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Influence of Moisture Conserving Polymer and integrated Nutrient Management on Nutrient content and uptake in Wheat (*Triticum aestivum* L.) under Limited Irrigated condition

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ABSTRACT: The field experiment was carried out at Chandra Shekhar Azad University of Agriculture & Technology, Kanpur (U.P.) during *Rabi* season of 2020-21 and 2021-22 to study the "Influence of moisture conserving polymer and integrated nutrient management on productivity of wheat (*Triticum aestivum* L.) under limited irrigated condition". The experiment comprised of twenty four treatment combinations and conducted in split plot design and replicated three times. Experiment consisted of three irrigation schedules *viz.* One irrigation, Two irrigations, and Three irrigations in main plots, two moisture conservation practices *viz.* Pusa Hydrogel 5 kg ha^{-1} and Paddy straw mulch 5 t ha^{-1} in sub plots and four nutrient management *viz.* 100% RDF, 100% RDF + Azotobacter, 75% RDF + Azotobacter + FYM 5 t ha^{-1} and 75% RDF + Azotobacter + FYM 5 t ha^{-1} + $ZnSO_4$ 20 kg ha^{-1} were kept in sub-sub plots. On pooled basis of two years experimentation result revealed that application of three irrigations at CRI, booting and milking stage resulted significant increase in the dry weight of plant, crop growth rate (CGR), phosphorus and zinc content, N, P, K and Zn uptake and protein yield in grain. Whereas, higher content of nitrogen, potash and protein in grain was recorded with one irrigation treatment. However, in moisture conservation practices higher value of all parameters as given above was recorded with the application of Pusa Hydrogel 5 kg ha^{-1}. Among the integrated nutrient management practices, significantly higher value of N, K, Zn except phosphorus content and uptake as recorded higher with the integration of 75% RDF + Azotobacter + FYM 5 t ha^{-1} + $ZnSO_4$ 20 kg ha^{-1} but low in phosphorus.

Keywords: Irrigation, Pusa hydrogel, Nutrient, Protein, FYM, Azotobacter and Wheat.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is a king of cereal crop has major contribution in food security at national and international levels. It rank first in the world among the all cereals in respect of area 222.21 million hectare and production 779.03 million metric tonne during the year 2021-22 (USDA, 2022). Besides staple food for human beings, wheat straw also serves as an important dry matter source of feed for animals (Sarwar *et al.,* 2006). In India it is second important staple food crop after rice. India is the second largest wheat producing country after China. In India total area under wheat is 31.61 million hectares, with the production of 109.59 million tonnes during the year 2020-21 (DES, DAC&FW, 2022). Among the different states of India, Uttar Pradesh ranks first in area and total production of wheat, while Punjab ranks first in productivity. In Uttar Pradesh, wheat area occupy 9.85 million hectares that is 31.16 % of total wheat growing area of India production 35.50 million tonnes with the productivity of 3604 kg ha^{-1} during the year of 2020-21 (Agricultural statistics at a glance 2021).

Water is considered as one of the most crucial input for agricultural production. It facilitates a higher productivity potential from the land, and significant response from applied agricultural inputs, viz. high-yielding varieties and fertilizer etc. (Kukal *et al*., 2014). Water scarcity is an emerging global concern in context of increasing population as well as competitive demand from agriculture, industry and urban inhabitants (Babel and Wahid 2008).

Moisture conservation practices are utmost requirement for increasing water use efficiency of crop. Polymers as hydrogel play an important role in soil moisture conservation in agriculture. Pusa hydrogel is an insoluble, cross-linked three-dimensional hydrogel which absorbs water more than 400 times of its weight and gradually releases it and also improves soil hydro-physical properties such as porosity, aggregate stability and hydraulic conductivity (Dabhi *et al.,* 2013). In this context 'Pusa hydrogel', a novel semi-synthetic super absorbent polymer has shown potential to realize higher crop yield with limited water. A significant improvement in yield and water use efficiency in most of the test crops was reported by application of Pusa hydrogel (Anupama and Parmar 2012).

Integrated nutrient management (INM) is one of the agronomic practices aiming at the usage of the harmonious properties of both sources by making a combination that can be used for decreasing the enormous use of chemical fertilizers and accreting a balance between fertilizer inputs and crop nutrient requirement options. Integrated nutrient management (INM) or integrated plant nutrient supply system (IPNS) is an approach, which adopts plant nutrition to a specific farming system and particular yield targets, whole depends upon the resource base, the available plant nutrient source and socio-economic background (Dudal and Roy 1995). Organic manures, which were perhaps the main sources of plant nutrients in traditional agriculture, receive less emphasis with the advent of high analysis inorganic fertilizers. Among the organic sources of nutrients, farmyard manure (FYM) is the most commonly and easily available source in India. Biofertilizers emerged as one of the integral component of integrated nutrient management. These are cost effective, eco-friendly and renewable source of plant nutrition. Azotobacter sp. has been observed to augment plant growth and yield by production of IAA, fixation of atmospheric nitrogen, antibiotic production. Plants generally require zinc in small quantities. In different soils, it can range from the lowest values of 10 ppm to a maximum of 1000 ppm. Zinc is a major requirement for optimum plant development and maturity because of its role in the formation of structural components and growth hormones.

Keeping this in view, the present field experiment was conducted to find out the "Influence of moisture conserving polymer and integrated nutrient management on productivity of wheat (*Triticum aestivum* L.) under limited irrigated condition".

MATERIALS AND METHODS

The field experiment was carried out during *Rabi* season of 2020-21 and 2021-22 at Students' Instructional Farm, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur (U.P.) which is situated in the alluvial tract of Indo-Gangetic plain in central part of Uttar Pradesh between 25°26′ to 26°58′ North latitude, 79°31′ to 31°34′East longitude and on the altitude of 125.9 meters. The average annual rainfall of this zone was 850-900 mm of which about 90% of annual rainfall of region is received during later half of June to September with erratic distribution over time and space. The experiment comprised of twenty four treatment combinations and conducted in split plot design with three replications. Experiment consisted of three irrigation schedules *viz*. One irrigation at CRI stage, Two irrigations at CRI and late jointing stage, and three irrigations at CRI, booting and milking stage, in main plots, two moisture conservation practices *viz*. Pusa Hydrogel 5 kg ha^{-1} and paddy straw mulch 5 t ha^{-1} in sub plots and four nutrient management *viz*. 100% RDF, 100% RDF + Azotobacter, 75% RDF + Azotobacter + FYM 5 t ha^{-1} and 75% RDF + Azotobacter + FYM 5 t ha^{-1} + $ZnSO_4$ 20 kg ha^{-1} were kept in sub-sub plots.

The soil of the experimental field was sandy loam in texture and slightly alkaline in reaction having initial pH 7.69, organic carbon percentage 0.30 per cent, with available nitrogen 185.40 kg ha^{-1}, available phosphorus 15.52 kg ha^{-1}, available potassium was 172.12 kg ha^{-1}.

The field preparation included one deep ploughing and two cross harrowing and planking. The wheat variety K 1317 was sown on first December with a recommended seed rate of 100 kg ha^{-1}. The recommended dose of nitrogen, phosphorus, potash and zinc was 120-60-40 and 20 kg ha^{-1}, respectively, which was applied through urea, diammonium phosphate, muriate of potash and zinc sulphate. However, biofertilizer (Azotobacter) was applied as seed inoculation. During both the seasons 50 per cent nitrogen and whole quantity of P_2O_5 and K_2O were applied at sowing time, while remaining amount of nitrogen was applied after first irrigation as per treatment. Among moisture conservation practices Pusa hydrogel was mixed with soil and applied in furrows at the time of sowing, paddy straw mulch was applied in inter row at 20 days after sowing.

Dry weight of the plant, plant samples were oven dried at 65°C till the constant weight was obtained. Crop growth rate (CGR) was recorded at 30, 60, 90 DAS and harvest stage, CGR was the rate of dry matter production per unit area per unit time. It was computed by using the formula: CGR = W_2-W_1/T_2-T_1, where, W_1 and W_2 are the dry weight values at time T_1 and T_2, respectively. T_1 and T_2 are time values in days.

The nitrogen, phosphorus, potash and zinc in grain and straw were estimated at the time of maturity with standard laboratory methods. Nutrient uptake was computed by formula: uptake = Nutrient (%) × Yield (kg) divided by 100 and expressed as kg ha^{-1}.

The percentage of protein content in grain was estimated by multiplying nitrogen content by a factor of 6.25 (AOAC, 1989). Protein yield was estimated by the following formula: Protein yield (kg ha^{-1}) = Protein content (%) × Grain yield (kg ha^{-1}) divided by the hundred.

RESULTS AND DISCUSSION

Influence on growth characters.

The irrigation schedules, moisture conservation and integrated nutrient management practices had significant influence on growth of wheat crop during both years as well as pooled basis (Table 5).

Dry weight of plant. Significantly, higher dry weight of plant was recorded with the three irrigations, which was followed by two irrigations and lowest dry weight of plant was recorded with one irrigation. The enhancement in dry matter accumulation of plant under high moisture availability was reported by Rahim *et al.* (2010); Kaur *et al.* (2018).

In moisture conservation practices, the dry weight of plant increased as the growth progressed. Maximum dry matter production per plant was recorded with the application of Pusa hydrogel 5 kg ha^{-1} as compare to paddy straw mulch 5 t ha^{-1}. The dry matter production is the sum of total effect on overall growth. Polymers improve water holding capacity and nutrient supplying capacity of soil which ultimately improve growth and dry matter production of plants similar result reported by (El-Hady *et al*., (1981) as well as Kumar *et al*. (2019).

Among the integrated nutrient management practices, The significantly, higher dry weight of plant was recorded with the application of 75% RDF + Azotobacter + FYM 5 t ha^{-1} + $ZnSO_4$ 20 kg ha^{-1} (N_4) followed by 75% RDF + Azotobacter + FYM 5 t ha^{-1} (N_3), 100% RDF + Azotobacter (N_2) and minimum dry weight was recorded in 100% RDF (N_1) treatment. This might be due to additional use of farm yard manure which improve the soil health (physical, chemical and biological condition) and supply of essential nutrients during all stages of crop growth, Azotobacter enhanced growth of the plant by production of auxin hormone and fixation of atmospheric nitrogen in the soil, while, zinc plays key role in biosynthesis of the indole acetic acid (IAA) phytohormone and initiation of primordia for reproductive parts and a result of favourable influence of Zn on metabolic activities within the plant. Similar result also reported by Badiyala and Kumar (2003); Shaheen *et al.* (2007); Chauhan *et al.* (2011); Maurya *et al.* (2015); Singh *et al.* (2019).

Crop growth rate. Maximum crop growth rate of the plant was recorded with the application of three irrigations at CRI, booting and milking stages as compared to two and one irrigation. The crop growth rate increased with advancement of crop growth up to harvest. This was due to high growth rate of plant under adequate moisture condition more nutrient absorption by plant which resulted into better growth with higher photosynthetic activity and net assimilation of nutrient along with water, while under minimum moisture condition CGR of plant decreases due to poor plant nutrition because of low moisture condition.

Higher crop growth rate was recorded from the Pusa hydrogel applicated as compare to paddy straw mulch treatment. The significantly higher crop growth rate of plant was recorded between 90 DAS to harvest that is gradually increases up to harvest from 30 DAS. Growth of plant depends mainly due to active cell division and enlargement of cell, which dependent on plant-water relations, Pusa hydrogel retaining more water their utilize by plant for longer period ultimately resulted into translocation of more nutrient. Similar result reported by Kumar *et al*., (2019).

Among the integrated nutrient management practices, higher dry weight of plant was recorded in the application of 75% RDF + Azotobacter + FYM 5 t ha^{-1} + $ZnSO_4$ @ 20 kg ha^{-1} followed by 75% RDF + Azotobacter + FYM 5 t ha^{-1} and minimum dry weight was recorded with 100% RDF treatment.

Influence on nutrient content and uptake. In different irrigation schedules significant higher content of nitrogen and potash in grain and straw were recorded with one irrigation at CRI stage which was followed by two irrigations at CRI and Late jointing stage and minimum was recorded with three irrigation at CRI, Booting and Milking stages (Table 1 and 2). In rainfed crop high nitrogen content absorbed in grain compare to irrigated crop reported by Rahman *et al*., (2001). Nitrogen and potash content in grain and straw was decreased with increasing frequency of irrigation as compared to one irrigation at CRI stage only might be due to leaching of nutrients. This may be attributed to higher amount of dry matter production per plant resulting in dilution under more irrigation as reported by Mehta *et al*., (1982). Whereas, higher phosphorous and zinc content in grain and straw was recorded higher when crop irrigated three times as compare to two and one time irrigation. It might be due to P absorption by plant is directly depends on the concentration of phosphorus in the soil solution which in turn regulated by the labile pool. Similar result reported by Parihar and Tiwari (2003).

The significantly higher uptake of nitrogen, phosphorus, potash and zinc in straw and grain were recorded with the application of three irrigations at CRI, Booting and Milking stages, which was followed by two irrigations at CRI and Late jointing stages and minimum uptake was recorded from one irrigation at CRI stages only (Table 3 and 4). It might be due to adequate supplying of moisture and nutrient resulted better root establishment, which resulted into improve uptake and translocation from different depth of soil profile, ultimately better growth of plant resulted into maximum grain and straw yield. Appropriate soil moisture in the plant rhizosphere enhanced translocation of nutrient in the soil and absorption by the plant, as reported by Dubey and Sharma (1996).

In moisture conservation practices, Pusa hydrogel had significant influenced on content of nitrogen, phosphorus, potash and zinc (Table 1 and 2) and their uptake in grain and straw of wheat (Table 3 and 4), respectively. Higher N, P, K and Zn content and uptake in grain and straw were recorded with the application of Pusa hydrogel 5 kg ha^{-1} as compared to paddy straw mulch 5 t ha^{-1}. This might be due to Pusa hydrogel enhanced the vigorous plant growth by the adequate and longer period availability of soil moisture during entire growth period, thus sufficient soil moisture increases absorption and translocation of nutrients from soil that resulted more nutrient content in grain and straw.

Among integrated nutrient management practice significantly higher content of nitrogen, potash and zinc (Table 1 and 2) and their uptake in grain and straw of wheat (Table 3 and 4) was recorded with the application of 75% RDF + Azotobacter + FYM 5 t ha^{-1} + $ZnSO_4$ @ 20 kg ha^{-1} followed by 75% RDF + Azotobacter + FYM 5 t ha^{-1}. The higher phosphorus content and uptake in grain and straw was recorded with 75% RDF + Azotobacter + FYM 5 t ha^{-1} whereas uptake of phosphorus in straw was recorded with 75% RDF + Azotobacter + FYM 5 t ha^{-1} + $ZnSO_4$ @ 20 kg ha^{-1} treatment. However, minimum content of N, P, K, and Zn were recorded with 100% RDF treatment. Therefore, the higher content in grain and straw might be due to synergetic effect increase in N, K and Zn content and uptake by between nitrogen and zinc and positive interaction of potassium and zinc. Whereas decrease in P content might be due to antagonistic effect of phosphorus with zinc. Zinc was recorded to inhibit the transportation of phosphorus from root to top of plant. Similar findings were reported by Alam *et al.* (2000), Singh and Agrawal (2004); Shaheen *et al.* (2007); Ashok *et al*. (2008); Morshedi and Farahbakhsh (2010); Singh *et al.* (2010); Keram *et al*. (2012); Lal Bahadur *et al.* (2013); Chauhan *et al*. (2014), respectively.

Influence on protein content and protein yield

Among the irrigation schedules, higher protein content in grain was recorded with one irrigation at CRI stage only which was followed by two irrigations at CRI and Late jointing stage and lowest content of protein in grain was recorded with three irrigations at CRI, Booting and Milking stages (Table 5). This might be due to more loss of nitrogen by leaching under adequate and abundance amount of water that resulted into minimum nitrogen content in grain. Protein content in grain mainly depend on the nitrogen content in grain, thus maximum protein was recorded from one irrigation because higher nitrogen content recorded from same treatment. However, significantly higher protein yield in grain was recorded with three irrigations at CRI, Booting and Milking stages which was followed by two and one irrigation (Table 5). This might be due to adequate supply of moisture and nutrient resulted better root establishment, that resulted into higher uptake and translocation from different depth of soil profile, better growth of plant increases intake and translocation of nitrogen in the plant and assimilation in the grain and improved yield. Protein yield mainly depends on nitrogen content in grain and grain yield of plant that is by higher protein yield was recorded from the application of three irrigations because maximum grain yield also recorded with same treatment.

In the moisture conservation practices higher protein content in grain and protein yield in wheat grain was recorded with Pusa hydrogel 5 kg ha^{-1} than paddy straw mulch 5 t ha^{-1} (Table 5). This might be due to Pusa hydrogel improve water holding capacity of soil and reduce leaching loss of nutrients under adequate soil moisture availability thus, increases intake and translocation of nitrogen in the plant and assimilation in the grain. Protein yield mainly depends on nitrogen content in grain and grain yield of plant, therefore higher protein yield was recorded from Pusa hydrogel applied treatment because maximum grain yield also recorded with Pusa hydrogel 5 kg ha^{-1} applied treatment.

In nutrient management practices higher protein content and protein yield in grain were recorded with the integration of 75% RDF + Azotobacter + FYM 5 t ha^{-1} + $ZnSO_4$ @ 20 kg ha^{-1} followed by 75% RDF + Azotobacter + FYM 5 t ha^{-1} and 100% RDF + Azotobacter while, minimum protein content and yield were recorded from 100% RDF (Table 5). This might be due to improvement in soil health, reduce loss of leaching of nutrient under adequate soil moisture and nutrient availability thus, increases intake and translocation of nitrogen in the plant and assimilation in the grain. However, protein yield mainly depends on nitrogen content and grain yield of plant therefore, higher protein yield was recorded from same applied treatment because maximum grain yield also recorded with same treatment. Singh *et al.* (2010); Chauhan *et al*. (2014), respectively.

Table 1 : Influence of treatments on N, P, K and Zn content in grain.

Treatments	N content in grain (%)			P content in grain (%)			K content in grain (%)			Zn content in grain (%)		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
Irrigation scheduling												
One irrigation (CRI stage)	1.82	1.83	1.83	0.285	0.295	0.290	0.620	0.640	0.630	0.0033	0.0033	0.0033
Two irrigations (CRI and Late jointing stage)	1.80	1.81	1.81	0.295	0.305	0.300	0.600	0.620	0.610	0.0033	0.0033	0.0033
Three irrigations (CRI, Booting and Milking stage)	1.78	1.79	1.79	0.305	0.315	0.310	0.590	0.610	0.600	0.0033	0.0036	0.0034
S.Em. ±	0.002	0.002	0.002	0.002	0.003	0.002	0.001	0.001	0.000	0.000	0.000	0.000
CD at 5%	0.007	0.008	0.006	0.009	0.013	0.008	0.006	0.004	0.001	0.000	0.000	0.000
Moisture conservation practices												
Pusa hydrogel @ 5 kg ha^{-1}	1.81	1.82	1.81	0.300	0.310	0.305	0.608	0.628	0.618	0.0033	0.0035	0.0034
Paddy straw mulch @ 5 t ha^{-1}	1.80	1.81	1.80	0.290	0.300	0.295	0.598	0.618	0.608	0.0033	0.0033	0.0033
S.Em.±	0.005	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000
CD at 5%	0.017	0.010	0.008	0.006	0.004	0.003	0.003	0.002	0.002	0.000	0.000	0.000
Nutrient Management												
100% RDF (N 120, P 60, K 40 kg ha^{-1})	1.79	1.80	1.79	0.285	0.295	0.290	0.588	0.608	0.598	0.0030	0.0032	0.0031
100% RDF + Azotobacter	1.80	1.81	1.80	0.295	0.305	0.300	0.598	0.618	0.608	0.0030	0.0032	0.0031
75% RDF + Azotobacter + FYM @ 5 t ha^{-1}	1.81	1.82	1.81	0.305	0.315	0.310	0.608	0.628	0.618	0.0030	0.0032	0.0031
75% RDF + Azotobacter + FYM 5 t ha^{-1} + $ZnSO_4$ @ 20 kg ha^{-1}	1.82	1.83	1.82	0.295	0.305	0.300	0.618	0.638	0.628	0.0040	0.0040	0.0040
S.Em. ±	0.006	0.006	0.006	0.003	0.003	0.002	0.003	0.003	0.002	0.000	0.000	0.000
CD at 5%	0.017	0.017	0.018	0.007	0.007	0.005	0.009	0.008	0.007	0.000	0.000	0.000

Table 2 : Influence of treatments on N, P, K and Zn content in straw.

Treatments	N content in straw (%)			P content in straw (%)			K content in straw (%)			Zn content in straw (%)		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
Irrigation scheduling												
One irrigation (CRI stage)	0.500	0.530	0.515	0.064	0.073	0.068	1.26	1.29	1.28	0.0021	0.0021	0.0021
Two irrigations (CRI and Late jointing stage)	0.490	0.520	0.505	0.072	0.084	0.078	1.21	1.24	1.23	0.0023	0.0023	0.0023
Three irrigations (CRI, Booting and Milking stage)	0.470	0.500	0.485	0.083	0.092	0.087	1.16	1.19	1.18	0.0023	0.0023	0.0023
S.Em. ±	0.001	0.001	0.001	0.000	0.000	0.000	0.001	0.002	0.002	0.000	0.000	0.000
CD at 5%	0.004	0.002	0.003	0.000	0.000	0.001	0.004	0.009	0.007	0.000	0.000	0.000
Moisture conservation practices												
Pusa hydrogel @ 5 kg ha^{-1}	0.492	0.522	0.507	0.073	0.083	0.078	1.22	1.25	1.23	0.0023	0.0023	0.0023
Paddy straw mulch @ 5 t ha^{-1}	0.482	0.512	0.497	0.072	0.082	0.077	1.21	1.24	1.22	0.0022	0.0022	0.0022
S.Em.±	0.001	0.002	0.001	0.000	0.000	0.000	0.003	0.003	0.001	0.000	0.000	0.000
CD at 5%	0.004	0.006	0.004	0.001	0.001	0.001	0.011	0.011	0.004	0.000	0.000	0.000
Nutrient Management												
100% RDF (N 120, P 60, K 40 kg ha^{-1})	0.472	0.502	0.487	0.072	0.082	0.077	1.20	1.23	1.21	0.0020	0.0020	0.0020
100% RDF + Azotobacter	0.482	0.512	0.497	0.073	0.083	0.078	1.21	1.24	1.22	0.0020	0.0020	0.0020
75% RDF + Azotobacter + FYM @ 5 t ha^{-1}	0.492	0.522	0.507	0.074	0.084	0.079	1.22	1.25	1.23	0.0020	0.0020	0.0020
75% RDF + Azotobacter + FYM 5 t ha^{-1} + $ZnSO_4$ @ 20 kg ha^{-1}	0.502	0.532	0.517	0.073	0.083	0.078	1.23	1.26	1.24	0.0028	0.0028	0.0028
S.Em. ±	0.003	0.003	0.003	0.001	0.001	0.000	0.008	0.008	0.007	0.000	0.000	0.000
CD at 5%	0.009	0.009	0.010	0.001	0.002	0.001	0.021	0.022	0.019	0.000	0.000	0.000

Table 3 : Influence of treatments on N, P, K and Zn uptake (kg ha^{-1}) in grain.

Treatments	N uptake in grain (kg ha^{-1})			P uptake in grain (kg ha^{-1})			K uptake in grain (kg ha^{-1})			Zn uptake in grain (kg ha^{-1})		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
Irrigation scheduling												
One irrigation (CRI stage)	51.93	53.79	52.86	8.13	8.68	8.40	17.70	18.82	18.26	0.094	0.100	0.097
Two irrigations (CRI and Late jointing stage)	58.49	60.47	59.48	9.59	10.19	9.89	19.51	20.72	20.11	0.110	0.118	0.114
Three irrigations (CRI, Booting and Milking stage)	66.87	69.41	68.14	11.46	12.22	11.84	22.17	23.66	22.92	0.131	0.141	0.136
S.Em. ±	0.236	0.458	0.197	0.088	0.073	0.074	0.033	0.142	0.074	0.001	0.001	0.001
CD at 5%	0.920	1.786	0.770	0.343	0.284	0.287	0.127	0.554	0.288	0.004	0.006	0.003
Moisture conservation practices												
Pusa hydrogel @ 5 kg ha^{-1}	60.10	62.26	61.18	10.03	10.68	10.35	20.24	21.54	20.89	0.115	0.123	0.119
Paddy straw mulch @ 5 t ha^{-1}	58.09	60.18	59.14	9.43	10.05	9.74	19.35	20.60	19.97	0.108	0.116	0.112
S.Em.±	0.233	0.303	0.134	0.050	0.068	0.034	0.089	0.141	0.108	0.001	0.000	0.000
CD at 5%	0.805	1.045	0.464	0.172	0.233	0.116	0.307	0.488	0.373	0.002	0.002	0.001
Nutrient Management												
100% RDF (N 120, P 60, K 40 kg ha^{-1})	56.68	58.69	57.68	9.09	9.69	9.39	18.66	19.87	19.26	0.105	0.112	0.108
100% RDF + Azotobacter	58.43	60.50	59.47	9.64	10.27	9.96	19.45	20.70	20.08	0.107	0.115	0.111
75% RDF + Azotobacter + FYM @ 5 t ha^{-1}	59.84	62.00	60.92	10.15	10.80	10.48	20.14	21.44	20.79	0.109	0.117	0.113
75% RDF + Azotobacter + FYM 5 t ha^{-1} + $ZnSO_4$ @ 20 kg ha^{-1}	61.44	63.69	62.57	10.03	10.69	10.36	20.91	22.26	21.58	0.125	0.134	0.130
S.Em. ±	0.535	0.559	0.360	0.083	0.086	0.056	0.199	0.168	0.099	0.001	0.001	0.001
CD at 5%	1.535	1.603	1.034	0.238	0.248	0.162	0.570	0.482	0.285	0.003	0.003	0.002

Table 4 : Influence of treatments on N, P, K and Zn uptake (kg ha^{-1}) in straw.

Treatments	N uptake in straw (kg ha^{-1})			P uptake in straw (kg ha^{-1})			K uptake in straw (kg ha^{-1})			Zn uptake in straw (kg ha^{-1})		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
Irrigation scheduling												
One irrigation (CRI stage)	16.55	18.08	17.32	2.10	2.47	2.29	41.70	43.98	42.84	0.073	0.078	0.076
Two irrigations (CRI and Late jointing stage)	18.64	20.33	19.48	2.72	3.26	2.99	46.00	48.47	47.23	0.088	0.094	0.091
Three irrigations (CRI, Booting and Milking stage)	20.84	22.79	21.82	3.66	4.17	3.91	51.42	54.22	52.82	0.107	0.115	0.111
S.Em. ±	0.110	0.150	0.107	0.026	0.029	0.014	0.203	0.233	0.165	0.000	0.001	0.000
CD at 5%	0.429	0.586	0.417	0.101	0.114	0.057	0.792	0.909	0.645	0.001	0.005	0.002
Moisture conservation practices												
Pusa hydrogel @ 5 kg ha^{-1}	19.14	20.89	20.01	2.88	3.37	3.13	47.23	49.79	48.51	0.093	0.099	0.096
Paddy straw mulch @ 5 t ha^{-1}	18.22	19.91	19.07	2.77	3.23	3.00	45.52	47.99	46.76	0.085	0.093	0.089
S.Em.±	0.034	0.146	0.075	0.015	0.016	0.009	0.225	0.383	0.217	0.001	0.000	0.000
CD at 5%	0.117	0.504	0.259	0.053	0.055	0.030	0.776	1.322	0.749	0.002	0.001	0.001
Nutrient Management												
100% RDF (N 120, P 60, K 40 kg ha^{-1})	17.50	19.14	18.32	2.70	3.15	2.93	44.28	46.68	45.48	0.082	0.089	0.086
100% RDF + Azotobacter	18.32	20.01	19.17	2.80	3.27	3.04	45.78	48.25	47.02	0.084	0.092	0.088
75% RDF + Azotobacter + FYM @ 5 t ha^{-1}	19.05	20.79	19.92	2.89	3.37	3.13	47.02	49.57	48.30	0.086	0.093	0.090
75% RDF + Azotobacter + FYM 5 t ha^{-1} + $ZnSO_4$ @ 20 kg ha^{-1}	19.85	21.65	20.75	2.91	3.41	3.16	48.41	51.06	49.73	0.104	0.109	0.107
S.Em. ±	0.182	0.196	0.107	0.029	0.034	0.014	0.473	0.511	0.200	0.001	0.001	0.000
CD at 5%	0.524	0.563	0.308	0.082	0.097	0.041	1.357	1.466	0.574	0.002	0.003	0.001

Table 5 : Influence of treatments on dry weight per plant, crop growth rate, protein content and protein yield.

Treatments	Dry weight of plant at harvest (g)			Crop growth rate at harvest (g/cm^2/day)			Protein content in grain (%)			Protein yield in grain (kg ha^{-1})		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
Irrigation scheduling												
One irrigation (CRI stage)	14.47	16.28	15.37	7.56	10.36	8.96	11.38	11.44	11.41	324.54	336.16	330.35
Two irrigations (CRI and Late jointing stage)	18.77	20.35	19.56	11.68	13.58	12.63	11.25	11.31	11.28	365.58	377.91	371.74
Three irrigations (CRI, Booting and Milking stage)	20.40	22.84	21.62	13.22	15.76	14.49	11.13	11.19	11.16	417.92	433.83	425.88
S.Em. ±	0.071	0.093	0.057	0.044	0.090	0.042	0.013	0.012	0.011	3.378	4.141	1.031
CD at 5%	0.278	0.364	0.222	0.171	0.353	0.163	0.049	0.047	0.042	13.190	16.169	4.024
Moisture conservation practices												
Pusa hydrogel @ 5 kg ha^{-1}	18.59	20.51	19.55	11.15	13.76	12.46	11.28	11.34	11.31	375.62	389.15	382.39
Paddy straw mulch @ 5 t ha^{-1}	17.17	19.13	18.15	10.49	12.71	11.60	11.22	11.28	11.25	363.07	376.11	369.59
S.Em.±	0.087	0.156	0.084	0.045	0.067	0.028	0.030	0.018	0.014	1.397	2.484	1.680
CD at 5%	0.299	0.537	0.291	0.156	0.231	0.096	0.104	0.063	0.048	4.822	8.573	5.799
Nutrient Management												
100% RDF (N 120, P 60, K 40 kg ha^{-1})	17.23	19.23	18.23	10.54	12.59	11.56	11.16	11.22	11.19	354.22	366.80	360.51
100% RDF + Azotobacter	17.66	19.62	18.64	10.73	13.02	11.87	11.22	11.28	11.25	365.18	378.15	371.67
75% RDF + Azotobacter + FYM @ 5 t ha^{-1}	18.10	20.02	19.06	10.92	13.45	12.18	11.28	11.34	11.31	373.99	387.50	380.75
75% RDF + Azotobacter + FYM 5 t ha^{-1} + $ZnSO_4$ @ 20 kg ha^{-1}	18.53	20.42	19.47	11.10	13.88	12.49	11.34	11.41	11.38	384.00	398.08	391.04
S.Em. ±	0.185	0.207	0.081	0.099	0.124	0.075	0.037	0.037	0.038	3.571	4.076	2.367
CD at 5%	0.531	0.595	0.233	0.283	0.355	0.214	0.107	0.107	0.109	10.244	11.693	6.790

CONCLUSIONS

It is concluded from the study that cultivation of wheat with the application of three irrigations, Pusa hydrogel and integration of 75% RDF + Azotobacter + FYM 5 t ha^{-1} + $ZnSO_4$ @ 20 kg ha^{-1} resulted into improvement in the growth attributes, nutrient uptake and quality parameters as compared to other treatments. In limited irrigation condition, it is a viable option to use hydrogel @ 5 kg ha^{-1} for resources conservation in wheat cultivation.

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Conflict of Interest. None.

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