.24	5.02	8.91	2.67	5.79
LSD $_{(0.05\%)}$	NS	9.89	9.89	NS	2.23	2.23
Fertilizer management × Level of liming						
M_1L_1	61.17	64.00	62.59	46.43	44.43	45.43
M_1L_2	63.50	68.33	65.92	49.33	46.53	47.93
M_1L_3	66.50	76.00	71.25	54.33	55.47	54.90
M_2L_1	58.83	59.33	59.08	41.37	40.00	40.69
M_2L_2	61.67	59.67	60.67	43.33	42.13	42.73
M_2L_3	61.33	68.33	64.83	46.23	47.30	46.77
CV (%)	1.80	8.24	5.02	8.91	2.67	5.79
LSD $_{(0.05\%)}$	2.04	9.89	5.965	7.59	2.23	4.91

M_1: Soil test based (STB) recommended fertilizer and M_2: Fertilizer dose practiced by farmers (FP) and Level of limes L_1: 0 t ha^{-1}, L_2: 1 t ha^{-1} and L_3: 2 t ha^{-1}

Cost and return analysis : Dolomite, 2 t ha^{-1} with fertilizer nutrients N_{201}, P_{63}, K_{65}, S_{23}, $Zn_{0.5}$ and N_{157}, P_{57}, K_{116}, S_{20}, $Zn_{0.5}$ Kg ha^{-1} was contributed the highest net returns (Tk. 426577 and Tk. 383667 ha-1) from cabbage and cauluflower, respectively (Table 4). Fertilizer package practiced by the farmers without lime application provided lowest economic profit of both vegetables.

Table 4. Cost and return analysis of fertilizer management with levels of limes on the yield of cabbage and cauliflower at Zokigonj, Sylhet (2013-2015)

Treatments	Cabbage				Cauliflower			
	GR ($Tk.ha^{-1}$)	TC ($Tk.ha^{-1}$)	GM ($Tk.ha^{-1}$)	BCR	GR ($Tk.ha^{-1}$)	TC ($Tk.ha^{-1}$)	GM ($Tk.ha^{-1}$)	BCR
M_1L_1	500720	172123	328597	2.91	454300	156033	298267	2.91
M_1L_2	527360	177023	350337	2.98	479300	160933	318367	2.98
M_1L_3	570000	181423	388577	3.14	549000	165333	383667	3.32
M_2L_1	472640	166268	306372	2.84	406900	153638	253262	2.65
M_2L_2	485360	171168	314192	2.84	427300	158538	268762	2.70
M_2L_3	518640	175568	343072	2.95	467700	162938	304762	2.87

GR: Gross return ($Tk.ha^{-1}$), TC: Total cost ($Tk.ha^{-1}$) and GM: Gross margin ($Tk.ha^{-1}$)
Price of input and output ($Tk.Kg^{-1}$): Dolomite lime- 5.00, Urea-20.00, TSP-22.00, MoP-15.00, Cowdung-1.00, Cabbage-8.00, Cauliflower-10.00

Location: Moulvibazar

***Head yield of cabbage*:** Fertilizer application affected head yield of cabbage where maximum head yield (62.89 t ha^{-1}) was produced by STB fertilizer management (M_1) compared to farmers dose (M_2).

The head yield of cabbage was increased by increasing the rates of limewhere 2 tha^{-1} produced higher yield than the other rate of lime and no liming. The STB recommended fertilizer management with 2 t ha^{-1} of dolomite lime (M_1L_3) produced maximum head yield (65.49 t ha^{-1}) that was followed by M_1L_2 (64.88 t ha^{-1}), while the lowest head yield (51.59 t ha^{-1}) was gained in the treatment combination of M_2L_1 (Table 5). Sultana *et al.*, (2009) reported that the grain yield of wheat was increased due to application of 2.0 t ha^{-1} lime at low soil pH (> 6.0).

***Curd yield of cauliflower*:** It was observed that the effect of fertilizer management on the curd yield of cauliflower was significant. The higher curd yield (45.31t ha^{-1}) was recorded in STB recommended fertilizer management (M_1) compared to farmers dose (M_2) (39.33 tha^{-1}) although yields were non-significant. The level of dolomite, 2 t ha^{-1} (L_3) gave the maximum curd yield (45.67 t ha^{-1}) which was statistically followed by 1 t ha^{-1} (L_2) of dolomite lime. On the contrary, the lowest curd yield (39.57 t ha^{-1}) of cauliflower was observed in without lime (L_1).The interacxtion result showed that the maximum average curd yield (48.88 t ha^{-1}) was recorded in M_1L_3 that was statistically followed by M_1L_2 (44.56 t ha^{-1})while lowest yield (36.66 t ha^{-1}) from farmers practice without dolomite.(Table 5).

Table 5. Effect of fertilizer management and level of liming on the head and curd yield of cabbage and cauliflower, respectively at Moulvibazar in acidic soil of Sylhet (2013-2015)

Treatments	Head yield			Curd yield		
	2013-2014	2014-2015	Average	2013-2014	2014-2015	Average
A. Fertilizer management						

M_1	66.16	59.62	62.89	50.00	40.61	45.31
M_2	57.52	53.70	55.61	46.40	32.25	39.33
CV (%)	6.48	3.34	4.91	5.85	8.73	7.29
B. Level of liming						
L_1	56.31	53.57	54.94	45.38	33.75	39.57
L_2	65.13	56.17	60.65	47.67	35.77	41.72
L_3	64.07	60.23	62.15	51.55	39.76	45.67
CV (%)	6.48	3.34	4.91	5.85	8.73	7.29
LSD $_{(0.05\%)}$	7.29	3.45	5.37	NS	NS	NS
Fertilizer management × Level of liming						
M_1L_1	59.81	56.78	58.30	46.45	38.47	42.46
M_1L_2	60.27	59.48	59.88	49.43	39.69	44.56
M_1L_3	68.38	62.59	65.49	54.10	43.65	48.88
M_2L_1	52.81	50.37	51.59	44.30	29.02	36.66
M_2L_2	59.98	52.85	56.42	45.90	31.85	38.88
M_2L_3	59.76	57.87	58.82	49.00	35.87	42.44
CV (%)	6.48	3.34	4.91	5.85	8.73	7.29
LSD $_{(0.05\%)}$	7.29	3.45	5.37	5.13	5.78	5.455

M_1: Soil test based (STB) recommended fertilizer and M_2: Fertilizer dose practiced by farmers (FP) and Level of limes L_1: 0 t ha^{-1}, L_2: 1 t ha^{-1} and L_3: 2 t ha^{-1}

Cost and return analysis : The cost benefit analysis exhibited that maximum gross return (Tk. 523920 and Tk. 488800 ha^{-1}) and net return (Tk. 342497 and Tk. 323467 ha^{-1}) was obtained from the treatment combination of STB recommended fertilizer management with dolomite 2 t ha^{-1} (M_1L_3) with higher benefit cost ratios (2.89 and 2.96) for cabbage and cauliflower, respectively. However, the treatment combinations without lime (M_1L_1, M_2L_1) contribute lower economic returns (Table 6).

Table 6. Cost and return analysis of fertilizer management with levels of lime on the cultivation of cabbage and cauliflower at Moulvibazar, Sylhet (2013-2015)

Treatments	Cabbage				Cauliflower			
	GR (Tk.ha^{-1})	TC (Tk.ha^{-1})	GM (Tk.ha^{-1})	BCR	GR (Tk.ha^{-1})	TC (Tk.ha^{-1}) (	GM (Tk.ha^{-1})	BCR
M_1L_1	466400	172123	294277	2.71	424600	156033	268567	2.72
M_1L_2	519040	177023	342017	2.93	445600	160933	284667	2.77
M_1L_3	523920	181423	342497	2.89	488800	165333	323467	2.96
M_2L_1	412720	166268	246452	2.48	366600	153638	212962	2.39
M_2L_2	435360	171168	264192	2.54	388800	158538	230262	2.45
M_2L_3	470560	175568	294992	2.68	424400	162938	261462	2.60

GR: Gross return (Tk.ha^{-1}), TC: Total cost (Tk.ha^{-1}) and GM: Gross margin(Tk.ha^{-1})
Price of input and output (Tk.Kg^{-1}): Dolomite lime- 5.00, Urea-20.00, TSP-22.00, MoP-15.00, Cowdung-1.00, Cabbage-8.00, Cauliflower-10.00

Conclusion

The results revealed that the maximum head yield of cabbage and curd yield of cauliflower was obtained with the application of STB recommended fertilizer (N_{201}, P_{63}, K_{65}, S_{23}, $Zn_{0.5}$ for cabbage and N_{157}, P_{57}, K_{116}, S_{20}, $Zn_{0.5}$ Kg ha^{-1} for cauliflower). Liming at the rate 2 t ha^{-1} supported for the highest yields of cabbage and cauliflower in both the years in all the locations but identical to that of 1 t $ha^{-1}$of dolomite lime with similar dose of fertilizers Therefore, application of lime at the rate 1 t ha^{-1} with recommended fertilizer might be

effective for economic productivity of both the cabbage and cauliflower in the acidic soils of the greater Sylhet region.

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