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Productivity potential of wheat (*Triticum aestivum*) in relation to different planting methods and nitrogen management strategies*

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Food security dilemma is the problem of the future for countries like India where resources are getting stretched to the limits. There is no doubt that intensive agriculture in irrigated areas has brought out substantial enhancement in foodgrain production but has also threatened the environmental safety and promoted the degradation and inefficient use of basic resources and production inputs. In the present situation, the only option left is to shift towards eco-friendly technology advances and efficient utilization of production resources especially soil, water and nutrients.

In the recent years, furrow irrigated raised bed planting system (FIRBS) has proved to be one of the important components of low cost sustainable production system. This planting system facilitates mechanical weed control, increased water-use efficiency, reduced crop lodging and has lower seed requirement (Sayre 2000 and Yadav *et al.* 2002). Imbalanced use of fertilizers warrants their judicious use to maximize fertilizer-use efficiency. Recovery of added fertilizer nitrogen is only 50% or less in most of the arable soils owing to volatilization, leaching and denitrification losses. Beneficial effects of N applied through top/side dressing in comparison to broadcasting have also been reported. Majority of the wheat (*Triticum aestivum* L. emend Fiori & Paol.) planted either by drill or broadcast makes it difficult for N application in standing crop. Broadcast N application and flooding in flat-sown wheat leads to higher N losses. However, bed planted wheat provides an access to field after planting, thus providing an alternative to broadcast fertilizers in standing crop by way of placement (Limon-Ortega and Sayre 2003). There have been some reports on potential of furrow irrigation in improved N efficiency and increasing recovery of applied N fertilizers (Fahong *et al.* 2004). Since the concept of bed planted wheat is recent in India and information regarding response of bed planted wheat to timing and method of N application are scanty, the present investigation was carried out to assess the effectiveness of methods and time of N application in relation to different planting methods to increase the productivity potential of wheat.

The field study was conducted for 2 years (2002–03 and 2004–05) at the agronomy research farm of the CCSHAU, Hisar located at 29°10′ N, 75° 48′ E, 251.2 m above mean sea level. The experimental region represents a semi-arid sub-tropical climate with hot desiccating winds with frequent dust storms during summer, severe cold during winter and warm humid conditions during monsoon months. The average annual rainfall is 420 mm, of which nearly 80–90% is received in July to September by south-western monsoons. The mean relative humidity remains nearly 80–90% from July to March and remains around 40–50% for the remaining part of the year. The soil was sandy loam in texture (sand 58.4 ± 0.2, silt 18.3 ± 0.1 and clay 22.4 ± 0.1), slightly alkaline (7.75 ± 0.05), tested low in available N ($KMnO_4$-N, 163.3 ± 2.1 kg/ha), medium in available P (Olsens-P, 11.0 ± 0.6 kg/ha) and high in available K (NH_4OAC-K, 326.0 ± 2.2 kg/ha). A total of 18 treatments were tested in split-plot design with 3 replications by allocating method of sowing and N application to the main plots and timings of N application to the sub-plots. The treatments comprised 3 methods of sowing, viz conventional system (CS) (flat sowing in lines 20 cm apart), furrow irrigated raised bed system with 2 rows/bed 15 cm apart and furrow irrigated raised bed system with 3 rows/bed 10 cm apart; 2 methods of N application, viz broadcast and placement of N in between rows and 3 timings of N application, viz 1/2 before sowing + 1/2 after first irrigation (N_1), 1/3 before sowing + 1/3 after first irrigation + 1/3 at spike initiation (N_2) and 1/3 after first irrigation + 1/3 at boot stage + 1/3 at anthesis (N_3). The field was well

*Short note

Based on complete information of Ph D thesis of the first author submitted to CCSHAU, Hisar during 2005

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prepared by having 3–4 ploughings (harrowing and cultivation), followed by planking both under furrow irrigated raised bed system as well as conventional sowing. However, under furrow irrigated raised bed system, beds were prepared after field preparation and then it was followed by wheat sowing in second pass. 'PBW 343' wheat was sown on 21 and 18 November at 5–6 cm seeding depth using 100 kg seed/ha with the help of bed planter under furrow irrigated raised bed system and with zero-till seed-cum-fertilizer drill under conventional tillage during 2002–03 and 2004–05, respectively. The experiment could not be repeated during 2003–04 due to some unavoidable circumstances. Recommended dose of nitrogen (150 kg N/ha) was applied as per treatments, whereas phosphorus (diammonium phosphate (DAP), 18% N and 46% P_2O_5) and K (muriate of potash, 60% K_2O) was drilled uniformly as basal dose across all the treatment plots as per state recommendations. Basal dose of N was applied through DAP, whereas remaining N dose was top-dressed as urea (46% N) depending on the treatments. A total of 4 (28, 67, 103 and 124 days after sowing) and 3 (26, 74 and 105 days after sowing) irrigations were applied with canal water during the respective years. The crop was harvested on 22 and 15 April during 2002–03 and 2004–05, respectively. The data on growth and other yield, attributing characters were recorded on 10 selected plants at harvest. The crop was threshed plot-wise and grain yield thus obtained from net plot was converted into kg/ha. The experimental results were almost similar in each year, therefore, the pooled analysis was carried out to explain the treatment effects.

The data presented in Table 1 revealed that significantly taller plants, more dry matter accumulation (DMA) and higher leaf area index (LAI) was recorded with crop sown under furrow irrigated raised bed system with 3 rows/bed as compared to conventional sowing, however, it was at par with furrow irrigated raised bed system with 2 rows/bed. This increase was primarily due to faster growth, better root development and aeration owing to more free space available on both sides of bed under furrow irrigated raised bed system. These results are in line with those of Kumar (2005).

The grain yield of wheat under conventional sowing was significantly lower than both furrow irrigated raised bed system either with 3 rows/bed or 2 rows/bed, which were statistically at par among themselves. The sowing of wheat under furrow irrigated raised bed system with 3 rows/bed and 2 rows/bed produced 12.5 and 8.3% higher mean grain yield as compared to conventional sowing. This increase in yield could be accredited to higher numbers of spikes/m row length, more spikelets/spike, grains/spike and 1000-grain weight under furrow irrigated raised bed planting system. These findings are in confirmation with those of Yadav *et al.* (2002). The modified microclimatic conditions within the field due to the orientation of the wheat plants in rows on the beds resulted in reduced crop lodging and decreased insect-pests incidence owing to reduced canopy humidity which contributed towards enhanced crop yield (Fahong *et al.* 2004). Further, irrespective of the row arrangements, improvement in fertilizer nitrogen-use efficiency (34.1 and 33.3 kg/kg of added N) due to bed planting might be ascribed to statistically better yield when compared with traditional flat system (30.3

Table 1 Effect of method of sowing and N management on growth characteristics of wheat (mean of 2 years)

Treatment	Plant height (cm)	Dry matter accumulation (g/mrl)	Leaf area index	Spikes/mrl	Spikelets/ spike	Grains/ spike	1 000-seed weight(g)
Method of sowing							
Conventional system (CS)	86.7	258.6	0.91	84.4	13.2	42.1	40.6
FIRBS (2 rows/bed)	89.4	276.6	0.94	114.3	14.6	44.7	42.1
FIRBS (3 rows/bed)	92.4	296.2	0.96	109.9	15.2	46.5	42.9
CD (*P=0.05*)	3.4	21.2	0.03	6.8	0.7	2.9	1.0
Method of N application							
Broadcast	87.8	262.5	0.92	98.3	13.7	43.1	41.5
Placement	2.6	290.2	0.95	107.5	15.0	46.2	42.2
CD (*P=0.05*)	3.0	18.4	0.02	4.7	0.6	2.4	NS
Time of N application							
1/2 before sowing + 1/2 after first irrigation (N_1)	89.4	277.5	0.93	102.5	13.6	41.6	41.6
1/3 before sowing + 1/3 after first irrigation + 1/3 at spike initiation (N_2)	90.8	290.9	0.98	110.3	14.4	44.9	41.9
1/3 after first irrigation + 1/3 at boot stage + 1/3 at anthesis (N_3)	88.2	263.1	0.90	95.9	15.0	46.8	42.1
CD (*P=0.05*)	1.8	20.4	0.05	4.8	1.0	3.6	NS

Table 2 Effect of method of sowing and N management on grain and straw yield and harvest index of wheat (mean of 2 years)

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)
Method of sowing			
Conventional system (CS)	4 546	6 829	39.9
FIRBS (2 rows/bed)	4 921	7 248	40.7
FIRBS (3 rows/bed)	5 112	7 680	40.0
CD (*P=0.05*)	278	482	NS
Method of N application			
Broadcast	4 637	6 996	39.9
Placement	5 043	7 508	40.5
CD (*P=0.05*)	233	378	NS
Time of N application			
1/2 before sowing + 1/2 after first irrigation (N_1)	4 786	7 077	40.3
1/3 before sowing + 1/3 after first irrigation + 1/3 at spike initiation (N_2)	5 128	7 757	39.8
1/3 after first irrigation + 1/3 at boot stage + 1/3 at anthesis (N_3)	4 669	6 925	40.4
CD (*P=0.05*)	261	4 123	NS

kg/kg of added N). Similar findings were reported by Limon-Ortega *et al.* (2000).

Compared to broadcasting method, placement of N resulted into significant improvement in yield attributes to the tune of 9.4% for spikes, 9.5% for spikelets/spike and 7.3% for grains/spike. This superiority in terms of yield attributes due to N placement culminated in grain yield advantage of 8.7% in comparison to broadcasting method of N application. More availability, less leaching losses and effective use of applied N could be responsible for yield advantage. Similar advantages of N placement have also been reported by Kumar (2005).

Nitrogen applied in 3 splits (1/3 before sowing + 1/3 after first irrigation + 1/3 at spike initiation) (N_2) recorded significantly taller plants, more dry matter accumulation and higher LAI (Table 1), followed by N applied in 2 splits (1/2 before sowing + 1/2 after first irrigation) (N_1). The per cent increase in grain yield due to splitting of N in 3 splits (N_2) was 7.2% in comparison to N_1 (2 splits) and 9.9% in comparison to N_3 (3 splits). Splitting of top-dressed nitrogen (2 splits) gave yield advantage over single top-dressing. Nitrogen top-dressed in single split (N_1) was available up to tillering stage. However, when top-dressed N was splitted (N_2), it was efficiently utilized ensuing improvement in yield attributes (Table 3) which culminated into significant yield advantage. Omitting basal N application during the initial growth period (N_3) could be the reason for the lowest yield obtained under this treatment. The differences in magnitude of yield might be partly ascribed to differences in N utilization efficiency under different timings of N application. Applying the entire dose in 3 splits (1/3 before sowing + 1/3 after first irrigation + 1/3 at spike initiation) resulted in fertilizer nitrogen-use efficiency (NUE) of 34.2 kg/kg of applied N, followed by its application in 2 splits as 1/2 before sowing + 1/2 after first irrigation (31.9 kg/kg N applied). The application of N in 3 splits at 1/3 after first irrigation + 1/3 at boot stage + 1/3 at anthesis was the least efficient method and gave NUE of 31.1 kg/kg of applied N in the respective years.

Based on the study, it can be concluded that wheat sown under furrow irrigated raised bed planting system (3 rows/bed) with nitrogen applied in 3 splits (1/3 before sowing + 1/3 after first irrigation + 1/3 at spike initiation) through placement method gave higher yield on sustainable basis.

SUMMARY

Field experiment was carried out during 2002–03 and 2004–05 to evaluate the productivity potential of wheat in relation to method and timing of nitrogen application under different planting methods. Sowing of wheat under furrow irrigated raised bed system with 3 and 2 rows/bed showed yield superiority of 12.5 and 8.3%, respectively over the flat sowing owing to better nitrogen-use efficiency and higher values of yield-attributing components. Compared to broadcast method of N application, placement of nitrogen resulted in significant yield increase to the tune of 8.7%. Results indicated that increasing the number of splits can not compensate for basal nitrogen application. Application of nitrogen in 3 splits (1/3 before sowing + 1/3 after first irrigation + 1/3 at spike initiation) resulted in significantly taller plants, more dry matter accumulation, higher leaf area index and finally grain yield.

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