Comment [WU1]: Similarity index report???

Original Research Article

Combined Effect of Nitrogen Fertilization and Seeding Rate on Regional Wheat Yield and Yield Components

Comment [WU2]: In what agro ecological condition??

Comment [WU3]: Name of the country???

ABSTRACT

Seed rate and nitrogen fertilization are two main critical factors that affect wheat (*Triticum aestivum* L.) growth and yield. But a little knowledge on the interaction effects of these two factors in wheat cultivation under course, strong acidic nutrient deficit soil condition aimed us to conduct this research. We grew wheat at the field laboratory of the department of Agronomy and Haor Agriculture, Sylhet Agricultural University, Sylhet-3100, Bangladesh, during crop growing period (November-March) of wheat 2021-2022 with split plot design assigning seed rate (100, 120, 140 & 160 kg ha^{-1}) in main plot and nitrogen fertilizer (0, 120, 140, 160 & 180 kg ha^{-1}) in sub plot. We have found that, the maximum grain yield (2.96 t ha^{-1}) was obtained at 140 kg ha^{-1} and 160 kg ha^{-1} seeding rate and nitrogen fertilization respectively. Whereas, the minimum grain yield (1.51 t ha^{-1}) was recorded in control treatment (100 kg ha^{-1} seed with zero nitrogen). The highest value of the entire yield contributing parameters i.e. effective tillers $plant^{-1}$ (2.87), spike length (14.72 cm), spikelet $spike^{-1}$ (17.00), florets $spike^{-1}$ (52.33), grain $spike^{-1}$ (51.00) and 1000 seed weight (42.63 g) were recorded at 140 kg ha^{-1} and 160 kg ha^{-1} seeding rate and nitrogen fertilization respectively and the values were increased with the increase of seeding rate and nitrogen fertilization rate upto 140 kg ha^{-1} and 160 kg ha^{-1} respectively then declined. The growth parameter i.e. plant height (114.07 cm) increased with the increase of nitrogen fertilization upto 180 kg ha^{-1} and the minimum value (54.10 cm) was recorded at control treatment.

Keywords: Wheat, Seed Rate, Nitrogen Fertilizer, Growth and Yield

1. INTRODUCTION

Comment [WU4]: Back ground of research???

Wheat (*Triticum aestivum* L.) is a major cereal crop, produced 778.6 million tons in an area of more than 220 million ha of land by 2021, ranked first in terms of production worldwide [1]. In Bangladesh, wheat is considered as second most important cereal crop after rice produced 1.09 million tons in an area of 812805 acres of land [2]. World wheat production depends on genotypes [3], environmental conditions as well as management practices including nitrogen fertilization, seeding rates, water application, sowing time and their combined interactions [4, 5, 6, 7]. Nitrogen fertilization, as per recommended doses and methods, is very crucial for crop production as well as soil and environmental health [8,7]. However, over fertilization of nitrogenous fertilizer may increase 23-60% nitrous oxide (N_2O, a greenhouse gas) emission by 2030 [9, 10] which may have negative impact on crop growth and development, soil and environmental health [11, 7]. Therefore, appropriate rate of nitrogen fertilization is very essential in wheat cultivation to reduce leaching loss and correlated environmental hazard with better crop growth and development.

Comment [WU5]: What about other macro & micro nutrients????

Moreover, seeding rate along with nitrogen fertilization is another crucial factor regulates successful implementation of crop production in wheat production system [12, 5]. Very high to low seeding rates abate the potentiality of obtaining full yield of specific genotype of wheat [13, 14, 15]. An increased yield response [14, 15] or optimum yield response [16] was found with the increase of seeding rate in wheat. High seeding rate increases overall cost of production but minimize the risk of reducing yield associated with lower seeding rate [17]. However, Fang et al. [18] reported a negative yield response with increased seeding rate. A mixed response of seeding rate on grain yield of wheat demands more specific research combined with nitrogen fertilization.

Comment [WU6]: Seeding rate depend upon cultivar potential about tillering &its nature???

In Bangladesh, fertilization in wheat is largely depends on the soil analysis interpretation ranged from very low to optimum soil nutrient content [19]. Very low nutrient content soil demands high amount of fertilizer supplementation in contrast optimum. Our study area, Sylhet region, is a very important agricultural production area in Bangladesh includes two major Agro Ecological Zones i.e. Surma-Kushiyara Flood Plain (AEZ-20) and Sylhet Basin (AEZ-21). Strong soil acidity, heavy soil texture and deficient nutrient status of soils are the main obstacles of crop production in this area. High soil acidity adversely affects crop production in two ways: directly by its acidify effects and indirectly through reducing nutrient availability for crops. However, fertility status of this area is medium to high with very low to low concentration of nitrogen and medium to low concentration of phosphorus [19]. So, our hypothesis is that high amount of nitrogen fertilization then the optimum recommendation will be required for better growth and yield of wheat in this region. Along with this, the higher seeding rate then the optimum will provide better yield. With this regards, our study was conducted to evaluate the optimum seeding rate and nitrogen fertilizer level for wheat production in sylhet region.

2. MATERIAL AND METHODS

The experiment, to observe the effect of seeding rates and different doses of nitrogen, was conducted at the field laboratory of the department of Agronomy and Haor Agriculture, Sylhet Agricultural University, Sylhet-3100, Bangladesh, during crop growing period (November-March) of wheat 2021-2022. A recognized drought resistant variety BARI Gom-28 seeds were obtained from Bangladesh Wheat and Maize Research Institute (BWMRI) and sown at seeding rates of 100, 120, 140 and 160 kg ha^{-1} with five nitrogen (N) levels of 0, 120, 140, 160 and 180 kg N ha^{-1} to fulfill the objectives of the current study. The experiment was laid out in split plot arrangement placing seeding rate in main plot and fertilizer doses in sub plots with three replications. The total number of experimental plot was 60 (5 × 4 × 3). The size of each sub plot was 6 m^2 (3.0 m x 2.0 m). Seed bed was prepared by ploughing the field for 3 times followed by laddering. The field was fertilized with P, K, S, Zn and B at the rate of 40-120-20-1.5-1.5 kg ha^{-1} [19] including N in the form of triple super phosphate (TSP), muriate of potash (MoP), gypsum, zinc sulphate , boric acid, and urea respectively. The whole amount of P, K, S, Zn, B and half of N were incorporated in the soil at the time of final land preparation in each plot. The remaining amount of N was top dressed at 20 days after emergence of seedlings. Wheat crop seed was sown manually by maintaining row to row distance of 25 cm. All experimental plots received uniform cultural practices other than treatments. Data on yield and its different contributing components were recorded as per recommended procedure. The recorded data were analyzed statistically by using statistical software package R (version 3.13.2). The difference among the treatment means was estimated by LSD (Least Significance Difference) test at 5% level of probability wherever F values were found significant.

3. RESULTS AND DISCUSSION

3.1 Plant height:

The results of our study showed that, plant height was statistically influenced by different seeding rates and nitrogen level (N) (Table 1). The tallest plant (95.81 cm) was recorded at the seeding rate 160 kg ha^{-1} and gradually decreased 77.77 cm, 69.89 cm and 62.53 cm with the decreased of seeding rate i.e. 140 kg ha^{-1}, 120 kg ha^{-1} and 100 kg ha^{-1} respectively (Table 2). Nitrogen has also showed noticeable effect on plant height. Results indicated that plant height increased sharply with the increment of N levels. The tallest plant (81.01 cm) was produced by the treatment N_3 (160 kg ha^{-1}) while the smallest one (64.53 cm) recorded in N_0 (control) treatment (Table 3). The interaction effect of these two variables was found significantly correlated with each other (Table 4). Moreover, at 140 kg ha^{-1} seeding rate with a combination of 160 kg ha^{-1} N level produced the taller plant in our study. However, our result of seeding rate is in a contradiction with some other previous findings [13, 20], suggesting that 125 kg ha^{-1} seeding rate produced the tallest plant. The course soil texture, strong acidity and nutrient deficit soil condition in our study region could contribute high seeding rate in wheat cultivation. Additionally, the results of N level is in a coordination with Iqbal et al. [20] Bhatta et al. [15] and Wang et al. [7] suggesting that increased N application impact on high photosynthesis rate thus provided the higher biomass accumulation and distribution which contributed on higher plant height.

3.2 Effective tillers plant^{-1}:

Vegetative growth in the form of tillers is very crucial to final yield in wheat (*Triticum aestivum* L.) [21]. In wheat, numbers of effective tillers per plant is influenced by seeding rate and nitrogen levels [20]. However, the highest number of tillers (2.60) was recorded at 140 kgha^{-1} seeding rate while less number of tillers (2.28) was observed at 100 kg ha^{-1} which was statistically similar with S_3 treatment where 160 kg ha^{-1} seed rate was applied (Table 2). Number of tillers was also affected by nitrogen fertilization (Table 1). Maximum numbers of tillers were produced by the nitrogen level of 160 kg ha^{-1} followed by 140 kg ha^{-1} and 120 kg ha^{-1} (Table 3) which was statistically similar to each other. At control treatment, the minimum numbers of tillers (2.20 tillers Plant^{-1}) were recorded where no nitrogen fertilizer was applied. However, the result of effective tiller per plant indicated a positive interaction effect between seeding rate and nitrogen fertilization. More number of tillers was recorded at S_2N_3 treatment combination where 160 kg ha^{-1} nitrogen was applied along with 140 kg ha^{-1} seed rate. Sarker et al. [22] reported that the number of spikes per unit area was increased with the increase in seed rate upto 140 kg ha^{-1} and the increasing rate of spikes per unit area was less compared to increasing rate of plant population. Increase in number of tillers per unit area is due to increased seeding rate [20]. Nitrogen doses also contributed in increasing tiller production up to an optimum level [23, 24, 25, 20] and above optimum, tillers number is decreased due to the competition for space.

3.3 Spike length (cm):

The spike length is significantly affected by seed rate and N level (Table 1). The longest spike 12.61 cm was recorded at 140 kg ha^{-1} seed rate followed by 160 kg ha^{-1} while the shortest one 6.97 cm was recorded at 100 kg ha^{-1} seed rate (Table 2). Nitrogen fertilizer also significantly influenced the spike length. Longer spike length was observed at the nitrogen level of 160 kg ha^{-1} followed by 180 kg ha^{-1} and 140 kg ha^{-1} while the shorter one (8.29 cm) was observed at control (100 kg ha^{-1}) treatment (Table 3). Spike length increased sharply with increasing N level up to a certain level then declined with further increased. This result was in line with the results of Sushila & Gajendra [26] and Asif et al. [27]. The interaction

Comment [WU7]: Plant height dependence upon canopy ??? & tillering capacity???

Comment [WU8]: Why, give reason???

Comment [WU9]: Tillering capacity depend upon space ???? this data about number of tillres per pliant or per m2???

Comment [WU10]: Tillering capacity of a plant you may know when you knew about number of seeds sown or maintain plant population in the plot according to seeding rate????

Comment [WU11]: It provide axis for seed setting???role of genotype??? & plant population???

between seed rate and nitrogen was found significant (Table 4). Longest spike (14.27) was found at 140 kg seed rate in a combination with 180 kg ha^{-1} N and shortest one (5.92 cm) from 100 kg seed rate with zero level of nitrogen.

3.4 Spikelet's $spike^{-1}$:

Comment [WU12]: Need more discussion

As like spike length, spikelet's $spike^{-1}$ was also significantly influenced by different seed rate and N labels (Table 1). Maximum number of spikelet's $spike^{-1}$ (14.73) was observed at seeding rate 140 kg ha^{-1} followed by 160 kg ha^{-1} and 120 kg ha^{-1} while the minimum (9.33) was observed at 100 kg ha^{-1} seed rate (Table 2). Nitrogen fertilizer significantly influenced the spikelet's $spike^{-1}$. Highest number of spikelet's spike (14.25) was noted in 160 kg ha^{-1} followed by 180 kg ha^{-1} N (13.00), while the lowest number (10.58) in control treatment. Nitrogen fertilizer and seed rate had significant effects on the number spikelet's spike (Table 4). Highest value of number of spikelet's $spike^{-1}$ (17.00) was recorded when 160 kg ha^{-1} N and140 kg ha^{-1}seed rate was used in S_2N_3 treatment combination while less value was noted viz. 8.00 for number of spikelet's $spike^{-1}$ when no nitrogen (control) and 100 kg ha^{-1} was used in S_0N_0 treatment combination. Although, our findings is favorably compared with the previous findings of Islam et al. [25] and Iqbal et al. [20], but a contrast finding that spikelet's $spike^{-1}$ is increased with the increase of seeding rate [28].

3.5 Floret's $spike^{-1}$:

Results showed the maximum number of floret's $spike^{-1}$ (44.87) 140 kg ha^{-1} seeding rate followed by 160 kg ha^{-1} and 120 kg ha^{-1} while the minimum (26.87) was observed at 100 kg ha^{-1} seed rate (Table 2). Additionally, 160 kg ha^{-1} N level produced the highest number of floret's $spike^{-1}$ (41.42) followed by 180 kg ha^{-1} N (37.58) which was statistically similar with 140 kg ha^{-1} N (37.17) .On the other hand, the lowest number of floret's $spike^{-1}$ (31.75) was recorded in zero label of nitrogen application. The variables like seeding rate, nitrogen fertilization and interaction between them were found statistically significant (Table 4).

3.6 Grains $spike^{-1}$:

Grains $spike^{-1}$ is an important yield contributing attribute to the ultimate grain return of wheat crop. Number of grains $spike^{-1}$ was statistically influenced by all the variables i.e. seeding rate, nitrogen levels and interaction between them (Table 1). The maximum number of grains (51.00) $spike^{-1}$ were observed in seeding rate of 140 kg ha^{-1} in a combination with 160 kg ha^{-1} N level while the lowest number of grains (17.00) $spike^{-1}$ were recorded in zero level of nitrogen at 100 kg ha^{-1} of seeding rate (Table 4). However, the result showed that, after 160 kg ha^{-1} N level the grain $spike^{-1}$ reduced significantly because of detrimental effect of excessive application of N in wheat cultivation [19]. This result can be compliant with the results of Mozumder [29], Ali et al. [30] and Iqbal et al. [20], found significant effect of seeding rate and N levels on grains $spike^{-1}$. Additionally, Islam et al. [25] obtained maximum grains $spike^{-1}$ at 170 kg N ha^{-1}.

Comment [WU13]: Why ??? give reasons

3.7 Thousand-grains weight:

Comment [WU14]: Need more discussion

As like as grains $spike^{-1}$, grain weight is also an important yield contributing character. We measured grain weight in the form of random 1000 grains from harvested wheat for various treatments. The obtained 1000 grains weights were statistically significant for seeding rate

Table 1: Mean square values of different yield and yield components of wheat

Source of variance	df	Plant height (cm)	Effective tillers plant^{-1}	Spike length (cm)	Spikelet's spike^{-1}	Florets spike^{-1}	Grain spike^{-1}	1000 grain weight (g)	Grain yield (t ha^{-1})	Biological yield (t ha^{-1})
Seed rates	3	3065.8***	0.352**	92.33***	85.53***	925.0***	1096.6***	11.44*	2.80***	18.49***
Nitrogen levels	4	844.8***	0.303***	25.00***	24.53***	161.3***	179.73***	10.62^{NS}	0.186***	1.45***
S×N	12	52.3***	0.953**	0.937***	0.569*	3.6***	7.26***	16.91***	0.05***	0.267***
Error	32	9.9	0.025	0.120	0.233	0.4	1.33	4.05	0.011	0.062

Table 2: Effect of seeding rates on yield and yield components of wheat

Treatments (Kg ha^{-1})	Plant height (cm)	Effective tillers plant^{-1}	Spike length (cm)	Spikelet's spike^{-1}	Florets spike^{-1}	Grain spike^{-1}	1000 grain weight (g)	Grain yield (t ha^{-1})	Biological yield (t ha^{-1})
S_0	62.53d	2.28c	6.97d	9.33d	26.87d	23.07	38.00c	1.67c	4.32c
S_1	69.89c	2.44b	9.25c	11.47c	33.67c	31.53c	38.67bc	2.49b	6.37b
S_2	77.77b	2.60a	12.61a	14.73a	44.87a	43.27a	40.05a	2.64a	6.81a
S_3	95.81a	2.28c	11.40b	13.60b	40.27b	36.87b	39.29ab	2.42b	6.30b
LSD (*P*=.05)	6.16	0.15	0.63	0.71	1.57	1.94	1.05	0.086	0.260

Table 3: Effect of nitrogen levels on yield and yield components of wheat

Treatments (Kg ha^{-1})	Plant height (cm)	Effective tillers plant^{-1}	Spike length (cm)	Spikelet's spike^{-1}	Florets spike^{-1}	Grain spike^{-1}	1000 grain weight (g)	Grain yield (t ha^{-1})	Biological yield (t ha^{-1})
N_0	64.53e	2.20d	8.29e	10.58e	31.75d	28.42d	38.58	2.14c	5.49d
N_1	72.68d	2.38bc	9.04d	11.33d	34.17c	31.58c	39.18	2.25b	5.74c
N_2	77.66c	2.48b	10.25c	12.25c	37.17b	34.67b	37.73	2.38a	6.09b
N_3	86.61a	2.61a	11.97a	14.25a	41.42a	38.67a	39.23	2.46a	6.40a
N_4	81.01b	2.31cd	10.74b	13.00b	37.58b	35.08b	40.28	2.30b	6.03b
LSD (*P*=.05)	2.62	0.13	0.29	0.40	0.53	0.96	1.67	0.085	0.21

Table 4: Effect of seeding rates and nitrogen levels on yield and yield components of wheat

Seed rates (kg ha^{-1})	Nitrogen levels (Kg ha^{-1})	Plant height (cm)	Effective tillers plant^{-1}	Spike length (cm)	Spikelet's spike^{-1}	Florets spike^{-1}	Grain spike^{-1}	1000 grain weight (g)	Grain yield (t ha^{-1})	Biological yield (t ha^{-1})
S_0	N_0	54.10m	1.93i	5.92p	8.00k	22.00l	17.00m	36.77de	1.51k	3.93k
	N_1	60.20l	2.27fgh	6.41p	8.67jk	25.00k	21.00l	36.90de	1.61jk	4.14jk
	N_2	65.87kl	2.27fgh	7.05o	9.33ij	27.67j	24.00k	37.40cde	1.72ij	4.41ij
	N_3	66.43ijk	2.67abc	8.20lm	10.67gh	30.33h	26.67j	39.47abcd	1.84i	4.79i
	N_4	66.07jk	2.27fgh	7.28no	10.00hi	29.33hi	26.67j	39.47abcd	1.68ijk	4.34jk
S_1	N_0	61.27kl	2.13ghi	7.83mn	10.00hi	29.00i	25.00jk	35.73e	2.27h	5.77h
	N_1	66.33jk	2.40def	8.57kl	10.67gh	31.67g	30.00i	37.73cde	2.42fgh	5.17fgh
	N_2	71.47hi	2.53cde	9.20ij	11.67ef	34.67f	32.67h	37.80cde	2.59cde	6.57def
	N_3	76.83fg	2.80ab	10.95ef	13.00cd	38.00e	36.33ef	40.00abcd	2.77b	7.07bc
	N_4	73.53gh	2.33efg	9.71hi	12.00ef	35.00f	33.67gh	42.07ab	2.41fgh	6.29efg
S_2	N_0	65.00kl	2.47cdef	10.43fg	13.00cd	40.33d	39.00cd	39.63abcd	2.42fgh	6.17fgh
	N_1	71.10hi	2.53cde	11.30e	13.67c	42.33c	40.67c	39.93abcd	2.47efg	6.31efg
	N_2	78.83f	2.53cde	13.26c	14.67b	44.67b	43.00b	37.60cde	2.65bcd	6.76cd
	N_3	89.10de	2.87a	14.72a	17.00a	52.33a	51.00a	42.63a	2.96a	7.62a
	N_4	84.80e	2.60bcd	13.32c	15.33b	44.67b	42.67b	40.43abc	2.71bc	7.21ab
S_3	N_0	77.77fg	2.27fgh	8.98jk	11.33fg	35.67f	32.67h	42.17ab	2.35gh	6.10gh
	N_1	93.10cd	2.33efg	9.87gh	12.33de	37.67e	34.67fg	42.17ab	2.49def	6.34defg
	N_2	94.47bc	2.60bcd	11.48e	13.33c	41.67c	39.00cd	38.10cde	2.57cde	6.63de
	N_3	114.07a	2.13ghi	14.03b	16.33a	45.00b	40.67c	34.80e	2.28h	6.13gh
	N_4	99.63b	2.07hi	12.63d	14.67b	41.33cd	37.33de	39.17bcd	2.38gh	6.30efg
	LSD (*P*=.05)	5.23	0.26	0.58	0.80	1.05	1.92	3.35	0.171	0.41

and interaction factors but non-significant for N levels (Table 1). The highest heaviest grains weight (40.05 g) was observed at seeding rate of 140 kg ha^{-1}, which was statistically similar with the seeding rate 160 kg ha^{-1} while lowest grains weight (38.00 g) was recorded at 100 kg ha^{-1} Seeding rate (Table 2). Although, the effects of nitrogen fertilization was insignificant but had noticeable difference on 1000-seeds weight which might lead significant difference in interaction. The 140 kg ha^{-1} seeding rate in a combination with 160 kg ha^{-1} N level contributed the height grain weight in our study (Table 4). The result indicated that the 1000 grain weight is increased with the increase of N level [31, 30] and seeding rate [32, 20].

3.8 Grain yield:

Seed yield is the ultimate outcome of its unique yield attributes in response to nitrogen levels and seeding rate of the crop. We found that the final outcome was statistically influenced by seeding rate, nitrogen fertilization and interaction between them. The highest grain yield (2.96 t ha^{-1}) was recorded in 140 kg ha^{-1} seeding rate plus 160 kg ha^{-1} nitrogen fertilization treatment. However, the individual 140 kg ha^{-1} seeding rate and 160 kg ha^{-1} nitrogen fertilization produced 2.64 t ha^{-1} and 2.46 t ha^{-1} seeds. All the cases the minimum seed yield was found in control treatments (0 kg ha^{-1} N, 100 t ha^{-1}seeding rate) (Table 2, 3 & 4). The obtained highest seed yield was attributed by the higher number of tiller plant^{-1}, spikelets'spike^{-1}, florets spike^{-1}, grain spike^{-1} and 1000-grain weight [33, 34]. Moreover, nitrogen level, nitrogen application timing and seeding rate imposed significant effect on seed yield [20] of our current study.

3.9 Biological yield:

Comment [WU15]: Harvest index?????

Biological yield symbolize total growth performance of the crop and is considered to be the crucial yield attribute to acquire useful knowledge about overall growth of the wheat crop. Biological yield is highly influenced by crop nourishment and planting distance. Seeding rate and nitrogen levels were statistically influenced the biological yield (Table 1). The maximum biological yield (6.81 t ha^{-1}) was counted at seeding rate of 140 kg ha^{-1} while the minimum biological yield (4.32 t ha^{-1}) was observed at seeding rate of 100 kg ha^{-1} (Table 2). Application of nitrogen fertilizer also has prominent effect on biological yield of wheat (Table 1). Highest biological yield (6.40 t ha^{-1}) was recorded at nitrogen level of 160 kg ha^{-1}followed by 180kg ha^{-1} (6.03t ha^{-1}) while lowest grain yield (5.49 t ha^{-1}) was noted at zero level of nitrogen (Table 3). The interaction of seeding rate and nitrogen levels were found significant (Table 1). Highest biological yield (7.62 t ha^{-1}) was recorded at seeding rate of 140kg ha^{-1} with 160 kg ha^{-1} nitrogen fertilizer while lowest biological yield (3.93 t ha^{-1}) was observed at zero level of nitrogen with 100kg ha^{-1} of seeding rate (Table 4). Higher biomass production is the result of the increased number of plant due to higher seeding rate with better nitrogen application. These results are in line with Islam et al. [25], Mojiri and Arzani [35]. Otteson et al. [4] and Iqbal et al. [20] found that biological yield was significantly increased by increasing nitrogen up to optimal levels.

4. CONCLUSION

In our study area, the effects of seeding rate on yield of wheat depend on nitrogen fertilization rate. 140 kg seeds ha^{-1} maximize the grain and biological yield along with the entire growth and yield contributing characters i.e. plant height, effective tillers plant^{-1}, spike length, florets spike^{-1}, grain spike^{-1} and 1000 seed weight, when 160 kg N ha^{-1} applied. However, the minimum yield was observed in the control treatment where 100 kg seeding rate ha^{-1} was implemented with no nitrogen fertilizer application. The value of most of the yield contributing parameters increased with the increase of seeding rate and nitrogen fertilization rate upto 140 kg ha^{-1} and 160 kg ha^{-1} respectively then decline. An exception was found in plant height where growth increases with the increase of nitrogen fertilization upto 180 kg ha^{-1}. Course soil texture, strong acidity in soil and low nutrient content in soil specially nitrogen and phosphorus [19] could contribute high seeding rate and higher amount of nitrogen fertilization for optimum yield of wheat then the recommended doses in our study area.

Comment [WU16]: Economic analysis like BCR

Comment [WU17]: Recomendation????

Comment [WU18]: Future scope of research???

Comment [WU19]: Tally each refrence with text

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REFERENCES

1. FAO. Food Outlook - Biannual Report on Global Food Markets, Rome; 2022. https://doi.org/10.4060/cb9427en

2.BBS (Bangladesh Bureau of Statistics). Yearbook of Agricultural Statistics of Bangladesh; Stat. Div., Ministry of Planning, Govt. Bangladesh; 2021.

3. Johansson E, Prieto-Linde ML, Jönsson JÖ. Effects of wheat cultivar and nitrogen application on storage protein composition and breadmaking quality. Cereal Chemistry. 2001 Jan;78(1):19-25.

4. Otteson BN, Mergoum M, Ransom JK. Seeding rate and nitrogen management effects on spring wheat yield and yield components. Agronomy journal. 2007 Nov;99(6):1615-21.

5. Zhang Y, Dai X, Jia D, Li H, Wang Y, Li C, Xu H, He M. Effects of plant density on grain yield, protein size distribution, and breadmaking quality of winter wheat grown under two nitrogen fertilisation rates. European Journal of Agronomy. 2016 Feb 1;73:1-10.

6. Si Z, Zain M, Mehmood F, Wang G, Gao Y, Duan A. Effects of nitrogen application rate and irrigation regime on growth, yield, and water-nitrogen use efficiency of drip-irrigated winter wheat in the North China Plain. Agricultural Water Management. 2020 Mar 31;231:106002.

7. Wang J, Hussain S, Sun X, Zhang P, Javed T, Dessoky ES, Ren X, Chen X. Effects of Nitrogen Application Rate Under Straw Incorporation on Photosynthesis, Productivity and Nitrogen Use Efficiency in Winter Wheat. Frontiers in Plant Science. 2022 Mar 16;13:862088.

8. Shah AN, Wu Y, Tanveer M, Hafeez A, Tung SA, Ali S, Khalofah A, Alsubeie MS, Al-Qthanin RN, Yang G. Interactive effect of nitrogen fertilizer and plant density on photosynthetic and agronomical traits of cotton at different growth stages. Saudi Journal of Biological Sciences. 2021 Jun 1;28(6):3578-84.

9. FAO. Agricultural Outlook; Can Agriculture Meet the Growing Demand for Food?. OECD-FAO; 2009.

10. Tan Y, Xu C, Liu D, Wu W, Lal R, Meng F. Effects of optimized N fertilization on greenhouse gas emission and crop production in the North China Plain. Field Crops Research. 2017 Apr 1;205:135-46.

11. Bhattacharya A. Global climate change and its impact on agriculture. Changing climate and resource use efficiency in plants. 2019:1-50.

12. Nakano H, Morita S. Effects of seeding rate and nitrogen application rate on grain yield and protein content of the bread wheat cultivar 'Minaminokaori'in Southwestern Japan. Plant production science. 2009 Jan 1;12(1):109-15.

13. Geleta B, Atak M, Baenziger PS, Nelson LA, Baltenesperger DD, Eskridge KM, Shipman MJ, Shelton DR. Seeding rate and genotype effect on agronomic performance and end-use quality of winter wheat. Crop Science. 2002 May;42(3):827-32.

14. Lloveras J, Manent J, Viudas J, Lopez A, Santiveri P. Seeding rate influence on yield and yield components of irrigated winter wheat in a Mediterranean climate. Agronomy Journal. 2004 Sep;96(5):1258-65.

15. Bhatta M, Eskridge KM, Rose DJ, Santra DK, Baenziger PS, Regassa T. Seeding rate, genotype, and topdressed nitrogen effects on yield and agronomic characteristics of winter wheat. Crop Science. 2017 Mar;57(2):951-63.

16.Dai X, Zhou X, Jia D, Xiao L, Kong H, He M. Managing the seeding rate to improve nitrogen-use efficiency of winter wheat. Field Crops Research. 2013 Dec 1;154:100-9.
17. Spink JH, Semere T, Sparkes DL, Whaley JM, Foulkes MJ, Clare RW, Scott RK. Effect of sowing date on the optimum plant density of winter wheat. Annals of applied biology. 2000 Oct;137(2):179-88.
18. Fang Y, Xu BC, Turner NC, Li FM. Grain yield, dry matter accumulation and remobilization, and root respiration in winter wheat as affected by seeding rate and root pruning. European Journal of Agronomy. 2010 Nov 1;33(4):257-66.
19. Ahmmed S, Jahiruddin M, Razia S, Begum RA, Biswas JC, Rahman AS, Ali MM, Islam KM, Hossain MM, Gani MN, Hossain GM. Fertilizer recommendation guide-2018. Bangladesh Agricultural Research Council (BARC), Farmgate, Dhaka. 2018;1215:223.
20. Iqbal J, Hayat K, Hussain S, Ali A, Bakhsh MA. Effect of seeding rates and nitrogen levels on yield and yield components of wheat (Triticum aestivum L.). Pakistan Journal of Nutrition. 2012 Jul 1;11(7):531-36.
21. Tilley MS, Heiniger RW, Crozier CR. Tiller initiation and its effects on yield and yield components in winter wheat. Agronomy Journal. 2019 Mar;111(3):1323-32.
22. Sarker MA, Malaker PK, Bodruzzaman M, Barma NC. Effect of management and seed rate on the performance of wheat varieties with varying seed sizes. Bangladesh Journal of Agricultural Research. 2009;34(3):481-92.
23. Pandy RK, Maranvilla JW, Admou A. Response of durum wheat genotypes to nitrogenous fertilizers. Rastenievdni-Nauki, 38.2001; 203-207.
24.Singh CB, Kumar J, Khan AA, Katiyar RA, Katiyar AK. Effect of nitrogen levels and dates of sowing on yield and quality of wheat (Triticum aestivum L.) seeds. Progressive Agriculture. 2002;2(1):92-93.
25. Islam Z, Khan S, Bakht J, Shah WA. Frequency of various N Levels, lodging and seed quality in wheat. Asian Journal of Plant Sciences. 2002;510-12.
26. Sushila R, Gajendra GIRI. Influence of farmyard manure, nitrogen and biofertilizers on growth, yield attributes and yield of wheat (Triticum aestivum) under limited water supply. Indian journal of Agronomy. 2000;45(3):590-95.
27. Asif M, Ali A, Safdar ME, Maqsood M, Hussain S, Arif M. Growth and yield of wheat as influenced by different levels of irrigation and nitrogen. International Journal of Agriculture and Applied Sciences. 2009;1:25-8.
28. Khaliq A, Iqbal M, Basra SM. Optimization of seeding density and nitrogen application in wheat cv. Inqlab-91 under Faisalabad conditions. Int. J. Agric. Biol. 1999;1(4):241-43.
29. Mozumder AS. Effect of different seed rates and levels of nitrogen on the performance of Shourav variety of wheat M. Sc (Doctoral dissertation, Thesis, Dept. of Agronomy, Banagladesh Agril. Univ., Mymensingh);2001.
30. Ali A, Syed AA, Khaliq T, Asif M, Aziz M, Mubeen M. Effects of nitrogen on growth and yield components of wheat.(Report). InBiol. Sci. 2011;3(6):1004-1005.
31. Akter H. Yield and seed quality of wheat cultivars as influenced by fertilizer nitrogen level under rainfed and irrigated conditions (Doctoral dissertation, M. Sc. Thesis, Dept. of Agronomy, Bangladesh Agril. Univ., Mymensingh); 2005.
32. Maqsood MU, Ali AS, Aslam Z, Saeed M, Ahmad S. Effect of irrigation and nitrogen levels on grain yield and quality of wheat (Triticum aestivum L). Int. J. Agri. Biol. 2002;4(1):164-5.
33. Ali L, Mohy-Ud-Din Q, Ali M. Effect of different doses of nitrogen fertilizer on the yield of wheat. International Journal of Agriculture & Biology. 2003;5(4):438-9.
34. Mondal, H. Response of wheat varieties to different levels of nitrogen fertilizer. Doctoral dissertation, Department of Agronomy; 2014.
35.Mojiri A, Arzani A. Effect of nitrogen rate and plant density on yield and yield components of sunflower. Isfahan University of Technology-Journal of Crop Production and Processing. 2003 Jul 10;7(2):115-25.