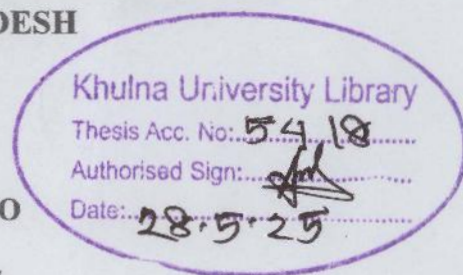


**EFFECT OF SEED AND NITROGEN RATES ON BIOMASS YIELD AND
QUALITY OF WHEAT FODDER IN THE COASTAL SOIL OF
SOUTHWESTERN BANGLADESH**

**A THESIS
BY
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**A Thesis (Course No. 081108 AN 6118) Submitted to Agrotechnology Discipline in
Partial Fulfilment of the Requirement for the Degree of Master of Science in Animal
Nutrition**



**AGROTECHNOLOGY DISCIPLINE
KHULNA UNIVERSITY
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DECEMBER, 2024

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PRODUCTION OF WHEAT AS A FODDER IN THE COASTAL SALINE SOIL OF
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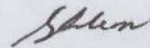
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DEDICATED
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Effect of Seed and Nitrogen Rates on Biomass Yield and Quality of Wheat Fodder in the Coastal Soil of Southwestern Bangladesh

Abstract

Green fodders, are rich in nutrient and also the primary source of vitamin-A and is highly palatable and digestible for ruminant animal. Scarcity of fodders are the major limitation of livestock farming in the coastal region of southwestern Bangladesh. Biomass yield and quality of fodders are determined by nitrogen (N) fertilization, seed rates and cutting age. Therefore, a study was conducted in the farmers field at the coastal region of southwestern Bangladesh to investigate the effect of N rates, seed rates and cutting age on the yield and biomass quality of wheat as fodder. Five rates of N (0, 105, 120, 175 and 210 kg ha⁻¹) and four levels of seed rates (120, 150, 180 and 210 kg ha⁻¹) were considered as the experimental treatments. The experiment was arranged in a factorial randomized complete block design and replicated in three times. The analyzed data were substantially influenced with the N rates and seed rates separately yet their interaction had no significant effect. The fresh biomass, crude protein, crude fibre, ash and ether extract content were higher with 210 kg N ha⁻¹, but gradually declined with the reduced rate. Lower seed rate (120 kg ha⁻¹) resulted in higher crude protein, crude fibre, ash, and ether extract, then steadily decreased with the increased seed rate, but fresh biomass accumulation was higher with a higher seed rate (210 kg ha⁻¹). Benefit cost ratio (BCR) was increased by 540% to 20% and 23% to 9% more due to higher N rate (210 kg ha⁻¹) and higher seed rate, respectively, compared to other treatments. The quality of biomass (dry weight basis) in all aspects was higher in the earlier cut (50 DAS), but fresh biomass accumulation and BCR were comparatively higher with the later cut (60 DAS). From the findings of this study, it could be suggested that application of N @ 175-210 kg ha⁻¹ and maintaining of 180-210 kg seed ha⁻¹ with early cut (50 DAS) is better for wheat fodder in the coastal soil of southwestern Bangladesh.

Keywords: *Wheat, Fodder, Biomass productivity, Quality attributes, Coastal region, Profitability*



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CHAPTER I

INTRODUCTION

In the livestock industry feed is the major components and it comprises ~60% and sometimes goes up to ~70-75% of the total cost of production (Grover et al., 2012; Becker, 2008). Green fodder improves the health and productivity of livestock particularly for milk cow with the supply of good quality feed and nutrient compared to concentrated feed. Green fodder is highly palatable and digestible and cost effective than concentrated feed. Green fodder serves as an important feed for ruminants, ensuring a reliable source of nutrients, including energy, digestible proteins, carbohydrates, lipids, minerals, vitamins, and, most importantly, fiber, which facilitates the development of rumen microorganisms that extract these nutrients from the fodder. Consequently, an adequate supply of green fodder is essential for an animal to sustain a healthy microbial population and effective microbial digestion in the rumen (Singh et al., 2018). Superior pasture quality and increased forage consumption enhance productivity and profitability. An increase in dry matter intake of 500 g per day may result in an additional 800 g to 1.0 kg of milk per day. Green fodder not only supplies vital nutrients for growth and production but is also readily digestible in the rumen. Fodder cultivation in Bangladesh is quite limited compared to the demand for livestock. The country's fodder cultivation spans 20,263 hectares, producing a total of 424,178 metric tons, with an average green fodder yield of 20.93 t ha⁻¹ (BBS, 2023).

Livestock plays a crucial role in agriculture, accounting for about 1.60% of GDP with a growth rate of 3.32%. It directly supports the livelihoods of 20% of the population and indirectly benefits 50% of the people in the country (Sarker et al., 2015). Cultivating wheat (*Triticum aestivum* L.) fodder is an important aspect of agriculture in Bangladesh, as it combines the country's agricultural traditions with the needs of modern animal production. Wheat has long been an important crop in Bangladesh, mainly grown for its grain. Forage availability limits in winter; hence, cereal crops with dual-purpose characters can supply high-quality forage while expanding the area allocated for grain production (Arzadun et al., 2003) and it can act as an important source of feed for livestock. Wheat has emerged as the primary forage utilized as hay, silage, or straw for feeding productive ruminants (FAO, 2015). It is one of the main coarse cereals that can produce more grain and significantly more green fodder. In addition to being high in protein, calories, and minerals, it is a valuable source of high-quality fodder (Hossain et al., 2003). Wheat fodder is nutritionally rich, with crude protein (11.0%), crude fiber (28.0 %), total digestible nutrients (TDN) (55-65%), ash (8.2 %), and ether extract (fats) 2.7 % (Fulkerson et al., 2008).

In addition, it also contains NDF 56.4%, ADF 31.9% and lignin 4.6% (Fulkerson et al., 2008) with higher quality in younger stages but increased carbohydrates and biomass as it matures.

Effective management of these dual-purpose cereal crops results in superior grazing and high-quality silage or hay (Arif et al., 2006a). The consistent and sufficient supply of feed is essential for enhancing animal productivity and ensuring cost-effective livestock production. Without guaranteeing a sufficient supply of high-quality fodder, the attainment of the desired expansion in the livestock sector in the forthcoming year appears nearly unattainable. Now a days the average land invested to fodder farming was rising (Sayeed et al, 2008). Moreover, it offers a backup feed supply during a feed shortage, and farmers' living standards and farm profit are raised by the double profit from grain and livestock feed. However, Livestock generates chances for the utilization of communal grazing areas, enhances collateral and savings, and diversifies sources of income (Faruque, 2003). Over time, improvements in agricultural practices, together with changing livestock farming techniques, have emphasized the significance of cultivating wheat fodder as an important role of Bangladesh's agricultural system. Agriculture is vital to Bangladesh's economy, with more than two-thirds of arable land cultivated two or more times annually (FAO, 2015). Wheat fodder plays a crucial role in enhancing livestock productivity in Bangladesh. Livestock farming is an essential economic and nutritional activity for many rural communities, playing a crucial role in the socioeconomic structure of the nation. Fodder is crucial in reducing the production costs of cattle products, particularly milk. Within this particular framework, wheat fodder assumes a crucial role, serving as a highly nutritious feed that is vital for maintain the health, productivity, and general welfare of cattle. In addition, the planting of wheat fodder encourages agricultural diversification, enabling farmers to reduce the hazards associated with mono-cropping and improve overall farm resilience.

The primary reasons contributing to low crop production are inadequate plant density and insufficient crop nutrition. The density of plants is a crucial component that determines the crop's capacity to acquire resources and produce a yield. Employing an appropriate seeding rate allows for its cultivation. Application of nitrogen (N) and seed rate are crucial management factors that have a major impact on wheat production and yield components (Bisht et al., 2004). N fertilization increase cell division and elongation, nucleotides and enzyme formation resulting higher rate of photosynthesis which leads to better accumulation of fodder biomass (Kebede et al., 2024; Corkran et al., 2015) and quality of fodder but excess application may increase the production cost. Environmental factors influence the growth and productivity of wheat, which can control by adjusting the timing of sowing and the rate of seed placement (Ozturk et al.,

2005). The yield and yield components of wheat were considerably influenced by variations in seed rate and N application, as reported by (Dean & Munford., 2004, Singh et al.,2000). The seed rate has a significant impact on the utilization of environmental resources by altering the relative significance of competition within and between plants for light, water, and nutrients throughout the growth of the crop (Gooding et al., 2002). To achieve maximum yields in wheat fodder cultivation, it is necessary to pay careful attention to sowing and fertilization procedures. Nitrogen is the most essential nutrient for promoting vegetative crop growth, enhancing fodder productivity, and improving grain quality in the field (Gwal et al., 1999; Ali et al., 2000; Iqbal et al., 2012). The strategic use of nitrogen not only promotes strong plant development but also enhances the nutritional value of the animal feed, making it more beneficial for animals.

Fodder yield and quality attributes also influenced by plant population unit⁻¹ area. Optimum plant population ensures higher fodder yield and quality but lower plant population increase the fodder quality but decrease the fodder yield but in case of excess plant population fodder yield may increase but quality will be declined (Panwar et al., 2020). The seed rate plays a vital role in achieving optimal plant density, ensuring efficient resource utilization. In fodder crop production programs, seed is the most crucial input. Given the significant role of fodder crops, the importance of appropriate seed rates is even more distinct (Prajapati et al., 2017). Despite having a higher seed rate, fodder crops exhibit a lower seed multiplication ratio compared to other crops, as they are primarily cultivated to maximize biomass production.

In the coastal soil of southwestern Bangladesh health condition and productivity of livestock is very poor due to acute shortage of feed particularly green fodder. In the southwestern coastal region of Bangladesh *T. aman* is the main crop and most the land remains fallow during rest of the year (December-June) due to the constraints of poor drainage system, excessive soil wetness during sowing of winter crops, soil salinity scarcity of fresh irrigation water (Sarker et al., 2023). However, during winter residual moisture can be a potential resource for the cultivation of short duration crops. There is a scope to cultivate utilize these fallow lands for fodder cultivation. Perennial fodder is not suitable to cultivate in the arable land in this region because *T. aman* is the only crop and farmers never compromise with *aman* rice. Different types of annual fodder crops may be cultivated in this area and among the fodder crops wheat is considered as potential due to its low nutrient requirement, limited water requirement with higher nutritional quality. As a fodder crop wheat is a new thus it is necessary to develop suitable management practice and nutrient management. Forage availability is reduced during the winter period; therefore, cereals as dual-purpose crop can be used to provide good quality forage and also increases the area

devoted to grain production (Arzadun et al., 2003). Although wheat fodder cultivation in Bangladesh has numerous advantages, it faces some obstacles that hinder its effective production and utilization. A great deal of optimistic farmers across the country starts the cultivation of fodder for their cattle and for generating cash. Despite the reduction of cultivated areas, the area and fodder production are progressively declining thus it is desirable to cultivate high biomass yielding potential fodder crops with better nutritional quality (Sayeed et al., 2008). Therefore, the current research has been conducted with the aim to investigate the effect seed rate and N dose, with suitable cutting age on biomass yield and quality of wheat fodder grown under zero tillage condition in the coastal soil of southwestern Bangladesh.



CHAPTER II

REVIEW OF LITERATURE

Wheat is a major grain crop globally. Many areas in southwestern Bangladesh, characterized by extensive fallow land, are impacted by salinity, preventing farmers from cultivating wheat as a fodder due to the absence of effective salt-tolerant varieties, inadequate nutrient management strategies, and insufficient access to fresh irrigation water. A substantial number of researchers have undertaken extensive studies on many aspects of its growth and yield under diverse ecological conditions. Nitrogen fertilizer significantly influences the growth and productivity of wheat. A number of research studies on the effects of nitrogen fertilizer application have been conducted both domestically and internationally on fodder crops but not on wheat. In the southwestern coastal region of Bangladesh very few researches have been conducted on fodder cultivation and very few information regarding N rates and seed rates on fodder. Wheat as green fodder is a new in this SW region also in other part of the country even in the world. Very few and/or no study has been undertaken to optimize nitrogen application and seed rate for wheat fodder cultivation. An investigation has been conducted to assess the performance of wheat at varying nitrogen levels and seed rates in the coastal soil of southwestern Bangladesh. The literature regarding wheat as a fodder crop is very limited however the use of wheat straw as a livestock feed source is well recognized. This chapter reviews several literatures on fodder cultivation using seed rate and N rates to support the research efforts, organized under the following headings:

2.1 Effect of nitrogen (N) yield on growth of fodder crops

Maqsood et al. (2014) conducted an experiment impact of nitrogen fertilization on the yield and yield components of three varieties of wheat (As-2002, Bhakar-2002, Inqlab-91). Five nitrogen levels (control, 90, 120, 150, and 180 kg N ha⁻¹) were utilized to evaluate their effects. Nitrogen fertilizer markedly influenced wheat production and the majority of yield components ($P \leq 0.05$). But germination count and spike length were unaffected by differing nitrogen levels. The ideal nitrogen application rate for increasing grain yield and efficiency in the As-2002 variety has been found to be 120 kg N ha⁻¹.

Nadeem et al. (2009) conducted an experiment that the impact of nitrogen application on the forage yield and quality of maize (variety Afgooi) cultivated both in monoculture and in combination with legumes (cowpea and sesbania). The experiment employed a randomized complete block design featuring a split-plot arrangement and three replications. Nitrogen levels

of (0, 50, 100, and 150 kg ha⁻¹) were administered. The application of nitrogen markedly improved maize growth rates. Increasing nitrogen levels enhanced crude protein content while diminishing crude fiber and ether-extractable fat levels. Dry matter yield: Notable variations in dry matter yield were evident among the treatments. The combination of maize and sesbania yielded the maximum dry matter production at 13.25 t ha⁻¹. It is recommended to cultivate maize in conjunction with sesbania and apply 150 kg N ha⁻¹ to produce superior quality fodder production.

Mansoor et al. (2020) conducted an experiment to examine the impacts of nitrogen fertilization and cutting dates on fodder and grain productivity. The experiment employed a split-plot design within a randomized complete block framework, consisting of three replications. Nitrogen levels (0, 50, 100, 150, 200, 250 kg N ha⁻¹) were allocated to main plots, whereas cutting dates (no cutting, cutting after 45, 65, and 85 days) were designated to subplots. The result indicates that the highest green fodder yield (42.647 tons ha⁻¹) was attained by the combination of C3 and 250 kg N ha⁻¹ (N5). The highest grain output (7.607 tons ha⁻¹) and spikes per square meter (591 spike m⁻²) were recorded with C₀ and 250 kg N ha⁻¹ (N5). A greater nitrogen levels (250 kg N ha⁻¹) increased both green fodder and grain yields. Pal et al. (2021) found that the application of nitrogen to the oat crop considerably enhances plant height, growth, and leaf length.

Afridi et al. (2010) conducted a field experiment investigated the impact of decapitation stress (removing foliage at 60 days) and nitrogen (N) management on wheat yield. Decapitation reduced spikes per square meter, grains per spike, thousand-grain weight, and biological yield. However, applying N at higher rates (100, 150, and 200 kg ha⁻¹) and splitting the application (half at sowing and half at the second irrigation) significantly improved yield components and overall performance. The results highlight that wheat can be utilized as a dual-purpose crop, with appropriate N management minimizing yield reductions.

Khan et al. (2022) concluded a field experiment that mitigate the deficiency of green fodder in rainfed areas and enhance forage production during severe winter conditions. The research assessed two winter forages (barley and triticale) at three nitrogen levels (0, 75, and 150 kg N ha⁻¹) utilizing a Randomized Complete Block Design (RCBD) with split-plot configurations and three replications. Triticale, when paired with a nitrogen application of 150 kg N ha⁻¹, is the optimal winter forage crop for elevated yields and enhanced nutritional quality for livestock feed during the severe winter months.

Paul et al. (2019) executed a field experiment on fodder maize and discovered that differing nitrogen levels substantially affect growth performance indicators. Application of 200 kg N ha^{-1} yielded the greatest plant height (204.9 cm) and the highest leaf count per plant (12.22), while 100 kg N ha^{-1} resulted in a shorter plant height (155.4 cm) and a lower leaf count per plant (10.56).

Ayub et al. (2002) conducted an experiment examining nitrogen (0, 120, 160, and 200 kg ha^{-1}) and phosphorus (0, 40, 60, and 80 kg ha^{-1}) levels on maize fodder, concluding that 200 kg N ha^{-1} produced the maximum plant height (198.8 cm), stem diameter (1.58 cm), and leaf area per plant (4218 cm^2). An experiment was done to examine the effects of different nitrogen levels on fodder maize, given the importance of nitrogen for economic returns.

Ahmed et al. (2017) noted that excessive amounts of urea negatively impacted plant development. Conversely, Khanna et al. (2019) observed that the application of azotobacter produced optimal outcomes, and a combination of FYM application also demonstrated beneficial enhancements in crop development and production.

Cheema et al. (2010) found that nitrogen is present in protoplasm, proteins, nucleic acids, and chlorophyll, playing a crucial role in the vegetative and reproductive phases of crop development. Increased nitrogen concentrations are associated with improved plant height, stem diameter, leaf size, leaf area index, dry matter accumulation, net absorption rate, and yield per hectare.

Ali et al. (2017) conducted an experiment on impact of varying nitrogen rates on the yield and quality of maize. This trial examined four nitrogen treatments (70, 130, 160, and 180 kg ha^{-1}) with a control group. Maximum growth and yield characteristics, along with quality metrics, included plant height (210.23 cm), stem diameter (3.68 cm), leaf area per plant (210.5 cm^2), chlorophyll content (39.78%), green fodder yield (44.89 tons per hectare), dry matter yield (9.1 tons per hectare), crude protein (10.75%), crude fiber (31.87%), and ash percentage (8.85%). It was determined that elevating nitrogen levels (130, 160, and 180 kg N ha^{-1}) to an optimal threshold can enhance the growth, production characteristics, and quality of maize.

Ullah et al. (2015) found that the highest benefit-cost ratio was estimated when 240 kg N ha^{-1} was applied which was found best compromise between forage yield and quality for maize cultivar

Ayub et al. (2003) conducted a field trial in Faisalabad, Pakistan, examined the impact of varying N and seed rates on maize fodder yield and quality. Nitrogen application resulted to improved plant height, leaf area, leaf number, stem diameter, green fodder production, dry matter, protein, fiber, and ash content, but decreased ether extractable fat. Seed rate increases plant density, green fodder yield, and dry matter, but decreases leaf area, stem diameter, ether extractable fat, and ash content. Seed rate did not significantly affect plant height, crude protein, or fiber content. The study indicated that a 120 kg ha⁻¹ nitrogen and seed combination yielded the highest green fodder yield of maize.

Plant density grows greater, competition for resources, particularly nitrogen, intensifies, adversely impacting the final output. The addition of nitrogen may be posited to improve output by augmenting plant population, but only to an optimal extent. Increased nitrogen levels can result in plant lodging at elevated seed rates (Nazir et al., 2000).

Eltelib et al. (2006) showed that plant height, stem diameter, and leaf area index (LAI) significantly increased with rising nitrogen levels from 0 to 80 kg N ha⁻¹. Nonetheless, 40 and 80 kg N ha⁻¹ were statistically equivalent in fodder maize. Increasing nitrogen levels did not significantly impact the number of leaves per plant. The application of 80 kg N ha⁻¹ resulted in a considerably greater LAI (20.20) compared to 40 kg N ha⁻¹ (16.78) and the control (7.93)

Onasanya et al. (2009) from southern Nigeria indicated that the application of 120 kg N ha⁻¹ + 0 kg P ha⁻¹ and 60 kg N ha⁻¹ + 40 kg P ha⁻¹ greatly enhanced the growth and growth characteristics of maize plants. The maximum and minimum leaf area and plant girth were observed at 120 kg N ha⁻¹ and in the control group, respectively.

2.2 Effect of N on biomass accumulation of fodder

Erega et al. (2020) conducted an experiment on effects of seed rate (60, 80, and 100 kg ha⁻¹) and nitrogen rate (50, 100, and 150 kg ha⁻¹) on the biomass yield and nutritional quality of oat (*Avena sativa* L.). The experiment, arranged in a 3x3 factorial within a Randomized Complete Block Design (RCBD), revealed that the interaction between seed and nitrogen rates significantly affected most growth and yield parameters, except tiller number per plant. Green forage and dry matter yields increased with higher seed and nitrogen levels, with the combination of 100 kg ha⁻¹ seed rate and 150 kg ha⁻¹ nitrogen producing the highest yield

Valdabadi and Farahani (2012) in their study indicated that the use of nitrogen fertilizer considerably influenced the total dry weight (TDW), leaf area index (LAI), relative growth rate (RGR), and crop growth rate (CGR) of maize. The maximum total dry weight (TDW) of 1910

gm⁻², leaf area index (LAI) of 4.2, relative growth rate (RGR) of 0.08 gg⁻¹.day⁻¹, and crop growth rate (CGR) of 31.2 gm⁻²day⁻¹ were achieved with the administration of 520 kg urea ha⁻¹

Sharifi and Teghizadeh (2009) documented that plant height augmented with escalating nitrogen application levels, with a peak height of 204.6 cm observed at 240 kg N ha⁻¹. The application of nitrogen up to 150 kg N ha⁻¹ enhanced wheat production and its components in comparison to the control (Ahmad et al., 2007). Fluegel & Johnson (2001) indicated that elevated nitrogen levels positively influenced plant height and dry matter accumulation.

Ahmad (1999) and Ayub et al. (2002b) in their study showed that the percentage of dry matter increased with higher nitrogen rates; however, the rise in dry matter content did not attain statistical significance between 50 and 100 kg N ha⁻¹. Nitrogen application at a rate of 150 kg ha⁻¹ produced the highest percentage of dry matter.

Grazia et al. (2003) found that the effect of different levels of nitrogen (0, 100, and 200 kg N ha⁻¹) and phosphorus (0, 40, and 80 kg P₂O₅ ha⁻¹) fertilization on the yield and uniformity of the sweet corn hybrid. Nitrogen and phosphorus fertilization significantly influenced various growth and yield traits of sweet corn hybrid 'Freshy,' with an N × P interaction observed only for shoot dry matter content.

El et al. (2015) found that nitrogen administration did not substantially influence plant density. But nitrogen administration enhanced both the fresh and dry weight of individual plants across all treatments. Moreover, nitrogen administration greatly increased fresh forage yield and dry matter output. Green fodder output was lowest (81.18 q ha⁻¹) when crop was cut at 45 DAS. Green fodder output increased by 31.64 and 67.26 percent at 65 DAS compared to 55 and 45 DAS cuts, respectively. Gill et al. (2017) found that a 60 DAS forage cut yielded 13.4 t ha⁻¹ more green fodder than a 45 DAS cut. Khalil et al. (2011) found that forage dry matter yield improved with a delay in cutting from 75 to 90 days post-sowing.

2.3 Effect of N on quality attributes of fodder

Pal et al. (2021) found that the production and quality of fodder oats enhance with increasing nitrogen levels. The use of nitrogen led to increased yields of both green and dry fodder, along with enhanced efficiency in fodder output and improved quality measurement, including ether extract and crude fiber.

Ullah et al. (2015) carried out an experiment on the effects of nitrogen fertilization rates on growth, quality and economic return of fodder maize (*Zea mays* L.) This trial examined six

nitrogen treatments (80, 120, 160, 200, 240, and 280 kg ha⁻¹) with a control group. The growth and yield characteristics, along with quality parameters including plant height, stem diameter, leaf area per plant, leaf area index, chlorophyll content, green fodder yield, dry matter yield, crude protein, crude fibre, and ash percentage, were significantly enhanced with increasing nitrogen levels.

Witt et al. (2008) conducted an experiment that the optimal supply of plant nutrients is essential for the enhanced growth and development of a crop. Yield and quality indices are significantly influenced by insufficient availability of plant nutrients. The low yield of fodder maize is attributed to numerous restrictions, with NPK fertilizer use being a significant role.

Reddy et al. (2010) observed that the application of 240 kg N ha⁻¹ resulted in significantly increased green fodder yield, dry matter yield, and crude protein content.

Karasu et al. (2009) conducted an experiment on biomass and crude protein of fodder maize increased with higher nitrogen content. The field trials were conducted using a randomized complete block design with three replications. Three cultivars' varieties were (LG 2687, PR34N43, and H 2547) together with four nitrogen application rates (0, 150, 300, and 450 kg ha⁻¹) were apply. The application of 300 kg ha⁻¹ N resulted in increased forage and dry matter yield of maize cultivars LG 2687, PR34N43, and H 2547.

Aslam et al. (2011) found that the linear increase in crude protein (%) with rising nitrogen concentration may result from nitrogen being a fundamental component of protein molecules and a precursor of amino acids. at the maximum nitrogen application rate of 150 kg ha⁻¹ is height for maize fodder.

Chakravarthi et al. (2017) examined 50 samples of sorghum fodder in the Rayalaseema district of Andhra Pradesh for its chemical composition. The results showed that sorghum fodder is nutritionally superior to other grain fodders for animals in arid regions. The dry matter content ranged from 11.82 to 38.19 % with a mean of 26.30 ± 0.50 percent. The average crude protein content was 12.42 ± 0.47 percent, and the total ash content was 9.18 ± 0.21 percent. The percentage of cell wall constituents ranged from 70.13 to 82.19 (NDF), 47.87 to 78.86 (ADF), 1.32 to 22.18 (ADL), 13.85 to 45.57 (cellulose), 0.33 to 8.33 (silica), and 0.34 to 28.38 (hemicellulose).

Feyisa et al. (2022) assessed the biomass production and nutritional value of fodder sources in Ethiopia, highlighting crop residues as the highest biomass producers, followed by grazing

berseem clover range from 15 to 30 kg ha⁻¹, depending on the sowing time and method. Research suggests that an optimal seeding rate of 20–25 kg ha⁻¹ is ideal for maximizing both green forage production and seed yield in various agro-climatic conditions

2.5 Effect of salinity on fodder cultivation

Joardar et al. (2018) conducted a field experiment at Khulna University during the dry season evaluated the growth performance of sorghum (*Sorghum bicolor* L. cv. *Morokoshi*) under irrigation with saline water of varying EC levels (0.78, 4.19, 7.18, 10.79, and 14.04 dS m⁻¹). Results indicated that agronomic traits and biomass decreased with increasing salinity, but growth was not significantly harmed at lower salinity levels. Plant height and biomass were notably reduced at 10.79 dS m⁻¹, though soil salinity did not increase after harvest, likely due to monsoon rainfall. The study suggests that sorghum can be cultivated in coastal regions of Bangladesh, tolerating irrigation water salinity up to 10.79 dS m⁻¹, making it suitable for areas with limited freshwater resources.

Forage biomass production is greatly influenced by soil salinity and alkalinity. Salinity hinders plant growth by disrupting ionic balance and osmotic processes, which results in reduced cellular water content and diminished turgor pressure (Bennett et al., 2009). Salinity is a form of soil degradation that hinders plants from effectively absorbing water and nutrients, thereby reducing soil fertility and agricultural productivity. Salinity and alkalinity stress negatively affect plant development, growth, and yield by disrupting ionic balance and water potential (Kumar et al., 2020). Salinity and alkalinity also influence alfalfa germination in saline–alkali substrates, where low salinity levels promote radicle growth, supporting early development (Zhang et al., 2017). Irrigation with saline water reduces the growth rate of alfalfa, leading to decreased levels of acid detergent fiber (ADF) and neutral detergent fiber (NDF) but an increase in shoot nitrogen (N). Salinity stress enhances the leaf-to-stem ratio by approximately 6%, alongside higher crude protein (CP) and shoot nitrogen, primarily due to shorter internodes and reduced plant height. This improved leaf-to-stem ratio reflects enhanced nutritional value in the forage (Barnes et al., 2003).

2.6 Effect of zero tillage on fodder

Khan et al. (2020) conducted an experiment in the new alluvial zone of West Bengal during the summers of 2016 and 2017 assessed the performance of conservation tillage (zero tillage and minimum tillage) compared to conventional tillage for various fodder crops, including maize, sorghum, rice bean, and cowpea. Conservation tillage significantly improved soil health and crop

yields. Among cereals, maize grown under zero tillage achieved the highest green forage yield (42.33 t ha^{-1}) and dry matter yield (7.84 t ha^{-1}). Cowpea, however, outperformed other crops in crude protein yield (1.071 t ha^{-1}) and was the most economically viable (B:C ratio of 2.21) under zero tillage. Based on these findings, cowpea cultivation under zero tillage is highly recommended for this region.

Khan et al. (2021) conducted another experiment on assessed the impact of tillage practices on fodder crops and soil moisture retention. Zero tillage proved most effective, boosting crop growth and minimizing soil moisture loss, especially in rice bean. The findings highlight the advantages of conservation tillage (zero/minimum) over conventional methods for improving crop performance and conserving soil moisture in the region.

Zero tillage offers several advantages, including enhanced soil carbon accumulation and increased soil nitrogen levels, which contribute to better conservation of soil, moisture, and nutrients, ultimately boosting crop productivity (Ofstehage & Nehring, 2021).

Xu et al. (2021) conducted an experiment In South China, a study compared no-tillage sowing (5 days before or 1 day after rice harvest) and conventional tillage for planting forage wheat and Italian ryegrass in fallow paddy fields. Results showed that no-tillage increased soil bulk density and capillary porosity while reducing total porosity and enzyme activity. The NA1 treatment improved soil nitrogen and organic matter. Sowing methods did not significantly affect dry matter or crude protein yields, but no-tillage increased weed biomass. The study concluded that no-tillage is the best method for planting winter forage crops in fallow paddy fields.

CHAPTER III

MATERIALS AND METHODS

The study was conducted at the farmer's field in the village of Pankhali, Dacope, Khulna which located at 26 km southwest from Khulna University campus. The main objectives of this study aimed to investigate the effect of seed rate and nitrogen rate on yield and quality of wheat fodder in the southwestern (SW) coastal region of Bangladesh. A brief description of the experimental materials and methods has been presented below.

3.1 Location and soil of the experimental site

The experiment was conducted at farmer's field in Pankhali (22°24' north latitude and 89°24' to 89°35' east longitude with an elevation of ~3 m above the mean sea level), Dacope, Khulna (26 km away from Khulna university campus), located in Agro-ecological Zone of Ganges Tidal Floodplain (AEZ-13). The experimental period in the field was January to March 2024. Dacope is surrounded by Batiaghata upazila to the north, the Pasur River, Rampal and Mongla to the east, Paikgacha and Koyra upazila to the west, and the Sundarbans to the south. The experimental site had a sub-tropical environment, featuring elevated temperatures and substantial rainfall during the Kharif season (April to October), and reduced rainfall with mild temperatures during the Rabi season (November to March). The temperature in the research area during the growth period ranged from 9.4 to 35.2 °C (Fig. 2A). The average monthly maximum temperatures for January, February, and March 2024 were 27.4 °C, 33.0 °C, and 35.2 °C, respectively, while the minimum monthly average temperatures were 9.4 °C, 12.8 °C, and 15.6 °C, respectively (Fig. 2A). The maximum and minimum temperatures consistently risen during time (Fig. 2A). The total rainfall during the growth season was 87 mm (Fig. 2B). The soil texture of the experimental field varied from silty clay to clayey with medium organic matter content (2.54%), low N content (0.15%), high P, very high K, nearly neutral pH (7.6) and mild salinity level (EC 4.2 dS m⁻¹). The physicochemical properties of the experimental field soil have been presented in Table 1.

Table 1. Physical and chemical properties of the experimental field soil before sowing of seeds

Parameter	pH	Salinity	OM	Total nitrogen	K	P	Cu	Zn	B
		dS m ⁻¹	%		µg/g soil				
Soil test value	7.6	4.2	2.54	0.147	0.53	32.83	115.72	2.29	0.88
Status	Mild Alkali	Little	Medium	Low	V. high	High	V. high	V. high	V. high

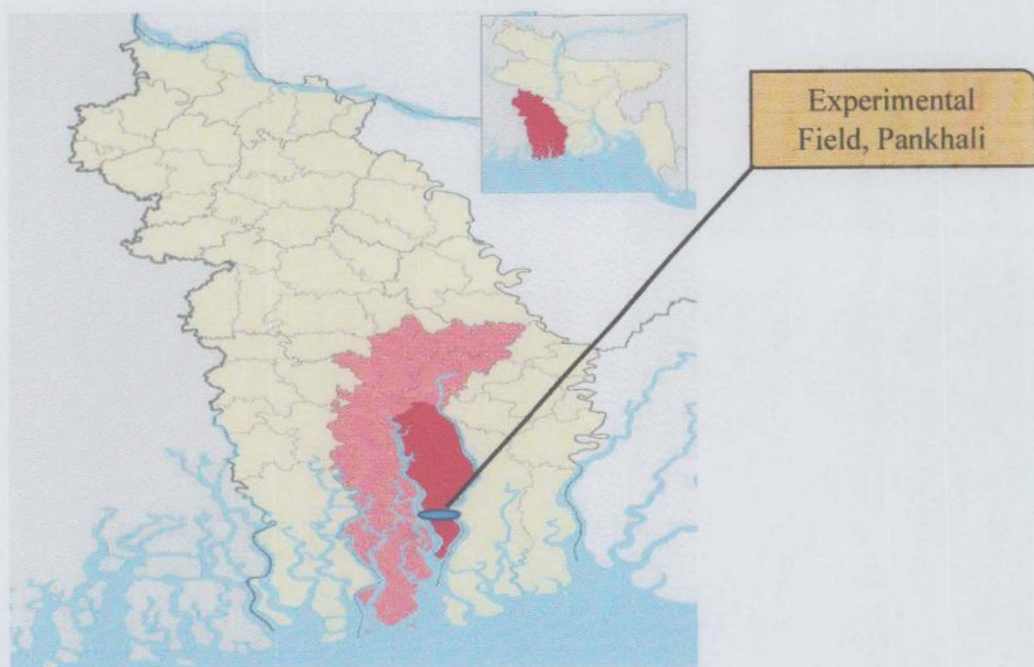


Figure 1. Location map of the experimental field

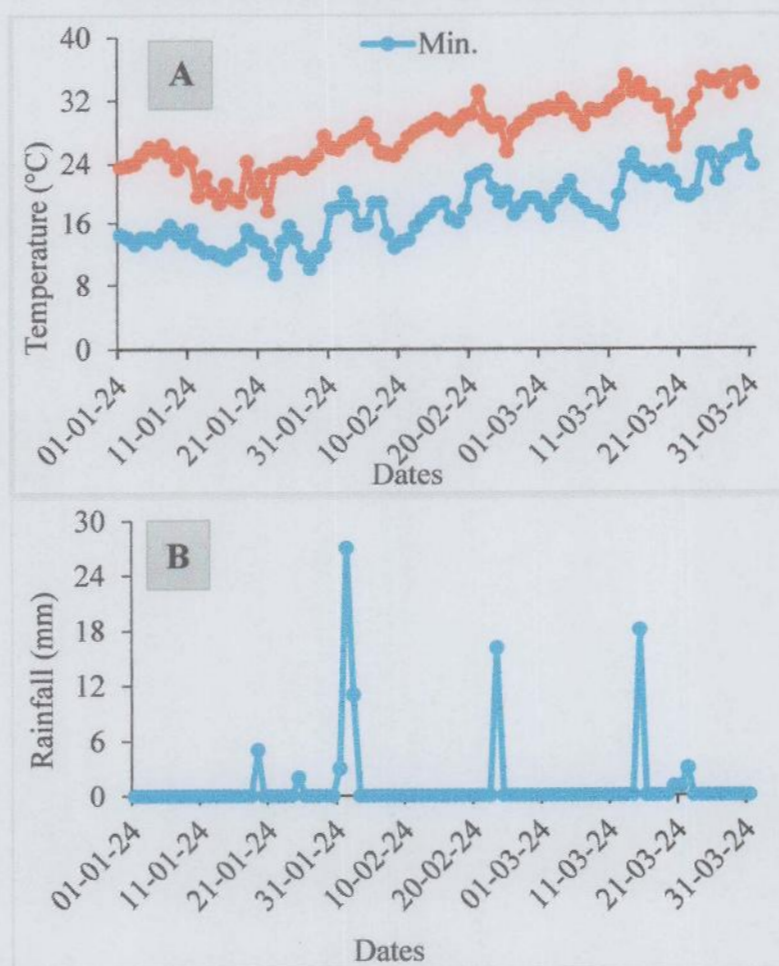


Figure 2. Temperature (A) and Rainfall (B) pattern in the study area during the growing season (January-April, 2024)

3.2 Experimental design and treatment

The experiment was conducted in a factorial randomized complete block design (RCBD) with three replications. The experimental treatment comprised of five nitrogen rates and four levels of seed rate and their combinations are mentioned bellow. The size of the experiment plot was 10 m² (4 m × 2.5 m) maintaining a spacing of 1.5 m and 1.0 m between replication to replication and plot to plot, respectively.

Factor-A (Nitrogen rates kg ha ⁻¹)	Factor-B (Seed rates kg ha ⁻¹)
N ₀ =No N added	S ₁ =120
N ₁ =105	S ₂ =150
N ₂ =140	S ₃ =180
N ₃ =175	S ₄ =210
N ₄ =210	

Thus, the treatment combination was: N₀S₁, N₀S₂, N₀S₃, N₀S₄, N₁S₁, N₁S₂, N₁S₃, N₁S₄, N₂S₁, N₂S₂, N₂S₃, N₂S₄, N₃S₁, N₃S₂, N₃S₃, N₃S₄, N₄S₁, N₄S₂, N₄S₃, and N₄S₄

3.3 Planting materials

BARI Gom-25 was collected from Bangladesh Agricultural Research Institute (BARI) Joydebpur, Gazipur and used as planting materials in this research

3.4 Seed sowing and fertilizer application

3.4.1 Seed sowing

The previous crop was BR23, a long duration HYV rice, harvested in last week of December 2023. After harvest, the field was almost in saturate condition and under this condition sowing of seeds with conventional tillage is totally impossible. Thus, the seeds were sown under zero tillage condition. This method facilitated minimal soil disruption, consistent with conservation agriculture principles designed to improve soil health and water retention. The seeds (BARI Gom-25) were sown (3rd January, 2024) in a continuous line on the furrow (3-4 cm depth) under zero tillage condition. After sowing the seeds were covered with dry soil. The row sowing technique in zero tillage offers an effective and sustainable approach for seed placement, enhancing germination and growth conditions.

3.4.2 Fertilizer application: Urea, triple super phosphate (TSP), muriate of potash (MoP) and gypsum were used as the source of N, P, K and S. The rate of P, K and S was 30, 50 and 20 kg ha⁻¹, respectively whereas N fertilizer was used as per the treatment. After emergence of seedling the prescribed amount (as per treatment) of urea, TSP, MoP, gypsum was applied in the alternate

furrow (5-7 cm depth) along the lines. First and second split of urea was applied 25 and 40 days after sowing (DAS) respectively as side dressing. Light irrigation was provided immediate after each split application of urea.

3.5 Irrigation

The wheat field was irrigated three times first at 20 DAS and then at 35 and 45 DAS. The field was irrigated from the nearby canal using a hose pipe and time of irrigation was equal in all the plots.

3.6 Weeding

During the early stage of crop establishment, the field was infested by weed. To manage this, one manual hand weeding was performed with the help of spade at 20 DAS.

3.7 Harvesting and postharvest operations

The first cut of the fodder was conducted at 50 DAS, when the wheat fodder was in the booting stage. Following the harvest, the fresh weight of the fodder was taken immediately after harvest and then the fodder was meticulously sun-dried for 4-5 days to diminish moisture content. After drying, the fodder was divided into smaller segments with a sickle and subsequently packaged in paper bags. The samples were subsequently dried in an oven @ 70 °C until reached a constant weight. The second cut was carried out at 60 DAS and then same protocols was followed on first cut. This method yielded precise measurements of the fresh and dry weight of the fodder, crucial for assessing its quality and biomass productivity.

3.8 Data collection and calculation

3.8.1 Plant height (cm)

Five plants were selected randomly and tagged from each plot avoiding the side line for data collection. The height of plant was recorded in centimeter (cm) at the time of 30, 40, 50 and 60 days after sowing (DAS). Data were recorded from the five-individual plant of each plot carefully. A large scale was used in measuring the height of the plant. The height was measured from the ground level to the tip of the plant leaf. Finally, the average plant height was calculated from the collected data.

3.8.2 Tiller number plant⁻¹

The number of tillers were counted and recorded from five randomly selected plants at the time of 30, 40, 50 and 60 DAS. Data were recorded carefully by counting all tiller number from the five plants of each plot and then calculate the mean value for analysis.

3.8.3 Chlorophyll content of leaves

Leaf greenness was (leaf chlorophyll content index) was measured at 30, 40, 50 and 60 DAS from the selected five plants in each plot with the help of a portable SPAD meter. The collected data were then compiled and measure the mean value.

3.8.4 Biomass yield

For biomass 1 m² area from each plot were randomly selected and then harvest from the ground level. Immediate after harvest the weight was taken and then left in the field for 2-3 days for sun drying. The biomass from the sample area were cut and dried in the oven at 75 °C until a constant weight was achieved. Then the fresh biomass and dry biomass were calculated as t ha⁻¹. After that a portion of the oven dried sample from each plot was crushed and prepared for chemical analysis.

3.9 Proximate analysis

Researchers extract a certain number of observations from a broader population as part of the statistical analysis process referred to as sampling. Sampling was done to determine the proximate composition of wheat fodder.

3.9.1. Dry matter

Test procedure

Envelopes were initially weighted (W1). Fresh weight (W2) of wheat fodder was measured and the envelope was filled with the sample and dried in an oven at 105°C for 24 hours. The dried sample with the envelope (W3) inside was then weighted.

Calculation

$$\text{Dry Matter (\%)} = \frac{W3 - W1}{W2} \times 100$$

Where, W1 = Weight of envelope in gram, W2 = Weight of fresh sample in gram

W3 = Weight of envelope and dried sample in gram

3.9.2. Crude protein analysis

Test procedures

Digestion

VELP SCIENTIFICA the DK 8 Heating Digester was utilized for the digestion process. A gram of the substance (grinded dry biomass) was measured with an accuracy of ±0.1 mg. Twelve milliliters of H₂SO₄ (98%) and two catalysts were incorporated into each sample before to its

placement in the digesting block. The sample was subjected to heating for 60 minutes at 420°C to suppress the emissions while the digesting block maintained that temperature. The sample was subsequently cooled to a temperature range of 50 to 60°C.

Distillation

The VELP SCIENTIFICA UDK 129 Distillation Unit was employed to execute the distillation operation. The sample was chilled and subsequently mixed with 50 milliliters of distilled water. Fifty milliliters of NaOH were added to the mixture. Subsequently, the distillation chamber accommodated the digesting flask. A conical flask was filled with 30 ml of boric acid solution, to which three drops of indicator were added. The water flow was modified previously. Distillation was conducted until the color of the indicator combination solution remained unchanged at green.

Titration

The flask sample was subsequently extracted for titration. A burette was filled with 0.1% HCl and dispensed drop-by-drop. The procedure was executed frequently until the solution in the conical flask transitioned from green to blue. The titration process concluded upon the alteration of the solution's color. The strength of the titrate was then recorded.

Calculation

$$\text{Nitrogen (\%)} = \frac{(\text{ml HCl required for sample} - \text{ml HCl}) \times 14.007 \times 100}{(\text{Wight of sample} \times 1000)}$$

$$\text{CP\%} = \text{Nitrogen (\%)} \times 6.25$$

3.9.3. Crude fiber analysis

Test procedures

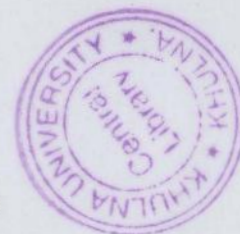
An analysis of crude fibre was conducted using the VELP SCIENTIFICA FIWE Raw Fibre Extractor. A one-gram specimen was positioned in crucibles with secured passages. Three to five drops of n-octanol were introduced into 150 milliliters of 1.25% H₂SO₄ in the analyzer flask as an antifoaming agent. The fiber analyzer's switch was activated. Simmer for exactly thirty minutes. Filter the leftover agent after thirty minutes. Rinse the crucible thrice, introducing 30 ml of hot deionized water each time, then employ compressed air to agitate the crucible's contents. After draining the final wash, 150 ml of 1.25% KOH and three to five drops of an anti-foaming agent were introduced. Subsequently, following 30 minutes of boiling and three rinses, the crucible was cooled with a final rinse in cold deionized water. The crucible was thereafter cleaned thrice with 25 milliliters of acetone while being agitated with compressed air. The

crucible's contents were cleaned using 25 cc of acetone. Subsequently, the crucibles were dried in an oven at 105°C for one hour and then cooled in a desiccator to ascertain their dry weight (F1). Following cooling in a desiccator (F2), the crucibles were placed in a muffle furnace and heated to 550° C for three hours for reweighing.

Calculation

$$\text{Crude Fiber (\%)} = \frac{F1-F2}{F0} \times 100$$

Where, F0 = Weight of sample in gram, F1= Weight of oven dried sample in gram
F2= Weight of ash containing crucible in gram



3.9.4. Ether extract analysis

Test procedure

The examination of ether extract was performed utilizing the VELP SCIENTIFICA SER 148 Solvent Extractor.

Sample: A digital weighing balance was utilized to measure an extraction thimble containing 3 g of homogenized and pulverized material. The weight of the wet sample is determined by subtracting the weight of the thimble from the overall weight.

Chemicals: Petroleum ether at 40–60° C with a maximum residue evaporation of 10 milligrams per liter. Following one hour at 125° C, the thimble underwent sample drying.

Immersion: The glass crucible with the dry hydrolyzed sample or the sample with a thimble was introduced into the extraction device. 40 milliliters of petroleum ether were introduced into the extract collection jar subsequent to its weighing. A thimble filled with a sample is linked to the extraction unit using a thimble connector. The flow of heating and cooling water commenced at the closure of the extraction unit. The glass crucibles or thimbles were positioned in the "Immersion" orientation for 30 minutes following the commencement of solvent boiling.

Washing: Thimbles or glass crucibles were placed in the "Washing" position for 60 minutes after a 30-minute extraction phase.

Recovery: After washing, the submerged stopcock was sealed, the condenser was cooled, and the solvent in the extraction tank was completely evaporated.

Weighing: Following a period of cooling in a desiccator, the cups containing the extract were weighed after being dried for 30 minutes at 125 degrees Celsius in the oven.

Calculation

$$\text{Ether Extract (\%)} = \frac{W3 - W2}{W1} \times 100$$

Where, $W1$ = Weight of sample in gram, $W2$ = Weight of empty vessel in gram

$W3$ = Weight of vessel and ether extract in gram

3.9.5. Ash analysis

Test procedure

Firstly, placed the crucibles in a muffle furnace and heated them to 600 °C for thirty minutes. then recorded the crucible's weight ($W1$). A tarred crucible contained a sample weighing approximately 3 grams. then recorded the sample's weight ($W2$). I was maintained the crucibles in a muffle furnace at 600°C for six hours. After cooling in a furnace to below 20 °C, we positioned the crucibles in a desiccator with a vented top. Immediately upon reaching room temperature in a desiccator, weigh the crucibles and record the weight ($W3$). Then, provide the anticipated ash percentage with one decimal point.

Calculation

$$\text{Ash (\%)} = \frac{W3 - W1}{W2} \times 100$$

Where, $W1$ = Weight of crucible in gram, $W2$ = Weight of sample in gram

$W3$ = Weight of crucible and ash in gram

3.10 Economic analysis

Economic analysis was performed by calculating all the costs (material and non-material cost) related to the production of wheat fodder per unit area (as per the treatment) along with the fixed cost. The net income and benefit cost ratio were calculated using the following formulae-

Net income = Gross income (tk) – total cost of production (tk)

$$\text{Benefit cost ratio} = \frac{\text{Gross income (tk)}}{\text{Total cost of production (tk)}}$$

3.11 Statistical analysis

The collected, measured and calculated data were then compiled and performed statistical analysis following the analysis of variance techniques (two-way ANOVA) by using 'Statistix 10' a statistical software. The significant differences among the treatment means were compared following all pair wise comparison by Tukey's HSD at 95% confidence level. Among the two cuts (irrespective of seed rate and N rates) was analyzed following analysis of variance (three-way ANOVA) and mean difference was determined following all pair wise comparison by Tukey's HSD at 5% level of probability.

CHAPTER IV

RESULTS

4.1 Effect of seed rate, nitrogen rate and their interaction on growth parameters (plant height and tiller number) of wheat fodder

Growth parameters (plant height and tiller number) of wheat as fodder was differed significantly with the variation of seed rate and N rate separately at different days after sowing (DAS) but their interaction effect was not significantly varied (Table 2 & Table 3).

4.1.1 Plant height(cm)

Among the different seed rates, at 30 DAS, the highest plant height (21.10 cm) was achieved from 120 kg seed ha⁻¹ which was statistically at par (20.33 cm) with 150 kg ha⁻¹ while the lowest was (19.06 cm) found in 210 kg ha⁻¹ seed rate (Table 2). At 40 DAS, the highest plant height (34.59 cm) was achieved from 120 kg ha⁻¹ which was statistically at par (32.74 cm) with 150 kg ha⁻¹ whereas the lowest was (29.31 cm) found in 210 kg ha⁻¹ seed rate. At 50 DAS, the highest plant height (49.66 cm) was achieved from 120 kg ha⁻¹ which was statistically at par (47.62 cm) with 150 kg ha⁻¹ and the lowest was (43.02 cm) found in 210 kg ha⁻¹ seed rate. At 60 DAS, the highest plant height (66.44 cm) was achieved from 120 kg ha⁻¹ which was statistically similar at par (63.29 cm) with 150 kg ha⁻¹ and the lowest was (56.50 cm) found in 210 kg ha⁻¹ seed rate.

Table 2. Effect of seed rate on growth of wheat as fodder grown in the coastal soil of southwestern Bangladesh.

Seed rate (kg ha ⁻¹)	Plant height (cm)				Tiller number			
	30 DAS	40 DAS	50 DAS	60 DAS	30 DAS	40 DAS	50 DAS	60 DAS
120	21.10a	34.59a	49.66a	66.44a	1.53a	2.23a	2.37a	2.37a
150	20.33ab	32.74ab	47.62ab	63.29ab	1.41a	2.04a	2.14b	2.23a
180	19.76bc	30.80bc	45.55bc	59.89bc	1.35ab	1.92ab	1.99bc	1.97b
210	19.06c	29.31c	43.02c	56.50c	1.22b	1.71b	1.85c	1.65c
SEM (±)	0.47	0.75	1.18	1.37	0.07	0.12	0.08	0.08
P value	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
CV (%)	6.46	6.51	6.97	6.14	13.81	16.92	10.15	10.99

Here, SEM, and CV indicate the mean standard error and coefficient of variation. There is no significant variation with the values having similar letter (s) in a column whereas, dissimilar letter denotes statistically significant different.

Among the different N rates, at 30 DAS, the highest plant height (23.15 cm) was achieved with the application of N @ 210 kg N ha⁻¹ which was statistically at par (21.85 cm) with 175 kg N ha⁻¹ while the lowest was found (14.37 cm) in no nitrogen kg N ha⁻¹ nitrogen rate. At 40 DAS, the highest plant height (38.81 cm) was achieved with the application of N @ 210 kg N ha⁻¹ which

was statistically at par (36.55 cm) with 175 N kg ha⁻¹ when the minimum was (16.30 cm) found in no nitrogen kg ha⁻¹ nitrogen rate. At 50 DAS, the highest plant height (55.25 cm) was achieved with the application of N @ 210 kg N ha⁻¹ which was statistically at par (52.76 cm) with 175 kg N ha⁻¹ whereas the lowest was (24.38 cm) found in no nitrogen applied treatment. At 60 DAS, the highest plant height (71.38 cm) was achieved with the application of N @ 210 kg N ha⁻¹ which was statistically at par (69.06 cm) with 175 kg N ha⁻¹ and the lowest was (37.00 cm) found in no nitrogen kg ha⁻¹ nitrogen rate (Table 3)

Table 3. Effect of nitrogen rate on growth of wheat as fodder grown in the coastal soil of southwestern Bangladesh

Nitrogen rate (kg ha ⁻¹)	Plant height (cm)				Tiller number			
	30 DAS	40 DAS	50 DAS	60 DAS	30 DAS	40 DAS	50 DAS	60 DAS
No N added	14.37d	16.30d	24.38c	37.00d	0.93d	1.09c	1.16d	1.12d
105	19.67c	33.42c	48.98b	63.25c	1.26c	1.60b	1.76c	1.73c
140	21.26b	34.20bc	50.95b	66.95bc	1.45bc	2.20a	2.42b	2.29b
175	21.85ab	36.55ab	52.76ab	69.06ab	1.58ab	2.39a	2.43ab	2.55ab
210	23.15a	38.81a	55.25a	71.38a	1.68a	2.58a	2.67a	2.58a
SEM (±)	0.52	0.84	1.32	1.54	0.08	0.14	0.09	0.09
P value	<0.01	<0.01	<0.01	<0.01	<0.01	0.0013	<0.01	<0.01
CV (%)	6.46	6.51	6.97	6.14	13.81	16.92	10.15	10.99

Here, SEM, and CV indicate the mean standard error and coefficient of variation. There is no significant variation with the values having similar letter (s) in a column whereas, dissimilar letter denotes statistically significant different.

4.1.2 Tiller number

Tiller number was varied significantly with the individual effect of seed rate and nitrogen rate yet their interaction was not significant (Table 2 & Table 3).

At 30 DAS, the highest tiller number was (1.53) achieved from 120 kg ha⁻¹ which was statistically at par (1.41) with 180 kg ha⁻¹ while the lowest was (1.22) found in 210 kg ha⁻¹ seed rate. At 40 DAS, the highest tiller number was (2.23) achieved from 120 kg ha⁻¹ which was statistically at par (2.04) with 180 kg ha⁻¹ when the lowest was (1.71) found in 210 kg ha⁻¹ seed rate. At 50 DAS, the highest tiller number was (2.37) achieved from 120, kg ha⁻¹ which was statistically at par (2.14) with 150 kg ha⁻¹ whereas the lowest was (1.85) found in 210 kg ha⁻¹ seed rate. At 60 DAS, the highest tiller number was (2.37) achieved from 120 kg ha⁻¹ which was statistically at par (2.23) with 180 kg ha⁻¹ and the minimum was (1.65) found in 210 kg ha⁻¹ seed rate.

At 30 DAS, the highest tiller number was (1.68) achieved from 210 kg ha⁻¹ which was statistically at par (1.58) with 175 kg ha⁻¹ when the lowest (0.93) was found no nitrogen kg ha⁻¹ nitrogen rate. At 40 DAS, the highest tiller number was (2.58) achieved from 210 kg ha⁻¹ which was statistically at par (2.39) with 175 kg ha⁻¹ and the lowest was (1.09) found no nitrogen kg ha⁻¹ nitrogen rate. At 50 DAS, the highest tiller number was (2.67) achieved from 210 kg ha⁻¹ which was statistically at par (2.43) with 175 kg ha⁻¹ and the lowest was (1.16) found no nitrogen kg ha⁻¹ nitrogen rate. At 60 DAS, the highest tiller number was (2.58) achieved from 210 kg ha⁻¹ which was statistically at par (2.55) with 175 kg ha⁻¹ when the lowest was found (1.12) no nitrogen kg ha⁻¹ nitrogen rate.

4.2. Effect of seed rate and nitrogen rate and their interaction on leaf chlorophyll content index (SPAD value) of wheat fodder

Leaf chlorophyll content index was differed substantially with the effect of seed rate and nitrogen rate ha⁻¹ yet their interaction was not significant (Table 4 & Table 5).

At 30 DAS, the highest leaf chlorophyll content index (36.80) was achieved from 120 kg ha⁻¹ which was statistically at par (35.34) with 150 kg ha⁻¹ while the lowest was (32.98) found in 210 kg ha⁻¹ seed rate. At 40 DAS, the highest leaf chlorophyll content index (33.08) was achieved from 120 kg ha⁻¹ which was statistically at par (33.67) with 150 kg ha⁻¹ while the lowest was (31.33) found in 180 kg ha⁻¹ seed rate. At 50 DAS, the highest leaf chlorophyll content index (38.33) was achieved from 120 kg ha⁻¹ which was statistically at par (37.04) with 150 kg ha⁻¹ and the lowest was (34.74) found in 180 kg ha⁻¹ seed rate. At 60 DAS, the highest leaf chlorophyll content index (41.20) was achieved from 120 kg ha⁻¹ which was statistically at par (39.77) with 150 kg ha⁻¹ whereas the minimum (36.68) was found in 210 kg ha⁻¹ seed rate.

At 30 DAS, the highest leaf chlorophyll content index (39.25) was achieved from 140 kg ha⁻¹ which was statistically at par (38.90) with 175 kg ha⁻¹ while the lowest was (18.83) found no nitrogen kg ha⁻¹ nitrogen rate. At 40 DAS, the highest leaf chlorophyll content index (38.35) was achieved from 210 kg ha⁻¹ which was statistically at par (36.26) with 175 kg ha⁻¹ while the lowest was (21.77) found no nitrogen kg ha⁻¹ nitrogen rate. At 50 DAS, the highest leaf chlorophyll content index (41.22) was achieved from 140 kg ha⁻¹ which was statistically at par (40.69) with 210 kg ha⁻¹ while the lowest was (22.43) found no nitrogen kg ha⁻¹ nitrogen rate. At 60 DAS, the highest leaf chlorophyll content index (43.77) was achieved from 210 kg ha⁻¹ which was statistically at par (43.02) with 175 kg ha⁻¹ when the lowest was (23.92) found no nitrogen kg ha⁻¹ nitrogen rate.

Table 4. Effect of seed rate on leaf chlorophyll content index (SPAD value) of wheat as fodder grown in the coastal saline soil of southwestern Bangladesh

Seed rate (kg ha ⁻¹)	Leaf chlorophyll content index (SPAD value)			
	30 DAS	40 DAS	50 DAS	60 DAS
120	36.80a	33.08a	38.33a	41.20a
150	35.34ab	33.67a	37.04ab	39.77ab
180	33.77b	31.33a	34.74c	37.44bc
210	32.98b	31.64a	35.62bc	36.68c
SEM (±)	1.00	1.66	0.70	0.99
P value	<0.01	0.4446	<0.01	<0.01
CV (%)	7.89	14.05	5.32	7.01

Here, SEM, and CV indicate the mean standard error and coefficient of variation. There is no significant variation with the values having similar letter (s) in a column whereas, dissimilar letter denotes statistically significant different.

Table 5. Effect of nitrogen rate on leaf chlorophyll content index (SPAD value) of wheat as fodder grown in the coastal saline soil of southwestern Bangladesh

Nitrogen rate (kg ha ⁻¹)	Leaf chlorophyll content index (SPAD value)			
	30 DAS	40 DAS	50 DAS	60 DAS
No N added	18.83b	21.77c	22.43c	23.92b
105	37.96a	30.57b	37.77b	40.71a
140	39.25a	35.19ab	41.22a	42.43a
175	38.90a	36.26a	40.06a	43.02a
210	38.66a	38.35a	40.69a	43.77a
SEM (±)	1.11	1.86	0.79	1.10
P value	<0.01	<0.05	<0.01	<0.01
CV (%)	7.89	14.05	5.32	7.01

Here, SEM, and CV indicate the mean standard error and coefficient of variation. There is no significant variation with the values having similar letter (s) in a column whereas, dissimilar letter denotes statistically significant different.

4.3. Effect of seed rate, nitrogen rate and their interaction on biomass accumulation (fresh weight basis & dry weight basis) of wheat fodder

Fresh biomass weight

Separately, seed rate and N rate had significant influence on biomass yield (fresh weight basis) of wheat fodder at different days after sowing (DAS) but their interaction had no significant effect (Fig. 3A & 3B). At 50 DAS, the highest fresh weight (16.79 t ha⁻¹) was achieved from 210 kg ha⁻¹ which was statistically at par with 180 kg ha⁻¹ whereas the lowest (12.88 t ha⁻¹) was found in 120 kg ha⁻¹ seed rate. At 60 DAS, the highest fresh weight (19.51 t ha⁻¹) was achieved from

210 kg ha⁻¹ which was statistically at par with 180 kg ha⁻¹ and the minimum (15.86 t ha⁻¹) was found in 120 kg ha⁻¹ seed rate.

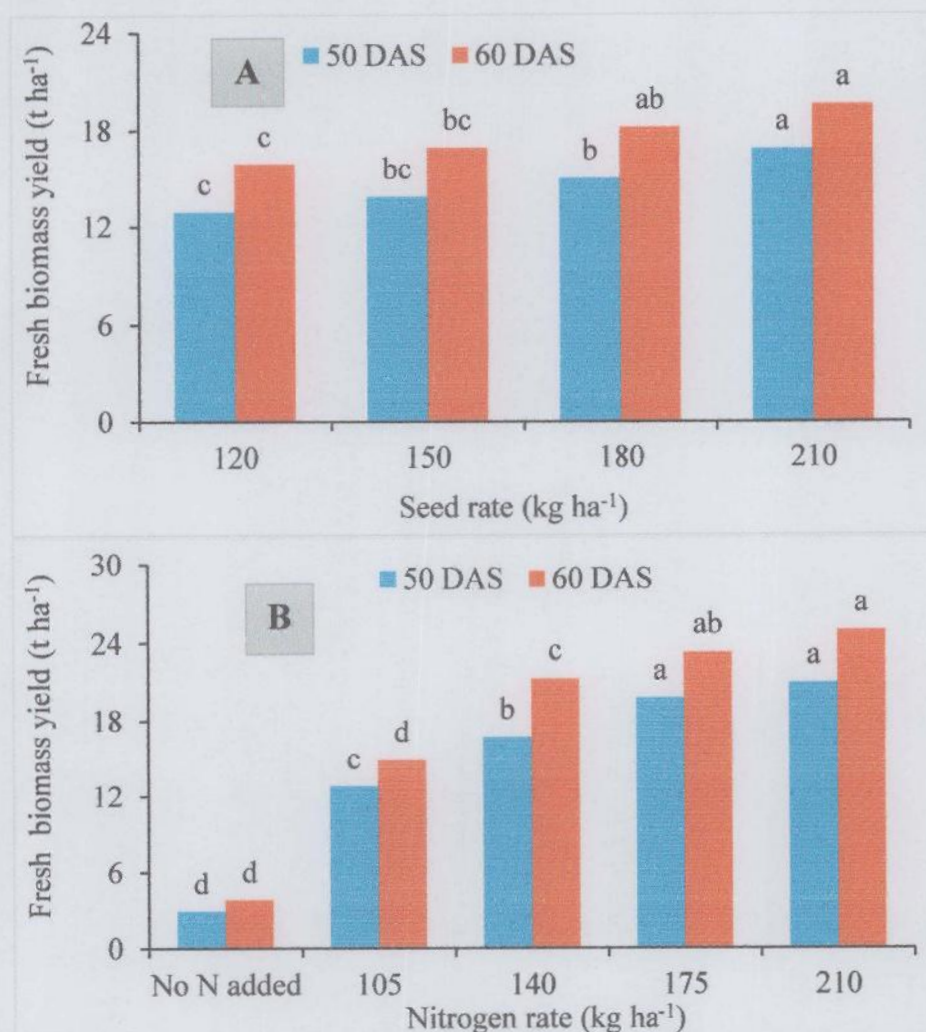


Figure 3. Effect of seed rates (A) and N rates (B) on biomass yield (fresh weight basis) of wheat fodder basis grown in the coastal saline soil of southwestern Bangladesh

At 50 DAS, the highest fresh weight (20.86 t ha⁻¹) was achieved from @ 210 N kg ha⁻¹ which was statistically at par with 175 kg ha⁻¹ while the lowest (2.94) was found no nitrogen kg ha⁻¹ nitrogen rate. At 60 DAS, the highest fresh weight (24.84 t ha⁻¹) was achieved from @ N 210 kg ha⁻¹ which was statistically at par with 175 kg ha⁻¹ whereas the lowest (3.84 t ha⁻¹) was found no nitrogen added treatment.

Dry biomass weight

Dry weight of biomass of wheat fodder was differed significantly with the effect of seed rate and N rate separately yet no significant effect was found due to their interaction. (Fig. 4A & 4B).

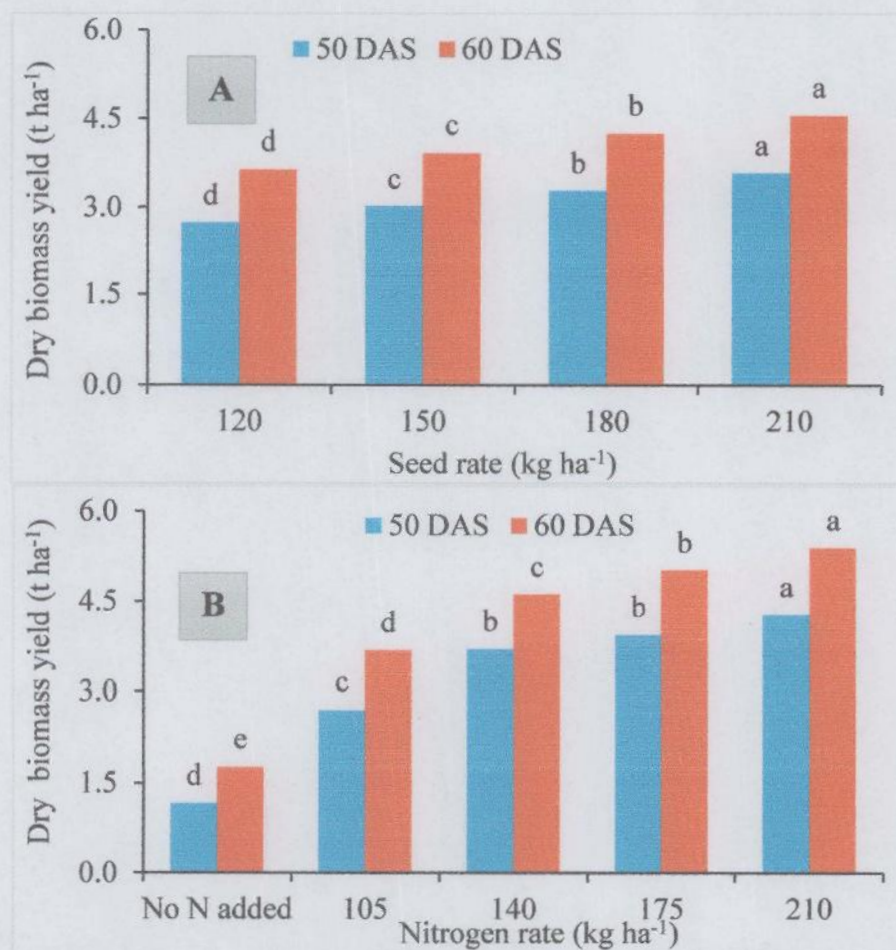


Figure 4. Effect of nitrogen rates (A) and N rates (B) on biomass yield (dry weight basis) of wheat fodder basis grown in the coastal saline soil of southwestern Bangladesh

At 50 DAS, the highest dry weight (3.58 t ha⁻¹) was achieved from the seed rate @ 210 kg ha⁻¹ which was statistically at par with 180 kg ha⁻¹ whereas the lowest (2.73 t ha⁻¹) was found in 120 kg ha⁻¹ seed rate. At 60 DAS, the highest dry weight (4.56 t ha⁻¹) was achieved from 210 kg ha⁻¹ which was statistically at par (4.25 t ha⁻¹) with 180 kg ha⁻¹ and the minimum (3.64 t ha⁻¹) was found in 120 kg ha⁻¹ seed rate.

In case of N rates, at 50 DAS, the highest dry weight (4.26 t ha⁻¹) was achieved from with the use of N@ 210 kg ha⁻¹ while the lowest (1.16 t ha⁻¹) was found no nitrogen kg ha⁻¹ nitrogen rate. At 60 DAS, the highest dry weight (5.39 t ha⁻¹) was achieved from the application of @N 210 kg ha⁻¹ whereas the lowest (1.76 t ha⁻¹) was found no nitrogen kg ha⁻¹ nitrogen rate.

4.4. Effect of seed rate and nitrogen rate and their interaction on quality attributes of wheat fodder

4.4.1 Crude protein

Crude protein content of wheat fodder was varied significantly due to the used of different seed rate and N rates individually but their interaction was not significant (Table 6 and Table 7).

At 50 DAS, the highest crude protein (12.14%) was achieved from 120, kg ha⁻¹ whereas the lowest (10.70%) was found in 210 kg ha⁻¹ seed rate. At 60 DAS, the highest crude protein (9.40%) was achieved from 120 kg ha⁻¹ whereas the minimum (8.12%) was found in 210 kg ha⁻¹ seed rate.

At 50 DAS, the highest crude protein (12.43%) was achieved from @ 210 N kg ha⁻¹ and the lowest (9.87%) was found no nitrogen kg ha⁻¹ nitrogen rate. At 60 DAS, the highest crude protein (10.29%) was achieved from @ 210 N kg ha⁻¹ when the lowest (7.08%) was found no nitrogen kg ha⁻¹ nitrogen rate.

4.4.2 Crude fiber

Separately, seed rate and N rate had significant influence on crude fibre content of wheat fodder but their interaction had no significant effect (Table 6 & Table 7).

Among the used seed rate, at 50 DAS, the highest crude fiber (25.52%) was achieved from 120, kg ha⁻¹ whereas the lowest (23.50 %) was found in 210 kg ha⁻¹ seed rate. At 60 DAS, the highest crude fiber (29.87 %) was achieved from 120 kg ha⁻¹ and the lowest (25.99%) was found in 210 kg ha⁻¹ seed rate.

At 50 DAS, the highest crude fiber (27.12 %) was achieved from @ 210 N kg ha⁻¹ while the lowest (21.69 %) was found no nitrogen kg ha⁻¹ nitrogen rate. At 60 DAS, the highest crude fiber (29.87 %) was achieved from @ 210 N kg ha⁻¹ and the lowest (24.82 %) was found no nitrogen kg ha⁻¹ nitrogen rate.

Table 6. Effect of seed rate on crude protein and crude fiber of wheat as fodder grown in the coastal saline soil of southwestern Bangladesh

Seed rate (kg ha ⁻¹)	Crude Protein (%)		Crude Fiber (%)	
	50 DAS	60 DAS	50 DAS	60 DAS
120	12.14a	9.40a	25.52a	29.87a
150	11.61b	8.86b	25.02b	28.11b
180	11.18c	8.43c	24.23c	27.03c
210	10.70d	8.12d	23.50d	25.99d
SEM (±)	0.08	0.08	0.11	0.09
P value	<0.01	<0.01	<0.01	<0.01
CV (%)	2.11	2.77	1.32	0.98

Here, SEM, and CV indicate the mean standard error and coefficient of variation. There is no significant variation with the values having similar letter (s) in a column whereas, dissimilar letter denotes statistically significant different.

Table 7. Effect of nitrogen rate on crude protein and crude fiber of wheat as fodder grown in the coastal saline soil of southwestern Bangladesh

Nitrogen rate (kg ha ⁻¹)	Crude Protein (%)		Crude Fiber (%)	
	50 DAS	60 DAS	50 DAS	60 DAS
No N added	9.87e	7.08e	21.69e	24.82e
105	11.04d	7.81d	23.33d	26.90d
140	11.68c	8.70c	24.53c	27.74c
175	12.00b	9.65b	26.19b	28.99b
210	12.43a	10.29a	27.12a	29.87a
SEM (±)	0.09	0.09	0.13	0.11
P value	<0.01	<0.01	<0.01	<0.01
CV (%)	2.11	2.77	1.32	0.98

Here, SEM, and CV indicate the mean standard error and coefficient of variation. There is no significant variation with the values having similar letter (s) in a column whereas, dissimilar letter denotes statistically significant different.

4.4.3 Ash

Ash content of wheat fodder was varied significantly with the use of different seed rate and N rate separately yet no significant effect was found due to their interaction. (Table 8 & Table 9).

At 50 DAS, the highest ash content (8.45%) was achieved from 120, kg ha⁻¹ whereas the lowest (7.76%) was found in 210 kg ha⁻¹ seed rate. At 60 DAS, the highest ash content (5.66%) was achieved from 120 kg ha⁻¹ and the lowest (4.95%) was found in 210 kg ha⁻¹ seed rate.

At 50 DAS, the highest ash content of (8.69 %) was achieved from @ 210 N kg ha⁻¹ while the lowest (7.38%) was found with no nitrogen treatment. At 60 DAS, the highest ash content (5.69%) was achieved from @ 210 N kg ha⁻¹ and the lowest (4.54%) was found from no nitrogen treatment.

Table 8. Effect of seed rate on ash and ether extract of wheat as fodder grown in the coastal saline soil of southwestern Bangladesh

Seed rate (kg ha ⁻¹)	Ash (%)		Ether Extract (%)	
	50 DAS	60 DAS	50 DAS	60 DAS
120	8.45 a	5.66 a	6.36 a	5.15 a
150	8.25 b	5.36 b	6.13 b	4.95 b
180	7.99 c	5.19 b	5.85 c	4.83 b
210	7.76 d	4.95 c	5.56 d	4.62 c
SEM (±)	0.07	0.07	0.0542	0.0578
P value	<0.01	<0.01	<0.01	<0.01
CV (%)	2.48	3.68	2.48	3.24

Here, SEM, and CV indicate the mean standard error and coefficient of variation. There is no significant variation with the values having similar letter (s) in a column whereas, dissimilar letter denotes statistically significant different.

4.4.4 Ether extract

Ether extract of wheat fodder at different cutting (50 and 60 DAS) was varied significantly with the effect of seed rate and nitrogen rate (kg ha^{-1}) and their interaction was not significant (Table 9 & Table 10).

At 50 DAS, the highest ether extract (6.36%) was achieved from 120 kg ha^{-1} whereas the lowest (5.56%) was found in 210 kg ha^{-1} seed rate. At 60 DAS, the highest ether extract (5.15%) was achieved from 120 kg ha^{-1} and the lowest (4.62%) was found in 210 kg ha^{-1} seed rate.

At 50 DAS, the highest ether extract (6.51%) was achieved from @ 210 N kg ha^{-1} while the lowest (5.24%) was found no nitrogen kg ha^{-1} nitrogen rate. At 60 DAS, the highest ether extract (5.32%) was achieved from @ 210 N kg ha^{-1} which was statistically at par (5.18%) with 175 kg ha^{-1} and the lowest (4.35%) was found no nitrogen kg ha^{-1} nitrogen rate.

Table 9. Effect of nitrogen rate on ash and ether extract of wheat as fodder grown in the coastal saline soil of southwestern Bangladesh

Nitrogen rate (kg ha^{-1})	Ash (%)		Ether Extract (%)	
	50 DAS	60 DAS	50 DAS	60 DAS
No N added	7.38 c	4.54 e	5.24 e	4.35 d
105	8.08 b	4.95 d	5.74 d	4.66 c
140	8.14 b	5.36 c	6.09 c	4.93 b
175	8.28 b	5.63 b	6.31 b	5.18 a
210	8.69 a	5.96 a	6.51 a	5.32 a
SEM ($\pm$)	0.08	0.07	0.06	0.06
P value	<0.01	<0.01	<0.01	<0.01
CV (%)	2.48	3.68	2.48	3.24

Here, SEM, and CV indicate the mean standard error and coefficient of variation. There is no significant variation with the values having similar letter (s) in a column whereas, dissimilar letter denotes statistically significant different.

4.4.5 Nitrogen concentration

Nitrogen concentration of wheat fodder at different cutting (50 and 60 DAS) was varied significantly with the effect of seed rate and nitrogen rate (kg ha^{-1}) and their interaction was not significant (Table 10& Table 11).

At 50 DAS, the highest nitrogen concentration (1.94 %) was achieved from 120 kg ha^{-1} whereas the lowest (1.71%) was found in 210 kg ha^{-1} seed rate. At 60 DAS, the highest nitrogen concentration (1.50 %) was achieved from 120 kg ha^{-1} and the lowest (1.30 %) was found in 210 kg ha^{-1} seed rate.

At 50 DAS, the highest nitrogen concentration (1.99 %) was achieved from @ 210 kg N ha⁻¹ while the lowest (1.58 %) was found from no nitrogen treatment. At 60 DAS, the highest nitrogen concentration (1.64 %) was achieved from @ 210 kg N ha⁻¹ and the lowest (1.13 %) was found from no nitrogen application.

Table 10. Effect of seed rate on nitrogen concentration and total nitrogen uptake of wheat as fodder grown in the coastal saline soil of southwestern Bangladesh

Seed rate (kg ha ⁻¹)	Nitrogen concentration (%)		Total nitrogen uptake (kg ha ⁻¹)	
	50 DAS	60 DAS	50 DAS	60 DAS
120	1.94 a	1.50 a	54.68c	57.24b
150	1.85 b	1.42 b	57.44bc	57.76b
180	1.79 c	1.35 c	60.18ab	59.41ab
210	1.71 d	1.30 d	62.88a	61.52a
SEM (±)	0.01	0.01	1.44	1.29
P value	<0.01	<0.01	<0.01	<0.01
CV (%)	2.13	2.73	6.73	5.99

Here, SEM, and CV indicate the mean standard error and coefficient of variation. There is no significant variation with the values having similar letter (s) in a column whereas, dissimilar letter denotes statistically significant different.

Table 11. Effect of nitrogen rate on nitrogen concentration and total nitrogen uptake of wheat as fodder grown in the coastal saline soil of southwestern Bangladesh

Nitrogen rate (kg ha ⁻¹)	Nitrogen concentration (%)		Total nitrogen uptake (kg ha ⁻¹)	
	50 DAS	60 DAS	50 DAS	60 DAS
No N added	1.58 e	1.13 e	18.23 e	19.70 e
105	1.76 d	1.24 d	47.37 d	45.56 d
140	1.87 c	1.39 c	68.68 c	63.91 c
175	1.92 b	1.54 b	75.15 b	77.23 b
210	1.99 a	1.64 a	84.54 a	88.53 a
SEM (±)	0.01	0.01	1.61	1.44
P value	<0.01	<0.01	<0.01	<0.01
CV (%)	2.13	2.73	6.73	5.99

Here, SEM, and CV indicate the mean standard error and coefficient of variation. There is no significant variation with the values having similar letter (s) in a column whereas, dissimilar letter denotes statistically significant different.

4.4.5. Total nitrogen uptake

Total nitrogen uptake of wheat fodder at different cutting (50 and 60 DAS) was varied significantly with the effect of seed rate and nitrogen rate (kg ha⁻¹) and their interaction was not significant (Table: 10 & Table 11).

At 50 DAS, the highest total nitrogen uptake (62.88 kg ha^{-1}) was achieved from 210 kg ha^{-1} which was statistically at par (60.18 kg ha^{-1}) with 180 kg ha^{-1} whereas the lowest (54.68 kg ha^{-1}) was found in 120 kg ha^{-1} seed rate. At 60 DAS, the highest total nitrogen uptake (61.52 kg ha^{-1}) was achieved from 210 kg ha^{-1} which was statistically at par (59.41 kg ha^{-1}) with 180 kg ha^{-1} and the lowest (57.24 kg ha^{-1}) was found in 120 kg ha^{-1} seed rate.

At 50 DAS, the highest total nitrogen uptake (84.54) was achieved from @ 210 N kg ha^{-1} while the lowest (18.23) was found no nitrogen kg ha^{-1} nitrogen rate. At 60 DAS, the highest total nitrogen uptake (88.53) was achieved from @ 210 N kg ha^{-1} and the lowest (19.70) was found no nitrogen kg ha^{-1} nitrogen rate.

4.5 Economics

4.5.1. Net income

Net income of wheat fodder at different cutting (50 and 60 DAS) was varied significantly with the effect of seed rate and nitrogen rate ha^{-1} and their interaction was not significant (Fig. 5A & 5B).

At 50 DAS, the highest total net income (27877.00 BDT) was achieved from 210 kg ha^{-1} which was statistically at par (16982.00 BDT) with 180 kg ha^{-1} whereas the lowest (5497.00 BDT) was found in 120 kg ha^{-1} seed rate. At 60 DAS, the highest total net income (37151.00 BDT) was achieved from 210 kg ha^{-1} which was statistically at par (30091.00 BDT) with 180 kg ha^{-1} and the lowest (18610.00 BDT) was found in 120 kg ha^{-1} seed rate.

At 50 DAS, the highest total net income (55038.00 BDT) was achieved from @ 210 kg N ha^{-1} which was statistically at par (48803.00 BDT) with 175 kg ha^{-1} while the lowest (-60767.00 BDT) was found no nitrogen kg ha^{-1} nitrogen rate. At 60 DAS, the highest total net income (70478.00 BDT) was achieved from @ 210 kg N ha^{-1} which was statistically at par (61453.00 BDT) with 175 kg ha^{-1} and the lowest (-56442.00 BDT) was found with no nitrogen application.

4.5.2. Benefit cost ratio

Separately, seed rate and N rate had significant influence on benefit cost ratio of wheat fodder at different days after sowing (DAS) but their interaction had no significant effect (Fig. 6A & 6B).

At 50 DAS, the highest total benefit cost ratio (1.29) was achieved from 210 kg ha^{-1} which was statistically at par (1.17) with 180 kg ha^{-1} whereas the lowest (1.05) was found in 120 kg ha^{-1} seed rate. At 60 DAS, the highest total benefit cost ratio (1.39) was achieved from 210 kg ha^{-1}

which was statistically at par (1.31) with 180 kg ha⁻¹ and the lowest (1.21) was found in 120 kg ha⁻¹ seed rate.

At 50 DAS, the highest total beneficial cost ratio (1.60) was achieved from @ 210 N kg ha⁻¹ while the lowest (0.25) was found no nitrogen kg ha⁻¹ nitrogen rate. At 60 DAS, the highest total beneficial cost ratio (1.77) was achieved from @ 210 N kg ha⁻¹ which was statistically at par (1.68) with 175 kg ha⁻¹ and the lowest (0.310) was found in no nitrogen application.

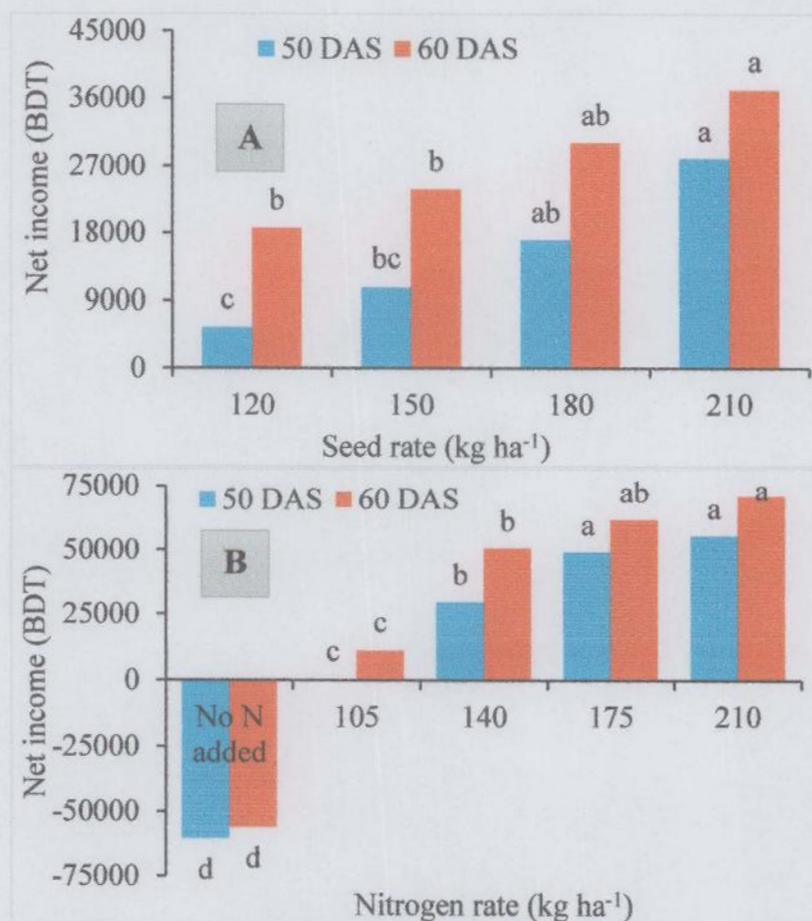


Figure 5. Effect of seed rate (A) and nitrogen rate (B) net income and benefit cost ratio of wheat as fodder grown in the coastal saline soil of southwestern Bangladesh

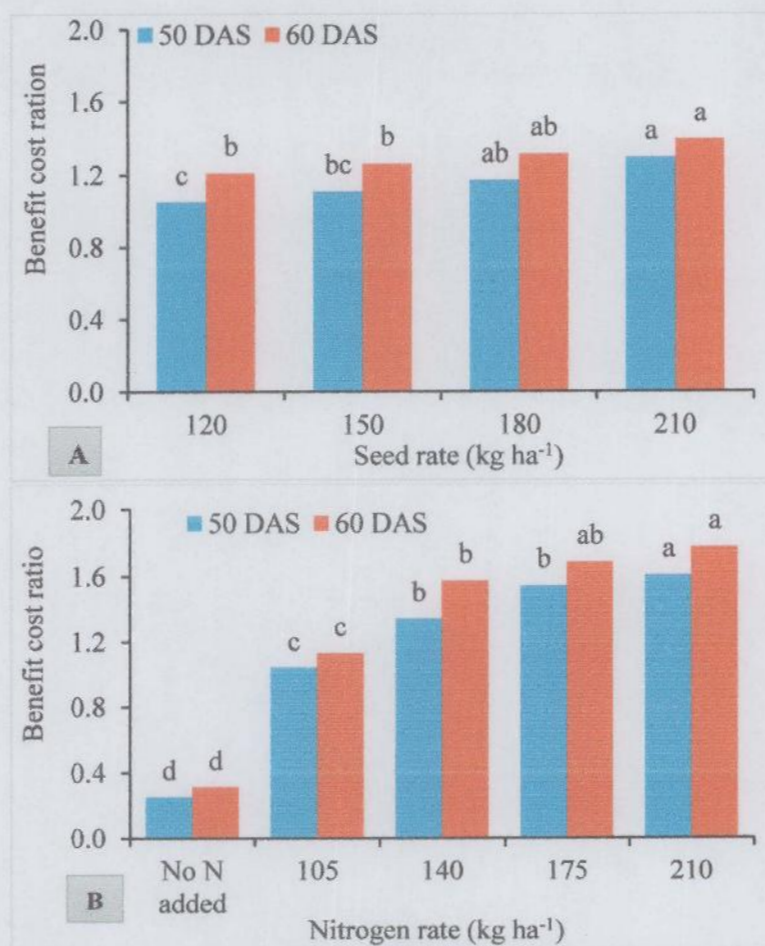


Figure 6. Effect of seed rate (A) and nitrogen rate (B) on Beneficial cost ratio of wheat as fodder grown in the coastal saline soil of southwestern Bangladesh

4.6. Effect of cutting age on biomass accumulation, quality attributes, net income and BCR

4.6.1. Biomass accumulation

Effect of seed and N rates, significantly the highest biomass accumulation (17.60 t ha⁻¹) was found in the 60 DAS cut while the lowest biomass accumulation (14.61 t ha⁻¹) was found in the 50 DAS cut.

4.6.2. Quality attributes

Regardless of seed and N rates, among the different cutting ages, significantly the highest ash content (9.58 %) crude protein (11.41 %) and Ether extract (5.98 %) were observed in 50 DAS cut and the highest crude fiber (27.67 %) achieved at 60 DAS cut whereas the lowest ash content (5.29 %) crude protein (8.71 %), and ether extract (4.89%) were found in the 60 DAS cut and lowest crude fiber (24.58 %) achieved at 50 DAS cut.

4.6.3. Net income and BCR

Regardless of seed and N rates among the various cutting ages, the net income (BDT 27412) and BCR (1.29) were significantly higher in the 60 DAS cut whereas the minimum net income and benefit-cost ratio were detected in the 50 DAS cut.

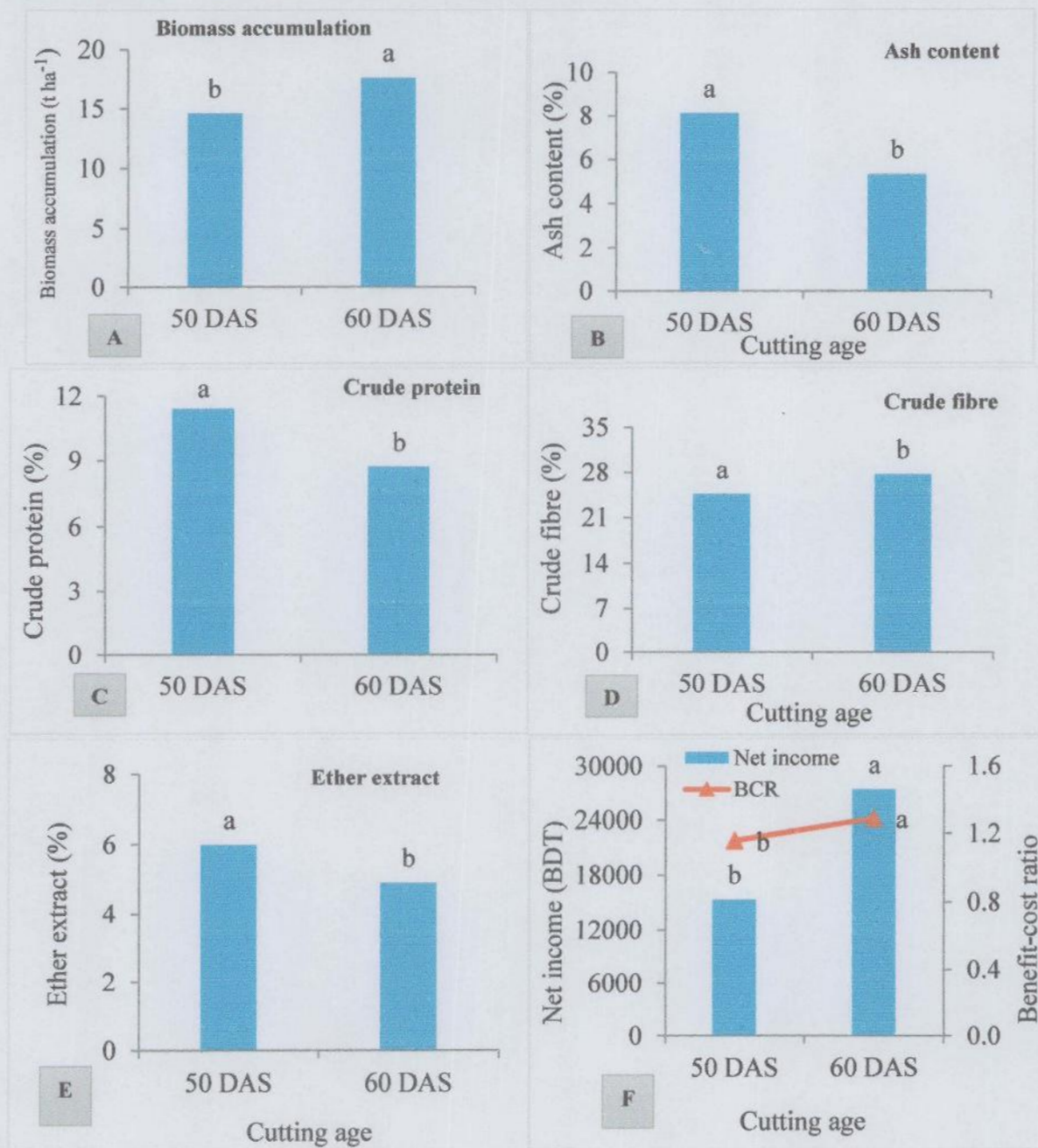


Figure 7. Effect of different cutting age on biomass yield (A), ash content (B), ether extract (C), crude fibre (D), crude protein (E), net income and benefit-cost ratio (F)

4.7 Functional relations of seed rate and N rate with biomass yield and quality attributes

4.7.1 Functional relationship between seed rate and fresh biomass yield of wheat fodder

There was a positive and significant relationship exist between seed rate and fresh biomass yield (Fig. 8). The higher the seed rate the higher the biomass accumulation. The linear relationship between seed rate and fresh biomass accumulation at 50 and 60 DAS could be clarified at 98% and 88%, respectively by the equation of $y = 0.0429x + 7.531$ and $y = 0.0307x + 12.8$, respectively.

4.7.2 Functional relationship between N rate and fresh biomass yield of wheat fodder

The relationship between N rate and fresh biomass accumulation was positively and significantly correlated (Fig. 9). The effect of N rate on fresh biomass accumulation could be explained by 99% and 97% with the equation of $y = 0.1048x + 4.3947$ and $y = 0.089x + 3.3936$ at 50 and 60 DAS, respectively.

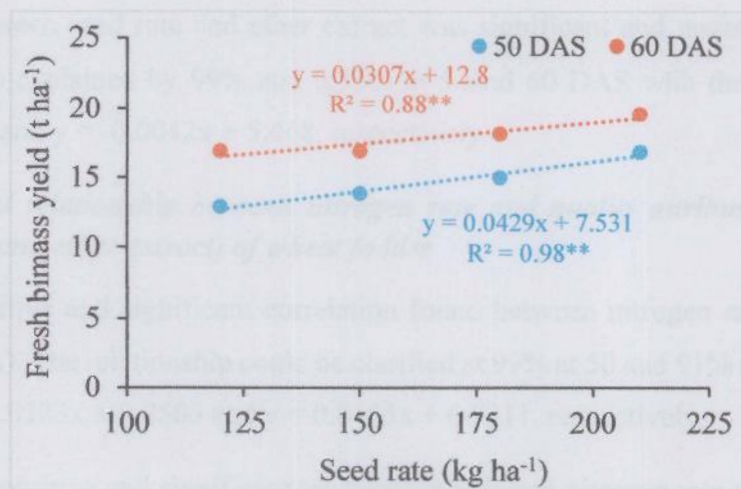


Figure 8. Functional relationship between seed rate and fresh biomass yield of wheat fodder

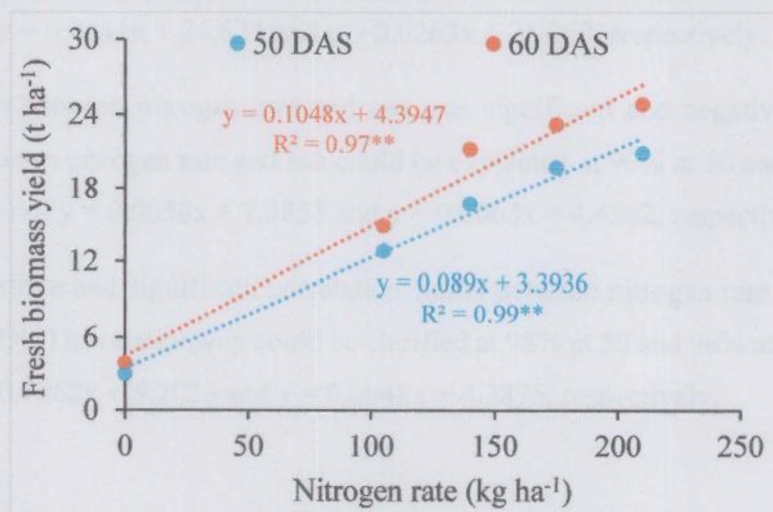


Figure 9. Functional relationship between nitrogen rate and fresh biomass yield of wheat fodder

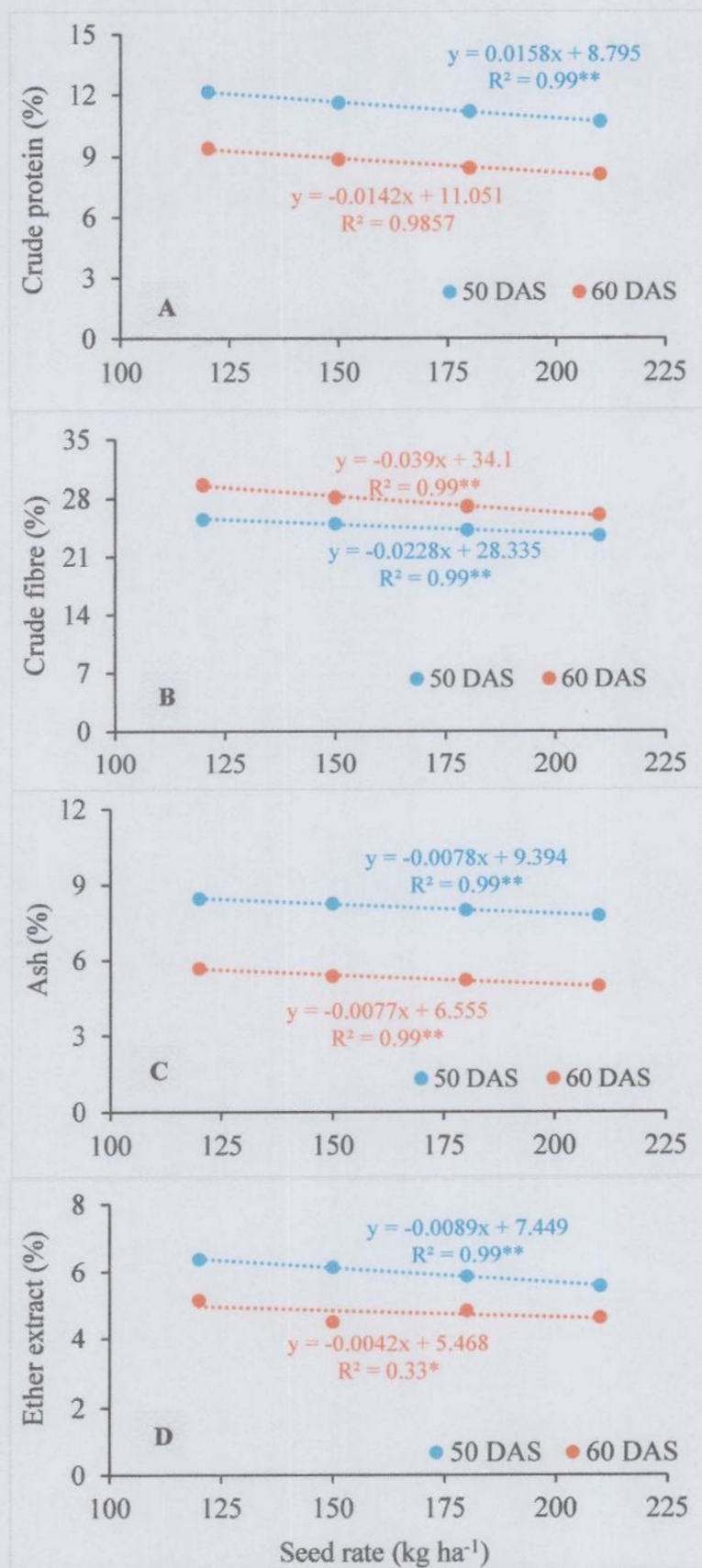


Figure 10. Functional relationship between seed rate with crude protein (A) crude fibre (B), ash (C) and ether extract (D) of wheat fodder

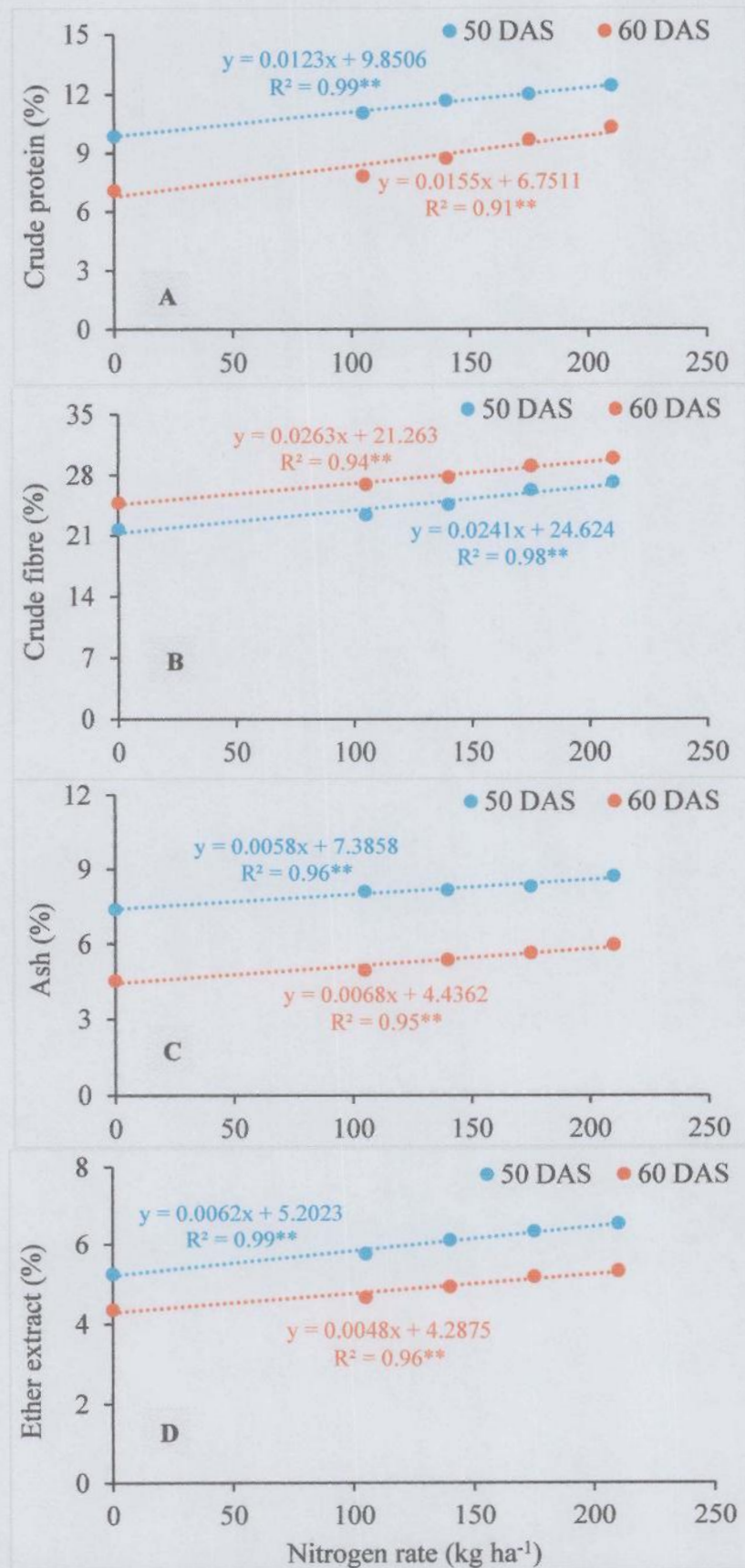


Figure 11. Functional relationship between nitrogen rate with crude protein (A) crude fibre (B), ash (C) and ether extract (D) of wheat fodder



CHAPTER V

DISCUSSION

The collected data from the experiment on different parameters of the study were discussed in this chapter under the following heading. Most of the parameters related to growth, yield and quality attributes showed significant variation with the different seed and nitrogen rates yet no significant for interaction effect. The possible explanation and justification of the results and the finding of the present research has been presented in this chapter.

Effect of seed rate on growth, biomass accumulation and quality of wheat fodder

Growth, biomass accumulation and quality attributes of wheat fodder significantly varied with the variation of seed rate. In this research, growth parameters (plant height and no. of tiller plant⁻¹) was higher due to the use of lower seed rate and significantly decreased with the increased of seed rate. The highest growth parameters in the lower seed rate means lower plant population unit⁻¹ area which facilitates better utilization of below (nutrient and water) and above ground (space and sunlight) resources whereas due to higher seed rate dense plant population compete for those resources that negatively affect plant growth (Erega et al., 2020; Sadig et al., 2014; Ayub et al., 2017). higher seed rate resulted in a decrease in productive tillers, consistent with the findings of Singh et al. (2000), who reported a decline in productive tillers per square meter with increased seed rates which was similar to findings of this study. Similar findings also noted by Reddy et al. (1976) that plant height tends to decrease as the seeding rate increases, highlighting the competition for light. (Reddy et.al.,1976)

The chlorophyll content of wheat fodder crops is greatly influenced with the seed rate. With a lower seed rate, reduced competition for essential resources such as sun light, water, and nutrients allow plants to grow more robustly, producing larger and greener leaves with elevated chlorophyll levels. On the other hand, a higher seed rate results in overcrowding, intensifying competition among plants. This heightened competition limits access to light and other resources, hindering photosynthesis and reducing chlorophyll synthesis, ultimately lowering the chlorophyll content index. Lower seed rates result fewer plant population unit⁻¹ area can get more inter plant spaces that enables to intercept more light, absorbed more nutrient resulting increased leaf chlorophyll content (Kilic and Gursoy, 2010; Jamaati et al., 2009).

The seed rate plays a critical role in fodder biomass accumulation, including fresh and dry weight. At a lower seed rate, plants experience less competition for resources like light, nutrients, and water, allowing individual plants to grow larger with higher biomass per plant. However,

overall biomass per unit area may decrease due to fewer plants. Conversely, a higher seed rate increases the plant population, which can enhance total biomass per unit⁻¹ area despite reduced biomass per plant due to competition. Excessively high seed rates may lead to overcrowding, resulting in stunted growth and lower biomass accumulation. Finding an optimal seed rate ensures maximum biomass yield by balancing plant density and resource availability. (Iqbal et al., 2009; Oad et al., 2004)

Dense planting reduces wheat fodder quality, affecting crude protein, crude fiber, ash, and ether extract due to competition for sunlight, water, and nutrients. Limited light hinders photosynthesis, lowering protein and energy compounds, while overcrowding increases crude fiber and reduces digestibility. Higher seed rates decrease stem diameter, whereas increased nitrogen enhances it. Additionally, a higher seed rate reduced the fresh weight of the plant and quality of fodder whereas an increase in nitrogen dose boosted the fresh weight and quality increases. Both dry matter yield and fodder yield showed an increase with higher seed rates and nitrogen levels. (Aslam et al., 2011)

Effect of seed rate on growth, biomass accumulation and quality of wheat fodder

Higher nitrogen rates enhance the growth characteristics of fodder, including plant height, stem thickness, and leaf area. Nitrogen rates significantly affected plant height ($p < 0.001$), with plant height increasing as nitrogen levels rose. Nitrogen application had a strong influence, and each incremental dose produced taller plants. These findings are consistent with those of (Zada et al 2000 and Iqbal et al, 2009) who reported that plant height increases with higher nitrogen doses. Similarly, (Sharar et al., 2003 and Ayub et al., 2017) observed an increase in oat plant height with nitrogen application

Nitrogen plays a critical role in influencing the chlorophyll content index (CCI) in plants. As an essential element in the chlorophyll molecule, nitrogen facilitates its synthesis, thereby promoting greener foliage and improved physiological function. Elevated nitrogen levels are generally associated with an increase in CCI, enhancing photosynthetic capacity and overall plant health. The maximum chlorophyll content (47.0) was recorded in plants treated with 275 kg N ha⁻¹. The increasing chlorophyll levels with higher nitrogen application indicate that fodder maize plants efficiently assimilate nitrogen, resulting in enhanced leaf greenness (Ayub et al., 2007; Hassan et al., 2010).

Nitrogen application significantly enhances biomass yield and quality attributes of fodder, including crude protein (CP), crude fiber (CF), ash, and ether extract (EE). Nitrogen promotes

cell division, leaf area expansion, and chlorophyll synthesis, leading to increased photosynthesis and plant growth, which collectively boost biomass production, in plant height with higher nitrogen doses indicates that plants effectively utilized nitrogen during active cell division to synthesize proteins, which are crucial for cell elongation (Iqbal et al., 2006). Crude protein content rises with nitrogen due to improved nitrogen assimilation in plants. However, excessive nitrogen may elevate crude fiber, reducing digestibility. Nitrogen also influences ash and ether extract levels, The linear increase in crude protein percentage with rising nitrogen levels can be attributed to nitrogen's role as a vital component of protein molecules and a fundamental building block of amino acids. A comparable trend was reported by Aslam et al. (2011) at the highest nitrogen application rates. contributing to overall forage quality. Optimal nitrogen management is essential to balance yield and quality in fodder crops.

Effect of cutting age on biomass accumulation and quality of wheat fodder

The cutting age plays a crucial role in determining the biomass accumulation and quality of wheat fodder. Harvesting at 50 DAS (Days After Sowing) produces younger fodder with higher crude protein content but a lower overall biomass yield compared to harvesting at 60 DAS. On the other hand, cutting at 60 DAS results in greater biomass production due to extended vegetative growth, though it may slightly reduce protein content and increase fiber, potentially impacting digestibility. Balancing these trade-offs is vital for optimizing fodder production, particularly in the coastal southern region of Bangladesh. (Suhartanto et al.,2020; Bulcha et al., 2022) cutting age significantly influenced ($P<0.05$) plant height, plant length, leaf width, ether extract, crude fiber, crude protein, and total digestible nutrients. Crude protein content was notably higher ($P<0.05$) at the 6-week cutting stage compared to the 8-week stage. The results indicate that growth and yield tend to reduce during the second ratoon phase. Furthermore, as plants age, both growth and crude fiber content show an upward trend

CHAPTER VI

SUMMARY, CONCLUSION AND RECOMMENDATION

Farmers of the southwestern coastal region of Bangladesh cannot cultivate all types of seasonal fodder in the *rabi* season because of excessive soil wetness during the owing/planting time, soil scarcity of fresh irrigation water. At these circumstances, wheat has high potentiality for cultivation in this coastal region as fodder because of easy adaptation, early maturity, adaptability to wide range of climate and soil conditions, photo and thermos insensitiveness, drought tolerance, easy management, and good economic performance. But still now the productivity of wheat is lower in this area compared to the standard. The low productivity is mainly due to the crop growing under on poor fertilizer management of soil, salinity, and inadequate plant protection measure. Besides, there is know there is no recommended dose of nitrogen and fertilizer in this region for wheat production. At this situation, the experiment was conducted at Pankhali, Dacope, Khulna during *rabi* season of January 2024 to march 2024 with a view to study the effect of different seed rate and N rate on quality and biomass production of wheat as a fodder in the costal saline soil of southwestern region. The experiment was laid out in randomized complete block design having net plot size (4.0 m x 2.5 m) with three replications (R1, R2 and R3) and twenty treatment combinations. Results from this experiment indicate the wheat fodder production response to N and seed rate. All the growth parameter, biomass yield and fodder quality attributes significantly increased with the increase of N rate while in case of seed rate biomass accumulation was improved with the use of higher seed rate but growth parameters and quality attributes substantially declined with the higher seed rate.

At 60 DAS, the highest plant height (66.44 cm) was found in the 120 kg seed ha⁻¹ treatment and the highest plant height (71.38 cm) was found in @ N 210 kg ha⁻¹. The highest leaf chlorophyll content index (41.20) was found in the 120 kg seed ha⁻¹ treatment and the highest leaf chlorophyll content index (43.77) was found in @ N 210 kg ha⁻¹. The highest biomass accumulation on fresh weight basis (66.44 t ha⁻¹) was found in the 120 kg seed ha⁻¹ treatment and the highest biomass accumulation fresh weight basis (71.38 t ha⁻¹) was found in @ N 210 kg ha⁻¹. The highest biomass accumulation dry weight basis (66.44 t ha⁻¹) was found in the 120 kg seed ha⁻¹ treatment and the highest biomass accumulation on dry weight basis (71.38 t ha⁻¹) was found in @ N 210 kg ha⁻¹. The highest crude fiber (29.53%) was found in the 120 kg seed ha⁻¹ treatment and the highest crude fiber (29.87%) was found in @ N 210 kg ha⁻¹. The highest total nitrogen uptake (57.24 kg ha⁻¹) was found in the 120 kg seed ha⁻¹ treatment and the highest total nitrogen uptake (88.53 kg ha⁻¹) was found in @ N 210 kg ha⁻¹. The highest total nitrogen uptake (88.53) was found @210

kg N ha⁻¹. the highest total net income (37151.00 BDT) was achieved from 210 kg ha⁻¹ seed rate and the highest total net income (70478.00 BDT) was achieved from @ 210 N kg ha⁻¹. The highest total benefit cost ratio (1.39) was achieved from 210 kg ha⁻¹ and the highest benefit cost ratio (1.77) was achieved from @ 210 N kg ha⁻¹

At 50 DAS, the highest tiller number (2.37) was found in the 120 kg seed ha⁻¹ treatment and the highest tiller number (2.67) was found in @ N 210 kg ha⁻¹. The highest crude protein (12.14%) was found in the 120 kg seed ha⁻¹ treatment and the highest crude protein (12.43%) was found in @ N 210 kg ha⁻¹. The highest ash (8.45%) was found in the 120 kg seed ha⁻¹ treatment and the highest ash (8.69%) was found in @ N 210 kg ha⁻¹. the highest ether extract (6.36%) was found in the 120 kg seed ha⁻¹ treatment and the highest ether extract (6.51%) was found in @ N 210 kg ha⁻¹. The highest nitrogen concentration (1.94 %) was found in the 120 kg seed ha⁻¹ treatment and the highest nitrogen concentration (1.99 %) was found in @ N 210 kg ha⁻¹. The highest total nitrogen uptake (62.88 kg ha⁻¹) was found in the 210 kg seed ha⁻¹ treatment.

Conclusion

From the results of this experiment and relevant discussion, it could be concluded that application of N @ 175-210 kg ha⁻¹ and using of 180-210 kg seed ha⁻¹ with early cut (50 DAS) was formed to be best for wheat fodder cultivation under zero tillage condition in the coastal saline soil of southwestern Bangladesh.

Recommendations

However, to reach a specific conclusion, it is recommended that-

- For better understanding and confirmation of the results the experiment needs to be repeated at least one more year using more farmers.
- The experiment should be trialed in different locations of the southwestern coastal region.



CHAPTER VII

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APPENDICES

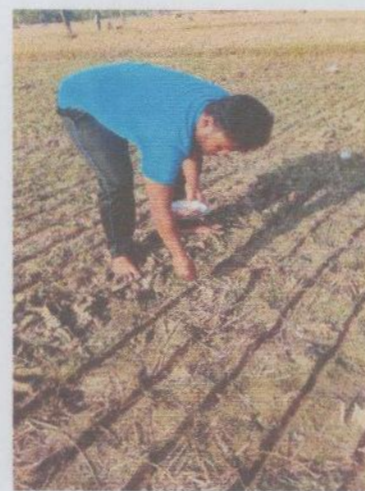
Photographic Presentation of the study



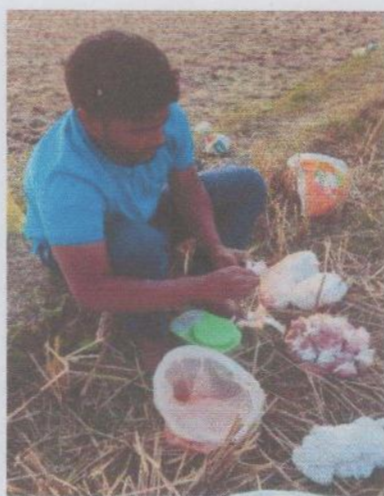
Harvest of previous crop



Furrow making



Seed sowing



Fertilizer weighing



Emergence of seedlings



SPAD reading

Photograph 1. Pictorial view of different management practices in the experimental field



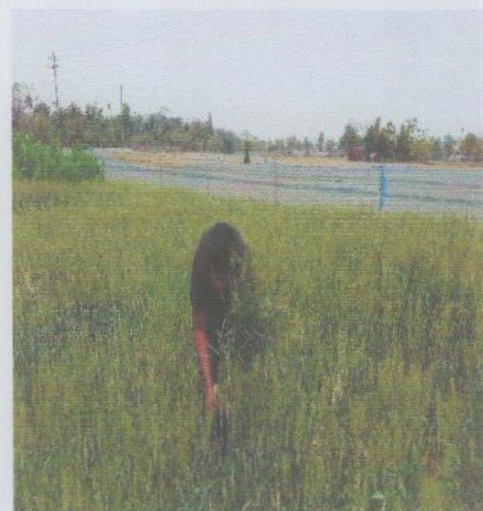
Split application of urea



Field irrigation



Crop at early vegetative stage



Fodder harvesting

Photograph 2. Pictorial view of different management practices in the experimental field