CHANGES OF ACIDIC SOIL PROPERTIES AND YIELD OF WHEAT AS INFLUENCED BY APPLICATION OF DOLOMITE AND VERMICOMPOST

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ABSTRACT

A field experiment was conducted during 2018 - 2019 to evaluate the combined effects of dolomite and vermicompost on soil properties, growth traits, and the yield of wheat (BARI Gom-30) grown in the High Barind Tract in the Amnura soil series of Gomastapur, Chapainawabganj. The experiment included five treatments involving application of dolomite ($CaCO_3 \cdot MgCO_3$) and incorporation of 4 kg decimal^{-1} of vermicompost in soil for each plot. Data on yield and yield components were recorded during crop's growth stages and at harvest. Post-harvest soil samples were analyzed for pH, organic matter (OM), and different macro and micronutrients. Application of varying doses of dolomite combined with vermicompost increased soil pH by 0.1-1.4 units and enhanced the availability of plant nutrients such as P, Ca, and Mg. Grain yield of wheat was positively correlated with soil pH and available P in soils after harvest. Plant height, tillers per hill, spike length, grains per spike, 1000-grain weight, and grain yield were significantly influenced by dolomite application. Treatment T_4 (1.0 t dolomite ha^{-1}) produced the significantly highest grain yield of 5.8 t ha^{-1} compared to the treatments T_1, T_2, T_3, and T_5. Total uptake of P, K, and S increased with application of dolomite and vermicompost, which was strongly associated with the increased wheat yields. The results demonstrate that application of vermicompost and dolomite not only improves soil health and also supports wheat productivity and promotes microbial activity in soil. The combination of dolomite and vermicompost considering 1 t ha^{-1} each appears to be optimal for achieving the desired soil pH (6.5), enhancing nutrient availability, and increasing wheat yield.

Keywords: Barind Tract, Acid soil, Dolomite, Vermicompost, Wheat

1. Introduction

In acid soils, low phosphorus (P) availability and iron (Fe) toxicity are considered major yield-limiting factors for crop production, particularly in the Barind soils of Bangladesh. Soils in the study area are becoming increasingly acidic, with many areas experiencing strongly acidic conditions. Soil pH is a key indicator of the soil environment and quality, as it regulates the availability of plant nutrients, crop yield, and crop quality. Most soils in Bangladesh exhibit a low to medium level of acidity due to high rainfall and leaching. The three primary types of acid soils found in Bangladesh include acid basin clay, acid sulfate soils, and brown hill soils (Alam, 2006).

In the northwest region of Bangladesh, soils are light-textured, low in organic matter, and strongly to moderately acidic, with pH ranging from 4.5 to 6.5. These soils also have low levels of available phosphorus (P), calcium (Ca), and magnesium (Mg). Aluminum toxicity in acid soils is another factor contributing to poor crop yields. The application of dolomite to acidic soils increases soil pH, reduces the toxicity of iron (Fe), aluminum (Al), and manganese (Mn), and enhances the availability of nitrogen (N), phosphorus (P), calcium (Ca), magnesium (Mg) (Khandakhar *et al.,* 2004; Bodruzzaman, 2010; FRG, 2012) and microbial activity. In acid soils, dolomite application significantly increases water-soluble nitrogen and fixed ammonium.

Dolomite (CaCO3.MgCO3) is widely recognized as an effective amendment for soil acidity and organic matter is a material commonly recommended for the improvement of soil properties. The combined application of dolomite and organic matter may have positive impact on the improvement of soil health including of soil moisture status. Although dolomite increases soil pH, but organic matter acts as a buffering agent controlling the detrimental effects of soil pH on crop production. Soil organic matter (OM) is a key factor in maintaining long-term soil fertility since it is the reservoir of metabolic energy, which drives soil biological processes involved in nutrient availability. A good soil should have at least 2.5% organic matter, but in Bangladesh most of the soils have less than 1.5%, and some soils contain even less than 1% organic matter (FRG, 2024).

Organic matter improves soil structure through aggregation, which positively influences soil properties such as tillage, crusting, water infiltration, moisture retention, aeration, temperature, and root penetration (Datta and Hundal, 1984). Additionally, organic matter supplies plant nutrients, increases the soil's water-holding capacity, and mitigates the negative residual effects of fertilizers and pesticides (Padre *et al.,* 2007). Soil pH is an important factor in determining whether the soil is acidic, alkaline, or neutral, which ultimately influences plant growth. Acidic soils are a significant constraint on crop production due to their negative effects on soil fertility and productivity. In Bangladesh, the problem of soil acidification has worsened over time, largely due to the removal of base materials from the topsoil. Therefore, this study was conducted in the acidic soils of Gomastapur Upazila, Chapainawabganj district, to assess the changes in soil properties resulting from the application of dolomite and vermicompost in wheat fields, and to evaluate their effects on wheat yield and yield-contributing traits.

2. Materials and Methods

2.1 Site description and Soil & Seed Information

The experiment was conducted at farmer's field of Gomastapur upazila under Chapainawabganj District from November 2018 to June 2019. The experimental field is located at 24°50'54.0" latitude and E- 88°26'35.6" longitude at a height of 22 m above the mean sea level. It belongs to the Agro Ecological Zone- 26 (High Barind Tract). The top soil texture was loam, initial soil having pH 5.5, Organic matter 1.69%, total N 0.10%, available P 9.4 μg g^{-1}, K 0.13 meq 100 g $soil^{-1}$, available Ca 8.54 meq 100 g $soil^{-1}$, Mg 3.10 meq 100 g $soil^{-1}$, S 5.35 μg g^{-1}, B 1.23 μg g^{-1},Zn μg g^{-1} and Mn 6.1 μg g^{-1}. The test crop was wheat *Triticum aestivum* cv. BARI Gom-30 for the study. Certified seeds were collected from the Bangladesh Wheat and Maize Research Centre, Nashipur, Dinajpur.

2.2 Treatments, experimental design and fertilization

Five different doses (treatments) of dolomite were applied along with 4 kg vermicompost (VC) $decimal^{-1}$, incorporated into the soil in each treatment plot in the wheat experiments field. The treatments were as follows T_1 (Control); T_2 (0.5 t ha^{-1} dolomite); T_3 (0.75 t ha^{-1} dolomite); T_4 (1.0 t ha^{-1} dolomite); T_5 (1.25 t ha^{-1} dolomite). The dolomite material had 20% Ca and 10% Mg. The dolomite material was applied to the soil on 1 November 2018 and mixed well with soil by repeated ploughing by power tiller and country plough. Final land was prepared on 21 November, 2018.

The experiment was laid out in a randomized complete block design with three replications. There were altogether 15 (5×3) unit plots (5m ×4 m). Inter-block and Inter-plot spacing were 1m and 0.7m, respectively. Fertilization was as N @ 880 g $decimal^{-1}$ from urea, P @ 505 g $decimel^{-1}$ from TSP, K @ 605 g $decimel^{-1}$ from MoP, S @ 405 g $decimal^{-1}$ from gypsum, Zn @ 13 g $decimal^{-1}$ from zinc sulphate (heptahydrate) and B @ 6 g $decimal^{-1}$ from boric acid.

Three irrigations were applied, the first irrigation after 18 days of sowing, second irrigation after 55 days of sowing at crown root initiation stage and the third after 75 days of sowing at heading stage. Weeding and pest control program were done when necessary. The crop was harvested at maturity after about three months of sowing (March 29, 2019). Ten plants from each plot were sampled randomly recording for yield parameters. Then plot wise weights of grain and straw were recorded.

2.3 Soil sampling and analysis

Before setting up the experiment initial soil samples were collected randomly from 9 different spots of the field from a depth of 0-15cm were taken using an auger. 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 analysed 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 & Simon, 1945) and exchangeable Ca and Mg content were determined by extraction with 1M ammonium acetate by atomic absorption spectrophotometer (Schollenberger & Simon, 1945), available B was extracted by hot water-0.02M CaCl2 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).

2.4 Statistical analysis

The data were analyzed statistically by F-test to examine whether the treatment effects were significant or not. The mean comparisons of the treatments were evaluated by LSD (Least significant Difference Test) if the treatments were significant. The analysis of variance (ANOVA) for different parameters was done by computer using "Statistix-10" software program.

3. Results and Discussion

3.1 Effects of dolomite and vermicompost on changes of Soil properties

The changes in pH, P, Ca and Mg content in soil markedly varied after the harvest of wheat. 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 5.5 which increased to 5.6, 5.9, 6.3, 6.9 and 6.6 T1, T_2, T_3, T_4 and T_5 respectively. The increased in soil pH was due to available of Ca and Mg in soils. The initial value of available phosphorus in the soil was 9.4 μg g^{-1} soil and the post harvest soils had the values 21.98, 25.37, 26.68, 50.10 and 40.81 μg g^{-1} soils in T_1, T_2, T_3, T_4 and T_5 respectively. Dolomite application increased the soil pH which helped the release of fixed P from the oxides and hydroxides of Fe and Al thus increased the P availability in soils. The available Ca of the initial soil was 7.34 meq 100 g $soil^{-1}$ which increased to 7.24, 7.71, 8.57, 9.57 and 8.68 meq 100 g $soil^{-1}$ in T_1, T_2, T_3, T_4 and T_5 respectively. The dolomite material used as dolomite (CaCO3.MgCO3), which on dissolution released a large amount of Ca & Mg and thus the available of Ca increased in post harvest soils. The available Mg of the initial soil was 3.10 meq 100g $soil^{-1}$ which decreased to 2.45, 2.66, 2.96 and increased 3.40, 3.66 meq 100 g soil-1 in T_1, T_2, T_3, T_4 and T_5 respectively.

Table1. Effects of dolomite and vermicompost on soil properties

Treatments	pH	Organic Matter (%)	TN (%)	K (meq 100g^{-1}soil)	Ca (meq 100g^{-1}soil)	Mg (meq 100g^{-1}soil)	P (µg g^{-1}soil)	S (µg g^{-1}soil)	Zn (µg g^{-1}soil)	B (µg g soil^{-1})	Mn (µg g soil^{-1})
Initial soil values	5.5	1.69	0.10	0.13	8.54	3.10	9.4	5.35	0.98	1.23	6.1
Analytical values of post-harvest soil											
T_1: Control + VC	5.5-5.6	1.30^{a}	0.07^{a}	0.12^{a}	7.24^{c}	2.45^{c}	22.0^{b}	2.39^{b}	0.44^{a}	0.24^{b}	6.17^{c}
T_2: 0.5 t ha^{-1} + VC	5.8-5.9	1.32^{a}	0.08^{a}	0.13^{a}	7.71^{bc}	2.66^{bc}	25.4^{b}	3.75^{b}	0.52^{a}	0.33^{ab}	6.70^{bc}
T_3 : 0.75 t ha^{-1}+ VC	6.1-6.3	1.37^{a}	0.08^{a}	0.19^{a}	8.57^{abc}	2.96^{abc}	26.7^{b}	5.69^{b}	0.56^{a}	0.40^{ab}	8.20^{ab}
T_4: 1.0 t ha^{-1} + VC	6.6-6.9	1.48^{a}	0.09^{a}	0.30^{a}	9.75^{a}	3.40^{ab}	50.1^{a}	14.92^{a}	0.70^{a}	0.66^{a}	8.80^{a}
T_5 : 1.25 t ha^{-1} + VC	6.4-6.6	1.43^{a}	0.08^{a}	0.28^{a}	8.68^{ab}	3.66^{a}	40.8^{a}	11.21^{a}	0.52^{a}	0.48^{ab}	8.60^{a}
F-test		NS	NS	NS	*	*	*	*	NS	*	*
$LSD_{0.05}$		0.26	0.015	0.21	1.41	0.83	4.2	4.74	0.36	0.37	1.56

VC= Vermicompost, *= Significant at 0.05% level of probability
The Figures having common letter in a column are not significantly different by F-test at 5%level.
LSD= Least Significant Difference, CV= Co-efficient of Variation

Table 2. Effects of dolomite and vermicompost on growth and yield components of wheat

Treatments	Plant height (cm)	Tillers hill^{-1} (no.)	Spike length (cm)	Grains spike^{-1}	1000-grain weight (g)	Grain yield (t ha^{-1})
T_1: Control + VC	86.00^{d}	2.67^{d}	9.67^{b}	34.00^{e}	38.00^{c}	4.03^{c}
T_2: 0.5 t ha^{-1} + VC	91.00^{c}	3.33^{cd}	10.33^{ab}	41.00^{d}	40.33^{b}	4.37^{c}
T_3 : 0.75 t ha^{-1}+ VC	93.67^{ab}	4.33^{bc}	10.33^{ab}	43.00^{c}	40.33^{b}	5.10^{b}
T_4: 1.0 t ha^{-1} + VC	94.67^{a}	5.67^{a}	11.33^{a}	55.00^{a}	44.00^{a}	5.80^{a}
T_5 : 1.25 t ha^{-1} + VC	92.33^{bc}	5.33^{ab}	10.33^{ab}	51.00^{b}	41.50^{b}	5.43^{ab}
F-test	*	*	*	*	*	*
LSD value	1.38	1.19	1.14	1.97	1.71	0.42

VC= Vermicompost, equally incorporated in soil in every treatment plot
*= Significant at 0.05% level of probability
The Figures having common letter in a column are not significantly different by F-test at 5%level.
LSD= Least Significant Difference, CV= Co-efficient of Variation

3.2 Effects of dolomite and vermicompost on the growth and yield components of wheat

Application of different doses of dolomite significantly increased the plant height, the effective number of tillers hill^{-1}, spike length plant^{-1}, number of grains spike^{-1}, 1000-grain weight and grain yield (t ha^{-1}) are presented in Table 2.

Plant height of wheat progressively increased with increase in dolomite doses. The plant height ranged from 86.00 cm in T_1 (control) treatment to 94.67 cm in T_4 treatment. The tallest plant recorded in T_4 was significantly comparable to those obtained in T_5 treatments. All the treatments of T_1, T_2, and T_3 differed statistically from each other in plant height. The Tillers hill^{-1} by different treatments varied from 2.67 to 5.67. The highest number of tillers was obtained in the treatment T_4 and T_5 which was significantly comparable to those obtained in T_3 treatment. The treatments of T_1 and T_2 differed statistically from each other in tillers plant^{-1}. Spike length of wheat ranged from 9.67 to 11.33 cm, the tallest spike was found in $T_{4.}$ Th treatment T_2, T_3 and T_5 treatment which values are same and statistically similar. The treatments of T_1 differed statistically from each other in spike length. The number of grains spike^{-1} of wheat ranged from 34.00 to 55.00. The highest number of grains was found in T_4 treatment which was significantly comparable to those obtained in all treatments. The treatment T_2 recorded higher number of grains spike^{-1} over T_1 treatment and statistically superior to T_1 treatment. The 1000- grains weight of wheat ranged from 38.00 g to 44.00 g. The highest 1000 grains weight was found in T_4 which was significantly comparable to those obtained in T_5 treatment. The treatments of T_2 and T_3 recorded identical 1000- grain weight and $T_{2,\ T3}$ and T_5 statistically similar. The treatment T_2 significantly comparable to those obtained in T_1 treatment. The grain yield of wheat (var. BARI Gom30) was significantly responded due to application of different doses of dolomite along with vermicompost (Table 2). The highest grain yield was found in T_4 (5.80 t ha^{-1}) while the lowest in T_1 (4.03 t ha^{-1}) treatment. All the treatments of T_1, T_2, T_3 and T_5 differed statistically from each other in grain yields of wheat. Combined application of dolomite with vermicompost @ 1.0 t ha^{-1} each increased grain yield of wheat to a desired level.

4. Conclusions

Application of dolomite in combination with organic matter significantly improved the growth and yield of wheat (var. BARI Gom-30) in the study area. Dolomite application increased soil pH, P, Ca and Mg availability, which contributed to enhanced plant growth such as plant height, tiller number, spike length, grains per spike, and 1000-grain weight. The highest grain yield was observed when dolomite was applied @1.0 t ha^{-1}, with a notable increase compared to the control treatment. The findings suggest that the combined use of dolomite (1.0 t ha^{-1}) and vermicompost (1 t ha^{-1}) found as an effective strategy for improving soil fertility and achieving optimal wheat yield in the High Barind Tract of Bangladesh.

Conflicts of Interest

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

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