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EFFECT OF LIME ON YIELD OF WHEAT AND MAIZE IN THE ACIDIC SOILS OF FARMERS' FIELD OF NORTHERN BANGLADESH

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Abstract

On-farm experiments were conducted on six farms in Thakurgaon and Panchagarh of northern Bangladesh during the 2022-23 and 2023-24 Rabi seasons. The experiment was laid out in a randomized complete block design (RCBD) with six dispersed replications. The unit plot size was 400 square meters. Wheat (BARI Gom 33) was sown in a continuous pattern, with rows spaced 20 cm apart while the maize (BWMRI Hybrid Maize 2) planting was at a spacing of 60 cm × 25 cm. Seeding of both the crops took place on December 20 and 22 in Thakurgaon and December 4 and 5 in Panchagarh during two years, respectively. The treatment, Dolomite lime, was applied at 4 kilograms decimal^{-1} seven days before the final land preparation. Seed rate and fertilizer dose were maintained as per the recommendation of BWMRI, Dinajpur. The pH of the initial and post-harvest soil was determined at the Soil Science Laboratory, BWMRI. Dolomite increased the soil pH to 5.68 from 4.99 in the wheat field and 5.85 from 4.94 in the maize field. Due to dolomite application the yield of wheat was increased by 25% (4.84 t ha^{-1}) and that in maize by 14% (12.26 t ha^{-1}) compared to the control (3.87 t ha^{-1} and 10.81 t ha^{-1} for wheat and maize, respectively). The liming also increased the MBCR by 23 and 34% in wheat and maize over no liming, respectively.

Introduction

Soil pH, which measures acidity or alkalinity, significantly affects crop growth and yield. The pH scale of soil typically ranges from 4.0 to 8.0, with highly acidic soil having a pH below 4.5, moderately acidic soil between 4.5 and 5.5, and mildly acidic soil between 5.6 and 6.5. Neutral soil has a pH between 6.6 and 7.3. Soil pH directly influences the availability of essential nutrients for plants, which are vital for their growth. Crops depend on 17 essential nutrients, with carbon, oxygen, and hydrogen obtained from air and water, while the remaining nutrients come from the soil. When soil pH is within the mildly acidic to mildly alkaline range (5.6-7.3), nutrients become more accessible to plants, promoting healthy growth and higher yields (Barrow & Hartemink, 2023; O' Kennedy, 2022).

In Bangladesh, the total area of cropland spans approximately 8.5 million hectares, of which about 2.78 million hectares are highly acidic (pH below 4.5), and approximately 3.64 million hectares are moderately acidic (pH between 4.5 and 5.5). In total, this accounts for nearly

46% of the country's agricultural land. The high acidity of these soils limits crop growth, reducing yield due to nutrient deficiencies, particularly phosphorus, calcium, magnesium, and molybdenum, while the levels of toxic elements such as aluminum, iron, and manganese are elevated (Hosna *et al.,* 2024).

Regions in Bangladesh, including Greater Rangpur, Dinajpur, Sylhet, Chittagong, and the Barendra and Madhupur Garh areas, experience significant soil acidity, affecting agricultural productivity. To ensure optimal crop yields, it is essential to neutralize soil acidity and maintain a pH between 5.6 and 7.5. In northern Bangladesh, the deficiency of calcium, magnesium, and other alkaline elements exacerbates soil acidity. Approximately 2.1 million hectares of land have low to very low calcium levels, and around 1.1 million hectares suffer from low to very low magnesium levels. Applying recommended doses of dolomite ($CaCO_3.MgCO_3$) can effectively reduce acidity and raise the pH to a suitable level for crop growth, as dolomite contains 20% calcium and 11% magnesium (Hasan *et al.,* 2020).

Wheat and maize are the 2nd and 3rd critical staple crops in Bangladesh, contributing significantly to food security and the agricultural economy. Wheat is predominantly cultivated in the northern and western regions, while maize, due to its high yield potential and versatility, has gained increasing popularity all over Bangladesh. Both crops are extensively grown in these regions, where the soils are often acidic (pH 4.5 to 5.5), presenting challenges to crop production. Soil acidity hinders nutrient availability, microbial activity, and root growth. One of the most effective methods to mitigate soil acidity is lime application, which neutralizes acidity, reduces the toxicity of aluminum (Al), iron (Fe), and manganese (Mn), improves nutrient availability, and enhances soil structure. This study was undertaken to evaluate the effect of lime on yield performance of wheat and maize.

Materials and Methods

The experiment was conducted in Thakurgaon and Panchagarh district (AEZ 1: Old Himalayan Piedmont Plain) during Rabi 2022-23 and 2023-24 seasons. The experiment was laid out in a randomized complete block design (RCBD) with six dispersed replications. Land was medium high land, i.e., above normal flood level. Rainwater drains quickly, and the soils dry out very early in the dry season. The soil sample has a composition of 67.7% sand, 15.36% silt, and 16.97% clay, indicating a sandy texture with a relatively high proportion of sand. The sand-to-silt ratio is 4.4, suggesting that sand is significantly more abundant than silt, while the silt-to-clay ratio of 0.91 indicates a slightly higher amount of silt compared to clay. The unit plot size was 400 sq. m (20m X 20m). The wheat variety, BARI Gom 33, and maize variety, BWMRI Hybrid Maize 2, were used in the experiment. Wheat seeds were sown as continuous seeding with line to line 20 cm distance, and for maize variety, spacing was maintained at 60 cm and 25 cm between rows and plants. The pH of the soil was examined before sowing at the Soil Science Division, BWMRI. Treatment dolomite (Powered) was applied at 4 kg per decimal one week before final land preparation as recommended by Soil Resource Development Institute (SRDI). Seed rate, fertilizer dose and cultural practices were maintained as per the recommendation of BWMRI. Crops were harvested at full maturity. Grain yield was adjusted to 14% moisture content. The combined analysis of two years data on all measurement parameters was analyzed statistically using the STAR software (IRRI, 2013), and mean comparisons were done using DMRT at the 5% level (Gomez & Gomez, 1984).

Results and Discussion

The comparative yield performance of wheat and maize crops with dolomite and without dolomite application in the Thakurgaon and Panchagarh districts are presented in Table 1. The

average yield of wheat across the two districts improved in two years following the application of dolomite. Initially, the mean pH of the wheat fields was 4.99, which increased to 5.68 after applying dolomite at 4 kg per decimal. In the fields treated with dolomite, the wheat yield reached 25% higher (4.84 t ha^{-1}) than the control (3.87 t ha^{-1}). The average pH of the maize field was 4.94, which increased to 5.85 following the application of dolomite at a rate of 4 kg per decimal. The maize yield was 14% more in the dolomite-treated field, reaching 12.26 t ha^{-1}, compared to 10.81 t ha^{-1} in the untreated field. The application of dolomite lime is reported to neutralize soil pH effectively, which significantly reduces soil Al, Fe, and Mn toxicity (data not shown). Moreover, it increases base saturation, P and Mo availability of acid soils, and improves soil structure which might have cumulatively improved the grain yield of wheat and maize in this study. Increase in yield in the lime treatment consequently increased the marginal benefit cost ratio (MBCR) by about 23 and 34% in wheat and maize, respectively.

Table 1. Effect of dolomite on the soil pH and the yield of wheat and maize (two years' mean data of 2022-23 and 23-24 Rabi seasons)

Treatments	Wheat			Maize		
	pH	Yield (t ha^{-1})	MBCR	pH	Yield (t ha^{-1})	MBCR
Control	4.99b	3.87b	1.19b	4.94b	10.80b	1.87b
Dolomite	5.68a	4.84a	1.47a	5.85a	12.26a	2.51a
LSD (0.05)	0.47	0.34	0.21	0.58	1.14	0.18
CV (%)	6.36	5.50	3.84	7.61	7.02	4.47

MBCR: Marginal Benefit Cost Ratio; LSD: Least significant difference; CV: Co-efficient of Variance. Means with similar letters are significantly identical

It was evident from the results that dolomite liming markedly elevates both soil pH and crop yield in wheat and maize when compared to untreated control conditions. Specifically, for wheat, the soil pH increased from 4.99 in the control to 5.68 with dolomite, resulting in a yield rise from 3.87 to 4.84 t ha^{-1}. For maize, the soil pH enhancement from 4.94 (control) to 5.85 (dolomite) accompanied a notable yield jump from 10.8 t ha^{-1} to 12.26 t ha^{-1}, with these differences confirmed as significant by the provided LSD values (0.34 for wheat and 1.14 for maize). These findings are corroborated with the previous research, which consistently reports that lime amendments, especially dolomite, improve yields by alleviating soil acidity, increasing the availability of essential nutrients such as calcium, magnesium, and phosphorus, and reducing the detrimental effects of toxic manganese prevalent in acid soils (Agegnehu *et al.,* 2021; Hosna *et al.,* 2024; Sultana *et al.,* 2009).

Such improvements in plant nutrition directly foster enhanced grain formation and overall productivity, mirroring reports from long-term field trials where dolomite liming led to yield increases of up to 37% in wheat and up to 50% in maize depending on soil and crop parameters. The critical role of nutrient availability, particularly calcium and magnesium supplied by dolomite, is regularly emphasized in the literature as a driver of better root health and nutrient uptake capacity in both wheat and maize. Increased yield might have attributed to achieve the higher MBCR in the lime treated acidic soils in this study. Additionally, liming is shown to lower the risk of manganese and aluminum toxicity, which is known to suppress plant growth and yield under acidic soil conditions (Alemu *et al.,* 2022; Gitari *et al.,* 2015; Kibet *et al.,* 2023). Overall, the data and literature collectively advocate the widespread adoption of dolomite lime application in the acidic soils at the rate of four kilograms per acre in every four years as recommended by Soil resource development institute (SRDI).

Conclusion

Based on the experimental results it is concluded that application of lime in acidic soils increases maize and wheat productivity and economic return substantially in the northern Bangladesh.

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