Agriculture, Forestry and Fisheries
2014; 3(6-1): 23-27
Published online October 17, 2014 (http://www.sciencepublishinggroup.com/j/aff)
doi: 10.11648/j.aff.s.2014030601.14
ISSN: 2328-563X (Print); ISSN:2328-5648 (Online)

Effect of different levels of fertilizer and irrigation on the yield of wheat under raised bed system

Khokan Kumer Sarker[1], Dilip Kumar Roy[1], Akbar Hossain[2], Mohammed Monirul Islam[3]

[1]Irrigation and Water Management (IWM) Division, Bangladesh Agricultural Research Institute (BARI), Gazipur, 1701, Bangladesh
[2]Senior Scientific Officer, Wheat Research Centre, BARI, Nashipur, Dinajpur, Bangladesh
[3]Bangladesh Agricultural Development Corporation, Shera-Bangla Nagar, Dhaka

Email address:

ksarkerwrc@gmail.com (K. K. Sarker), droy49@gmail.com (D. K. Roy), tanjimar2003@yahoo.com (A. Hossain), mmonir_islam@yahoo.com (M. M. Islam)

To cite this article:

Khokan Kumer Sarker, Dilip Kumar Roy, Akbar Hossain, Mohammed Monirul Islam. Effect of Different Levels of Fertilizer and Irrigation on the Yield of Wheat under Raised Bed System. *Agriculture, Forestry and Fisheries.* Special Issue: Agriculture Ecosystems and Environment. Vol. 3, No. 6-1, 2014, pp. 23-27. doi: 10.11648/j.aff.s.2014030601.14

Abstract: The study was conducted on raised bed (one pass) tillage system on the effect of fertilizer and irrigation levels at Wheat Research Centre, Nashipur, Dinajpur (25°38´ N, 88°41´ E and 38.20 m above mean sea level). Treatments were: T_1; recommended fertilizer dose of N_{100} + $P_{26.5}$ + K_{40} + S_{20} + Z_4 + B_1 with irrigation up to 75% field capacity, T_2; recommended fertilizer dose with irrigation up to 100% field capacity, T_3; recommended fertilizer dose with irrigation up to 125% field capacity, T_4; 20% lower fertilizer dose than recommended dose with irrigation up to 75% field capacity, T_5; 20% lower fertilizer dose than recommended with irrigation up to 100% field capacity, T_6; 20% lower fertilizer dose than recommended with irrigation up to 125% field capacity. Irrigation water was applied at growth stages of 20, 55 and 75 days after sowing (DAS). Data on seasonal water use, yield and yield contributing characters of wheat were recorded during experimentations in raised bed cultivation systems. Results from this study indicated that the effect of fertilizer and irrigation level did not influence the grain yield and yield attributes of wheat under raised bed system. But, higher grain yield was found in the plots where recommended fertilizers were applied with irrigation up to 100% field capacity. Seasonal water was used by 211 – 231 mm and water use efficiency was found 1.53 – 1.78 kg m^{-3} by the treatments effect for one pass-tillage raised bed system. The short-term findings of this study raise the further crop physiological, fertilizer use efficiency and economics return study to confirm the results.

Keywords: Bed Planting System, Fertilizers, Irrigation, Water Use Efficiency, Wheat

1. Introduction

Wheat is the second most important cereal crop after rice in Bangladesh and its area and production has decreased by 0.34 million hectares and 0.47 million tons, respectively, while unit yield has increased by 0.7 ton per hectare from 2000 to 2014 [1; 2; 3]. Wheat is a strategic crop and it is highly responsive to irrigation water during the short winter season between November and March. So, water and fertilizer plays a vital role in crop production management. Application of only one irrigation increase the yield of wheat by more than 40%, whereas two to three irrigations with proper water and fertilizer management practices increase wheat yield by 50-100% [4]. Water should be utilized for optimum and economic yield. Modern High Yielding crop practices system can be sustained only with good water control and management at the farm level. Optimum water availability to plants during their growth is essential for realizing the full yield production. Every year crop production is essential to increase due to more and more efficient utilization of water through better management practices [5]. Bed planting is practiced in many parts of the world to reduce the cost of production and irrigation water [6]. Raised beds were introduced to Rice-Wheat systems of the Indo-Gangetic Plain (IGP) in the mid 1990s, initially for wheat, inspired by the success of irrigated maize-wheat on permanent raised beds (PRB) in Mexico. Many advantages of growing wheat on beds have been reported including increased yields, opportunities for mechanical weeding and improved

fertilizer placement, irrigation water savings, reduced lodging, water logging, seed rate and opportunities for intercropping [7]. Integrated irrigation and fertilizer management are of great importance for achieving optimum and sustainable yields of wheat. Fertilizer use efficiency is closely related to soil moisture content. Fertilizers are not readily available to plants due to deficit soil moisture. In Bangladesh conditions, three to four irrigations are required for optimum wheat yield whereas farmers provide only one to two irrigations. In general, farmers apply medium to higher doses of fertilizer with less irrigation water compared to its requirement. This causes low yield due to less availability of water as well as fertilizers to the plants [8]. Soil water status has a direct relationship with the availability and uptake of nutrients by plants as water is integral component of soil solution, and is involved in transportation of nutrient elements. Wheat roots have positive and significant association with the uptake of nutrients [9]. Recent studies have shown that wheat can be successfully grown on raised beds in various parts of the world, including northwest India, northwest Pakistan and northwest of Bangladesh. The size of beds for wheat in the IGP have found 37 to 40 cm bed top, 30 cm wide furrows and 15 to 20 cm high with two rows (20 cm apart) per bed. With bed planting, seed rate and irrigation water requirement can be reduced by about 30% as compared to conventionally tilled flat layouts [10]. There is no other study carried out in Bangladesh regarding fertilizer doses and amount of water for raised bed and furrow in wheat production. Bed planting with furrow system is becoming more popular for upland crops cultivating in Bangladesh. The size of the bed is also important to achieve the potential yield due to furrow spacing, seepage infiltration pattern and planting density. The bed planting and furrow irrigation system has been used in different countries with varying advantages [11; 12; 13; 14; 15] for some crops such as wheat, maize, legumes, oilseeds, cotton and sugar cane, etcetera. Bed planting and furrow system offers many advantages in water management, effective drainage, reducing risk of water logging, application of fertilizer and herbicides without significantly reduces yield. Therefore, the present study was undertaken to emphasize on soil conservation and water requirement, improving water use efficiency in conservation tillage farming systems through appropriate crop, fertilizers and efficient utilization of water & other inputs for wheat cultivation. The specific objectives were to determine the effect of fertilizer levels and amount of irrigation water on wheat yields and the seasonal water use for one pass tillage raised bed cultivation system.

2. Materials and Methods

The study was conducted during the *rabi* season of 2008-2009 at Wheat Research Centre (WRC), Nashipur, Dinajpur. The experimental site was situated at $25^0$45' N latitude and $88^0$40' E longitude. The topography of the study area was mainly medium high land and moderately well drained which was fallen under the old Himalayan piedmont plain. The topsoil was non-calcareous brown flood plain [16]. Soil samples were collected from 0-15, 15-30 and 30-45 cm depth of the experimental plots randomly to determine soil moisture, bulk density and field capacity by oven dry method. The data on other major property of soil, such as, soil type was collected from the research report of Bodruzzaman et al. [17]. The field experiment was laid out in randomized complete block design using strip plot arrangement with six treatment replicated thrice. The treatments were T_1 = Recommended fertilizer dose (N_{100} + $P_{26.5}$ + K_{40} + S_{20} + Z_4 + B_1) with irrigation up to 75% field capacity, T_2 = Recommended fertilizer dose with irrigation up to 100% field capacity, T_3 = Recommended fertilizer dose with irrigation up to 125% field capacity, T_4 = 20% lower fertilizer dose than recommended with irrigation up to 75% field capacity, T_5 = 20% lower fertilizer dose than recommended with irrigation up to 100% field capacity, T_6 = 20% lower fertilizer dose than recommended with irrigation up to 125% field capacity.

The unit plot size was 4 m × 5 m. The performance was conducted in raised bed planting using BARI bed former cum seeder. One pass raised bed size was 60 cm (furrow to furrow centre). Irrigation scheduling was followed to the experimental plots. Irrigation water was applied based on field capacity. The rainfall data was measured using rain gauge. The actual requirement was the depth of water needed to bring the crop rooting zone to field capacity uniformly throughout the field. The net irrigation depth was calculated from the following formula [18]:

$$d = \frac{P_w A_s D}{100}$$

Where, d = Net depth of irrigation water to be applied during each irrigation

A_s = Apparent specific density of soil

D = Rooting depth to be irrigated

P_w = ($F.C.$ - R_{sm})

Here, $F.C.$ = Field capacity, %

R_{sm} = Residual soil moisture level before irrigation, %

$$R_{sm} = (\frac{W_{ms} - W_{ods}}{W_{ods}})100$$

Where, W_{ms} is the weight of soil moisture, W_{ods} is the weight of oven dry soil.

The seasonal water use was calculated by the following relationship:

$$SWU = d + Rf + \sum_{i=1}^{n} \frac{M_{bi} - M_{ei}}{100} A_s D_i$$

Where, SWU = Seasonal water use (mm)

d = Net depth of irrigation water (mm)

Rf = Seasonal rainfall (mm)

M_{bi} = Moisture percentage at the beginning of the season

in the i^{th} layer of the soil.

M_{ei} = Moisture percentage at the end of the season in the i^{th} layer of the soil

n = No. of soil layer in the root zone (D) which was considered three layers, 0-150 mm, 150-300 mm and 300-450 mm

D_i = Depth of the i^{th} layer of soil within the root zone (mm)

A pre-sowing irrigation was applied for proper seed germination. A high yielding variety BARI gom-23 (Bijoy) was sown in the experimental plots on November 30, 2008 using the Bed former at the rate of 100 kg ha^{-1}. Seeding was done without land preparation by bed former cum seeder. Bed was consisted two rows depending on the crop on raised beds. Furrow to furrow distance was maintained by 55 cm. Bed height was 13 cm. Irrigation water was applied to the furrows between the beds. Seeds were treated with provax-200 @ 3 gm kg^{-1} of seed. Two fertilizers were applied at sowing and remaining N was top dressed after first irrigation. Weeding was done at 29 DAS by 2-4-D amine @ of 1200 ml ha^{-1} was applied. At maturity stages, two samples of each plot in 2×1.1 m for bed planting on 30 March 2009 were harvested. After threshed and cleaned, grain yields were recorded at 12% moisture content. Data on other plant characteristics during harvesting from each of the experimental plots were recorded, such as, Spike, plant height, spike length, spikelet $spike^{-1}$, grain $spike^{-1}$, 1000 grain weight, grain yield. Data were subjected to analysis of variance to sort out significant difference among treatments.

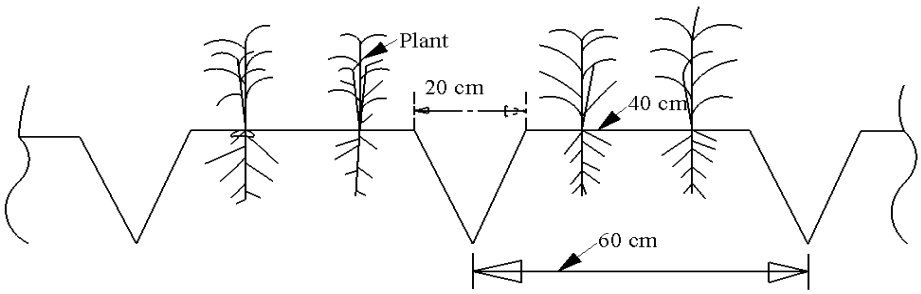

Figure 1. *Schematic view of wheat cultivation under raised bed and furrow using BARI two wheeled tractor bed former cum seeder.*

3. Results and Discussion

The yield and yield contributing characters are shown in Table 1. The effect of fertilizer levels and irrigation water had no significant difference on grain yield. All other yield contributing parameters were non-significant in terms of treatment effects. The variation of fertilizers and the amount of irrigation water have no significant influence on grain yields, but the treatment differences were followed same pattern of grain yields. Grain yield was dependent on spike, spikelet, grain and thousand grain weight. It was observed that no significant difference was found among the treatments but grain yield was found more in treatment T_2. It was also observed that less grain yield was found in treatment T_6 due to 25% excess irrigation water of field capacity and lower fertilizer levels. The grain yield was quite satisfying and relatively adequate. The obtained grain yields of this study were almost similar to that of the present and previous studies [13; 14; 15].

Table 1. *The effect of fertilizer levels and irrigation water on grain yield.*

*Treatment	Spike m^{-2}	Spikelet m^{-2}	Grain $Spike^{-1}$	Thousand grain weight (g)	Grain yield, (kg ha^{-1})
T_1	313	16.8	40.2	56.9	3711
T_2	327	17.3	39.8	58.7	3753
T_3	321.3	16.6	38.4	58.1	3687
T_4	314.7	15.9	38.4	56.8	3480
T_5	312	16.96	36.9	59.2	3682
T_6	298	16.9	36.8	58.6	3533
CV (%)	7.69	1.7	4.85	1.59	3.83
F-test	*NS	NS	NS	NS	NS

*Treatments: T_1 = Recommended fertilizer dose ($N_{100} + P_{26.5} + K_{40} + S_{20} + Z_4 + B_1$) with irrigation up to 75% field capacity, T_2 = Recommended fertilizer dose with irrigation up to 100% field capacity, T_3 = Recommended fertilizer dose with irrigation up to 125% field capacity, T_4 = 20% lower fertilizer dose than recommended with irrigation up to 75% field capacity, T_5 = 20% lower fertilizer dose than recommended with irrigation up to 100% field capacity, T_6 = 20% lower fertilizer dose than recommended with irrigation up to 125% field capacity.

*NS means no significant.

Seasonal crop water use in raised bed system is shown in Table 2. During sowing, the average bulk density, field capacity and soil moisture were 1.57 gm cc^{-1}, 24% and 19.5%, respectively. The amount of irrigation water was applied to the plots according to the treatments as shown in Table 2. The crop was irrigated three times on the basis of critical stages of wheat and the recommended irrigation scheduling for wheat cultivation. Average seasonal water

use varied from 211 to 231 mm by the treatments effect. The water use efficiency was varied from 1.53 to 1.78 kg m^{-3}. The lowest water use efficiency was observed in treatment T_6 and the highest water use efficiency was found in treatment T_2 due to the variation of grain yield and water. It was observed that seasonal water use was found slightly different due to variation of water application and soil water contribution. The results are in agreement with the findings of Hossain et al. [13] in bed planting system for wheat cultivation. The water productivity can be improved up to 1.31–1.99 kg m^{-3} by applying 20-30% less water. Water application in furrow method is easier than traditional systems and water could be saved about to 20% in bed planting system without drastically yield reduction [15]. The permanent bed planting system for wheat cultivation increases the fertilizer use efficiency and reduces production cost [19].

Table 2. *Seasonal water use in raised bed system for raised bed system.*

*Treatment	Irrigation water applied water (mm)	Soil water contribution (mm)	Effective rainfall (mm)	Seasonal water use (mm)	Grain yield, (kg ha-1)	Water use efficiency, (kg m-3)
T_1	136	65	15	216	3711	1.72
T_2	145	51	15	211	3753	1.78
T_3	161	49	15	225	3687	1.64
T_4	143	61	15	219	3480	1.59
T_5	152	48	15	215	3682	1.71
T_6	170	46	15	231	3533	1.53

*Treatments: T1 = Recommended fertilizer dose ($N_{100} + P_{26.5} + K_{40} + S_{20} + Z_4 + B_1$) with irrigation up to 75% field capacity, T2 = Recommended fertilizer dose with irrigation up to 100% field capacity, T3 = Recommended fertilizer dose with irrigation up to 125% field capacity, T4 = 20% lower fertilizer dose than recommended with irrigation up to 75% field capacity, T5 = 20% lower fertilizer dose than recommended with irrigation up to 100% field capacity, T6 = 20% lower fertilizer dose than recommended with irrigation up to 125% field capacity.

4. Conclusion

Based on the short term experiment, it was observed that seasonal water use was found almost similar. About 20% fertilizer could be saved for wheat cultivation by raised bed (one pass tilled) and furrow system without significant yield reduction. One pass bed planter cum seeder with less fertilizer might be used for wheat cultivation instead of conventional fertilizer use. Under the conditions of this field trial, there was little indication that raised bed and furrow with reduced fertilizer doses could replace the traditional fertilizers application without significantly yield reduction and this system could extend the acreage of wheat cultivation by 20% saving fertilizers. The outcome of this trial raises the further crop physiological, fertilizer use efficiency and economics study to confirm the findings. However, raised bed and furrow system could replace the conventional flooding irrigation system with advantages of environmental friendliness.

Acknowledgements

The authors would like to thank Wheat Research Centre, Bangladesh Agriculture Research Institute (BARI), Nashipur, Dinajpur, and Irrigation and Water Management Division, Gazipur, Bangladesh for providing all facilities and sharing their expertise for sustainable resource conserving technologies.

References

[1] WRC (Wheat Research Centre), "*Annual Research Report*", WRC, BARI. Nashipur, Dinajpur, Bangladesh, 2008.

[2] Hossain, A. and Silva, J.A.T. Wheat production in Bangladesh: its future in the light of global warming. *AoB Plants* 5: pls042. doi: 10.1093/aobpla/pls042, 2013.

[3] Mundi Index. Bangladesh wheat production by year: Market year, production (1000MT) and growth rate (%). Available online: *http://www.indexmundi.com/agriculture*, Accessed October 12, 2014.

[4] Hossain, M. A., M.H. Rashid, M.S. Rahman, S.K. Biswas, "Interaction of Irrigation Levels and fertilizer Doses on Wheat Production in Bangladesh". *Bangladesh J. of Agric. Engg*. 17 (1 & 2): 1- 8, 2006.

[5] Sarker, K.K., A.Z. Sarker, P.K. Malaker, , K.C. Roy, D. Islam, "Comparative Study on Water Requirement and Economic Return of Wheat and Boro rice". *Journal of the Bangladesh Society for Agricultural Science and Technology* 4 (3 & 4): 45-48, 2007.

[6] Abdelhadi, A.W., M.A. Bashir, S.E.A. El-Awad, H.Takeshi, "Evaluation of Wheat Bed Planting System in Irrigated Vertisols of Sudan". *Agricultural Mechanization of Asia, Africa & Latin America* 37, No. 3, 2006.

[7] Humphreys, E. and C.H. Roth, "Permanent Beds and Rice Residue Management for Rice–Wheat Systems in the Indo-Gangetic Plain". *Proceedings of a workshop held in Ludhiana*, India, 7– 9 September, ACIAR, Canberra, p10, 2008.

[8] Rashid, M.H., M.A.K. Mridha, M.S. Islam, M.S. Alam, S.K. Biswas, , M.A. Hossain, P.K. Sarker, and W. Kabir, "Improvement of the water Resources Management for Sustainable Rice–Wheat System in Dinajpur and Jessore Areas", *Research Project Report*, 1998 –2001, BARI, Joydebpur, Gazipur, p. 40, 2001.

[9] Islam, M.S., S.A.J.M. Karim, Q.A. Khaliq, and S. Ahmed, "Effect of Tillage and Irrigation on Root Growth, Nitrogen Uptake and Yield of Wheat in Shallow Red Brown Terrace Soils of Bangladesah". *Bangladesh J of Agril. Res*. 31(4), p 600, 2006.

[10] Humphreys, E. and J. Timsina, "Modeling of irrigated cropping systems with Special attention to rice-wheat sequences and raised bed planting". *Proceedings of a workshop at CSIRO Land Water*, Griffith 25–28 February, CSIRO Land Water Technical Report 25/02, NSW 2680, Austalia, p118, 2002.

[11] Sayre, K.D. and P.R. Hobbs, "The Raised Bed System of Cultivation for Irrigated Production Conditions". In: Sustainable Agriculture and the rice-Wheat System, Lal, R., Hobbs, P., Uphoff, N., Hansen, D.O. (Eds.). Ohio State University, Columbus, Ohio, USA, pp: 337-355, 2004.

[12] Tripathi, S.C., A.D. Mongia, D.S. Chauhan, R.K. Sharma, A.S. Kharub, R.S. Chhokar, S. Jag, "Bed Planting: A New Technique to Diversify/Intensify Rice-Wheat System in India", *Proceedings of the 4th International Crop Science congress*, September 26 - October 1, Brisborn, Australia, pp:1-1, 2004.

[13] Hossain, M.A., M.A.R. Akanda, S.K. Biswas, M.A. Hoque, M.S.Rahman, "Determination of Irigation Efficiency and Water Saving for Wheat Cultivation under Bed Planting System". *Bangladesh J. Agril. Sci.* 35 (2): 167-173, 2008.

[14] Sarker, K.K., P.K. Sarkar, M.A. Hoque, , P.K. Malaker, S. Islam, "Effect of Zero Tillage and Bed Planting Methods on Water Use for Wheat Cultivation". *Journal of Agricultural Engineering, the Institution of Engineers,* Bangladesh, Vol. 37/AE, December, 2009.

[15] Akanda, M.A.R., M.S. Islam, M.A. Hossain , M. Abdullah, "Evaluation of Irrigation Effectiveness of different Bed Widths for Wheat Cultivation", Journal of the Institution of Engineers, Bangladesh, Vol. 30 (1): December, 2003.

[16] BBS (Bangladesh Bureau of Statistics), "Statistical Year Book of Bangladesh", BBS, Dhaka, Bangladesh, 2004.

[17] Bodruzzaman,M., M.H.H. Khan, , M.A. Shaheed and A.S.M.G. Amin, "Response of Wheat to Different Rates of Phosphorus and Potassium Application". *Bangladesh J. Agril. Res*. 28 (4): 615-618, 2003.

[18] Khair, A. "Water Application Methods for Diversified Crops. Crop Diversification: Findings from a Field Research Programme", *The University Press Limited*, P43, 1995.

[19] Limon-Ortega, A. Sayre, K.D. Frances, "Wheat and Maize Yields in Response to Straw Management and Nitrogen under Bed Planting System", *Agronomy Journal* 92 (2): 293-302, 2000.