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WHEAT YIELD AND COTTON-WHEAT SYSTEM WATER PRODUCTIVITY AS AFFECTED BY RESIDUE MULCH, IRRIGATION AND NITROGEN LEVELS APPLIED ON Bt COTTON

R. Joshi* and C. B. Singh

Department of Soil Science, Punjab Agricultural University, Ludhiana - 141 004 (Punjab), India.

Abstract

Large scale rice cultivation in north-western India has led to an irrigation water crisis due to excessive withdrawal of underground water. Continuous cultivation with a rice-wheat cropping system and large scale rice and wheat residue production leads to burning of surplus rice and wheat residue by the farmers has also caused intense air pollution. Retaining rice and wheat residueas surface mulch as an alternative to burning and also changing rice-wheat to cotton -wheat cropping system could be useful for soil moisture conservation, reducingair pollution and improving soil organic matter level. A field experiment was conducted for two years in cotton-wheat sequence in research farm, Punjab Agricultural University, Ludhiana, India to study the wheat yield and cotton-wheat system water productivity as affected by residue mulch, irrigation and nitrogen levels applied on Bt cotton. Rice straw was used as crop residue mulch.

Key words : Rice residue, cotton-wheat system, water productivity, wheat yield.

Introduction

Wheat is the world's most widely cultivated food crop due toits wider adaptability to different climatic and edaphic conditions. In India, wheat is the main cereal crop and occupies the secondposition, in respect of area and production, next to rice. Water is an important input for realizing high wheat productivity, however,it is becoming the most limiting factor for crop production inmost of the north western parts of India where rice–wheat (RW) is the major cropping system (Hira, 2009). In India, RW systems account for >80% of the total cereal production and about 50% of the total calorie intake. More than 90% area of the RW area is irrigated and is facing yield stagnation, soil degradation, declining groundwater table (Hira, 2009) and air pollution (Bijay-Singh *et al*., 2008). Therefore, it is essential to improve irrigation water productivity and decrease irrigation demand while maintaining the crop productivity. A cotton-wheat system is an alternative to rice-wheat systems in north-western India. It could be useful for soil moisture conservation, reducingair pollution and improving soil organic matter level.

Intensive irrigated R-W systems in north-western India are generating large quantities of crop residues as a result of increased crop production. Because of limited time interval between rice and wheat crops and no alternate uses of rice straw, farmers often burn the residue in the open field. Burning crop residues also destroys organic matter and results in large nutrient losses, particularly, N, P and S (Yadvinder Singh *et al*., 2008). Thus technologies that enable retention of rice residues would greatly reduceair pollution and improve soil fertility. Mulching is an important agronomic practice to check moisture loss from soil surface. Sharma *et al*. (2010) in the north-western Himalayan regions of India observed that mulching is useful for conserving soil moisture, resulting in increased productivity and improved soil conditions for the maize-wheat cropping system. Langdale *et al*. (1992) reported that use of straw mulch reduces water loss and soil temperature of surface soil, but increases soil organic content. The quantity of mulching may have differential effects on water use and water use efficiency. The present investigation was therefore, carried out with the objectives to study the interactive effect of variable irrigation levels, rice straw mulch and

***Author for correspondece :** E-mail: ritikajoshi964@gmail.com

nitrogen levels applied on Bt cotton affect growth, productivity of wheat crop and water use efficiency of cotton-wheat systems in North West India.

Materials and Methods

The field experiment was conducted at the Punjab Agricultural University, Ludhiana during *kharif-rabi* seasons of 2015-16 and 2016-17. The climate of this area is characterized as sub-tropical and semi-arid with hot and dry summer from April to June, hot and humid from July to September and cold winter from November to January. The average annual rainfall is about 500–750 mm, most of which is received during the monsoon period from July to September. The soil of the experimental site was sandy loam in texture. The top 0–15 cm layer of the soil profile was neutral in pH (7.6, 1:2 soil:water ratio), with 0.12 ds m^{-1} electrical conductivity, low in $KMnO_4$-oxidizable N (184.3 kg ha^{-1}) and Walkley and Black

Table 1 : Plant height (cm) as affected by residue mulch, irrigation and nitrogen levels applied on Bt cotton.

Nitrogen rate (Kg/ha)	2015-16								Overall mean
	M_0				M_6				
	$I_{0.4}$	$I_{0.3}$	$I_{0.2}$	Mean	$I_{0.4}$	$I_{0.3}$	$I_{0.2}$	Mean	
N_0	85.5	84.0	85.2	**84.9**	87.0	86.0	86.5	**86.5**	**85.7**
N_{50}	88.0	88.2	89.0	**88.4**	88.5	89.2	90.2	**89.3**	**88.9**
N_{100}	86.0	85.5	84.3	**85.3**	92.5	90.0	84.8	**89.1**	**87.2**
N_{150}	92.2	90.9	86.0	**89.7**	90.5	91.0	89.0	**90.2**	**89.9**
Mean	**87.9**	**87.2**	**86.1**	**87.1**	**89.6**	**89.1**	**87.6**	**88.8**	
Factor Mean **Irrigation (I)** $I_{0.4}$ = 88.8 $I_{0.3}$ = 88.2 $I_{0.2}$ =86.9 **Mulch (M)** M_0 = 87.1 M_6 = 88.8 **Nitrogen (N)** N_0 = 85.7 N_{50} = 88.9 N_{100} = 87.2 N_{150} = 89.9									
LSD (0.05)	**I = NS, M = NS, N = NS**								
	2016-17								
N_0	90.6	90.6	80.0	**87.1**	90.6	89.4	86.2	**88.7**	**87.9**
N_{50}	85.0	82.5	88.1	**85.2**	85.6	82.6	81.9	**83.4**	**84.3**
N_{100}	91.9	89.4	80.6	**87.3**	92.2	92.1	88.5	**90.9**	**89.1**
N_{150}	89.4	90.6	88.7	**89.6**	88.6	91.3	91.9	**90.6**	**90.1**
Mean	**89.2**	**88.3**	**84.4**	**87.3**	**89.3**	**88.9**	**87.1**	**88.4**	
Factor Mean **Irrigation (I)** $I_{0.4}$ = 89.2 $I_{0.3}$ = 88.6 $I_{0.2}$ =85.8 **Mulch (M)** M_0 = 87.3 M_6 = 88.4 **Nitrogen (N)** N_0 = 87.9 N_{50} = 84.3 N_{100} = 89.1 N_{150} = 90.1									
LSD (0.05)	**I = NS, M = NS, N = NS**								
	Average of two year								
N_0	88.1	87.3	82.6	**86.0**	88.8	87.7	86.4	**87.6**	**86.8**
N_{50}	86.5	85.4	88.6	**86.8**	87.1	85.9	86.1	**86.3**	**86.6**
N_{100}	89.0	87.5	82.5	**86.3**	92.4	91.1	86.7	**90.0**	**88.2**
N_{150}	90.8	90.8	87.4	**89.6**	89.6	91.2	90.5	**90.4**	**90.0**
Mean	**88.6**	**87.7**	**85.2**	**87.2**	**89.4**	**89.0**	**87.4**	**88.6**	
Factor Mean **Year (Y)** 2015-16= 88.0 2016-17= 87.9 **Irrigation (I)** $I_{0.4}$ = 89.0 $I_{0.3}$ = 88.4 $I_{0.2}$ =86.3 **Mulch (M)** M_0 = 87.2 M_6 = 88.6 **Nitrogen (N)** N_0 = 86.8 N_{50} = 86.6 N_{100} = 88.2 N_{150} = 90.0									
LSD (0.05)	**Y= NS, I= NS, M = NS, N = NS**								

organic carbon (0.15%), medium in Olsen-P (13.6 kg ha^{-1}) and 1 N NH_4O Ac-extractable K (143.8 kg ha^{-1}). The experiment was laid out in a factorial split plot design keeping combination of three irrigations levels and two mulch rates in main plots and four levels of nitrogen in sub-plots and replicated three times. All main plot treatments were randomized in each replication and all sub plot treatments were randomized in each main plot treatment and replication. The experiment was established on same location and treatments were imposed on same plots in all the years of study.

Results and Discussion

Table 1 indicated the effect of rice straw residue (applied in cotton crop as mulch during cotton-wheat

Table 2 : Ear length (m) as affected by residue mulch, irrigation and nitrogen levels applied on Bt cotton.

Nitrogen rate (Kg/ha)	2015-16								Overall mean
	M_0				M_6				
	$I_{0.4}$	$I_{0.3}$	$I_{0.2}$	Mean	$I_{0.4}$	$I_{0.3}$	$I_{0.2}$	Mean	
N_0	0.11	0.10	0.09	**0.10**	0.12	0.11	0.11	**0.11**	**0.10**
N_{50}	0.11	0.11	0.11	**0.11**	0.11	0.13	0.12	**0.12**	**0.11**
N_{100}	0.10	0.09	0.11	**0.10**	0.10	0.11	0.11	**0.11**	**0.10**
N_{150}	0.11	0.11	0.10	**0.11**	0.11	0.09	0.09	**0.10**	**0.11**
Mean	**0.11**	**0.10**	**0.10**	**0.10**	**0.11**	**0.11**	**0.11**	**0.11**	
Factor Mean Irrigation (I) $I_{0.4}$= 0.10 $I_{0.3}$= 0.10 $I_{0.2}$=0.10; Mulch (M) M_0 = 0.10 M_6 = 0.11; Nitrogen (N) N_0 = 0.10 N_{50}= 0.11 N_{100} = 0.10 N_{150}= 0.11									
LSD (0.05) I = NS, M = NS, N = NS									
	2016-17								
N_0	0.13	0.11	0.09	**0.11**	0.12	0.11	0.09	**0.11**	**0.11**
N_{50}	0.12	0.10	0.11	**0.11**	0.10	0.10	0.12	**0.11**	**0.11**
N_{100}	0.12	0.12	0.10	**0.11**	0.11	0.09	0.11	**0.10**	**0.11**
N_{150}	0.10	0.11	0.11	**0.11**	0.09	0.11	0.13	**0.11**	**0.11**
Mean	**0.12**	**0.11**	**0.10**	**0.11**	**0.11**	**0.10**	**0.11**	**0.11**	
Factor Mean Irrigation (I) $I_{0.4}$= 0.11 $I_{0.3}$= 0.10 $I_{0.2}$=0.11; Mulch (M) M_0 = 0.11 M_6 = 0.11; Nitrogen (N) N_0 = 0.11 N_{50}= 0.11 N_{100} = 0.11 N_{150}= 0.11									
LSD (0.05) I = NS, M = NS, N = NS									
	Average of two year								
N_0	0.12	0.10	0.09	**0.10**	0.12	0.11	0.10	**0.11**	**0.11**
N_{50}	0.12	0.10	0.11	**0.11**	0.10	0.12	0.12	**0.12**	**0.12**
N_{100}	0.11	0.11	0.10	**0.11**	0.10	0.10	0.11	**0.11**	**0.11**
N_{150}	0.11	0.11	0.10	**0.11**	0.10	0.10	0.11	**0.10**	**0.11**
Mean	**0.11**	**0.10**	**0.10**	**0.11**	**0.11**	**0.11**	**0.11**	**0.11**	
Factor Mean Year (Y) 2015-16= 0.11 2016-17= 0.11; Irrigation (I) $I_{0.4}$= 0.11 $I_{0.3}$= 0.11 $I_{0.2}$=0.11; Mulch (M) M_0 = 0.11 M_6=0.11; Nitrogen (N) N_0 = 0.11 N_{50}= 0.12 N_{100} = 0.11 N_{150}= 0.11									
LSD (0.05) Y= NS, I= NS, M = NS, N = NS									

Table 3 : Wheat grain yield (q ha^{-1}) as affected by residue mulch, irrigation and nitrogen levels applied on Bt cotton.

Nitrogen rate (Kg/ha)	2015-16								Overall mean
	M_0				M_6				
	$I_{0.4}$	$I_{0.3}$	$I_{0.2}$	Mean	$I_{0.4}$	$I_{0.3}$	$I_{0.2}$	Mean	
N_0	44.0	43.2	42.2	**43.1**	45.6	44.0	43.6	**44.4**	**43.8**
N_{50}	43.9	43.6	42.5	**43.3**	45.8	43.2	42.8	**43.9**	**43.6**
N_{100}	43.2	43.2	44.5	**43.6**	45.9	43.8	44.7	**44.8**	**44.2**
N_{150}	43.4	44.1	44.1	**43.9**	44.9	43.7	44.4	**44.3**	**44.1**
Mean	**43.6**	**43.5**	**43.3**	**43.5**	**45.6**	**43.7**	**43.9**	**44.4**	
Factor Mean Irrigation (I) $I_{0.4}$= 44.6 $I_{0.3}$= 43.6 $I_{0.2}$=43.6; Mulch (M) M_0 = 43.5 M_6 = 44.4; Nitrogen (N) N_0 = 43.8 N_{50}= 43.6 N_{100} = 44.2 N_{150}= 44.1									
LSD (0.05)	**I = NS, M = NS, N = NS**								
	2016-17								
N_0	50.6	50.6	50.0	**50.4**	50.6	49.4	46.2	**48.7**	**49.7**
N_{50}	50.0	52.5	48.1	**50.2**	50.6	52.6	51.9	**51.7**	**51.2**
N_{100}	51.9	49.4	50.6	**50.6**	52.2	52.1	48.5	**50.9**	**50.9**
N_{150}	49.4	50.6	48.7	**49.6**	52.6	51.3	51.9	**51.9**	**50.3**
Mean	**50.5**	**50.8**	**49.4**	**50.2**	**51.5**	**51.3**	**49.6**	**50.8**	
Factor Mean Irrigation (I) $I_{0.4}$= 50.7 $I_{0.3}$= 51.3 $I_{0.2}$=49.5; Mulch (M) M_0 = 50.2 M_6 = 50.8; Nitrogen (N) N_0 = 49.7 N_{50}= 51.2 N_{100} = 50.9 N_{150}= 50.3									
LSD (0.05)	**I = NS, M = NS, N = NS**								
	Average of two year								
N_0	47.4	47.0	46.8	**47.1**	48.1	46.7	44.2	**46.3**	**46.7**
N_{50}	47.0	49.0	45.9	**47.3**	48.1	47.9	47.1	**47.7**	**47.4**
N_{100}	47.4	46.4	47.8	**47.2**	49.2	47.9	46.6	**47.9**	**47.5**
N_{150}	46.5	47.4	46.7	**46.9**	47.4	47.4	48.0	**47.6**	**47.2**
Mean	**47.1**	**47.5**	**46.8**	**47.1**	**48.2**	**47.5**	**46.5**	**47.4**	
Factor Mean Year (Y) 2015-16= 44.0 2016-17= 50.5; Irrigation (I) $I_{0.4}$= 47.6 $I_{0.3}$= 47.5 $I_{0.2}$=46.6; Mulch (M) M_0 = 47.1 M_6 = 47.4; Nitrogen (N) N_0 = 46.7 N_{50}= 47.4 N_{100} = 47.5 N_{150}= 47.2									
LSD (0.05)	**Y=NS, I = NS, M = NS, N = NS**								

sequence) on height (cm) of wheat crop and it was not significantly affected by residue. Plant height in mulch plots was slightly higher than no mulch plots in both the year and also in pooled data. On pooled data, plant height in mulched plot was 88.6 cm as compare to 87.2 cm in no mulch plot. Among the irrigation regimes, plant height was highest (89.0 cm) at $I_{0.4}$ irrigation regimes followed by $I_{0.3}$ and $I_{0.2}$ irrigation regimes. With increase in nitrogen rates plant height was increased and highest plant height was recorded at N_{150} (90.0 cm) followed by control, N_{50} and N_{100} treatment. Table 2 indicated the effect of rice straw residue (applied in cotton crop as mulch during cotton-wheat sequence) on ear length (m) of wheat crop and it was not significantly affected by crop residue. Ear

Table 4 : Wheat straw yield (q ha[-1]) as affected by residue mulch, irrigation and nitrogen levels applied on Bt cotton.

Nitrogen rate (Kg/ha)	2015-16								Overall mean
	M_0				M_6				
	$I_{0.4}$	$I_{0.3}$	$I_{0.2}$	Mean	$I_{0.4}$	$I_{0.3}$	$I_{0.2}$	Mean	
N_0	59.0	57.7	60.9	**59.2**	61.5	62.8	60.3	**61.5**	**60.4**
N_{50}	60.3	59.0	59.0	**59.4**	60.3	59.0	62.8	**60.7**	**60.0**
N_{100}	63.5	60.9	56.4	**60.3**	62.7	58.3	59.6	**60.2**	**60.2**
N_{150}	65.4	57.7	56.4	**59.8**	64.1	60.9	62.2	**62.4**	**61.1**
Mean	**62.0**	**58.8**	**58.2**	**59.7**	**62.1**	**60.3**	**61.2**	**61.2**	
Factor Mean Irrigation (I) $I_{0.4}$= 62.1 $I_{0.3}$= 59.5 $I_{0.2}$=59.6; Mulch (M) M_0 = 59.7 M_6 = 61.2; Nitrogen (N) N_0 = 60.3 N_{50}= 60.0 N_{100} = 60.3 N_{150}= 61.1									
LSD (0.05) I = NS, M = NS, N = NS									
	2016-17								
N_0	63.5	65.0	61.5	**63.3**	65.4	65.0	62.5	**64.3**	**63.8**
N_{50}	61.7	65.0	59.0	**61.9**	64.7	66.9	60.0	**63.9**	**62.9**
N_{100}	64.7	63.0	64.1	**63.9**	60.3	63.9	62.7	**62.3**	**63.1**
N_{150}	62.0	66.9	59.8	**62.9**	65.0	62.4	64.5	**64.0**	**63.4**
Mean	**63.0**	**65.0**	**61.1**	**63.0**	**63.9**	**64.6**	**64.0**	**63.6**	
Factor Mean Irrigation (I) $I_{0.4}$= 63.4 $I_{0.3}$= 64.7 $I_{0.2}$=61.7; Mulch (M) M_0 = 63.0 M_6 = 63.6; Nitrogen (N) N_0 = 63.8 N_{50}= 62.9 N_{100} = 63.1 N_{150}= 63.4									
LSD (0.05) I = NS, M = NS, N = NS									
	Average of two year								
N_0	61.1	61.2	61.1	**61.1**	63.5	63.9	61.3	**62.9**	**62.0**
N_{50}	61.1	62.0	58.9	**60.7**	62.6	62.7	61.4	**62.2**	**61.4**
N_{100}	64.0	62.1	60.4	**62.2**	61.6	61.2	60.9	**61.2**	**61.7**
N_{150}	63.8	62.2	58.0	**61.3**	64.4	61.7	63.4	**63.2**	**62.2**
Mean	**62.5**	**61.9**	**59.6**	**61.3**	**63.0**	**62.4**	**61.8**	**62.4**	
Factor Mean Year (Y) 2015-16= 60.4 2016-17= 63.3; Irrigation (I) $I_{0.4}$= 62.8 $I_{0.3}$= 62.1 $I_{0.2}$=60.7; Mulch (M) M_0 = 61.3 M_6 = 62.4; Nitrogen (N) N_0 = 62.0 N_{50}= 61.4 N_{100} = 61.7 N_{150}= 62.2									

length was slightly higher in mulched treatment as compare to no mulch treatment. On pooled data, there was no difference in ear length among irrigation and mulch treatments but ear length was highest in N_{50} nitrogen rates as compare to control, N_{100} and N_{150} treatments. Wheat grain yield in table 3 depicted effect of rice straw residue (applied in cotton crop as mulch during cotton-wheat sequence) on grain yield of wheat crop. It was clear from data that wheat grain yield was not significantly affected by residue and also by other treatment like irrigation and nitrogen on previous crop. Grain yield in mulch plots were slightly higher than no mulch plots. There was only 2.1 and 1.2 per cent higher yield in wheat crop due to mulch treatment was observed in 2015-16 and 2016-17. On pooled data only 0.64 per cent increase in grain yield due to mulch application over no mulch plots. Among the irrigation regimes, $I_{0.4}$ irrigation regimes recorded slightly higher (2.1 per cent) grain yield as

Table 5 : Water productivity of wheat (Kg/ha/mm) as affected by residue mulch, irrigation and nitrogen levels applied on Bt cotton.

Nitrogen rate (Kg/ha)	2015-16								Overall mean
	M_0				M_6				
	$I_{0.4}$	$I_{0.3}$	$I_{0.2}$	Mean	$I_{0.4}$	$I_{0.3}$	$I_{0.2}$	Mean	
N_0	10.8	10.1	9.80	**10.2**	11.3	10.9	10.8	**11.2**	**10.9**
N_{50}	10.7	10.3	10.2	**10.4**	11.3	10.7	10.6	**10.8**	**10.8**
N_{100}	10.8	10.2	10.4	**10.5**	11.3	10.8	11.0	**10.8**	**11.0**
N_{150}	10.4	10.4	10.4	**10.4**	11.1	10.8	11.0	**11.0**	**10.9**
Mean	**10.7**	**10.3**	**10.2**	**10.4**	**11.0**	**10.8**	**11.1**	**10.9**	
Factor Mean	**Irrigation (I)** $I_{0.4}$ = 10.8 $I_{0.3}$ = 10.5 $I_{0.2}$ = 10.6								
	Mulch (M) M_0 = 10.4 M_6 = 10.9								
	Nitrogen (N) N_0 = 10.9 N_{50} = 10.8 N_{100} = 11.0 N_{150} = 10.9								
	2016-17								
N_0	11.8	11.8	11.7	**11.8**	11.8	11.5	10.8	**11.4**	**11.6**
N_{50}	11.7	12.3	11.2	**11.7**	11.8	12.2	12.1	**12.1**	**11.9**
N_{100}	12.1	11.5	11.8	**11.8**	12.2	12.2	11.3	**11.9**	**11.9**
N_{150}	11.5	11.8	11.4	**11.6**	12.3	12.0	12.1	**12.1**	**11.9**
Mean	**11.8**	**11.9**	**11.5**	**11.7**	**12.0**	**12.0**	**11.6**	**11.9**	
Factor Mean	**Irrigation (I)** $I_{0.4}$ = 11.9 $I_{0.3}$ = 11.9 $I_{0.2}$ = 11.6								
	Mulch (M) M_0 = 11.7 M_6 = 11.9								
	Nitrogen (N) N_0 = 11.6 N_{50} = 11.9 N_{100} = 11.9 N_{150} = 11.9								

compare to $I_{0.2}$ irrigation regimes. With increase in nitrogen rate grain yield was increased and maximum grain yield was recorded in N_{100} treatment over control, N_{50} and N_{150} treatment. Wheat grain yield was not significantly affected by irrigation, mulch and nitrogen rates was mainly due to the fact that there may be long term effect of residue and in one or two year application of residue does not give significant result.Table 4 revealed theeffect of rice straw residue (applied in cotton crop as mulch during cotton-wheat sequence) on straw yield of wheat crop and wheat straw yield was not significantly affected by residue and also by other treatment like irrigation and nitrogen on previous crop. Wheat straw yield in mulch plots were slightly higher than no mulch plots in both the year. On pooled data, there was 1.8 per cent increase in straw yield due to mulch application over no mulch plots. Due to application of irrigation, 3.5 per cent higher straw yield was recorded at $I_{0.4}$ irrigation regimes as compare to $I_{0.2}$. With application of nitrogen highest straw yield was recorded at N_{150} nitrogen rates. Table 5 indicated water use efficiency of wheat crop as affected by residue mulch, irrigation and nitrogen levels applied on Bt cotton. Slight difference in water use efficiency of wheat crop was observed. Due to mulch water use efficiency was 4.8 and 1.7 per cent higher than no mulch treatment. In N_{100} slightly higher water use efficiency was observed than control treatment and also water use efficiency was slightly higher in higher irrigation regimes than lower irrigation regimes. Table 6 depicted the effect of residue mulch, irrigation regimes and nitrogen levels on cotton-wheat system water use efficiency. Cotton-wheat system water use efficiency was higher under mulched treatment, under higher irrigation regimes ($I_{0.4}$) and in N_{100} treatment in 2015-16 and 2016-17 it was higher under $I_{0.3}$ irrigation regimes. Mulch enhanced system water use efficiency by 19.8 and 11.5 per cent in 2015-16 and 2016-17 growing season. In 2015-16 growing season water use efficiency was 2.9 percent higher in $I_{0.4}$ irrigation regimes than $I_{0.2}$ and in 2016-17 water use efficiency was 3.8 percent higher in $I_{0.3}$ irrigation regimes than $I_{0.2}$. With increase in nitrogen rate water use efficiency was 6.7 and 7.6 per cent higher in N_{100} treatment over control in 2015-16 and 2016-17 growing season.

Conclusion

Crop residue mulching numerically increases wheat

Table 6 : Cotton-wheat system water productivity (Kg/ha/mm) as affected by residue mulch, irrigation and nitrogen levels.

Nitrogen rate (Kg/ha)	2015-16								Overall mean
	M_0				M_6				
	$I_{0.4}$	$I_{0.3}$	$I_{0.2}$	Mean	$I_{0.4}$	$I_{0.3}$	$I_{0.2}$	Mean	
N_0	6.37	6.32	6.22	**6.30**	7.26	7.14	6.92	**7.10**	**6.70**
N_{50}	6.53	6.56	6.38	**6.49**	7.76	7.53	7.09	**7.46**	**6.98**
N_{100}	6.56	6.69	6.79	**6.68**	7.83	7.65	7.40	**7.63**	**7.15**
N_{150}	6.44	6.65	6.63	**6.57**	7.70	7.62	7.42	**7.58**	**7.07**
Mean	**6.48**	**6.56**	**6.51**	**6.51**	**7.64**	**7.48**	**7.21**	**7.44**	
Factor Mean Irrigation (I) $I_{0.4}$= 7.06 $I_{0.3}$= 7.02 $I_{0.2}$=6.86; Mulch (M) M_0 = 6.51 M_6 = 7.44; Nitrogen (N) N_0 = 6.70 N_{50}= 6.98 N_{100} = 7.15 N_{150}= 7.07									
2016-17									
N_0	7.45	7.58	7.50	**7.51**	8.10	8.14	7.61	**7.95**	**7.73**
N_{50}	7.48	7.96	7.48	**7.64**	8.59	8.87	8.43	**8.63**	**8.14**
N_{100}	7.75	7.83	7.98	**7.86**	8.82	9.07	8.45	**8.78**	**8.32**
N_{150}	7.40	7.79	7.55	**7.58**	8.81	8.80	8.60	**8.74**	**8.16**
Mean	**7.52**	**7.79**	**7.63**	**7.65**	**8.58**	**8.72**	**8.27**	**8.53**	
Factor Mean Irrigation (I) $I_{0.4}$= 8.05 $I_{0.3}$= 8.23 $I_{0.2}$=7.93; Mulch (M) M_0 = 7.65 M_6 = 8.53; Nitrogen (N) N_0 = 7.73 N_{50}= 8.14 N_{100} = 8.32 N_{150}= 8.16									

yield and yield attributing parameters and also it saves water and improve water productivity in wheat crop and also in cotton-wheat sequencein North West India.

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