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Effect of different irrigation levels and moisture conservation techniques on relative water content (RWC), water use efficiency and productivity of wheat (*Triticum aestivum*)

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Abstract
A field experiment entitled "Effect of Different Moisture Irrigation levels and Moisture Conservation Techniques on Relative Water Content (RWC), Water Use Efficiency and Productivity of Wheat (*Triticum aestivum*)" was carried out at the Crop Research Centre of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, U.P. during Rabi season of 2018-19. The experiment was laid out in a split plot design considering the irrigation levels as main plot and moisture conservation techniques as sub plot treatments with three replications. The irrigation levels consisted of I_1– (5 irrigations at CRI, tillering, booting, milking and dough stage), I_2– (3 irrigation at CRI, tillering and booting stage), I_3– (2 irrigation at CRI and booting stage) and moisture conservation techniques consisted M_1 – Control (no moisture conservation techniques), M_2 - Rice residues @ 5 ton ha^{-1}), M_3 - application of Pusa hydrogel (3kg /Acre), M_4- seed treatment with *Pseudomonas fluorescens* (PF6) @ 4 g kg^{-1} seed, M_5- Seed treatment with *Pseudomonas fluorescens* (PF2) @ 4 g kg^{-1} seed and M_6- Seed treatment with (IRRI-1) @ 4 g kg^{-1} seed. The soil of the experimental site was sandy loam in texture, low in available nitrogen and organic carbon, medium in available phosphorus, potassium, zinc and alkaline in reaction. Wheat variety HD-2967 was grown as a test crop. Result reveal that relative water content increased with I_1 (5 irrigation) and I_2 (3 irrigation). The improvement in grain yield 8.74 and 17.38% over I_2 and I_3 respectively was due to maximum supply of water under I_1 (5 irrigation). Water use efficiency was higher under I_3 (2 irrigation) compare to various irrigation level during the study a decreased in the frequency of irrigation from I_1 (5 irrigations) to I_2 (3 irrigation). Among the moisture conservation techniques, relative water content, water use efficiency, straw and grain yield of wheat was recorded with the application of rice residue incorporate @ 5-ton ha^{-1}. Similarly yield attributes.

Keywords: Rice residues, *Pseudomonas fluorescens*, Moisture conservation techniques, relative water content and water use efficiency

Introduction
Wheat is a crop of global significance. It is grown in diversified environments. It's a staple food for millions of people. Around one-sixth of the total arable land in the world is cultivated with wheat. Whereas paddy is mainly cultivated in Asia, wheat has grown in all the continents of the world. It is one of the principal's cereal crops grown worldwide and one of the important staples of nearly 2.5 billion of the world population. Wheat is the significant staple nourishment crop, giving practically 50% of all calories in the region of North Africa and West, and Central Asia. It supplies about 20 percent of the food calories for the world's growing population. Globally wheat is cultivated in an area of about 220 million hectares with a record production of 763.06 million tonnes of grain. In India, the wheat crop is cultivated in Rabi season it is ordinarily sown during November and harvested among March and April. The cultivated area under wheat at a national level has shown an increasing trend, from 29.04 million hectares to 30.54 million hectares with a magnitude of 1.5 million hectares (5%) net gain regarding the area. Utter Pradesh has the largest share in an area with 9.75 million hectares (32%), followed by Madhya Pradesh (18.75%), Punjab (11.48%), Rajasthan (9.74%), Haryana (8.36%) and Bihar (6.82%) (Sendhil *et al.*, 2019) [10].

Wheat has a particular spot among the nourishment grain crops. Carbohydrate and protein are the two main constituents of wheat. It is rich in proteins, vitamins, and carbohydrates, and provides balanced food on average wheat contains 11-12% protein. The amount of precipitation required for wheat development varies between 30 cm and 100 cm. the temperature required for the wheat crop during the growing season is about 15.5 °C. The soil suitable for wheat crop growing is loam or light clay or heavy loam. The sensitive growth stages of wheat to water stress are from stem elongation to booting, followed by anthesis, and grain-filling. The vertical effort practices limited irrigation scheduling, application of mulches, anti-transparent and hydrophilic polymer increase the duration of moisture availability with an increase for available moisture in the soil. Irrigation scheduling is one of the important managerial activities and affects the effective and efficient utilization of water by the crops. Scheduling of irrigation based on phonological stages (crown root, tillering, booting, anthesis, soft dough, and hard dough stage) in wheat has been a practical approach to the farmers.

Relative water content is closely related to plant water potential. As plant water potential decreases, relative water content also decreases. Consequently with a decrease in stomata conductance and a plant's inaccessibility to CO_2, photosynthesis decreases. The relative water content and soluble protein of leaf were reduced under water deficit stress6. Reduced soil water availability will result in low plant leaf water potential, osmotic potential and relative water content7. Canopy temperature is a part of the canopy energy balance. As solar radiation is absorbed by leaves, leaf temperatures increase. Leaf cooling takes place as some of the thermal energy drives transpiration water loss. Under water deficit conditions, stomata close in response to loss of turgor pressure, causing a lowering of transpiration rate and hence, an increase in canopy temperature9. This is the basis for the use of canopy temperature to determine plant water status (Kumar *et al.*, 2017) [6].

Water use efficiency (WUE) refers to the ratio of water used in plant metabolism to water loss by plant transpiration. WUE can also be improved through different methods such as irrigation scheduling and different moisture conservation techniques. The impact of limited irrigation on crop yield and WUE depends on the growth stage and the most sensitive stage varies from region to region due to regional variability in environment and agronomic practices. Wheat response to water stress from stem elongation to booting, followed by anthesis and grain- filling stages (Singh *et al.,* 2017) [17]. The effect of mulching on water-use-efficiency by fennel crop was conditioned to the influence of better moisture recharging capacity under mulching on crop growth and yield and less loss of water by evaporation with proportionate increase in grain yield (Madhuri, M. 2010) [8]. The hydrogel increase efficient water consumption, decreasing irrigation costs and increasing irrigation intervals, also, implement soil's water holding capacity and soil porosity, providing plants with eventual moisture and nutrients as well as enhancing plant viability and ventilation and root development which provides a conducive atmosphere for better growth of plants and finally increases crop yield (Abobatta (2018) [2].

Saren *et al.,* (2004) [12] observed that wheat receiving four irrigations at crown root initiation, tillering, flowering and grain development stages resulted higher harvest index (34.11%) and yield components. Applied one irrigation at CRI, two irrigations (CRI and flowering), three irrigations (CRI, late jointing and milk stage), four irrigations (CRI, tillering, flowering and milk stage), and recorded higher yield and yield attributes were found with four irrigations (Yadav *et al.,* 2010) [15]. Increase in yield due to increasing frequency of irrigation might be due to higher photosynthesis and translocation of assimilates towards reproductive structures owing to increased supply of sufficient moisture. The sufficient moisture at grain development might have also increased mobilization of mineral nutrients including phosphorus, sulphur and mobile nutrients to seed which ultimately increased the seed yield (Patel *et al.,* 2000) [9] reported that soil mulching significantly influenced grain yield/ha (1209 kg) of wheat. Soil mulching gave one and six percent higher grain yield over check plots in the first and second year respectively. Effect of mulching in conserving moisture and increasing productivity of wheat has been reported. Hydrogel a semi synthetic super absorbent polymer has shown the potential to realize more yield per drop of water (Jalilian and Mohsennia 2013) [5]. Inoculation of wheat with *Burkholderia phytofirmans* PsJN significantly diluted the adverse effects of drought on relative water contents and CO2 assimilation rate, thus improving the photosynthetic rate, water use efficiency and chlorophyll content over the uninoculated control [135]. In a similar study conducted on wheat under water stress environment showed that mycorrhizal inoculation enhanced the activities of antioxidant enzymes such as peroxidase and catalase compared to those in uninoculated control plants. Abdelraou *et al.*, (2013) [1] reported that the significant increases and improvements in irrigation water use efficiency, growth, yield, yield attributes, protein and carbohydrate contents of wheat due to biofertilizer treatments under water stress. Le *et al.*, (2018) [7] conducted an experiment with Seedlings were inoculated with 1% liquid solution of Phylazonit MC® (Pseudomonas putrid, *Azotobacter chroococcum*, *Bacillus circulans, B. megaterium;* colony-forming unit: 109 CFU/mL) at sowing and planting out by irrigation. The result effect of PGPR treatment on marketable yield, total biomass and WUE was positive in both years when deficit irrigation was applied and only in the drier season in the case of optimum water supply. In the present study attempts were made to evaluate the effect of adequate and limited irrigation levels at critical stages with moisture conservation techniques *viz.,* rice residues, hydrogel and microbes on yield and relative water content and WUE in wheat.

2. Methods and Materials

The experiment was conducted at Crop Research Centre Chirori of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P) in Rabi season of 2018-19. Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P) is situated on the Delhi-Dehradun Road about 7 km from Meerut towards Dehradun.

Geographically this centre is situated at 29º4' N latitude and 77º46' E longitude at an altitude of 237 m above the mean sea level. The region is characterized by sub-tropical and semi-arid climate with hot and dry summer (April to June), hot and humid monsoon period (July to September), mild winter from October to November and cold winter from December to February. The mean minimum and maximum temperatures show considerable fluctuation during summer and winter. Maximum air temperature above 40 °C is common during summer and frequent frosty spells are experienced in December – January the coldest months of the year, whereas minimum temperature goes as low as 4.6 °C and relative humidity ranges between 37-83%. The mean annual rainfall 735 mm and greater portion (about 80%) of which is received through south-west monsoon from

July to September while in winter a few showers of cyclonic rains are received. The weather data recorded at meteorological observatory of Sardar Vallabhbhai Patel University of Agriculture & technology Meerut during crop period (*Rabi* 2018-19) are given in Table 1. The data have showed that average maximum weekly temperature ranged between 19.42 °C to 40.0 °C, while minimum weekly temperature ranged between 5.25 °C to 22.8 °C. The total amount of rainfall received during crop period was 96.4 mm, whereas mean relative minimum and maximum humidity varied between 34.1 to 96.14 percent. The experiment was laid out in a split plot design considering the irrigation levels as main plot and moisture conservation techniques as sub plot treatments with three replications. The irrigation levels consisted of I_1– (5 irrigations at CRI, tillering, booting, milking and dough stage), I_2– (3 irrigation at CRI, tillering and booting stage), I_3– (2 irrigation at CRI and booting stage) and moisture conservation techniques consisted M_1 – Control (no moisture conservation techniques), M_2 - Rice residues @ 5 ton ha^{-1}), M_3 - application of Pusa hydrogel (3kg /Acre), M_4- seed treatment with *Pseudomonas fluorescens* (PF6) @ 4 g kg^{-1} seed, M_5- Seed treatment with *Pseudomonas fluorescens* (PF2) @ 4 g kg^{-1} seed and M_6- Seed treatment with (IRRI-1) @ 4 g kg^{-1} seed. The soil of the experimental site was sandy loam in texture, low in available nitrogen and organic carbon, medium in available phosphorus, potassium, zinc and alkaline in reaction. Wheat variety HD-2967 was grown as a test crop.

Relative water content was calculated as described by Weatherly12. From fully expanded flag leaves the leaf sample were taken in 5 cm diameter plastic petri–plates. weighed immediately to determine the fresh weight. After subtracting the weight of empty petri-plates, the leaf sample were then floated on distilled water for about four hours at room temperature in the diffused light. The turgid leaves were weighed and dried at 65 °C in an oven to a constant weight. The RWC was calculated by the following formula:

$$\text{Relative water content (RWC) \%} = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Turgid weight} - \text{Dry weight}} \times 100$$

Water use efficiency

It was calculated by using following formula.

Water use efficiency (kg/ha-mm) = Grain yield (kg/ha)
Water use (mm)

Water use = Difference in moisture content at sowing and harvest (mm) + seasonal Rainfall (mm) + Irrigation water applied (mm)

3. Result and discussion

3.1 Relative water content

Relative water content is closely related to plant water potential. As plant water potential decreases, relative water content also decreases. The relative water content varied significantly under different irrigation levels and moisture conservation techniques. Application of I_1 (5 irrigations) recorded significantly higher relative water content over I_2 (3 irrigation) and I_3 (2 irrigation). Maximum relative water content 49.4% recorded in I_1 (5 irrigations) was significantly superior to 42.5% I_2 (3 irrigation) and 39.75% I_3 (2 irrigation) at harvest. Moisture conservation techniques also caused significant variation in relative water content (%). The maximum relative water content 50.3 (%) recorded with rice residues @ 5-ton ha^{-1} at harvest was significantly higher than the relative water content recorded in different moisture conservation techniques. Similarly, application of Pusa hydrogel (3kg /Acre) (45.7), rice residues did not different significantly from rest of the moisture conservation techniques with the exception of harvest, all the microbial inoculants did not differ significantly among themselves in respect of relative water content. The relative water content and leaf water potential at the level of two and four irrigations was significantly higher than one irrigation during experimentation.

3.2 Water use efficiency

WUE can also be improved through different methods such as irrigation scheduling and different moisture conservation techniques. Data about water use efficiency as affected by experimental variables are presented in Table 2 and fig 1. The water uses efficiency (kg/ha-mm) varied significantly from 8.7 to 11.4 under different irrigation levels. The data envisage that water use efficiency was higher under 11.4 kg ha^{-1} I_3 (2 irrigation) compare to various irrigation level during the study a decreased in the frequency of irrigation from I_1 (5 irrigations) to I_2 (3 irrigation). Moisture conservation techniques also influenced the water use efficiency significantly. The highest water uses efficiency 11.6 kg/ha-mm recorded in treatment (rice residues @ 5-ton ha^{-1} was significantly superior to all the treatments. Application of pusa hydrogel (3kg /Acre) with (11.0 kg/ha-mm) WUE was also superior as compare to other treatments except for the treatment rice residues @ 5-ton ha^{-1} (11.6 kg/ha-mm). Seed treatment with *Pseudomonas fluorescens* (PF6) @ 4 g kg^{-1} seed (10.4 kg/ha-mm) higher than seed treatment with *Pseudomonas fluorescens* (PF2) @ 4 g kg^{-1} seed (9.9 kg/ha-mm) and seed treatment with (IRRI-1) @ 4 g kg^{-1} seed (9.6 kg/ha-mm) it was lowest WUE (9.4 kg/ha-mm) but higher than control. The minimum water-use efficiency (9.2 kg/ha-mm) was recorded under treatment control (without residue hydrogel and seed treatment) (no moisture conservation techniques uses) and it was inferior to other treatment (moisture conservation techniques). This result also get support from the work of Huang *et al.*, (2005) [4] who observed the influence of straw mulch (4 t/ha) in wheat crop and concluded that straw mulching decreased evapo-transpiration, soil water depletion and increased water-use efficiency. Zhang *et al*., (2002) [16] showed that straw mulching reduced soil evapotranspiration by 40 mm for winter wheat. Water use efficiency was improved by over 10 percent. They concluded that regulation of the irrigation scheduling in combination with straw mulching could reduce irrigation applications in China. Combination of irrigation with mulch is advocated to improve water uptake and to reduce number of irrigations in the spring wheat.

3.3 Grain Yield

Data regarding the effect of different irrigation level grain yield are given in Table 3. Maximum grain yield (37.3 q ha-^{1}) recorded in I_1 (5 irrigations), and was significantly superior to I_2 (3 irrigation) and I_3 (2 irrigation). Similarly, I_2 (3 irrigation) was significantly superior over I_3 (2 irrigation). An examination of data on the effect of moisture conservation techniques on grain yield also indicates significant variation in yield. Treatment having rice residues @ 5-ton ha^{-1} recorded maximum grains yield (38.3 q ha^{-1}) which was significantly higher than all other moisture conservation techniques. The application of pusa hydrogel (3kg /Acre) yielded (36.8 q ha^{-1}) which was significantly higher than the treatments. The minimum grain yield was recorded with control (without residue hydrogel and seed treatment) where no moisture conservation technique was fallowed. Similar findings were also obtained by Rahim *et al.*, (2010) [11] studied the effect of irrigation scheduling on wheat with four irrigation schedules with no irrigation, 2 irrigations (crown roots and booting), 3 irrigations (crown roots, booting, and grain development stages) and 4 irrigations (crown root initiation, booting, late jointing and grain development stages) were applied at critical stages of wheat and revealed that three irrigation (crown roots, booting, and grain development stages) were sufficient to get maximum grain and biological yield compare to other irrigation schedules. Grain yield of wheat can only be improved to a limited degree by increasing grain size, as it is restricted by spikelet size. Effect of mulching in conserving moisture and increasing productivity of wheat has been reported.

3.4 Straw Yield

The data about straw yield showed significant variation in straw yield due to experimental variables (Table 3). The maximum straw yield (50.2 q ha^{-1}) recorded from I_1 (5 irrigations), was significantly at par to I_2 (3 irrigation) or significantly higher than I_3 (2 irrigation). I_2 (3 irrigation) was significantly superior over I_3 (2 irrigation). The data on the effect of moisture conservation techniques on straw yield indicate significant variation during the study with exception of hydrogel, application of rice residues @ 5-ton ha^{-1}significantly higher straw yield (50.6 q ha^{-1}) over the rest of treatments. Control (without residue hydrogel and seed treatment) produced the significantly lowest straw yield (46.4 q ha^{-}) than the rice residues incorporation, hydrogel and PF 6. All the moisture conservation techniques consisting seed inoculation.

3.6 Biological yield (q ha^{-1})

The data as showed a significant variation in biological yield due to all experimental variables during the study. The maximum biological yield (87.5 q ha^{-1}) was recorded from I_1 (5 irrigations), which was significantly superior to I_2 (3 irrigation) and I_3 (2 irrigation). Similarly, I_2 (3 irrigation) was also significantly superior over I_3 (2 irrigation). Moisture conservation techniques caused significant variation in biological yield during the study. The maximum biological yield (88.9 q ha^{-1}) recorded from rice residues @ 5-ton ha^{-1} which was significantly superior over other treatments. The minimum biological yield (77.6 q ha-^{1}) was recorded with control no moisture conservation practice followed. This result also get support from the work of studied the effect of mulching on growth of wheat straw mulch 1,2,3,4, t/ha. The results indicated that mulching significantly increased the number of fertile tillers, length of spike and biological yield in comparison to control.

3.7 Harvest Index

The data on the effect of irrigation levels on harvest index indicate significant variation. The maximum harvest index (42.6) recorded from I_1 (5 irrigations), was significantly superior to I_2 (3 irrigation) and I_3 (2 irrigation). Similarly, I_2 (3 irrigation) was significantly superior over I_3 (2 irrigation). The data on the effect of moisture conservation techniques on harvest index indicate significant variation. Harvest index with the application of rice residues @ 5-ton ha-^{1} was significantly higher harvest index over the rest of treatments. Control (without residue hydrogel and seed treatment) resulted in significantly lowest harvest index (40.3). Application of pusa hydrogel (3kg /Acre) (42.2) and seed treatment with *Pseudomonas fluorescens* (PF6) @ 4 g kg^{-1} seed (41.7) were statistically at par to each other. Similarly, seed treatment with *Pseudomonas fluorescens* (PF2) @ 4 g kg^{-1} seed (41.2) and seed treatment with (IRRI-1) @ 4 g kg^{-1} seed (40.8) were statistically at par to each. This result also get support from the work of Saren *et al.* (2004) [12] observed that wheat receiving four irrigations at crown root initiation, tillering, flowering and grain development stages resulted higher harvest index (34.11%) and yield components.

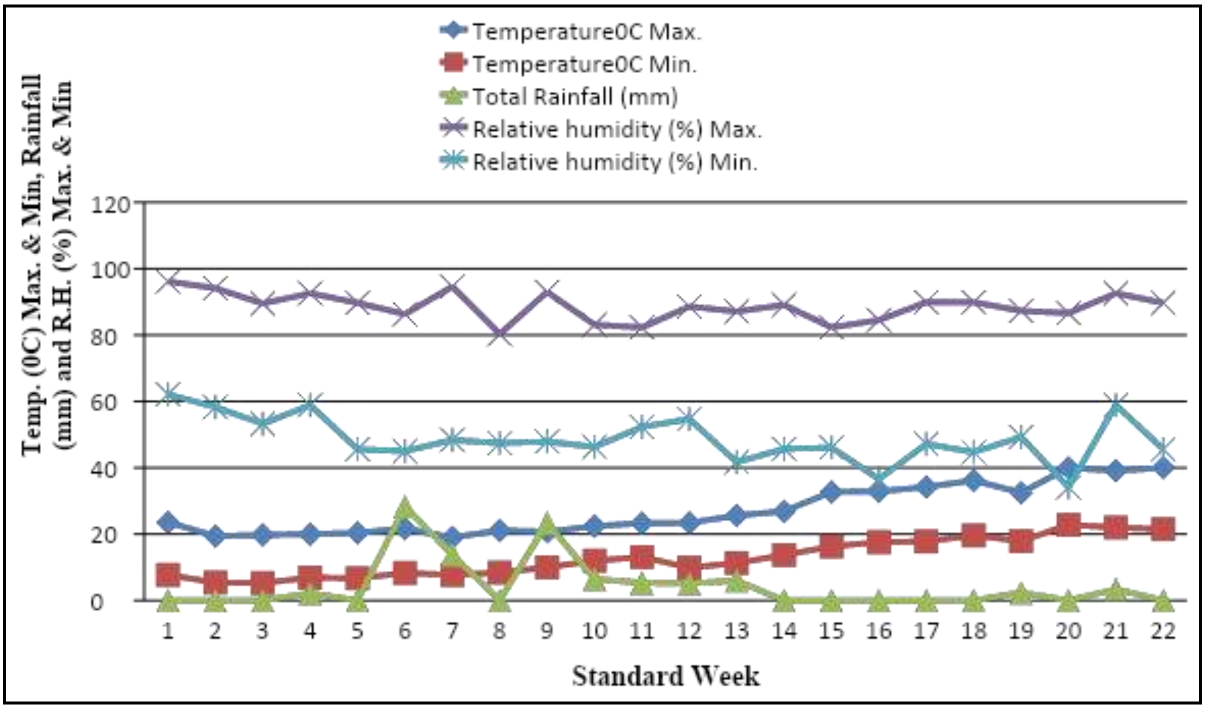

Fig 1: Weekly meteorological data: Meerut, year 2018-2019

Table 1: Meteorological data of crop season

Standard Metrological week	Period	Temperature °C		Total Rainfall (mm)	Relative humidity (%)	
		Max.	Min.		Max.	Min.
1	14 Dec to 20 Dec	23.57	7.71	0.0	96.14	62.14
2	21 Dec to 27 Dec	19.42	5.42	0.0	94.14	58.28
3	28 Dec to 31 Dec	19.75	5.25	0.0	89.5	53.25
4	1 Jan to 7 Jan	20	6.9	2.2	92.6	58.9
5	8 Jan to 14 Jan	20.4	6.7	0.0	89.7	45.6
6	15 Jan to 21 Jan	21.7	8.3	28.3	86.3	45.0
7	22 Jan to 28 Jan	19.0	7.7	13.8	94.6	48.4
8	29 Jan to 4 Feb	21.1	8.4	0.0	80.3	47.4
9	5 Feb to 11 Feb	20.7	10.0	23.4	93.0	47.9
10	12 Feb to 18 Feb	22.4	12.0	6.5	83.1	46.3
11	19 Feb to 25 Feb	23.3	13.1	5.3	82.3	52.3
12	26 Feb to 4 March	23.4	9.9	5.1	88.6	54.7
13	4 March to 11 March	25.6	11.3	6.0	87.1	41.7
14	12 March to18 March	26.9	13.7	0.0	89.1	45.7
15	19 March to 25 March	32.7	16.3	0.0	82.3	46.1
16	26 March to 1 April	32.9	17.6	0.0	84.5	36.6
17	2 April to 8 April	34.2	17.8	0.0	89.9	47.2
18	9 April to 15 April	36.2	19.6	0.0	89.9	44.7
19	16 April to 22 April	32.5	17.9	2.4	87.3	49.3
20	23 April to 29 April	40.0	22.8	0.0	86.6	34.1
21	30 April to 6 May	39.1	22.0	3.4	92.6	58.9
22	7 May to 13 May	40.0	21.5	0.0	89.7	45.6

Table-2: Effect of different irrigation levels and moisture conservation techniques on Relative water content (%) and water use efficiency of wheat

Treatments	RWC (%)	Water use efficiency
A (Irrigation levels)		
I_1(5 irrigations at CRI, Tillering, Booting stage, Milking stage and Dough stage)	49.7	8.7
I_2 (3 irrigation at CRI, Tillering and Booting stage)	42.5	10.7
I_3(2 irrigation at CRI and Booting stage)	39.7	11.4
SEm±	0.3	0.1
CD (0.05)	1.2	0.5
B (Moisture conservation techniques)		
M_1 (Control (without residue hydrogel and seed treatment)	34.7	9.2
M_2 (Rice residues @ 5-ton ha^{-1})	50.3	11.6
M_3 (Application of Pusa hydrogel (3kg /Acre)	45.7	11.0
M_4 (Seed treatment with *Pseudomonas fluorescens* (PF6) @ 4 g kg^{-1} seed)	46.3	10.4
M_5 (Seed treatment with *Pseudomonas fluorescens* (PF2) @ 4 g kg^{-1} seed)	44.0	9.9
M_6 (Seed treatment with (IRRI-1) @ 4 g kg^{-1} seed)	42.7	9.6
SEm±	0.9	0.1
CD (0.05)	2.7	0.2

Table 3: Effect of different irrigation levels and moisture conservation techniques on grain yield, straw yield, biological yield and harvest index of wheat

Treatments	Grain yield (q/ha)	Straw yield (q/ha)	Biological yield (q/ha)	Harvest index %
A (Irrigation levels)				
I (5 irrigations at CRI, Tillering, Booting stage, Milking stage and Dough stage)	37.3	50.2	87.5	42.6
I_2(3 irrigation at CRI, Tillering and Booting stage)	34.3	48.3	82.6	41.5
I_3(2 irrigation at CRI and Booting stage)	31.8	47.2	79.0	40.3
SEm±	0.2	0.5	0.6	0.2
CD (0.05)	0.9	1.9	2.4	0.9
B (Moisture conservation techniques)				
M_1 (Control (without residue hydrogel and seed treatment)	31.1	46.4	77.6	40.3
M_2 (Rice residues @ 5-ton ha^{-1})	38.3	50.6	88.9	43.1
M_3 (Application of Pusa hydrogel (3kg /Acre)	36.8	50.3	87.1	42.2
M_4 (Seed treatment with *Pseudomonas fluorescens* (PF6) @ 4 g kg^{-1} seed)	34.8	48.7	83.5	41.7
M_5 (Seed treatment with *Pseudomonas fluorescens* (PF2) @ 4 g kg^{-1} seed)	33.4	47.7	81.1	41.2
M_6 (Seed treatment with (IRRI-1) @ 4 g kg^{-1} seed)	32.3	47.6	79.9	40.4
SEm±	0.2	0.5	0.6	0.3
CD (0.05)	0.4	1.5	1.7	0.8

4. Conclusion
On the perusal of findings, it was observed that the soil water deficit induced by limited irrigation at different stages of crop growth significantly reduced relative water contents. The reduction in water potential and relative water contents reduced the stomatal conductance, decreased transpiration which ultimately limited access of photosynthetic apparatus to CO2; consequently, decreased rate of photosynthesis and final grain yield. Among the plant water relations parameters recorded at anthesis, the relative water content level of five and three irrigations was significantly higher than two irrigation. Water use efficiency was higher under I_3 (2 irrigation) compare to various irrigation level during the study a decreased in the frequency of irrigation from I_1 (5 irrigations) to I_2 (3 irrigation). Application of rice residues @ 5-ton ha^{-1} alone or in combination produced the highest relative water content, water use efficiency and yield. Therefore, it can be concluded that the rice residues @ 5-ton ha^{-1} supplemented with all irrigation levels will be beneficial to get the higher relative water content, water use efficiency and yield of wheat under limited irrigation condition. Use of microbial inoculants may also have a good option in respect to moisture conservation. However, these results are only indications and require further experimentation to arrive at some more consistent and final. Thus, we can get more production from limited irrigation area with less irrigation using with rice residues.

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