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EFFECT OF LIME AND INORGANIC FERTILIZERS ON GROWTH AND YIELD OF INDIAN SPINACH (*Basella alba*)

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Abstract

An experiment was conducted at Sylhet Agricultural University, Bangladesh in 2017 to see the effect of lime and NPKS fertilizers on the growth and yield of *Basella alba* using acid soil. This pot experiment used six treatments viz. control, lime, NPKS, lime + NPKS, 75% NPKS and lime + 75% NPKS. The 30 kg amended (cowdung @ 5 t ha^{-1}) soils were filled into 46 cm^2 earthen pots, and 3 healthy plants were used as test crop. The rate of urea-N, TSP-P, MoP-K, gypsum, and lime were 90, 18, 60, 15, and 3000 kg ha^{-1} respectively. The lime, TSP-P, gypsum, and 1/3 of urea-N and ½ of MoP-K were applied as basal doses. The rest of the fertilizers were applied at 35 (1/3 of N and ½ of K) and 52 (1/3 of N) days after sowing (DAS). Randomized Complete Block Design with three replications used to arrange treatments in this study. The data were recorded at 35, 50, 65, and 80 DAS. The data was statistically analyzed using the R software for ANOVA, and means were compared with LSD values. Combined application of lime + NPKS responded significantly in almost all growth and yield parameters of *B. alba*. The highest and lowest yields were 809.34 and 468.27 g pot^{-1} obtained from lime + NPKS and control, respectively. The treatments lime + 75% NPKS, NPKS and 75% NPKS showed the statistically identical result. Combined application of lime with fertilizers performed well due to the positive effect of lime with NPKS and reduction of soil acidity.

Keywords: Lime, inorganic fertilizer, soil acidity, *B. alba.*

Introduction

Indian spinach (*Basella alba*) is a promising leafy vegetable containing protein, vitamin C, Ca, Mg, P, K, Na, Zn, Cu, Mn, and Se in tropical regions, especially Southeast Asia and China. It has diversified use as salad, soups, and snacks (Singh et al., 2018) and has immense importance in medicine (Kumar et al., 2013). Another important trait of the plant is that it grows in any soil conditions, namely, acid, saline, degraded and poor nutrient soils (Singh et al., 2018).

However, soil acidity limits the interaction of plant growth-promoting factors involving soil's physical, chemical and biological properties. However, the natural and man-made process of soil acidification can be controlled by appropriate soil management practices (Fageria & Baligar, 2008). Therefore, liming in acid soil is the best-established practice for improving crop production (Mansingh et al., 2019). It improves soil nutrient efficiency by decreasing soil H^+ concentration. Liming helps the crop by increasing the availability of soil nutrients, namely Ca, Mg, P, K etc., and reducing toxicity of Al and Mn. Furthermore, liming enhances soil microbial status and soil health (Holland et al., 2019). However, a combination of lime with inorganic fertilizers is suitable to get more yields. Adding macro-nutrients through fertilizers in acid soil is essential to mitigate nutrient deficiency, and ameliorate crop productivity. The positive interaction of P and K with crops was observed for liming (Holland et al., 2019).

On the other hand, *B. alba* grows well when soil treats other fertilizers, especially NPK at 6.5 g pot^{-1} or 200 kg ha^{-1} (Aguoru et al., 2014). However, all leafy vegetables responded well in lime-ameliorated soil compared to untreated soil with lime, and yield increased by 100% (Hin et al., 2020). Besides, a combination of lime and inorganic fertilizers produced the highest crop yield, up to 92%, than soil treated with merely lime or without lime. Therefore, after considering the above discussion and research drawback, the present research is conducted to understand the effect of lime and inorganic fertilizers on the growth and yield of *B. alba* in acid soil.

Materials and Methods

Site selection

The pot experiment was conducted in the Soil Science Field of Agricultural University, Sylhet-3100, Bangladesh in 2017 to see the effects of lime and NPKS fertilizers on the growth and yield of Indian spinach (*B. alba*) using acid soil.

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Treatments

This experimentation used six treatments viz. control (no lime and NPKS fertilizers), lime, NPKS, lime + NPKS, 75% NPKS and lime + 75% NPKS. Here, BARC-recommended doses of NPKS fertilizers on Indian spinach were used (FRG, 2012) (below details).

Soil preparation and experimental design

The 30 kg sieved air-dried soils amended with cowdung @ 5 t/ha (75 g pot^{-1}) was filled into the 46 cm × 46 cm sized earthen pots. The soil type was sandy loam with pH 4.2 and poor soil nutrient contents. The rate of urea-N, TSP-P, MoP-K, gypsum and lime (CaCO3.MgCO3) were 90, 18, 60, 15 and 3000 kg ha^{-1} (45 g pot^{-1}), respectively (FRG, 2012). All of TSP-P and gypsum and 1/3 of urea-N, and ½ of MoP-K were applied as basal during final soil preparation as treatment-wise. The rest of MoP-K was applied at 35 days after sowing (DAS). Whereas urea-N was applied in two splits (35 and 52 DAS). The treatments were arranged at randomized complete block design (RCRD) with three replicates. Each earthen pot contained three healthy plants.

Intercultural operations

Each plant was tied with a long stick. Weeding and irrigation were done when necessary.

Observations

The data were recorded four times viz. 35, 50, 65 and 80 days after sowing (DAS). The plant was harvested at two times 50 and 80 DAS. During the first harvest, the vines were cut from 5 cm above the ground level, and vines were kept for branching and repeated plant growth. The first harvest was done by cutting the vine with a sharp knife at 50 DAS to observe the characteristics of fresh vine weight (g pot^{-1}), length (cm $plant^{-1}$) and weight (g $plant^{-1}$) of the tender shoot and leaf yield (g pot^{-1}). The final harvest was done by uprooting plant to observe the characteristics like branch number (Number $plant^{-1}$), tap root length (cm $plant^{-1}$) and fresh weight (g $plant^{-1}$), stalk yield (g pot^{-1}), vine length (cm $plant^{-1}$), and fresh weight (g pot^{-1}), the weight of tender shoot (g $plant^{-1}$) and leaf yield (g pot^{-1}).

Observations

Vine length was measured with a measuring tape from the top emerging leaves to the ground level of the plant. The plant was cut 5 cm above the ground level by a sharp knife at 50 and 80 DAS to get the vine fresh weight with a digital analytical balance (±0.001 g).The length of the tender shoot (cm) and weight consisting of the top 10 emerging leaves from the growing tip was measured with a measuring scale and by a digital analytical balance (±0.001 g). Emerging young to older leaves from the whole plant were counted to arrive at leaf number (No.). The largest young 15 leaves were stripped from the middle of three plants in a pot to get leaf yield per pot (g) and measured with a digital analytical balance (±0.001 g). Leaf length, width, and petiole length were measured using a measuring scale from the leaf base to the leaf tip of 15 leaves. The tap root length (cm) and weight (g) were observed from the ground to the end point of the primary root with a measuring tape and a digital analytical balance (±0.001 g). Total yield (g) per pot was the cumulative weight of fresh vine weight at 50 and 80 DAS.

Statistical analysis

The data obtained from the crop was statistically analyzed using the ANOVA function of R software. Mean differences were compared using LSD ($P < 0.1$, 1, and 5%) (Williams & Abdi, 2010).

Results

Vine length

Treatments significantly affected the vine length of *B. alba* (Table 1). The longest vines were 17.73 cm (35 DAS), and 95.84 cm (80 DAS) obtained from lime + NPKS treatment. The shortest lengths were 14.53 cm and 68.30 cm found from the control pot in 35 DAS and 80 DAS, respectively.

Fresh vine weight

The treatments had a significant ($P < 0.1$) effect on fresh vine weight of *B. alba* (Table 1). The highest weighted vines were 376.17 g in 50 DAS, and 433.33 g plant^{-1} in 80 DAS obtained from lime + NPKS treatment. The lowest weights were 144.10 g (50 DAS) and 308.54 g plant^{-1} (80 DAS) found from the control.

Table 1. Distribution Effect of lime and inorganic fertilizers on vine length and vine fresh weight of *B. alba* on different days after sowing (DAS).

Treatment	Vine length (cm)				Vine fresh weight (g plant^{-1})	
	DAS					
	35	50	65	80	50	80
Control	14.53 b	23.10 d	34.11 e	68.30 d	144.10 f	308.54 f
Lime	15.93 ab	29.33 c	58.83 d	72.44 cd	159.73 e	344.47 e
NPKS	16.38 ab	43.43 ab	79.50 b	85.33 b	331.33 c	383.94 c
Lime + NPKS	17.73 a	45.97 a	83.89 a	95.84 a	376.17 a	433.33 a
75% NPKS	16.27 ab	40.00 b	75.80 c	75.12 c	308.37 d	362.87 d
Lime + 75% NPKS	16.50 ab	44.20 ab	81.44 ab	92.33 a	352.27 b	404.47 b
F-test	*	***	***	***	***	***
CV (%)	7.44	6.70	2.86	3.49	1.35	1.18

*In a column, figures having the same letter (s) do not differ significantly. Figures *** and * indicate significance at 0.1 and 5% probability levels, respectively.*

Length and weight of tender shoot

The application of lime and NPKS fertilizers had no significant effect on the length of tender shoot of *B. alba*, but it significantly affected the weight of the tender shoot of the plant (Table 2). However, the longest and shortest shoots were observed after the application of lime with NPKS fertilizers and control, respectively. At 50 and 80 DAS, the highest weighted shoots were 12.53, and 6.43 g plant^{-1} was observed from the same treatment. While the lowest weights at 5.13 (50 DAS) and 4.17 (80 DAS) g plant^{-1} were found from the control.

Table 2. Effect of lime and inorganic fertilizers on length and weight of tender shoot of *B. alba* on different days after sowing (DAS).

Treatment	Length of tender shoot (cm plant^{-1})		Weight of tender shoot (g plant^{-1})	
	DAS			
	50	80	50	80
Control	13.38 b	12.15 c	5.13 c	4.17 c
Lime	15.16 b	13.33 bc	5.24 c	4.50 bc
NPKS	16.97 ab	16.26 abc	8.50 b	5.60 ab
Lime + NPKS	20.19 a	18.82 a	12.53 a	6.43 a
75% NPKS	14.38 b	15.94 abc	8.00 b	5.57 ab
Lime + 75% NPKS	17.20 ab	17.17 ab	9.70 b	5.83 ab
F-test	NS	NS	***	*
CV (%)	15.97	17.95	17.41	14.14

In a column, figures having the same letter (s) do not differ significantly. Figures *** and * indicate significance at 0.1 and 5% probability levels, respectively. NS means non-significant.

Leaf number and yield

The treatments had a significant effect on leaf number, but they did not significantly affect 80 DAS of leaf yield of *B. alba* (Table 3). The leaf number ranged from 15.90 at 35 DAS to 66.20 at 80 DAS. The highest and lowest numbers were recorded from lime + NPKS and control treatments. The highest yields at 34.03 and 17.53 g pot^{-1} were obtained from lime + NPKS, and the lowest yields at 14.00 and 9.27 g pot^{-1} were found from control at 50 and 80 DAS, respectively.

Table 3. Effect of liming and inorganic fertilizers on leaf number and leaf yield of *B. alba* at different days after sowing (DAS).

Treatment	Total leaf number (Number $plant^{-1}$)				Leaf yield (g pot^{-1})	
	DAS					
	35	50	65	80	50	80
Control	15.90 c	17.54 d	26.67 e	45.37 d	14.00 b	9.27 b
Lime	16.64 bc	26.67 c	42.63 d	50.00 c	16.47 b	13.13 ab
NPKS	19.44 ab	39.97 b	50.47 b	58.67 b	28.60 a	14.24 a
Lime + NPKS	21.34 a	43.30 a	61.67 a	66.20 a	34.03 a	17.53 a
75% NPKS	18.67 abc	28.97 c	46.67 c	57.34 b	28.47 a	13.33 ab
Lime + 75% NPKS	20.24 a	42.34 ab	53.40 b	65.34 a	31.43 a	14.23 a
F-test	*	***	***	***	***	NS
CV (%)	8.68	4.41	4.43	3.12	18.51	19.43

In a column, figures having the same letter (s) do not differ significantly. Figures *** and * indicate significance at 0.1 and 5% probability levels, respectively. NS means non-significant.

Leaf length and breadth

The treatments had no significant effect on the leaf length and breadth of *B. alba* (Table 4). Whereas the longest and shortest leaves were identified from lime + NPKS and control treatments, respectively. In addition, the broadest and narrowest leaves were identified from lime + NPKS and control treatments, respectively.

Petiole length

Petiole length of *B. alba* had no significant effect with treatments (Table 4). However, the longest and shortest petioles were identified from lime + NPKS and control, respectively.

Table 4. Effect of lime and inorganic fertilizers on leaf length and leaf breadth of *B. alba* at different days after sowing (DAS).

Treatment	Leaf length		Leaf breadth		Petiole length	
	(Cm $plant^{-1}$) DAS					
	50	80	50	80	50	80
Control	5.74 b	4.78 b	4.04 b	2.80 b	2.08 a	1.47 b
Lime	6.00 ab	5.36 ab	4.14 b	3.56 ab	2.11 a	1.64 ab
NPKS	7.81 ab	5.45 ab	5.27 ab	3.56 ab	2.17 a	1.74 ab
Lime + NPKS	7.89 a	6.10 a	5.64 a	3.81 a	2.35 a	1.97 a
75% NPKS	7.17 ab	5.43 ab	5.06 ab	3.40 ab	2.15 a	1.67 ab
Lime + 75% NPKS	7.82 ab	5.64 ab	5.27 ab	3.49 ab	2.24 a	1.90 ab
F-test	NS	NS	NS	NS	NS	NS
CV (%)	17.00	13.21	16.33	14.37	20.83	15.32

In a column, figures having the same letter (s) do not differ significantly. NS means non-significant.

Branches number

The application of fertilizers did not significantly affect the branch number of plants (Table 5). The highest (3.94) and lowest (2.57) branches were identified from lime + NPKS and control, respectively.

Taproot length and fresh root weight

The Treatments had no significant effect on taproot length (Table 5), but they significantly affected ($P < 0.1$) on root weight of *B. alba* (Table 5). The longest (21.55 cm) and shortest (15.67 cm) roots were identified from lime + NPKS and control, respectively. The highest and lowest root weights were 26.61 and 13.01 g identified from lime + NPKS and control.

Total yield

The application of lime and NPKS alone or combined had a significant ($P < 0.1$) effect on the yield of *B. alba* (Table 5). The highest and lowest yields were 809.34 and 468.27 g pot^{-1} obtained from lime + NPKS and control treatments. The treatments lime + 75% NPKS, only NPKS, and 75% NPKS showed statistically identical results 715.27, 715.13, and 712.84 g pot^{-1}, respectively.

Table 5. Effect of lime and inorganic fertilizers on branch number, taproot length and fresh root weight of *B. alba* at final harvest (80 DAS).

Treatment	Branches (No. $plant^{-1}$)	Taproot length (cm $plant^{-1}$)	Fresh root weight (g $plant^{-1}$)	Total yield (g pot^{-1})
Control	2.57 b	15.67 b	13.01 d	468.27 d
Lime	2.82 b	16.47 b	18.39 c	488.57 c
NPKS	3.17 ab	18.77 ab	21.58 bc	715.13 b
Lime + NPKS	3.94 a	21.55 a	26.61 a	809.34 a
75% NPKS	2.94 ab	17.22 ab	19.57 bc	712.84 b
Lime + 75% NPKS	3.94 a	21.33 a	23.42 ab	715.27 b
F-test	NS	NS	***	***
CV (%)	17.85	14.03	13.12	0.688

In a column, figures having the same letter (s) do not differ significantly. Figure *** indicates significance at 0.1 level of probability. NS means non-significant.

Discussion

The experiment was conducted to see the effect of lime and inorganic fertilizers on the growth and yield of *Basella alba*. Application of lime and NPKS alone or combined showed different effects on the growth and yield of *B. alba.* Lime and inorganic fertilizers application at different levels responded differently to the growth and yield of *Abelmoschus esculentus* (Olatunji et al., 2017). The better crop performance was identified from lime + NPKS on all studied characters of *B. alba*. The treatments lime, NPKS, lime + 75% NPKS, and 75% NPKS did not perform well. The application of lime with inorganic fertilizers produced more satisfactory results than only lime, and no lime-treated plots (Hin et al., 2020).

Combined application of lime + NPKS produced the longest vine (96 cm at 80 DAS) and higher vine weight (433 g $plant^{-1}$) compared to lime + 75% NPKS and other treatments. P and lime together produced higher shoot biomass of *B. alba* (Sarker et al., 2014). Moreover, supplied urea fertilizer helped to produce more biomass than other forms of nitrogenous fertilizer (Shormin & Kibria, 2018). The highest leaf yield (34 g pot^{-1} at 50 DAS) and large-sized leaves was identified from lime + NPKS treatment. NPK in the recommended amount was effective for producing the highest number of leaves, leaf length, and breadth of *B. alba* (Das et al., 2018). NPK (6.5 g pot^{-1}) produced the longest shoot, higher number of leaves, more leaf area, and higher fresh weight of *B. alba* than other treatments (Aguoru et al., 2014). Lime + NPKS had responded well on yield (809 g pot^{-1}) of *B. alba,* followed by lime + 75 % NPKS, only NPKS and 75% NPKS. The results illustrated that lime positively influenced inorganic fertilizers and applying recommended NPKS was better for crops than below NPKS rate. However, lime alone showed poor *B. alba* yield compared to NPKS

and 75% NPKS. This may be due to poor soil nutrient status. In this situation, *B. alba* responded well to the addition of lime with NPKS fertilizers because the positive interaction of N, P, K and S fertilizers with lime influence Al^{+3} and H^{+} ions reduction from the soil. *Zea mays*' yield increased with lime and higher inorganic fertilizers, and the poor yield was identified in control acid infertile soils (Beukes et al., 2012). Lime with inorganic fertilizers produced the highest yield, and yield increased up to 92% compared to only lime and nolime-treated plots (Hin et al., 2020). The positive interaction of liming with P and K was shown by (Holland et al., 2019). The combined application of lime and P produced the higher shoot and root biomass of *B. alba* than P or lime alone (Sarker et al., 2014). Lime-treated plots gave higher yield and yield components than lime untreated plots and yield reduction by 26% due to the acidity effect (Legesse et al., 2013).

References

Aguoru, C. U., Igba, P. & Olasan, J. O. (2014). Effects of different levels of organic and inorganic fertilizers on the growth and yield of indian spinach. *International Journal of Tropical Agriculture and Food Systems*. *8*(1):18-23.

Beukes, D. J., Mapumulo, T. C., Fyfield, T. P. & Jezile, G. G. (2012). Effects of liming and inorganic fertiliser application on soil properties and maize growth and yield in rural agriculture in the Mbizana area, Eastern Cape province, South Africa. South African *Journal of Plant and Soil*, *29*(3-4):127-133

Das, A., Dash, P. K. & Mannan, M. A. (2018). Performance of Indian spinach under different combinations of organic and inorganic fertilizers. *Bangladesh Journal of Agriculture and Environment*. *14* (1): 19-28.

Fageria, N. K. & Baligar, V. C. (2008). Ameliorating soil acidity of tropical Oxisols by liming for sustainable crop production. *Advances in Agronomy*. *99*:345-399.

FRG. (2012). Fertilizer Recommendation Guide. *Bangladesh Agricultural Research Council (BARC)*, Farmgate, Dhaka 1215, www.barc.gov.bd. pp274

Hin, S., Touch, V., Lim, V., Eberhard, J., Melland, A. R., McPhee, J. & Seng, V. (2020). Lime and Fertilizer Applications Increase Yield of Leafy Vegetable Crops in Cambodia. *Multidisciplinary Digital Publishing Institute Proceedings*. *36*(1):179.

Holland, J. E., White, P. J., Glendining, M. J., Goulding, K. W. T. & McGrath, S. P. (2019). Yield responses of arable crops to liming−An evaluation of relationships between yields and soil pH from a long-term liming experiment. *European Journal of Agronomy*. *105*:176-188.

Kumar, S., Prasad, A. K., Iyer, S. V. & Vaidya, S. K. (2013). Systematic pharmacognostical phytochemical and pharmacological review on an ethno medicinal plant, *Basella alba* L. *Journal of Pharmacognosy and Phytotherapy*. *5*(4):53-58.

Legesse, H., Nigussie-Dechassa, R., Gebeyehu, S., Bultosa, G. & Mekbib, F. (2013). Response to soil acidity of common bean genotypes (*Phaseolus vulgaris* L.) under field conditions at Nedjo, Western Ethiopia. Science. *Technology and Arts Research Journal*. *2*(3):03-15.

Mansingh, M. D. I., Suresh, S. & Vignesh, M. A. R. S. (2019). Effect of liming on yield and nutrient uptake of rice in acidic soils. *International Journal of Chemical Studies*, *7*(3):2540-2543.

Olatunji, O., Adoyi, E. & Ali, E. T. (2017). Effect of lime and mineral fertilizer on growth and yield of two varieties of okra (*Abelmoschus esculentus* (L) m*oench*) grown on soil from Otobi acid flood plain of Nigeria. *International Journal of Agriculture, Environment and Bioresearch*. *2* (4):43-57.

Sarker, A., Kashem, M. A. & Osman, K. T. (2014). Phosphorus availability, uptake and dry matter yield of Indian spinach (*Basella alba* L.) to lime and phosphorus fertilization in an acidic soil. *Open Journal of Soil Science*, *4*(1): 42-46.

Shormin, T. & Kibria, M. G. (2018). Effects of Nitrogen from Different Inorganic Fertilizers on Growth and Yield of Indian Spinach (*Basella alba* L.). *IOSR Journal of Pharmacy and Biological Sciences*. *13*(5):43-48.

Singh, A., Dubey, P. K., Chaurasiya, R., Mathur, N., Kumar, G., Bharati, S., & Abhilash, P. C. (2018). Indian spinach: an underutilized perennial leafy vegetable for nutritional security in developing world. *Energy, Ecology and Environment*. *3*(3):195-205.

Williams, L. J. & Abdi, H. (2010). Fisher's least significant difference (LSD) test. *Encyclopedia of Research Design*. *218*:840-853.