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SUSTAINABLE MANAGEMENT OF ACID SOIL IN BARIND TRACT FOR INCREASING WHEAT YIELD

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Abstract

A field experiment was conducted during 2024- 2025 to determine lime rate for acid soil and to evaluate the effects of liming and organic matter on soil properties and wheat yield in the High level Barind Tract (AEZ- 26). The experimental site was located at N-24˙38″42″″ latitude and E- 88˙24″24″″ longitude in Gleysol (Locally named as ‘Nachol’ soil series) of Nachole upazila under Chapainawabganj district. The experiment consisted of seven treatments which include control (no lime or organics), different doses of dololime (0.5, 1.0, 1.5, 2.0 and 2.5 t ha^{-1}) and 2.5 t ha^{-1} biochar + 1.0 t ha^{-1} vermicompost. Post-harvest soil analysis revealed significant changes in pH, organic matter (OM), and nutrient availability, including phosphorus (P), calcium (Ca), and magnesium (Mg). The results indicated that dolomite amendment effectively increased soil pH by 0.2-1.7 units, which correlated positively with nutrient availability and wheat yield. The growth and yield parameters such as plant height, spike length, grains per spike, 1000- grain weight, and grain yield. The grain yield of wheat significantly improved particularly in the plots receiving 1.5 t ha^{-1} dolomite and 2.5 t ha^{-1} biochar + 1.0 t ha^{-1} vermicompost. The findings underscore the need of using dololime, biochar and vermicompost as soil amendments to sustain soil fertility as well as wheat yield in acid soils of High Barind Tract (AEZ 26).

Keywords: Biochar, Dololime, Vermicompost, Soil health, Wheat

1. Introduction

Barind Tract (‘Varendra Bhumi’ in Bengali) has an area of 7727 sq km (772741 ha) extended over the north-west part of Bangladesh, containing part of greater Rajshahi, Dinajpur, Rangpur and Bogra districts. The Barind is floored by the characteristic Pleistocene sediments known as the Madhupur (Barind) Clay. Mophologically Barind Tract represents terrace soils having low pH, reddish brown color and oxidized (SRDI, 2020). Three AEZs, namely Level Barind Tract (AEZ 25), High Barind Tract (AEZ 26) and North Eastern Barind Tract (AEZ 27) represent whole Barind Tract. Dry climate, low rainfall and drought are the main threat to crop production. This situation particularly occurs in High Barind Tract (AEZ 26).

Soil pH regulates the availability of plant nutrients and crop yield. Maintaining soil pH above 6.0 optimizes nutrient use, particularly phosphorus (Khandakhar *et al*., 2004; Rahman *et al.,* 2005). Application of dololime ($CaCO_3$. $MgCO_3$) helps increases soil pH, P, Ca and Mg availability which contributed to crop yield (Islam *et al.,* 2024;. (Shaaban *et al.,* 2015; Shaaban *et al.,* 2018).

Liming increases soil pH decreases of iron (Fe), aluminum (Al) and manganese (Mn) toxicity and improves microbial activity, resulting in better root development and crop yields (Islam *et al.,* 2024; Islam *et al.,* 2021;. Han *et al.,* 2019). The method of application also matters; incorporating lime into the soil generally yields better results than surface application (Enesi *et al.,* 2023). Optimal liming rates maximizes yield and quality of crops, while excessive liming could lead to nutrient imbalances and reduced yields (Shevchuk *et al.,* 2024)

Dolomite is recognized as an amendment for soil acidity and vermicompost is a material commonly recommended for the improvement of soil properties. The combined application of dolomite and vermicompost have positive impact on the improvement of soil health. Although dolomite increases soil pH, but organic matter acts as a buffering agent controlling the detrimental effects of soil pH on crop production. . Vermicompost significantly enhance the soil phyco-chemical properties in acid soil (Zewide *et al.,* 2021). Use of vermicompost can increases wheat production and enhances seed quality as well as economic benefits to farmers and contributing to sustainable agricultural practices in Bangladesh (Haque *et al.,* 2025).

Biochar is black carbon produced from biomass sources i.e., wood chips, plant residues, manure or other agricultural waste products in an oxygen-limited environment. Biochar enhances soil physical, chemical, and biological properties, increasing nutrient availability and improving water retention (Baquy *et al.,* 2022;Ayaz *et al.,* 2021).

Therefore, a study was undertaken in acid soil of Nachole upazila under Chapainawabganj district, to see the changes of soil properties and wheat due to dololime application along with vermicompost and biochar.

2. Materials and Methods

2.1 Site description and Soil Information

The experiment was conducted at farmer's field of Nachole upazila under Chapainawabganj district from December 2024 to March 2025. It belongs to the Agro Ecological Zone-26 (High Barind Tract). The top soil texture was clay loam, initial soil having pH 5.4, Organic matter 1.57%, total N 0.09%, available P 18.1 $\mu g\ g^{-1}$, K 0.13 meq 100 g $soil^{-1}$, available Ca 5.7 meq 100 g $soil^{-1}$, Mg 2.08 meq 100 g $soil^{-1}$, S 15.0 $\mu g\ g^{-1}$, B 0.20 $\mu g\ g^{-1}$, Zn 0.69 $\mu g\ g^{-1}$, Fe 76.09 $\mu g\ g^{-1}$ and Mn 7.28 $\mu g\ g^{-1}$. The test crop was wheat (*Triticum aestivum L.*) cv. BARI Gom-30 for the study.

2.2 Treatments, experimental design and fertilization

The experiment consisted of seven treatments which are control (no lime or biochar or vermicompost), different doses of dololime (0.5, 1.0, 1.5, 2.0 and 2.5 t ha^{-1}) and 2.5 t ha^{-1} biochar + 1.0 t ha^{-1} vermicompost. Therefore, the treatments were: T_1 (Control); T_2 (0.5 t ha^{-1} dololime); T_3 (1.0 t ha^{-1} dololime); T_4 (1.5 t ha^{-1} dololime); T_5 (2.0 t ha^{-1} dololime), T_6 (2.5 t ha^{-1} dololime) and T_7 (2.5 t ha^{-1} biochar + 1.0 t ha^{-1} vermicompost). Chemically dololime is dolomite, $CaCO_3.MgCO_3$. . Dololime was applied to the soil on 02 December 2024 and mixed well with soil by repeated ploughing by power tiller and country plough. Vermicompost and biochar were applied after three days of dolomite application. Wheat seed was sown on 07 December 2024. The experiment was laid out in a randomized complete block design with three replications. There were altogether 21 (7×3) unit plots (5m ×4 m). Inter-block and Inter-plot spacing were 1m and 0.7m, respectively. Fertilization (Recommended fertilizer dose) was as N @ 120 kg ha^{-1} from urea, P @ 240 kg ha^{-1} from TSP, K @ 90 kg ha^{-1} from MoP, S @ 10 kg ha^{-1} from gypsum, Zn @ 1.5 kg ha^{-1} from zinc sulphate (heptahydrate) and B @ 1.0 kg $ha^{-1}$from Boric acid. Irrigations and other cultural practices were provided on time. The crop was harvested on 25 March 2025. Ten plants from each plot were sampled randomly recording for yield parameters. Then plot-wise weight of grain was recorded.

2.3 Soil sampling and analysis

Before setting up the experiment initial soil samples were collected randomly from nine different spots of the field from a depth of 0-15cm . After harvest of wheat, the soil samples again were collected using an auger from each plot at a depth of 0-15 cm. In both cases, the soil samples were left to dry naturally in a shaded area and then pulverized with a mortar and ground to attain a particle size capable of passing through a 2-mm sieve. The initial soil samples were analyzed in SRDI laboratory as per standard methods. Soil samples were analyzed for pH by glass-electrode pH meter maintaining 1:2.5 soil-water ratio (Jackson, 1962), organic matter by wet oxidation method (Walkley and Black, 1934), the total N content was determined by micro-Kjeldahl method (Kjeldahl, 1883), the available P was determined by developing blue color absorbance with ammonium molybdate-ascorbic acid solution and measuring the color by Spectrophotometer at 890 nm wavelength (Bray and Kurtz's, 1945), the S content in the extract was determined turbidimetrically and the turbid was measured by spectrophotometer at 535 nm wavelengths (Fox *et al.,* 1964), exchangeable K content was determined by ammonium acetate extraction method using a flame photometer (Schollenberger, 1945) and exchangeable Ca and Mg content were determined by extraction with 1M ammonium acetate by atomic absorption spectrophotometer (Schollenberger, 1945), available B was extracted by hot water-0.02M $CaCl_2$ solution (1:2), the extractable B was determined by spectrophotometer following azomethine-H method (Keren, 1996), available Zn, and Mn were extracted by 0.05M DTPA solution (pH 7.3) maintaining 1:2 soil-extractant ratio, the extracted level was measured by atomic absorption spectrophotometer (Lindsay and Norvell, 1978).

1.4 **Statistical analysis**

Statistical analysis was done using Microsoft EXCEL and "Statistix-10" software program. Mean differences between the treatments were evaluated by using LSD (Least significant Difference Test) at 5% level of significance.

3. Results and Discussion

3.1 Effects of dololime and vermicompost on post-harvest soils

The pH values, P, Ca and Mg availability of the post-harvest soils in different treatments of wheat increased steadily with increasing rates of dolomite application (Table 1). The pH of the initial soil was 5.4 which increased to 5.8, 5.8, 5.9, 6.1, 6.7, 6.8 and 6.0 in T_1, T_2, T_3, T_4 T_5, T_6, T_7 respectively. The increased in soil pH was due to available of Ca and Mg in soils (Leiva *et al.,* 2023). The initial value of available phosphorus in the soil was 18.1 μg g^{-1} soil and the post-harvest soils had the values 30.5, 37.4, 42.5, 45.4, 47.1, 49.5, and 47.9 μg g^{-1} under the treatments T_1, T_2, T_3, T_4 T_5, T_6, $T_{7,}$ respectively. The increased soil pH helped the release of fixed P from the oxides and hydroxides of Fe and Al thus increased the P availability in soils (Fan *et al.,* 2022). The available Ca of the initial soil was 5.7 meq 100 g $soil^{-1}$ which increased to 5.9, 6.06, 6.2, 6.53, 6.73, 7.06 and 6.58 meq 100 g $soil^{-1}$ in T_1, T_2, T_3, T_4 T_5, T_6, T_7 respectively. Dololime on dissolution released a large amount of Ca & Mg and thus the availability of Ca increased in post-harvest soils. The available Mg of the initial soil was 2.08 meq 100g $soil^{-1}$ which increased to 3.1, 3.0, 3.2, 3.8, 4.2, 4.1 and 3.1 meq 100 g $soil^{-1}$ in T_1, T_2, T_3, T_4 T_5, T_6, T_7 respectively.

Liming generally has little direct effect on potassium (K) availability, but there are some indirect influences. In acid soils, liming can temporarily increase Zn availability by reducing $Al^{3+}$and Mn toxicity in short term but in the long run liming generally decreases the availability of Zn in soil. The available K of the initial soil was 0.13 meq 100 g $soil^{-1}$ which increased to 0.42, 0.67, 0.83, 0.59, 0.34, 0.48 and 0.50 meq 100 g $soil^{-1}$ in T_1, T_2, T_3, T_4 T_5, T_6, T_7 respectively. The initial value of sulphur in the soil was 15.0 μg g^{-1} soil and the value after post-harvest was 13.4, 14.0, 16.7, 13.0, 13.5, 11.0 and 16.1 μg g^{-1} under the treatment T_1, T_2, T_3, T_4 T_5, T_6, T_7 respectively. The initial status of zinc was 0.69μg g^{-1} soil and the post-harvest soils had the values 2.2, 7.6, 4.1, 6.1, 3.4, 1.6 and 5.2 μg g^{-1} in T_1, T_2, T_3, T_4 T_5, T_6, $T_{7,}$ respectively (Table1).

Table 1. Effects of dololime and vermicompost on post-harvest soil at farmer's field

Treatments	pH	OM (%)	N (%)	P ($\mu g\ g^{-1}$soil)	K (meq 100g^{-1}soil)	Ca (meq 100g^{-1}soil)	Mg (meq 100g^{-1}soil)	S ($\mu g\ g^{-1}$soil)	Zn ($\mu g\ g^{-1}$soil)	B (μg g soil^{-1})
Initial	5.4^{d}	1.57^{b}	0.09^{a}	18.1^{b}	0.13^{c}	5.7^{b}	2.08^{c}	15.0^{a}	0.69^{a}	0.20^{c}
T_1	5.8^{Cd}	1.6^{ab}	0.09^{a}	30.46^{bc}	0.42^{bc}	5.9^{b}	3.1^{b}	13.4^{a}	2.2^{a}	0.24^{abc}
T_2	5.8^{cd}	1.6^{ab}	0.093^{a}	37.43^{ab}	0.67^{ab}	6.06^{ab}	3.0^{b}	14.0^{a}	7.6^{a}	0.26^{ab}
T_3	5.9^{cd}	1.6^{ab}	0.093^{a}	42.46^{ab}	0.83^{a}	6.20^{ab}	3.2^{ab}	16.7^{a}	4.1^{a}	0.29^{a}
T_4	6.1^{bc}	1.7^{a}	0.10^{a}	45.4^{ab}	0.59^{ab}	6.53^{ab}	3.8^{ab}	13.0^{a}	6.1^{a}	0.26^{ab}
T_5	6.7^{ab}	1.7^{ab}	0.10^{a}	47.13^{a}	0.34^{bc}	6.73^{ab}	4.2^{a}	13.5^{a}	3.4^{a}	0.20^{c}
T_6	6.8^{a}	1.6^{ab}	0.096^{a}	49.5^{a}	0.48^{abc}	7.06^{a}	4.1^{a}	11.0^{a}	1.6^{a}	0.23^{bc}
T_7	6.0^{c}	1.5^{b}	0.093^{a}	37.9^{a}	0.50^{abc}	6.58^{ab}	3.1^{b}	16.1^{a}	5.2^{a}	0.22^{bc}
F-test	*	*	NS	*	*	*	*	NS	NS	*
CV (%)	5.33	6.22	7.54	23.50	43.27	9.32	16.23	26.16	103.53	13.14

T_1 (Control); T_2 (0.5 t ha^{-1} dolomite); T_3 (1.0 t ha^{-1} dolomite); T_4 (1.5 t ha^{-1} dolomite); T_5 (2.0 t ha^{-1} dolomite), T_6 (2.5 t ha^{-1} dolomite) and T_7 (2.5 t ha^{-1} biochar + 1.0 t ha^{-1} vermicompost).
The Figures having common letter in a column are not significantly different by F-test at 5%level.

3.2 Growth, yield components and yield

Application of different doses of dololime with vermicompost significantly increased plant height, spike length, root length, grains per spike, 1000-grain weight and yield per hectare (Table 2). Biochar also plays a significant role on the yield contributing character of wheat. Plant height of wheat progressively increased with increase in dolomite doses. Plant height ranged from 87.2 cm to 94.7 cm in treatments. The tallest plant recorded in T_4 and all the treatments of T_1, T_2, T_3, T_5, T_6, T_7 differed statistically from each other in plant height. The spike length by different treatments varied from 13.67 cm to 14.8 cm. The number of grains per spike of wheat ranged from 37.2 to 46.6, the highest value being observed in T_4 treatment. The 1000-grain weight observed in different treatments varied from 42.3 g to 53.4 g, the highest grain weight observed in T_4 treatment. Grain weight of wheat (var. BARI Gom-30) significantly responded to the application of different doses of dololime along with vermicompost (Table 2). The highest yield was found in T_4 (4.57 t ha^{-1}), the second highest yield was in T_7 (4.55 t ha^{-1}), while the lowest in T_1 (4.2 t ha^{-1}) treatment. All the treatments of T_1, T_2, T_3, T_5, T_6, T_7 differed statistically from each other in yields of wheat. Plant height, spike length, grains spike $^{-1}$, , 1000-grain weight and yield per hectare were observed 88.5 cm, 14.1 cm, 9.8 cm., 41.6, , 42.3 g and 4.25 t ha^{-1} respectively. Farmers of Nachole upazila do not follow the soil test-based fertilizer dose. They use excessive fertilizer in their field for wheat production. At the initial cost in research field increase due to cost of lime application but considering yield the farmers will be benefited and use of dolomite can help retain fertility and reduce soil acidity for better crop growth and yield.

Table 2. Effects of dololime and vermicompost on the growth, yield components and yield of wheat

Treatments	Plant height (cm)	Spike length (cm)	Grains/spike (No.)	1000-grain weight (g)	Yield (t/ha)
Farmer`s Field	88.5^{d}	14.1^{b}	41.6^{bc}	42.3^{e}	4.25^{b}
T_1	89.13^{d}	14.13^{b}	43.53^{ab}	46.2^{de}	4.2^{ab}
T_2	89.4^{cd}	13.67^{b}	45.2^{ab}	47.8^{cd}	4.31^{ab}
T_3	94.73^{b}	14.6^{ab}	42.13^{bc}	48.5^{bcd}	4.26^{b}
T_4	98.6^{a}	16.2^{a}	46.6^{a}	51.3^{abc}	4.57^{a}
T_5	94.46^{b}	14.8^{ab}	39.13^{cd}	53.4^{a}	4.23^{b}
T_6	87.2^{d}	14.27^{b}	44.93^{ab}	49.6^{abcd}	4.32^{ab}
T_7	92.53^{bc}	13.73^{b}	37.2^{d}	52.7^{ab}	4.55^{a}
F-test	*	*	*	*	*
$LSD_{0.05}$	3.20	1.6	3.76	4.67	0.28
CV (%)	1.99	6.33	5.06	5.45	3.69

4. Conclusions

It is concluded that combined application of dololime and organic matter (OM) in High Barind Tract (AEZ-26) in the Nachole soil series increased soil pH to a desired level together with the improvement of soil health which in turn increased yield of wheat. It is supplementary that the amount of dolomite 1.5 t ha^{-1} in addition to 1.0 t ha^{-1} vermicompost is optimum for wheat cultivation in the clay loam acid soil of AEZ-26. This experiment will provide vital insights for stakeholders especially farmers involved in implementing sustainable agriculture and will contribute in selecting soil amendments in acid soil to promote climate smart agriculture.

Conflicts of Interest

The authors declare no conflicts of interest regarding publication of this paper.

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