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Determination of soil test based fertilizers for garlic-B.aman rice at Chalanbeel areas Natore, Bangladesh

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Abstract

Chalanbeel is a low land area of northern part of Bangladesh where garlic is considered a cash crop by farmers. Farmers practices zero or minimum tillage for garlic production. The appropriate fertilizer dose has not yet been determined for garlic in order to increase production. During the 2016 Rabi season, the experiment was carried out at the Chalanbeel area, Natore (AEZ-5) to determine the best fertilizer combinations for producing B.Aman and garlic with the least amount of tillage. Eight treatments total, with three replications, were outlined in RCBD. In 2016-17 the treatments T₂ produced the highest garlic (9.03 t/ha). There are differences in the yield metrics between the treatments in the case of B.Aman. Treatment T₂ had the highest B.Aman yield (3.40 t ha⁻¹) and it was statistically identical to all other treatments except T₈. In the subsequent year (2017-18), the highest garlic yield (8.17 t ha⁻¹) was produced from treatment T₆ (T₁+ 25% NPK). The most B.Aman production (3.27 t ha⁻¹) was found in treatment T₄ (T₁ + NP 25%) and in treatments T₈ produced lowest yield across the year and crops. According to soil test results and economic viability for the garlic-B.Aman rice cropping pattern in Bangladesh's Chalanbeel areas (AEZ-5 soil), the proper fertilizer doses for the garlic B.Aman rice in those places are N₁₂₅P₄₃K₁₂₅S₃₂Zn₂B₁ and B. Aman N₃₂P₁₀K₁₃S₈Zn₁ and restoring optimum growth and moisture retention is aided by the zero tillage.

Keywords: Garlic, B.Aman, fertilizer rate, yield

Introduction

According to the FAO (2016) ^[14], garlic (*Allium sativum* L.), is an aromatic herbaceous spice that belongs to the Alliaceae family. China and India have been using garlic for almost 5000 years and Egypt has been using it since 2000 B.C. The most significant allium crop worldwide is garlic (*Allium sativum* L.), with onions following in second (Allan, 2009) ^[3]. The most significant crop in the Allium family, garlic is ranked second globally only to onions (Voigt, 2004) ^[49]. Around the world, from temperate to subtropical regions, it is grown as a spice and medicinal plant (Kilgori, *et al.* 2007) ^[25]. The principal economic organ of garlic bulbs is their numerous cloves, which are primarily made up of inflated, bladeless storage leaves. One of the significant and extensively grown spice crops, it is used both medicinally and for food. It is well known for its ability to control and prevent a variety of conditions, including diabetes, headaches, cancer, ulcers, rheumatism, worms, germs, bacterial, and fungal infections, and heart problems (hypertension) (Kilgori *et al.* 2007) ^[25]. Most of the Bangladesh's population grows and consumes garlic during the Rabi season. Primarily grown in Natore, Manikgonj, Faridpur, Jashore, Rajshahi, Dinajpur, Dhaka, Pabna, and Rangpur, garlic is grown throughout Bangladesh (BBS, 2018) ^[6]. In Bangladesh, 73652 hectares of land yielded over 485448 metric tons of garlic in 2019-20 (BBS, 2020) ^[7]. The growth and productivity of garlic are specifically influenced by the use of suitable nutrition management. A well-balanced fertilizer application can greatly increase bulb yield and it contributes directly to photosynthesis. Because there is little organic matter on most of Bangladesh's agricultural land, there is a nitrogen shortage. Inadequate and uneven nitrogen application lowers yields and releases a large amount of reactive nitrogen into the atmosphere (Cassman *et al.* 2002) ^[9]. According to Hossain (1997) ^[20], nitrogen promoted bulb growth and development. Early root development and growth are facilitated by phosphorus.

Additionally, it increased water use efficiency and implicated cell growth and division (Diriba-Shiferaw *et al.* 2015) [10]. One component that is crucial for increasing garlic production is potassium (K). Applying the right amount of material at the right time is crucial to getting a good yield. The amount of K and all other nutrients needed increases with crop productivity (Mendez *et al.* 2001) [31]. Total bulb yield rose with higher K treatment levels (Sharma *et al.* 2003; Bybordi and Malakouti, 2003) [41, 8].

About 60 million metric tons of clean rice will be needed to feed the world's anticipated 215.4 million people by the year 2050, according to Kabir *et al.* (2020) [23]. According to Singh *et al.* (2016) [42], the world's rice demand is expected to rise by 25% between 2001 and 2025 in order to keep up with population growth. As a result, supplying the growing demand for rice in a sustainable manner is prevailed while managing the depletion of natural resources is a significant problem.

Since rainy season rice requires less irrigation and has the advantage of greater nutrient availability, transplanted Aman (*T. Aman*) rice has the potential to increase rice production in Bangladesh. Because of this, high-yielding crop types do not produce consistent yields over an extended period of time. A severe and unbalanced rate of inorganic fertilizer reduces soil fertility and rice output by 38% (Singh *et al.* 2001) [45]. The recommendations for fertilizer based on the fertilizer reaction data of a single crop, without taking into account the influence of previous crops and soil test values, and the nutrient requirements of a particular crop.

The fertilizers are most important input while appropriate dose is very crucial for agricultural production and nitrogen has the most impact on raising agricultural income and productivity among these. According to Zheng (2020) [53], the average rate of nitrogen fertilizer application in paddy fields was almost 60% greater than the global average, and nitrogen fertilizer accounted for 37% of all fertilizer used for rice worldwide. Overuse of nitrogen fertilizer exacerbates pollution in the environment and soil deterioration (Guo, 2019; Yu *et al.* 2018) [17, 50]. Although excessive nitrogen fertilization increases the rate of nitrogen fertilization of brown rice, milled rice, head rice, high viscosity, and breakdown values rise, it can help enhance the nutritional content and processing quality of rice (Bai, 2019; Li *et al.* 2019) [5, 28].

Applying appropriate nitrogen fertilizer rates and selecting nitrogen-efficient garlic varieties are essential to maintaining or increasing crop production on low nitrogen fertilizer rate soils. In the Chalanbeel areas, the farmers practice zero or minimum tillage for production of garlic. Fertilizer recommendation for garlic to achieve higher production has not yet been properly made. In light of this, the current study has been designed to determine the ideal dosage of nitrogen, phosphorus, and potassium for the cropping system of garlic and B.Aman rice in Chalanbeel, Bangladesh. The research aims to establish the best rate of N, P, and K fertilizer for improved rice and garlic yields.

Materials and Methods

Location

The location of the experiment is in Boraigram, Natore's district. Due to the medium-low land type and inadequate drainage system exists, garlic and B.Aman rice are the most typical cropping patterns in the area. The region is flooded

for three to four months of the year during the rainy season, which is the most significant circumstance.

Site and design

The studies were carried out at the Natore (AEZ-5) district's Chalanbeel area. Eight treatments for the crops (garlic and B.Aman) were used in the randomized complete block design (RCBD) studies, and each treatment was duplicated three times. A block was represented by each replication. Twenty-four (8×3) unit plots were present. The experiment's design was completed in compliance with the statistical design. The experiment's fertilizer treatments were in accordance with the treatments. At the last stage of land preparation, a full dose of P, K, S, Zn, and B fertilizers was applied, and urea was placed on top in two equal portions. Immediately following seeding, two equal portions of the urea fertilizer were applied: one half 10 days after seeding and the other half half thirty days later. When needed, irrigation and cross-cultural activities were carried out. T₁ was 100% NPK, T₂ was T₁+25% N, T₃ was T₁+25% NP, T₄ was T₁+25% NK, T₅ was T₁ + 25% PK, T₆ was T₁ + 25% NPK, T₇ was 75% of T₁, and T₈ was Control (Garlic: N₁₂₅P₃₅K₁₀₀S₂₅Zn₂-B.Aman: N₃₀P₈K₁₀S₆).

Crop managements

The climate in the experimental area is subtropical. While it has little rainfall, low humidity, low temperatures, and short days from October to March, it is distinguished by relatively heavy rainfall, high humidity, high temperatures, and a relatively long day period from April to September. The latter time frame is ideal for garlic growth. The study region is located in the Lower Atrai Basin's agro-ecological zone (AEZ#5) and is not salty. Without using any tillage techniques, the garlic bulb was planted straight into the field following the harvest of B.Aman rice and until the soil has retained a sufficient amount of moisture. Shortly after the garlic bulb is planted, the B.Aman rice straw is applied as mulch. The soil texture is silt loam under the Sonatala series of Inceptisols order. The overall soil fertility of the experimental field was low to medium. The bulk density of the initial soil was 1.33 g cm⁻³, pH 6.6, organic C 1.16%, total N 0.068%, available phosphorus (P) 9.5 mg kg⁻¹, available sulfur (S) 15.5 mg kg⁻¹, and exchangeable potassium (K) 0.15 c-mol kg⁻¹ soil.

Soil Analysis

The soil sample was analysis for soil texture, pH, organic matter, total N, exchangeable K available P, and S. Plant samples (Grain and straw) of B.aman rice were collected from the field experiment and were analyzed for NPKS content. Soil pH was measured with the help of a glass electrode pH meter, the soil-water ratio being 1:2.5 as described by Jackson (1962) [21]. Organic carbon content of soil was determined following wet oxidation method (Page *et al.* 1982) [35]. Total N content in soil was determined by Kjeldahl method. Available P content was extracted from soil with 0.5M NaHCO₃ solution at a pH 8.5 (Olsen *et al.* 1954) [34]. By extracting the soil using a 1M NH₄OAc solution at pH 7.0 and then measuring the extractable K using a flame photometer, the exchangeable K content of the soil was ascertained (Page *et al.* 1982) [35]. As explained by Page *et al.* (1982) [35], the soil sample was extracted using a CaCl₂ (0.15%) solution to determine the available S concentration. The extract's S concentration was ascertained

turbid metrically, and the turbidity was measured using a spectrophotometer set to 420 nm.

Data Analysis

The F-statistics concept was used to conduct the analysis of variance for different crop characteristics, nutrient content,

and absorption. The analysis of variance for various crop characters as well as for nutrient concentration and uptake were done following the principle of F-statistics. Mean comparisons of the treatments were adjudged by the Duncan's Multiple Range Test (Gomez and Gomez, 1984) [16].

Table 1: Initial soil characteristics of the soils under study

Sand (%)	Silt (%)	Clay (%)	Texture	pH	OM (%)	Total N (%)	Av. P (ppm)	Av. S (ppm)	Ex. K
37.6	39.0	23.4	Loam	6.6	1.16	0.068	9.50	15.5	0.15

In order to determine the best fertilizer combinations for minimum tillage garlic production, an experiment was carried out during the 2015 Rabi season in the Chalanbeel area of Natore (AEZ-5). Control is one of eight possible treatment combinations. Three replications of the experiment were set up in RCBD. During final land preparation, all fertilizers were applied, with the exception of urea. In a three-way split, Urea was the best dressed. Intercultural activities and irrigation were carried out as needed.

Partial Budget Analysis

To determine the treatments' economic viability, economic analysis was done. We employed marginal and partial budget analysis. To account for the discrepancy between the experimental output and the yield that farmers anticipated from the same treatment, the average bulb yield was reduced by 10%. The official urea prices and the average open market price for garlic crops were used for the analysis.

The nation's land resources have been under tremendous strain over the past few decades in order to provide the food, fiber, and fuel that its sizable population needs. In order to define soils for future land use planning, baseline data must be updated and adjusted in response to crop responses. Table 2 displays the findings of the baseline survey and evaluation of the physico-chemical characteristics of the soils in the research regions. The table displayed the basic soil characteristics of each experimental plot. The experimental plots' soils ranged from neutral in response to rather acidic. There was a range of 0.62 to 1.71 for organic matter and 0.06 to 0.22% for total nitrogen. There was a range of 3.02 to 28.0 mg kg⁻¹ for available phosphorus and 7.8 to 24.6 mg kg⁻¹ for available sulfur. Between 0.07 and 0.19 cmolkg⁻¹, the exchangeable potassium concentrations were found. With a pH value of 6.8 in the topmost layer and a neutral value in the middle and lower layers, the soil pH was found to be nearly neutral. The upper layer experiment site had a very low total nitrogen (TN) content of 0.179% (Table 2).

Results

Table 2: Mean and range (n=10 per layer) of selected characteristics of soil at different depth as baseline survey at Baraigram, Natore

Depth (cm)	pH		OM (%)		N (%)		P (mg kg ⁻¹)		K (cmol kg ⁻¹)		S (mg kg ⁻¹)	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
0-15	6.8	6.4-7.0	1.45	1.11-1.71	0.179	0.14-0.22	19.37	12.0-28.0	0.133	0.10-0.18	17.91	9.8-24.6
16-30	7.0	6.8-7.1	0.94	1.0-1.60	0.123	0.11-0.15	19.64	15.9-26.8	0.144	0.12-0.17	16.31	12.5-20.8
31-45	7.2	6.2-7.6	0.93	0.62-1.25	0.088	0.06-0.13	4.96	3.02-7.05	0.157	0.07-0.21	8.54	7.8-11.7

Soil test based fertilizer effect with conservation practices

Garlic: After the B.Aman rice was harvested and there was sufficient moisture left in the soil, the garlic bulb was planted straight into the field using zero tillage. The yield metrics varied significantly between the treatments. The treatments resulted in significantly varied garlic yields (Table 3). In the year 2016-17, the treatment T₂ (Soil test based fertilizer with 25% more nitrogen) produced the most garlic (9.03 t ha⁻¹), which was statistically identical to all other treatments with the exception of T₇ and T₈. Analysis of variance shows that the 25% additional nitrogen fertilizer rate has a substantial ($p < 0.05$) impact on the garlic bulb weight of the crop (Table 3). Bulb dry weight was significantly increased by the main effect of nitrogen delivery as well as the interaction of other nutrients like P and K. Regarding the year 2017-18, the highest grain yield (8.17 t ha⁻¹) was produced from treatment T₆ (25% extra NPK). The lowest yield was found from treatment T₈ at both the year.

B.Aman

Because the Chalanbeel region has medium-low ground, flooding occurs throughout the Aman season, which is the wet season. Certain native rice types that are grown in certain places have the unique quality of growing longer when the water level rises. There are some differences between the treatments in terms of yield characteristics varied treatments resulted in significantly varied B. aman yields (Table 3). Although it was statistically identical with all other treatments except T₈ (Control), the best yield of B. aman was observed in treatment T₂ (Soil test based fertilizers with 25% more nitrogen). B.Aman rice straw yields varied similarly, with the exception that treatments T₅ and T₇ as well as T₈ had lower yields. In the subsequent year (2017-18), the entire pattern is being replicated. Table 3 also displays the outcome of the second garlic. This year's yield level was little lower, but the impact of the fertilizer was astounding. T₆ had the highest yield, which was the same as T₄ and T₅, while T₈ had the lowest yield.

Table 3: Effects of fertilizers on yield (t ha^{-1}) of Garlic-B.Aman cropping pattern at Chalanbeel, Natore (AEZ-5)

Treatments	2016-17			2017-18		
	Garlic	B. Aman		Garlic	B. Aman	
	Bulb	Grain	Straw	Bulb	Grain	Straw
T ₁ = 100% (STB)	8.22ab	3.12a	10.50a	7.00c	2.92abc	9.11a
T ₂ = T ₁ + 25% N	9.03a	3.40a	10.60a	7.26bc	2.89abc	8.23ab
T ₃ = T ₁ + 25% NP	8.53ab	3.34a	10.00a	7.49bc	3.27a	8.21ab
T ₄ = T ₁ + 25% NK	8.71ab	3.20a	9.80a	7.71ab	2.78abc	9.06a
T ₅ = T ₁ + 25% PK	8.64ab	3.20a	8.40b	7.67ab	2.59abc	9.18a
T ₆ = T ₁ + 25% NPK	8.45ab	3.28a	10.50a	8.17a	3.02ab	8.23ab
T ₇ = 75% of T ₁	7.69b	3.12a	9.00b	6.22d	2.37bc	7.89b
T ₈ = Control	6.22c	2.73b	8.40b	5.13e	2.15c	7.67b
CV (%)	3.75	6.43	5.50	4.55	14.82	6.11

STB: Garlic = $\text{N}_{100}\text{P}_{35}\text{K}_{100}\text{S}_{25}\text{Zn}_{2}\text{B}_1$ and B.Aman = $\text{N}_{25}\text{P}_8\text{K}_{10}\text{S}_6\text{Zn}_1$

System productivity of garlic-B.Aman cropping pattern

Garlic production is the primary cash crop in that locality during the winter months. However, during the rainy season, indigenous rice varieties are grown, and the straw that is produced is used as mulch for the next garlic harvest to replenish the moisture in the soil. Because to the local conditions, there are no other cropping patterns. Nonetheless, the highest production was noted in areas with higher fertilizer application levels (Table 3). Treatment T₂ (Soil test based fertilizers with 25% additional nitrogen) generated the most garlic in the first year and treatment T₆ (Soil test based fertilizers with 25% additional NPK) produced the most garlic in the second year. Treatments T₂ (fertilizers based on soil tests with 25% more N) and T₃ (fertilizers based on soil tests with 25% more NP) had the maximum yields for B.Aman rice in the following two years, respectively. In both years, the control treatment had the lowest yield of B.Aman and garlic.

Soil test based fertilizer effect on nutrient uptake with conservation practices

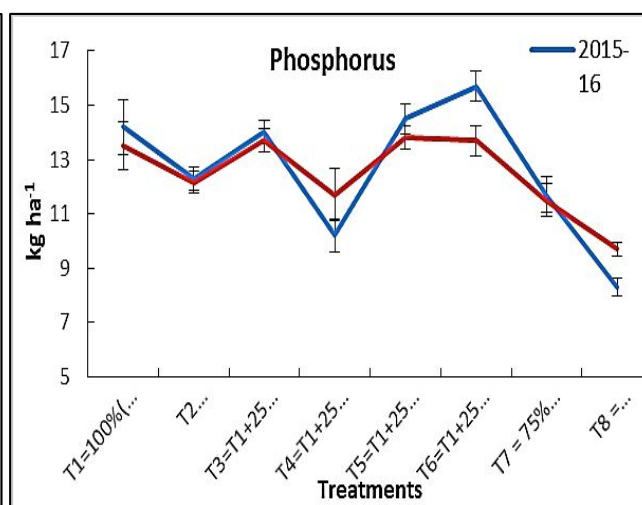
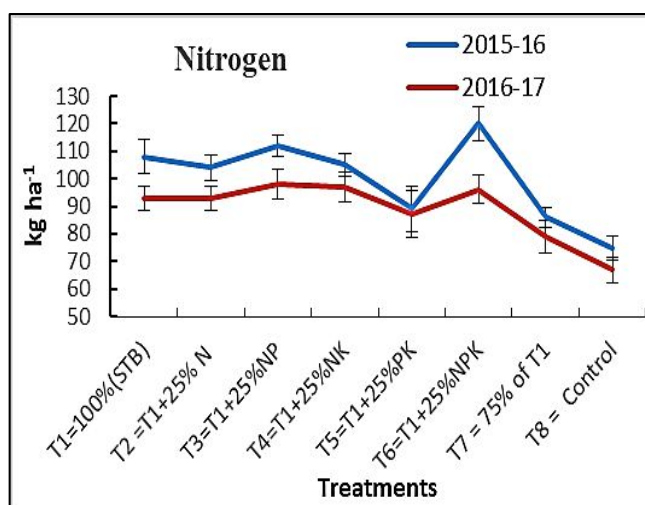
Conservation agriculture restores degraded fields while preventing the loss of arable land. It encourages the diversity of plant species, little disturbance of the soil, and preservation of a permanent soil cover. The benefits of this technique are becoming more and clearer when the monsoon rice fields are harvested in low-lying rice growing areas,

particularly at Chalanbeel locations, where the paddy soil retains enough moisture to create an optimal environment for garlic cultivation.

In this area, farmers have always grown garlic using traditional methods. In Bangladesh, the conventional approach depends on tillage, which causes planting delays and lowers output. But zero tillage-a unique approach that focuses on better crop establishment techniques, soil, water, and nutrients is gradually replacing the conventional ways. It also aims to increase soil health and soil microbial activities, as well as overall agricultural sustainability.

Nutrient uptake

Different treatments had an impact on the uptake of nutrients (N, P, K, and S) by B.Aman rice in Chalanbeel, Natore (Table 4). In 2016-17, treatments T₆=(STB nutrients with an additional 25% N, P, and K applied) had the highest uptake of N, P, and K, while treatments T₁, T₂, T₃, and T₄ had the highest uptake of S since S fertilizer was not added in excess. Treatments T₃ (STB nutrients with an additional 25% N and P administered) and T₄ (STB nutrients with an additional 25% N and K applied) showed the highest N uptake in 2017-18. Treatments T₁, T₂, T₄, and T₅ had greater S uptake. Nutrient intake was decreased in the control plot (T₈). With regard to the average nutrient uptake over a two-year period, T₆ had the highest uptake of N, P in T₁, T₃, T₄, and T₆, K in T₄ and T₆, and S in T₄.



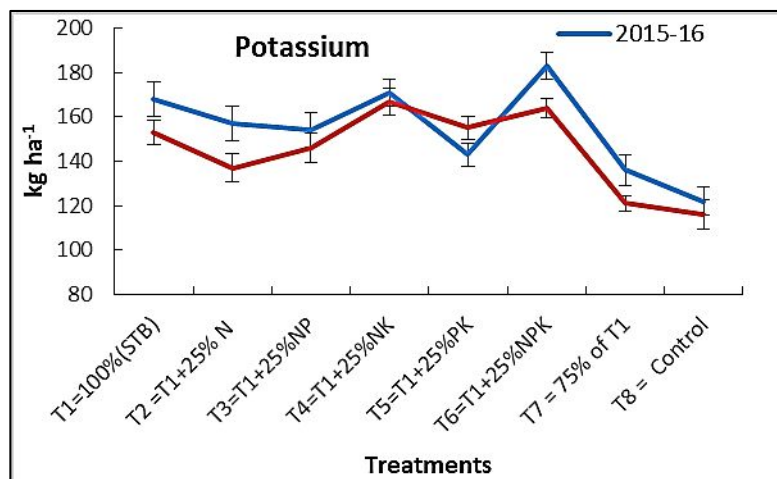


Fig 1: Nitrogen, phosphorus and potassium uptake in two years of B.Aman rice at Chalanbeel Natore.

Changes in post-harvest soil status at Chalanbeel, Natore

Table 4 shows the changes in soil pH, organic matter, and other nutrients brought on by fertilizer application in the garlic-B.aman cropping pattern over a two-year period. The pH of the soil seemed to be trending upwards. Conversely, there is an upward tendency in the modifications in the soil's organic matter, N, P, K, and S contents. In general, there was a tendency for the nutritional status to decline in comparison to the beginning value when there was no nutrient management (control treatment). When STB-based nutrient management was combined with additional nutrient management, the pH of the soil remained unchanged (Fig. 2). In garlic-B.Aman cropping sequences, a very slight (but not statistically significant) drop in soil pH was noted after two cycles in comparison to the starting value. With the

exception of T₈, SOM showed a growing trend as compared to the starting value.

However, there was an upward trend in the total N content (%) of the garlic-B.Aman rice cropping pattern soil. The highest amount of N was deposited in T₃ (0.116) and T₄ (0.109) in comparison to the original total N (%). Nevertheless, over a two-year crop cycle, the total N content in the control plot remained constant (Table 4). After two crop cycles, the P was deposited in T₆ (17.92) and T₃ (17.19), with the control treatment having the lowest P (Fig. 2). Similarly, after two years of crop cycles, the K and S content in the garlic-B.Aman rice cropping pattern soil was deposited, with the exception of K and S in the control plot (Figure 2).

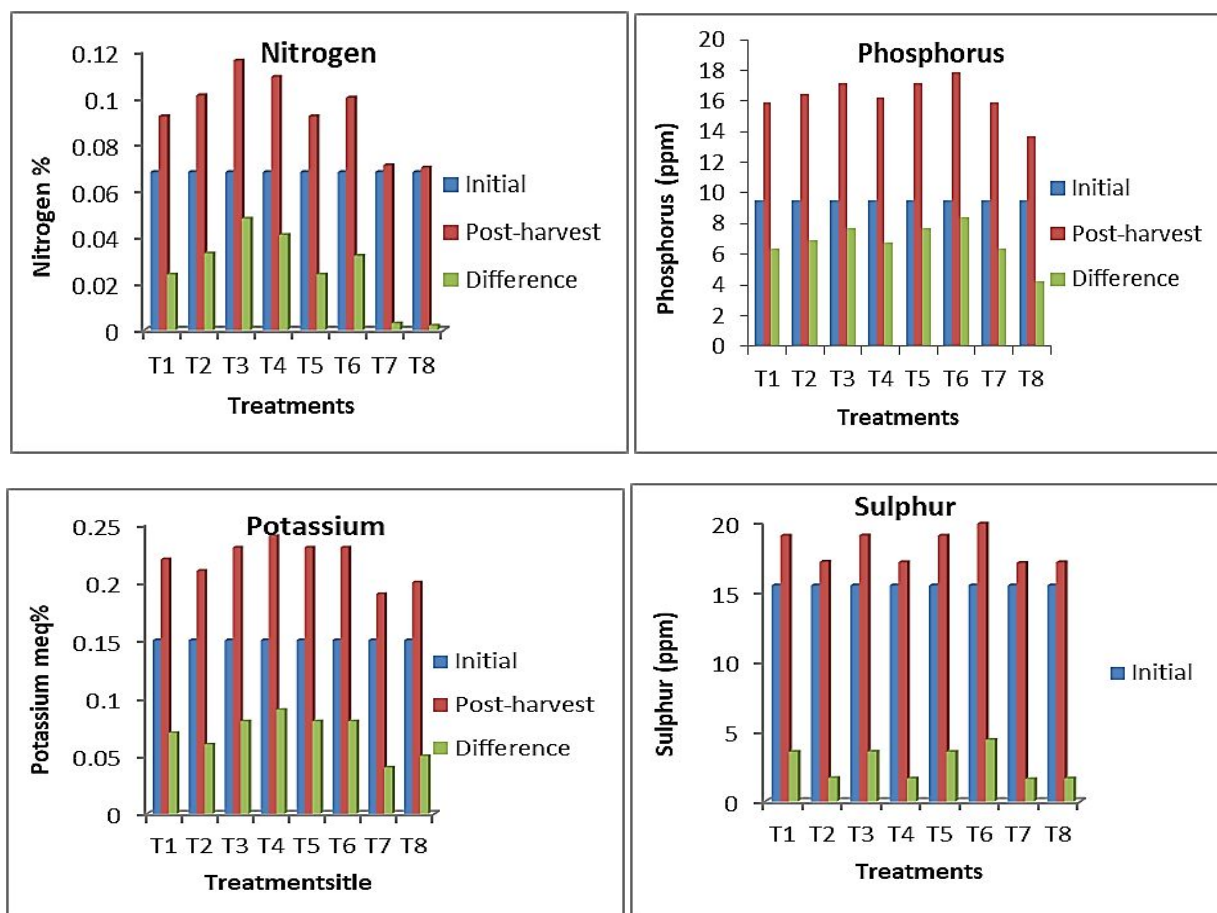


Fig 2: Changes in N, P, K and S nutrient of initial and post-harvest soil at Chalanbeel, Natore

Table 4: Changes in soil status at Chalanbeel after two years of cropping

Treatments	pH	OM (%)	N (%)	P (mg kg ⁻¹)	K (cmol kg ⁻¹)	S (mg kg ⁻¹)
T ₁ =100%(STB)	6.3	1.54	0.092	15.89	0.22	19.07
T ₂ =T ₁ + 25% N	6.2	1.50	0.101	16.44	0.21	17.16
T ₃ =T ₁ +25% NP	6.1	1.65	0.116	17.19	0.23	19.08
T ₄ =T ₁ + 25% NK	6.1	1.50	0.109	16.26	0.24	17.16
T ₅ =T ₁ + 25% PK	6.2	1.57	0.092	17.2	0.23	19.07
T ₆ =T ₁ +25%NPK	6.0	1.54	0.100	17.92	0.23	19.93
T ₇ =75% of T ₁	6.1	1.54	0.071	15.89	0.19	17.16
T ₈ = Control	6.3	1.14	0.070	13.70	0.20	17.16
Initial soil	6.6	1.15	0.068	9.50	0.15	15.50

Economics of fertilizers use

The findings of the partial budget analysis of the Garlic-B.Aman rice at Chalanbeel, Natore (Table 5) showed that Tk ha⁻¹ 1,91,529 in T₄ (STB nutrients with extra 25% N and K was applied) was the highest net benefit, with Tk ha⁻¹ 2,04,354 obtained in T₂ (STB nutrients with extra 25% N applied). A second attempt has also been made to calculate the therapies' marginal benefit cost ratio (MBCR), which is displayed in Table 5. The treatment T₂ had the highest

MBCR (0.76), while treatment T₄ had the lowest MBCR (0.40). For the purpose of maximizing productivity and providing an economically viable and profitable nutrient management strategy for the garlic-B.Aman rice cropping pattern in the Chalanbeel (AEZ-5) area of Bangladesh, N₁₂₅P₃₅K₁₀₀S₂₅Zn₂B₁ for garlic and N₃₂P₈K₁₀S₆ for B.Aman rice were recommended, based on the most profitable STB nutrients management (Table 5).

Table 5: Effects of fertilizers on the average yield (t ha⁻¹) of crops and fertilizer use economy in Garlic-B. Aman cropping pattern at Chalanbeel, Natore (AEZ-5)

Treatments	Average (2016-17 & 2017-18)			Gross return	Fert. cost	Net return	Marginal return	MBCR
	Garlic Bulb	B.Aman						
		Grain	Straw	Tk ha ⁻¹				
T ₁ =100%(STB)	7.61	3.02	10.31	2,22,700	36,315	1,86,385	11,635	0.32
T ₂ =T ₁ + 25% N	8.15	3.15	9.92	2,43,200	38,846	2,04,354	29,604	0.76
T ₃ =T ₁ +25% NP	8.01	3.31	9.61	2,31,700	41,771	1,89,929	15,179	0.36
T ₄ =T ₁ + 25% NK	8.21	2.99	9.93	2,33,000	41,471	1,91,529	16,779	0.40
T ₅ =T ₁ + 25% PK	8.16	2.90	9.29	2,30,200	41,865	1,88,335	13,585	0.32
T ₆ =T ₁ +25%NPK	8.31	3.15	9.87	2,29,700	44,396	1,85,304	10,554	0.24
T ₇ =75% of T ₁	6.96	2.75	8.95	2,10,600	28,236	1,82,364	7,614	0.27
T ₈ = Control	5.68	2.44	8.54	1,74,750	-	1,74,750		

Grain =20 Tk. kg⁻¹; Straw =2 Tk. kg⁻¹; Garlic=60 Tk. kg⁻¹; N =45 Tk. kg⁻¹; P =150 Tk. kg⁻¹; K =50 Tk. kg⁻¹; S =55 Tk. kg⁻¹ and Zn =102 Tk. kg⁻¹, MBCR =Marginal benefit cost ratio.

Discussions

The experiment site's soil pH was found to be neutral. FRG-2024 classifies pH values as follows: >8.5 strongly alkaline, 4.6-5.5 very acidic, 5.6-6.5 moderately acidic, 6.6-7.3 neutral, 7.4-8.4 moderately alkaline, and <4.5 strongly acidic. The pH of the soil was determined to be between 5.0 and 7.5, which is within the range that is appropriate for crop development. This means that the study's pH level is favorable for both rice cultivation for B.Aman and the production of garlic. The experimental soil had a total nitrogen (TN) content of 0.07% (Table 1). The findings demonstrated that N is a component that limits crop development. The available phosphorus in the soil was classified as low (9.5 ppm) (Table 1). The most potassium is found is 0.15 which is medium that the content is suitable for crop growth.

Zero tillage Positive Impact on Soil Health

The benefits of zero tillage for soil health are among its main selling points. It has been demonstrated that growing garlic without tillage enhances soil health in addition to yields, reduces production costs and irrigation water input, adapts to climate unpredictability, and increases revenue and sustainability. In general, the retention of straw mulch under zero tillage techniques promotes microbial activity, soil organic carbon and other nutrients, and soil water retention. The zero tillage method's sustainability emphasizes even

more how important it is for preserving soil health and nutrient balance.

In several cultures, garlic (*Allium sativum* L.) has gained recognition as a preventive and curative medicinal herb. Throughout history, garlic has been used for both culinary and medical purposes. By promoting growth and reproduction as well as enzymatic activities, chlorophyll formation, and assimilation in meristematic tissue, the N fertilizer increases the reproductive potential of plants. This may have been a significant factor in the overall growth of the plants, which encourages growth and development and produces a high plant yield (El-Shafie *et al.* 2002) [12]. The study's results corroborate those of Abou El-Magd *et al.* (2012) [1], who showed a considerable increase in garlic canopy dry matter yield with increasing N treatment. This study also corroborated the findings of Zaman *et al.* (2011) [51], who found that increasing the rate of nitrogen delivery enhanced the yield of garlic bulbs.

The main impacts of nitrogen rate and administration significantly increased dry weight and bulb breadth (Table 4). This is due to the fact that nitrogen increases the production of chlorophyll and enzymatic activity, which leads to a larger garlic bulb. Research by Farooqui *et al.* (2009) [15] and Nori *et al.* (2012) [33] also revealed comparable effects. The crop's bulb weight of garlic was significantly ($p<0.05$) influenced by the interaction between the nitrogen fertilizer rate and crop (Table 4). Garlic yield

rose with the application of nitrogen, and treatment T₂ (STB nutrients with an additional 25% N) generated the best yield. These results are also reported by Panse *et al.* (2013) [36] and Zaman *et al.* (2011) [51]. Treatment T₂, which included an additional 25% N in STB nutrients, yielded the highest yield. Similar findings regarding clove weight were reported by Singh *et al.* (2015) [43] and Sevak *et al.* (2012) [40].

The potassium application increased leaf numbers and each plant received enough K nutrients during this plant growth, which contributed to an increase in the fresh weight of each bulb resulted higher bulb yield (Talukder, 1998 [47] and El-Bassiony, 2006 [11]). The garlic highest production in this study was obtained from treatments T₂ (Soil test based fertilizers with 25% additional N) and followed by T₆ (Soil test based fertilizers with 25% additional N, P and K). Plant growth and development were aided by the optimal K nutrition, which came from chemical sources, resulting in bigger bulbs. Larger bulbs were also discovered by Hossain (1997) [20], Talukder (1998) [47], and El-Bassiony (2006) [11] as a result of elevated K levels.

B.Aman rice

Comprehensive characteristics governed by internal genes, external growth conditions, and cultivation techniques include rice yield in the Chalanbeel areas. The ideal fertilizer dose for rice that promotes sustainable grain production is determined by a soil test. Among these, rice plant growth and development are significantly influenced by the ideal nitrogen fertilizer dosage. It is crucial for rice's vegetative growth, development, and output (Sultana *et al.* 2019) [46].

Nitrogen fertilizer plays a critical role in rice agriculture in terms of both output and quality. To increase production, a number of experts are investigating rice types with high biological yields. It should be highlighted, nonetheless, that more nitrogen fertilizer has an impact on plant growth as well (Lv *et al.* 2017; Li *et al.* 2019) [30, 28]. Nitrogen may also raise rice canopies and the leaf area index in later stages of development. Jahan *et al.* (2014) reported that N fertilizer treatment has a substantial effect on rice output. B.Aman rice yield was greatly enhanced by the additional application of N, either by itself or in combination with N, P, and K fertilizer. According to a number of studies, brown rice rate and head rice rate were greater at medium nitrogen levels (Li *et al.* 2020) [27], and yield rise with increased nitrogen treatment within a specific range (Zhang *et al.* 2019) [52]. The changes in the cropping system from RG to RF could markedly increase SOC stocks, improve N utilization, reduce soil N surplus, and thus reduce the risk of N loss in the paddy soil. Overall, this study showed the potential of paddy agro-ecological systems to store C and maintain N stocks in the temperate regions.

When administered in conjunction with potassium and nitrogen, phosphorus has a beneficial effect on grain and straw. When P is added in addition, the treatments T₆ (soil test based fertilizers with 25% extra N, P and K) generated the maximum biological yield (Alam *et al.* 2009; Amin *et al.* 2004; Hasanuzzaman *et al.* 2010) [2, 4, 18]. Rice grows and yields more when N, P, and K are applied together (Khatun *et al.* 2023) [24]. Regarding the contribution of K, which favorably affects all the rice plant yield contributing characteristics, may be the cause of the greater K dose (Saha *et al.* 2011) [38]. Naher *et al.* (2011) [32] found that on the clay-loam soil of the BRRI farm Gazipur, potassium

fertilizer responded up to 80 kg K ha⁻¹. According to Fageria and Baligar (2001), lowland rice grain yield rose dramatically and quadratically as shoot dry weight increased. Hasegawa (2003) found a correlation between increased dry matter content and rice cultivar yields.

Increased agricultural yields and the maintenance of soil fertility brought about by balanced fertilization with treatment based on soil tests. Numerous researchers concur with these findings (Quaddus *et al.* 2014; Singh *et al.* 2014) [37, 44]. The yield of B.Aman rice when inorganic fertilizer doses are based on soil tests and 25% more N, P, and K fertilization is applied. According to the findings, a more steady fertilization may make this increased yield rise possible (Kumer and Singh, 2009) [26].

The higher synthetic fertilizer c treated plots based on soil tests consistently accumulated greater nitrogen uptake by BRRI dhan75 grain. This result is consistent with Timsina *et al.* (2006) [48], who found that fertilizer management based on soil test-based (STB) results in consistently and significantly higher N uptake. Grain in treatment T₆ (soil test-based fertilizers with 25% extra N, P, and K) absorbed the most phosphorus, with higher P fertilizer and higher N and K fertilizer in both seasons. Grain in treatment T₆ that received greater potassium fertilizer in both seasons showed a better absorption of potassium. The increased yield this treatment obtained could be the cause of the increased K intake and similar findings are also given by Sathish *et al.* (2011) [39].

Conclusion

Fertilizer dosage recommendations based on soil tests ought to be made in order to boost agricultural yield while lowering input costs and improving the environment. According to soil test results and economic viability for the garlic-B.Aman rice cropping pattern in Bangladesh's Chalanbeel areas (AEZ-5 soil), the proper fertilizer doses for the garlic B.aman rice in those places are N₁₂₅P₄₃K₁₂₅S₃₂Zn₂B₁ and B.Aman N₃₂P₁₀K₁₃S₈Zn₁. Restoring optimum growth and moisture retention is aided by the zero tillage. The study demonstrates that, in all two cropping sequences, soil test-based inorganic fertilizer treated plots consistently absorbed higher concentrations of nitrogen, phosphorus, and potassium in grain and straw of the following rice crop than did sole application of N-based organic fertilizer treated plots. The application of inorganic fertilizer by B.Aman rice grain utilizing the soil test-based method resulted in a considerable increase in N uptake.

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