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PERFORMANCE OF WHEAT POTENTIALITY INFLUENCED BY WATER RETAINER AND NITROGEN FERTILIZATION

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ABSTRACT

Parvej MMR, Hossain SMA, Bhuiya MSU, Amin MHA (2019) Performance of wheat potentiality influenced by water retainer and nitrogen fertilization. *Int. J. Sustain. Crop Prod.* 14(1), 1-11.

A modern wheat variety 'BARI gam-21' (Shatabdi) was grown with four rates of Flobond, a chemical water retainer, *viz.*, 35 kg, 70 kg, 140 kg, and 280 kg ha^{-1} under four levels of nitrogen such as 0 kg, 50 kg, 100 kg and 150 kg ha^{-1} at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh during the *Rabi* season November 2009 to March 2010. The experiment was laid out in a split-plot design with three replications. Rate of Flobond/irrigation level and nitrogen fertilization and their interaction exerted significant influence on yield, yield contributing and other crop characters. It was observed that the highest grain yield (3.58 t ha^{-1}) was obtained with 280 kg Flobond ha^{-1}. It was the outcome of the highest number of effective tillers plant^{-1} and the highest number of grains spike^{-1}. On the other hand, the highest straw yield (5.46 t ha^{-1}) was obtained with two irrigations. Grain yield showed an increasing trend to 280 kg Flobond ha^{-1}. But straw yield increased to 280 kg Flobond ha^{-1} and thereafter decreased. The highest grain yield (3.56 t ha^{-1}) was obtained with 100 kg N ha^{-1} and the highest straw yield (5.37 t ha^{-1}) was obtained from 100 kg N ha^{-1}. Interaction of rate of Flobond as chemical water retainer and level of nitrogen had a significant effect on yield, yield contributing characters except for 1000-grain weight. The highest grain yield (4.82 t ha^{-1}) was obtained with 280 kg Flobond ha^{-1} as a chemical water retainer and 100 kg N ha^{-1}. The lowest one (1.53 t ha^{-1}) was obtained from 35 kg Flobond ha^{-1} and no nitrogen. On the other hand, the highest straw yield (6.68 t ha^{-1}) was obtained with 100kg N ha^{-1} under two irrigation and the lowest one (3.42 t ha^{-1}) was found in 35 kg Flobond ha^{-1} with no nitrogen fertilization.

Key words: *wheat, water retainer, nitrogen fertilizer, application*

INTRODUCTION

In Bangladesh wheat is the second important cereal crop next to rice (Hossain and Teixeira, 2013) and its cultivated area was 0.56 million hectares having total production of 0.98 million metric tons with an average yield of 1.75 t ha^{-1} (BBS 2018). The world average yield of wheat (4.49 t ha^{-1}) is much higher than that of Bangladesh (Langemeier and Yeager, 2016). The present average yield of wheat is 7.1, 5.9, 5.6 and 4.1 t ha^{-1} was recorded in Holland, United Kingdom, France, and Norway. Even The low yield of wheat could be augmented with the adoption of improved varieties along with the use of appropriate agronomic practices like a judicial application of irrigation water, chemical water retainers (Flobond/Aquasorb) and nitrogen level. Irrigation at the optimum level is one of the most important management for boosting up the yield of wheat (Djagba *et al.* 2014). Water plays a vital role in the growth and development of wheat. It influences dry matter production, plant height, duration of grain filling and grain protein content of wheat (Kanety *et al.* 2014; Buttar *et al.* 2014). The yield of wheat under irrigated conditions is much higher than under rainfed conditions (Daryanto *et al.* 2016). Chapagain and Good (2015) reported that the difference in wheat yield was 24% in rainfed and irrigated wheat production. The application of irrigation water without proper planning based on the actual requirement of the crops results not only in wastages of irrigation water but also hampers crop growth and yield (Shen *et al.* 2013). Knowledge of the role of irrigation in the growth and development of plants and the optimum time of application of water may help to economize the use of the limited amount of water in obtaining the maximum yield of higher quality wheat. Irrigation frequency has a significant influence on the growth and yield of wheat. With the increase of irrigation frequencies, the grain yield of wheat can be increased. But the supply of irrigation water and preparing irrigation channel are costly. By using chemical water retainers like Flobond the quantity of water and the cost of irrigation, as well as the cost of crop production, can be minimized. Flobond is a chemical water retainer which is used to retain the water in the soil, keep the soil moist and reduce the frequency of irrigation. Flobond is a range of organic soil conditioner based on polyacrylamide (PAM). These are water-soluble anionic polymers of high molecular mass. Flobond products make it possible to reduce the soil erosion caused by surface water runoff and to enhance the permeability of the soil. Flobond enables the agglomeration of the fine particles of soil which would otherwise be carried away by surface water runoff. When the PAM dissolves in water, dissociation of the potassium ion exposes a negative site on the molecule at which the colloidal soil particles will be attached. The product is approved in the USA. Flobond increases the cohesion of poorly structured soils (which reduced 95% evaporation), improved in germination rate about 35%, reduce leaching of nutrients (e.g. 84% less for phosphates and nitrates) and the porosity of the soil is also conserved (35% on clay-loam soils to + 50% on clay soils). The duration of field efficacy of Flobond is very strong 4 to 8 weeks depending on the agro-climatic condition Flobond economizes the use of water, reduces the cost of cultivation and maximizes crop yield without affecting the health of the ecosystem. Nitrogen fertilizer has a significant effect on producing higher grain yield (Yousaf *et al.* 2014). The application of nitrogen above the optimum dose decreases grain and straw yields (AARD 2015). But in the case of wheat production, farmers of Bangladesh do not pay enough attention to the use of optimum N level. Therefore, a package of technologies needs to be developed for the farmers on water retainer and nitrogen fertilization for the maximization of wheat yield. Keep in the mind of the factors that directly and indirectly influence the growth and yield of wheat production opportunity, the research work was undertaken to evaluate the rate of chemical water retainer/irrigation as well as the level of nitrogen fertilization on the growth and yield of the wheat cultivar.

MATERIALS AND METHODS

Experimental site

The experimental site is located at the 24.75°N latitude and 90.5°E longitude at an elevation of 18 m above the sea level. The soil belongs to the non-calcareous dark grey floodplain under the Agro-ecological Region of the Old Brahmaputra Floodplain-AEZ-9.

Soil of experimentation

Sandy loam soil was used in the experiment. The soil was more or less neutral (5.9-6.5 pH) in reaction, low in organic matter content and its general fertility level was also low. Morphological characteristics (Non-calcareous Dark-Grey Flood Plain soil type, Old Brahmaputra River Borne Deposit and Sonatola soil series), physical properties (Sand 25.2%, silt 72.0%, clay 2.8%, and Silty loam textural class) and chemical composition (pH 6.8, Organic carbon 0.93%, total nitrogen 0.13%, phosphorus 13.9 ppm, potassium 16.3 ppm, and exchangeable potassium 028 ppm) of the soil which were collected from different of experimental plot at 0-15 cm depth.

Experimental design

The experiment was laid out in a split-plot design with three replications. Each replication was divided into four main plots and each of the main plots was then sub-divided into six-unit plots. The level of nitrogen was assigned in the main plot and the rate of Flobond/irrigation in the subplot.

Experimental treatment

This is a factorial experiment. Factor A, comprised with 6 water retainers (i.e., rate of Flobond, the chemical water retainer and irrigation) such as T_1 = 35 kg ha^{-1}, T_2 = 70 kg ha^{-1}, T_3 =140 kg ha^{-1}, T_4 = 280 kg ha^{-1}, T_5 = one irrigation and T_6 = two irrigation. Factor B comprised of 4 levels of nitrogen fertilization (i.e., N_0 = no nitrogen, N_1 = 50 kg N ha^{-1}, N_2 = 100 kg N ha^{-1} and N_3 = 150 kg N ha^{-1}. All treatments were repeated in three times in a split-plot design. Each replication was divided into four main plots and each of the main plots was then sub-divided into six-unit plots. The level of nitrogen was assigned in the main plot and the rate of Flobond/irrigation in the subplot. The total number of experimental pots was 72 (6 × 4 × 3). The size of each plot was 5 m^2 (2.5m × 2.0m).

Description of the wheat cultivar

Wheat variety BARI gam-21 (Shatabdi) was used as planting material. It was developed by the Bangladesh Agricultural Research Institute and released in 2000. It is a high yielding variety. It is a heat-tolerant variety. It is resistant to leaf rust and leaf spot disease. The characteristics of Shatabdi was sowing time mid-November, plant height 90-100 cm, 42-48 seed per spike, spike length 9-10 cm, seed color white, 40-45 gm thousand seed weight, and 3.6-5.0 t ha^{-1} seed yield.

Description of flobond

The Flobond is a range of polyacrylamide based (PAM) soil conditioners. It is the anionic hydrosoluble polymer of high molecular weight. "Flobond" products allow to reduce soil erosion due to water and wind effects and to increase its permeability (Floerger 2002). It is pertinent to note here that Flobond products must be stored in dry fresh places (from 0 to 35°C). There is no toxicity reported neither in the water nor in the soils which have been approved by the US Food and Drug Administration and by the Ministry of Health of France as an additive for water treatment (Vortex 2006).

Land preparation

The experimental field was opened with a power tiller 10 days before sowing. It was further ploughed four times with power tiller followed by breaking clods and leveling the land. All weeds, stubble and crop residues were removed from the experimental field. Each unit plot was prepared with spade before sowing.

Application of flobond and fertilizer

Flobond was applied in each plot as per treatment and was mixed with the soil by spade before sowing. During final land preparation the land was fertilized with cowdung at 10 t ha^{-1}, TSP at 160 kg ha^{-1}, MoP at 50 kg ha^{-1} gypsum at 110 kg ha^{-1} and one-third of urea of each treatment incorporated into the soil in each plot.

Seed sowing

Seeds of wheat cv. Shatabdi was sown in the well-prepared plots on 22 November 2009, at the rate of 120 kg ha^{-1}. Irrigation water was provided as one irrigation at 18 DAS, two irrigation given at 18 DAS and 55 DAS.

Intercultural operations

Weeds of different species infested the experimental plots, of these Bathua (*Chenopodium album*) and Mutha (*Cyperus rotundus*) were prominent. Two weedings, one at 20 and the other at 45 days after sowing were done by the help of a niri. No insect or disease infestation was observed during the experimentation.

Harvesting and processing

The maturity of the crop was determined as the time when 90% of the grains became golden yellow in color. The crop was harvested on 16 March 2010 with sickle at proper maturity. Harvesting was done plot-wise and tagged for proper identification for further processing. The grains were threshed, cleaned and sun-dried and the grain yield $plot^{-1}$ recorded at 14% moisture content. Afterward, the yield was converted to t ha^{-1}. Straw was sun-dried to record the straw yield $plot^{-1}$ and then converted to t ha^{-1}.

Data collection

Data were recorded on plant height, the total number of tillers $plant^{-1}$, number of effective tillers $plant^{-1}$, number of non-effective tillers $plant^{-1}$, spike length, number of total spikelets $spike^{-1}$, grains $spike^{-1}$, thousand-grain weight, grain yield, straw yield, moisture percentage of soil, moisture percentage of plant and harvest index. For collecting data on crop characters 5 hills were selected from each plot and uprooted prior to harvest.

Statistical analysis

The collected data were statistically analyzed using analysis of variance technique with the help of computer package programme MSTAT-C and the significance of mean difference was adjudged by Duncan's Multiple Range Test (DMRT) as laid out by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Effect of water retainer on growth and yield of wheat

Plant height

The plant height was found significantly different due to the application of Flobond. At the harvesting stage, the tallest plant (93.06 cm) was found in (T_4) treatment application of 280 kg Flobond ha^{-1} which was statistically identical to (91.45 cm) obtained in (T_6) treatment application of two irrigation followed by (91.11 cm) in (T_2) treatment application of 70 kg Flobond ha^{-1}. On the other hand, the shortest plant height (87.68 cm) was found in (T_5) treatment application of one irrigation for wheat production (Table 1). A similar result was observed by Rahman *et al.* (2019) in the case of rice production with irrigation and Flobond.

Total tiller $plant^{-1}$

The number of total tillers $plant^{-1}$ was significantly influenced by the rate of Flobond/irrigation. The highest number of total tillers $plant^{-1}$ (5.17) was obtained in (T_4) treatment application of 280 kg Flobond ha^{-1} followed by (4.95) and (4.87) recorded in T_5 and T_6 treatments, respectively. Conversely, the lowest number of total tillers $plant^{-1}$ (3.37) was obtained in (T_1) treatment application of 35 kg Flobond ha^{-1} (Table 1). An increase in total tillers $plant^{-1}$ by increasing rate of Flobond has also been reported by Hossain (2009).

Number of effective tillers $plant^{-1}$

The effective tillers $plant^{-1}$ was significantly influenced by the rate of Flobond/irrigation. The highest number of effective tillers $plant^{-1}$ (4.05) was found (T_4) treatment application of 280 kg Flobond ha^{-1} followed by (3.77) found in (T_6) treatment application of two irrigation. Then again, the lowest number of effective tillers $plant^{-1}$ (2.14) was obtained in (T_1) treatment application of 35kg Flobond ha^{-1} (Table 1). Hossain (2009) stated that effective tillers $plant^{-1}$ increased with increasing Flobond rate. Flobond/irrigation had a significant effect on the production of non-effective tillers $plant^{-1}$. Islam *et al.* (2018) mentioned that the maximum number of effective tillers was obtained from wheat production with three irrigation levels.

Number of non-effective tillers $plant^{-1}$

Flobond/irrigation had a significant effect on the production of non-effective tillers $plant^{-1}$. From the results (Table 1) it is found that the highest number of non-effective tillers $plant^{-1}$ (1.41) was produced in (T_2) treatment application of 70 kg Flobond ha^{-1} which was statistically identical to (1.25) in (T_3) application of 140 kg Flobond ha^{-1} and (1.32) in (T_5) application of one irrigation. The lowest number of non-effective tillers $plant^{-1}$ (1.10) was produced in (T_6) application of two irrigation which was statistically identical to (1.12) in (T_4) treatment application of 280 kg Flobond ha^{-1}.

Spike length

Spike length was significantly influenced by the application of Flobond/irrigation. The longest spike (9.36 cm) was found in (T_4) treatment application of 280 kg Flobond ha^{-1} which was identical to (9.19 cm) in (T_2) application of 70 kg Flobond ha^{-1}. Oppositely, the shortest spike (8.71 cm) was found (T_1) treatment application of 35 kg Flobond ha^{-1} (Table 1). It has been reported Hossain, (2009) that an increase in Flobond rate resulted in an increase in spike length. Hasil *et al.* (2014) was found similar results expressed that spike length was increased due to the increase of Flobond and irrigation.

Spikelets spike^{-1}

Spikelet is a yield contributing character and, in this experiment, it was found that spikelets spike^{-1} was significantly influenced by the rate of Flobond/irrigation. The highest number of spikelets spike^{-1} (20.07) was found in (T_4) treatment application of 280 kg Flobond ha^{-1} which was statically identical to (19.48) recorded in (T_2) treatment application of 70 kg Flobond ha^{-1}. On the other hand, the lowest number of spikelets spike^{-1} (18.73) was found in (T_5) treatment application of one irrigation (Table 1). Islam *et al.* (2018) stated that spikelets spike^{-1} increased with increasing Flobond rate.

Grains spike^{-1}

From the result, it is found that grains spike^{-1} was significantly influenced by Flobond/irrigation. The highest number of grains spike^{-1} (42.02) was found in (T_4) treatment application of 280 kg Flobond ha^{-1} followed by (40.78) observed in (T_2) treatment application of 70 kg Flobond ha^{-1}. Instead, the lower number of grains spike^{-1} (38.66) was found in (T_5) treatment application of one irrigation (Table 1).

Thousand Grain Weight

There was a significant effect of Flobond treatment on 1000 grain weight. The highest 1000 grain weight (49.91 g) was found in (T_5) application of one irrigation and the lowest 1000-grain weight (48.79 g) was found in both T_1 and T_3 treatments, respectively.

Grain Yield

Grain yield was found different significantly influence due to Flobond/irrigation. From the result significantly, the highest grain yield (3.58 tha^{-1}) was found in (T_4) treatment application of 280 kg Flobond ha^{-1} followed by (3.28 tha^{-1}) recorded in (T_6) application of two irrigation and the lowest grain yield (2.26 t ha^{-1}) was found in (T_1) treatment application of 35 kg Flobond ha^{-1}. Islam *et al.* (2018) was found the highest wheat grain yield in the four applications of irrigation. Hasil *et al.* (2014) said that the higher wheat yield was taken from optimum irrigation.

Straw Yield

The straw yield was significantly influenced by the application of Flobond/irrigation. The highest straw yield (5.46 t ha^{-1}) was found in (T_6) treatment application of two irrigation which is identical to (5.31 tha^{-1}) recorded in (T_4) treatment application of 280 kg Flobond ha^{-1} and the lowest straw yield (3.86 t ha^{-1}) was found in (T_1) treatment application of 35 kg Flobond ha^{-1}.

Harvest Index

Harvest index was initiated significantly different due to the Flobond/irrigation (Table 1). The highest harvest index (40.05%) was found in (T_4) treatment application of 280 kg Flobond ha^{-1} which was identical to (38.85) noted in (T_5) treatment. The lowest harvest index (36.46%) was observed in T_1 treatment application of 35 kg Flobond ha^{-1}.

Moisture Percentage in Soil

Flobond as a chemical water retainer had significant effects on moisture percentage of soil (Table 1). The highest moisture percentage (20.88%) was found in (T_4) treatment application of 280 kg Flobond ha^{-1} and the lowest moisture percentage (17.250%) was found in (T_5) treatment application of one irrigation.

Plant moisture percentage

Flobond exerted significant effects on plant moisture percentage (Table 1). The highest plant moisture percentage (28.46%) was taken in (T_4) treatment application of 280 kg Flobond ha^{-1} while the lowest plant moisture percentage (22.81%) was observed in (T_5) treatment application of one irrigation.

Table 1. Effect of water retainer on yield and yield contributing characters of wheat cv. Shatabdi

Water retainer Treatment	Plant height (cm)	Total tillers plant^{-1}	Effective tillers plant^{-1}	Non-effective tillers plant^{-1}	Spike Length (cm)	Spikelets spike^{-1}	Grains spike^{-1}	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)	Soil Moisture (%)	Plant moisture (%)
T_1	88.77cd	3.37e	2.14f	1.23bc	8.71d	19.01bc	39.42d	48.79b	2.26e	3.86e	36.46c	19.02c	24.59d
T_2	89.64bc	3.97d	2.56e	1.41a	8.94c	19.23bc	40.05cd	49.61a	2.54d	4.15d	37.51bc	19.73bc	25.51c
T_3	91.11b	4.21c	2.95d	1.25abc	9.19ab	19.48ab	40.78b	48.79b	2.95c	4.78b	38.15b	20.13ab	26.63b
T_4	93.06a	5.17a	4.05a	1.12c	9.36a	20.07a	42.02a	49.42a	3.58a	5.31a	40.05a	20.88a	28.46a
T_5	87.68d	4.95b	3.64c	1.32ab	9.02bc	18.73c	38.66e	49.91a	2.85c	4.46c	38.85ab	17.50d	22.81e
T_6	91.45ab	4.87b	3.77b	1.10c	8.90cd	19.15bc	40.43bc	49.40a	3.28b	5.46a	37.49bc	20.15ab	25.29cd
$S_{\bar{X}}$	0.42	0.06	0.04	0.06	0.07	0.21	0.23	0.20	0.05	0.05	0.43	0.23	0.23
F-test	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CV (%)	1.59	4.41	4.20	15.44	2.82	3.76	1.95	1.41	6.07	3.59	3.95	4.09	3.17

In a column, figurers with same letters or without letters do not differ significantly whereas figures with dissimilar letter differ significantly as per DMRT

T_1 = 35 kg Flobond ha^{-1}, T_2 = 70 kg Flobond ha^{-1}, T_3 = 140kg Flobond ha^{-1},

T_4 = 280 kg Flobond ha^{-1}, T_5 = One Irrigation, T_6 = Two Irrigation

NS = Not significant

Effect of level of nitrogen fertilization on growth and yield of wheat

Plant height

The plant height increased progressively with the application of nitrogen levels (Table 2). The tallest plant (93.45 cm) was obtained from (N_3) treatment application of 150 kg N ha^{-1}, which was statistically identical to (92.18 cm) recorded in (N_2) treatment application of 100 kg N ha^{-1}, respectively. On the other hand, the shortest plant (87.54 cm) was obtained from (N_0) treatment, the control having no nitrogen, which was statistically identical with (87.97 cm) from (N_1) treatment application of 50 kg N ha^{-1}. Similar results were also reported by Zhang *et al.* (2017) and Ullah *et al.* (2018). Increased plant height with an increasing level of nitrogen might be due to the fact that the supply of nitrogen increased the meristematic activities in plants and the formation of protoplasm (Espindula *et al.* 2010).

Total tiller plant^{-1}

The highest number of total tillers plant^{-1} (5.37) was found from (N_2) treatment application of 100 kg N ha^{-1} and the lowest number of total tillers plant^{-1} (3.17) was recorded from (N_0) treatment, the control having no nitrogen. An increase in total tillers plant^{-1} by increasing level of nitrogen has also been reported by McDonald, (2002) and Teixeira *et al.* (2010) which conforms the present findings.

Number of effective tillers plant^{-1}

The number of effective tillers plant^{-1} increased with the increasing level of nitrogen up to 100 kg N ha^{-1}. The highest number of effective tillers plant^{-1} (4.19) was recorded from (N_2) treatment application of 100 kg N ha^{-1}. On the other hand, the lowest number of effective tillers plant^{-1} (2.24) was observed from (N_0) treatment, the control having no nitrogen (Table 2). An increase in effective tillers plant^{-1} by fertilizer nitrogen application has also been reported by Sieling *et al.* (2005).

Number of non-effective tillers plant^{-1}

The effect level of nitrogen had a significant effect on the number of non-effective tillers plant^{-1}. The highest number of non-effective tillers plant^{-1} (1.68) was obtained from (N_3) treatment application of 150 kg N ha^{-1}while the lowest number of effective tillers plant^{-1} (0.93) was obtained from (N_0) treatment, the control having no nitrogen (Table 2).

Spike length

Spike length increased with the increasing rates of nitrogen up to 100 kg N ha^{-1}. The maximum spike length (9.25 cm) was produced in (N_2) treatment application of 100 kg N ha^{-1} and the shortest spike (8.84 cm) was observed in (N_0) treatment, the control having no nitrogen which was identical to (N_1) treatment application of 50 kg N ha^{-1} (Table 2). The reason for the longest spike with the optimum level of nitrogen might be due to the influence of uptake of the high amount of nitrogen. Kutman *et al.* (2011) reported that spike length increased up to 120 kg N.

Spikelets spike^{-1}

The effect of the level of nitrogen had a significant effect on the number of spikelets spike^{-1}(Table 2). The highest number of spikelets spike^{-1} (19.96) was obtained from (N_3) treatment application of 150 kg N ha^{-1} and the lowest number of spikelets spike^{-1} (18.47) was gotten from (N_0) treatment, the control having no nitrogen which was identical to (N_1) treatment application of 50 kg N ha^{-1}.

Grains spike^{-1}

The highest number of grains spike^{-1} (41.82) was obtained by the application of 100 kg N ha^{-1} which is identical to 150kg N ha^{-1} (41.32) and the lowest number of grains spike^{-1} (38.28) obtained from control treatment having no nitrogen (Table 2). Debnath *et al.* (2014) reported that increasing the nitrogen rate significantly increased the number of grains spike^{-1}. Linear and positive response for the number of grains spike^{-1} was found when nitrogen was applied to wheat at the rate of 0, 60, 90 and 120 kg N ha^{-1} (Yadav *et al.* 2005).

Thousand grain weight

It was found that there was no significant effect of the level of nitrogen on 1000 grain weight. However, numerically the highest 1000 grain weight (49.61 g) was found with 150kg N ha^{-1} and the lowest 1000 grain weight (48.81 g) was found with no nitrogen (Table 2).

Grain yield

The highest grain yield (3.56 t ha^{-1}) was produced in (N_2) treatment application of 100 kg N ha^{-1}. The lowest grain yield (2.28 t ha^{-1}) was obtained from the control treatment having no nitrogen (Table 2). Improvement in yield components i.e. the number of effective tillers plant^{-1}, spike length, number of grains spike^{-1} and 1000 grain weight contributed to high yield. It has been reported elsewhere that an increase in nitrogen rate resulted in the increase in grain yield of wheat (Zhang *et al.* 2017).

Straw yield

The straw yield was found to increase progressively with the increase in nitrogen level up to 100 kg N ha^{-1}. The highest straw yield (5.37 t ha^{-1}) was obtained at 100 kg N ha^{-1}. The lowest straw yield (4.11 t ha^{-1}) was observed from the control treatment having no nitrogen (Table 2). The improvement of vegetative growth in terms of plant height and number of tillers/plant due to nitrogen fertilization resulted in the improvement of straw yield. The result is in agreement with that of Liaqat *et al.* (2003) who reported that straw yield increased with the increase in nitrogen rates.

Harvest index

The highest harvest index (39.83%) was produced 100 N $ha^{-1}$and was followed by 50 kg N ha^{-1} (38.47%) and 150 kg N ha^{-1}(38.80%) (Table 2). It was noted that increasing the nitrogen level increased the harvest index. Semenov *et al.* (2007) stated that the harvest index increased with increasing nitrogen rate.

Moisture percentage in soil

Moisture Percentage in Soil was found statistically not significant due to the application of nitrogen (Table 2). Numerically the highest moisture in the soil (19.83%) was obtained from (N_0) treatment, the control having no nitrogen and the lowest moisture in the soil (19.44%) was taken from (N_3) treatment application of 150 kg N ha^{-1}.

Plant moisture percentage

Plant moisture percentage was significantly affected by the level of nitrogen (Table 2). The highest plant moisture percentage (26.73%) was conserved in (N_0) treatment, the control having no nitrogen and the lowest plant moisture percentage (24.92%) was measured in (N_2) treatment application of 100 kg N ha^{-1}.

Table 2. Effect of level of N fertilization on yield and yield contributing characters of wheat cv. Shatabdi

Nitrogen level	Plant height (cm)	Total tillers $plant^{-1}$	Effective tillers $plant^{-1}$	Non-effective tillers $plant^{-1}$	Spike Length (cm)	Spikelets $spike^{-1}$	Grains $spike^{-1}$	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)	Soil moisture (%)	Plant moisture (%)
N_0	87.54b	3.17d	2.24c	0.93c	8.84b	18.47b	38.28c	48.81	2.28d	4.11d	35.25b	19.83	26.73a
N_1	87.97b	4.33c	3.16b	1.17b	8.93b	18.73b	39.48b	49.36	2.72c	4.34c	38.47a	19.46	25.17b
N_2	92.18a	5.37a	4.19a	1.17b	9.25a	19.95a	41.82a	49.50	3.56a	5.37a	39.83a	19.54	24.92c
N_3	93.45a	4.83b	3.15b	1.68a	9.07ab	19.96a	41.32a	49.61	3.07b	4.86b	38.80a	19.44	25.37b
$S_{\bar{X}}$	0.41	0.05	0.02	0.06	0.07	0.20	0.16	0.14	0.04	0.02	0.39	0.20	0.07
F-test	0.01	0.01	0.01	0.01	0.01	0.01	0.01	NS	0.01	0.01	0.01	NS	0.01
CV (%)	1.59	4.41	4.20	15.44	2.82	3.76	1.95	1.41	6.07	3.59	3.95	4.09	3.17

In a column, figures with the same letters or without letters do not differ significantly whereas figures with dissimilar letters differ significantly as per DMRT

N_0 = Control, N_1 = 50 kg N ha^{-1}, N_2 = 100 kg N ha^{-1}, N_3 = 150 kg N ha^{-1}

NS = Not significant

Interaction effect of water retainer and nitrogen fertilization on growth and yield of wheat

Plant height

Plant height was significantly influenced by the interaction of rate of Flobond/irrigation and level of nitrogen. The tallest plant (97.53 cm) was found in 280 kg Flobond ha^{-1} with 150 kg N ha^{-1} but the shortest plant (84.45) was observed in 35 kg Flobond ha^{-1} with no nitrogen (Table 3).

Total tiller $plant^{-1}$

The number of total tillers $plant^{-1}$ was significantly influenced by the interaction of rate of Flobond/irrigation and level of nitrogen. The highest number of total tillers $plant^{-1}$ (6.22) was obtained with 280 kg Flobond ha^{-1} with 150 kg N ha^{-1} which was statistically identical with 280 kg Flobond ha^{-1} with100 kg N ha^{-1} (5.96). On the other hand, the lowest number of total tillers $plant^{-1}$ (2.20) was obtained in 35 kg Flobond ha^{-1} with no nitrogen (Table 3).

Number of effective tillers $plant^{-1}$

The effect of the interaction of rate of Flobond/irrigation and level of nitrogen had a significant effect on the number of effective tillers $plant^{-1}$. The highest number of effective tillers $plant^{-1}$ (5.30) was obtained from 280 kg Flobond ha^{-1} with 100 kg N ha^{-1} (Table 3). The lowest number of effective tillers $plant^{-1}$ (1.05) was obtained from 35 kg Flobond ha^{-1} with no nitrogen which was statistically identical in 70 kg Flobond with no nitrogen (1.27).

Number of non-effective tillers $plant^{-1}$

The number of non-effective tillers $plant^{-1}$ was significantly affected by the interaction of rate of Flobond/irrigation and nitrogen treatment. The highest number of non-effective tillers $plant^{-1}$ (2.56) was obtained in 280 kg Flobond ha^{-1} with 150 kg N ha^{-1}. On the other hand, the lowest one (0.43) was found in 280 kg Flobond ha^{-1} with no nitrogen (Table 3).

Spike length

It is seen that spike length was significantly influenced by the rate of Flobond and level of nitrogen. The longest spike (9.53 cm) was produced from 280 kg Flobond ha^{-1} with 100 kg N ha^{-1} and the shortest spike (8.37 cm) was found in 35 kg Flobond ha^{-1} with no nitrogen (Table 3).

Spikelets spike^{-1}

From Table 3 it is found that the spikelets spike^{-1} was found statistically not significant influenced by the interaction of rate of Flobond and level of nitrogen.

Grains spike^{-1}

Interaction of rate of Flobond and level of nitrogen had a significant effect on grains spike^{-1}. The highest number of grains spike^{-1} (44.67) was found in 280 kg Flobond ha^{-1} with 100 kg N ha^{-1} and the lowest one (37.20) was obtained from 35 kg Flobond ha^{-1} with one irrigation (Table 3).

Thousand grain weight

Analysis of variance reveals that the 1000 grain weight was not significantly influenced by the interaction of rate of Flobond and nitrogen treatment. However, numerically the highest 1000 grain weight (51.35 g) was obtained from70 kg Flobond ha^{-1} with 100 kg N ha^{-1}. On the other hand, the lowest 1000-grain weight (47.74 g) was obtained from 140 kg Flobond with 100 kg N ha^{-1} (Table 3).

Grain yield

From Table 3 it is found that the grain yield was significantly affected by the interaction of rate of Flobond/irrigation and level of Nitrogen. The highest grain yield (4.82 t ha^{-1}) was found in the combination of 280 kg Flobond ha^{-1} and 100 kg N ha^{-1}. The lowest grain yield (1.53t ha^{-1}) was found in 35 kg Flobond and no nitrogen which was statistically identical with 70 kg Flobond ha^{-1} (1.77 t ha^{-1}) under no nitrogen.

Straw yield

The straw yield was significantly affected by the interaction of rate of Flobond/irrigation and level of nitrogen. Table 3 shows that the highest straw yield (6.68 t ha^{-1}) was found in 100 kg N ha^{-1} with two irrigations. The lowest of that was obtained from 35 kg Flobond with no nitrogen (3.42 t ha^{-1}).

Harvest index

Harvest index was significantly affected by the interaction of rate of Flobond/irrigation and level of nitrogen. Table 3 showed that the highest harvest index (44.01%) was found in 280 kg Flobond ha^{-1} with 100 kg N ha^{-1} and the lowest harvest index (30.96%) was observed from the combination of 35 kg Flobond ha^{-1} with no nitrogen, which was statistically identical with 70 kg Flobond with no nitrogen (31.75%) (Table 3).

Moisture percentage in soil

Moisture percentage of soil was not significantly affected by the interaction of rate of Flobond/irrigation and level of nitrogen.

Plant moisture percentage

Plant moisture percentage was significantly affected by the interaction of rate of Flobond/irrigation and level of nitrogen. Table 3 showed that the highest plant moisture percentage (29.4%) was found with 280 kg Flobond ha^{-1} under 150 kg N ha^{-1} which was statistically identical with 280 kg Flobond under 100 kg N ha^{-1} (29.25%) and the lowest one (21.00%) with 100 kg N ha^{-1} with one irrigation.

Table 3. Effect (interaction) of levels of N and rate of Flobond/irrigation on yield and yield contributing characters of wheat cv. Shatabdi

Interaction (Nitrogen level x water retainer)	Plant height (cm)	Total tillers plant^{-1}	Effective tillers plant^{-1}	Non-effective tillers plant^{-1}	Spike length (cm)	Spikelets spike^{-1}	Grains spike^{-1}	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)	Soil moisture (%)	Plant moisture (%)
N_0T_1	84.95jk	2.20k	1.05m	1.15d-g	8.37f	18.28	37.20ij	47.96	1.53l	3.42o	30.96h	19.20	25.75d-i
N_0T_2	86.80ijk	2.58j	1.27m	1.31def	8.53ef	18.40	37.93hij	48.84	1.77l	3.80n	31.75h	19.92	26.45c-f
N_0T_3	87.87hij	2.61j	1.53l	1.08e-h	9.06a-d	18.50	38.47ghi	49.66	2.37jk	4.05lmn	36.87efg	20.25	27.15cd
N_0T_4	91.29efg	3.71gh	3.28g	0.43j	9.36ab	19.59	40.13def	49.02	2.90ghi	4.52hi	39.09b-f	22.40	29.00ab
N_0T_5	86.53ijk	3.90fgh	3.14g	0.76hij	9.27ab	17.52	36.93j	48.42	2.33jk	4.15klm	35.99g	17.25	24.25ijk
N_0T_6	87.80hij	4.00fg	3.18g	0.82ghi	8.42f	18.54	39.00e-h	48.95	2.75hi	4.70gh	36.87efg	19.93	27.75bc
N_1T_1	84.45k	3.63h	2.23j	1.41cde	8.73c-f	18.43	38.80fgh	49.59	2.18k	3.77n	36.66fg	19.35	23.85jk
N_1T_2	85.73ijk	3.86fgh	2.55i	1.31def	9.00b-e	18.70	39.07e-h	49.56	2.38jk	3.95mn	37.62c-g	19.60	25.75d-i
N_1T_3	87.53h-k	4.16ef	2.87h	1.29def	9.00b-e	18.83	39.67d-g	48.24	2.72hi	4.13klm	39.72b-e	20.05	25.85d-h
N_1T_4	88.67ghi	4.79c	3.97c	0.82ghi	9.13abc	19.36	40.80d	49.29	3.27c-f	4.83fg	40.30bc	19.50	26.20d-g
N_1T_5	87.87hij	4.73cd	3.53ef	1.20def	8.73c-f	18.33	38.17hij	50.76	2.77hi	4.30i-l	39.12b-f	17.80	24.00jk
N_1T_6	93.57b-f	4.80c	3.80cd	1.00f-i	8.97b-e	18.73	40.40de	48.72	3.03e-h	5.08ef	37.37c-g	20.45	25.40e-j
N_2T_1	90.47fgh	4.42de	3.34fg	1.08e-h	9.17abc	19.13	40.67d	49.66	2.70hi	4.05lmn	39.90bcd	18.85	24.35h-k
N_2T_2	92.10c-f	5.40b	3.71de	1.69c	9.20abc	19.40	40.73d	51.35	3.12d-g	4.48hij	40.98b	19.88	25.00f-j
N_2T_3	92.77c-f	5.50b	4.20b	1.30def	9.43ab	19.90	42.27bc	47.74	3.47c	5.72c	37.74c-g	20.15	26.55cde
N_2T_4	94.77a-d	5.96a	5.30a	0.66ij	9.53a	21.00	44.67a	48.89	4.82a	6.13b	44.01a	20.75	29.25a
N_2T_5	90.33fgh	5.58b	4.36b	1.22ij	8.97b-e	19.80	40.40de	49.82	3.33cde	5.15de	39.29b-f	17.75	21.00l
N_2T_6	92.67c-f	5.33b	4.25b	1.08def	9.20abc	20.47	42.20bc	49.56	3.93b	6.68a	37.02d-g	19.85	23.40k
N_3T_1	95.20abc	3.22i	1.94k	1.28e-h	8.57def	20.20	41.00cd	47.96	2.62ij	4.20j-m	38.32b-g	18.70	24.40h-k
N_3T_2	93.93b-e	4.03fg	2.71hi	1.33def	9.03a-d	20.40	42.47b	48.68	2.88ghi	4.38ijk	39.67b-e	19.50	24.85g-k
N_3T_3	96.27ab	4.55cd	3.22g	1.33def	9.27ab	20.67	42.73b	49.54	3.23c-f	5.22de	38.29b-g	20.05	26.95cd
N_3T_4	97.53a	6.22a	3.66de	2.56a	9.40ab	20.33	42.47b	50.46	3.35cde	5.75c	36.81efg	20.85	29.40a
N_3T_5	86.00ijk	5.60b	3.52ef	2.08b	9.10abc	19.27	39.13e-h	50.64	2.95f-i	4.25i-m	40.99b	17.20	22.00l
N_3T_6	91.77d-g	5.37b	3.86cd	1.51cd	9.03a-d	18.87	40.13def	50.37	3.40cd	5.38d	38.71b-g	20.35	24.60h-k
$S_{\bar{X}}$	0.83	0.11	0.08	0.11	0.15	0.42	0.45	0.40	0.10	0.10	0.87	0.46	0.47
LS	0.01	0.01	0.01	0.01	0.01	NS	0.01	NS	0.01	0.01	0.01	NS	0.01
CV (%)	1.59	4.41	4.20	15.44	2.82	3.76	1.95	1.41	6.07	.59	3.95	4.09	3.17

T_1 = 35 kg Flobond, T_2= 70 kg Flobond ha^{-1}, T_3 = 140 kg Flobond ha^{-1}, T_4 = 280 kg Flobond ha^{-1}, T_5= One Irrigation, T_6 = Two Irrigation, N_0 = Control, N_1= 50 kg N ha^{-1}, N_2 = 100 kg N ha^{-1}, N_3= 150 kg N ha^{-1}, LS= Level of significance, NS= Not significant

CONCLUSION

The findings of the experiment indicate that Flobond a chemical water retainer had remarkable positive effects on the growth, development, and productivity of wheat cv. Shatabdi. Within the scope and limitation of the present study, it may be concluded that a higher grain yield of wheat cv. Shatabdi could be obtained by using nitrogen fertilizer at the rate of 100 kg N ha^{-1} and 280 kg Flobond ha^{-1}. Water retainer-like Flobond may be promoted in Bangladesh agriculture in order to economize water and increase the efficiency of nitrogen for increasing wheat production.

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