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Water use efficiency, economic feasibility and suitable moisture regime for wheat (*Triticum aestivum* L.)

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Abstract
A field experiment was carried out at the Agronomy Research Farm of Narendra Deva University of Agriculture & Technology in Kumarganj, Faizabad (U.P.) over the rabi seasons of 2012-13 and 2013-14. The primary objective was to determine the most suitable wheat variety in conjunction with specific moisture regimes and nutrient supply systems. The experiment comprised 18 treatment combinations involving three wheat varieties (NW-2036, PBW-373, and HUW-234), two moisture regimes (irrigation at 0.8 and 1.0 IW/CPE ratio), and three nutrient supply systems (100% RDF through chemical fertilizers, 50% RDN + 50% N through FYM, and 50% RDN + 50% N through neem cake). The Split Plot Design (SPD) with three replications was employed on silt loam soil characterized by low organic carbon, medium phosphorus, potassium, sulfur, and available nitrogen, and high pH. The recorded rainfall during the crop seasons of 2012-13 and 2013-14 was 85.6 mm and 56.2 mm, respectively. The crop was sown on December 20 and 21 in the first and second years, respectively, with a seed rate of 125 kg/ha and row spacing of 20.0 cm. Harvesting took place on May 4 and 5 in 2013 and 2014, respectively. In conclusion, the treatment combination of wheat variety PBW-373, moisture regime 1.0 IW/CPE, and nutrient level of 150:60:40 NPK kg ha^{-1} (RDF100%) demonstrated significant superiority in terms of grain yield, straw yield, and economic returns compared to other treatment combinations in both years.

Keywords: Economic feasibility and suitable moisture regime, wheat (*Triticum aestivum* L.)

Introduction
Wheat (*Triticum aestivum* L.) stands as a crucial cereal crop globally, predominantly cultivated in temperate regions and at elevated altitudes within tropical climates during the winter season. Recognized as a vital component of food security systems in numerous nations, wheat holds the position of the foremost cereal crop worldwide. Key contributors to global wheat production include China, India, USA, France, Russia, Canada, Australia, Pakistan, Turkey, UK, Argentina, Iran, and Italy, collectively accounting for approximately 74.82% of the total output.

India takes precedence in cereals, leading in both area (225.43 million hectares) and production (708.0 million tons). The total wheat cultivation area in India spans 29.90 million hectares, yielding a production of 93.90 million tons and a productivity rate of 3.14 tons per hectare. Notably, around 90% of India's total wheat production is concentrated in the northern states, with Uttar Pradesh ranking first in terms of area (9.734 million hectares) and production (30.30 million tons). However, the productivity in Uttar Pradesh, at 3.11 tons per hectare, falls behind Punjab, which boasts a higher productivity rate of 4.72 tons per hectare.

The projected demand for wheat by 2020 is estimated to be in the range of 105-109 million tonnes. Meeting this increased production demand necessitates a focus on enhancing productivity, considering that the land area allocated to wheat cultivation is not expected to expand. Efficient input management and varietal improvements are fundamental factors that can contribute to achieving this target.

It is widely acknowledged that effective water management plays a crucial role in optimizing crop harvests. Timely and adequate irrigation not only improves crop yield but also enhances water productivity. To successfully grow wheat, it is imperative to achieve water economy, balancing the climate's demand with the available water supply. A challenge arises from the continuous atmospheric evaporation demand, contrasting with the sporadic supply of water through natural precipitation. Even short-term water deficits can significantly reduce crop yields.

Among various irrigation scheduling criteria, the critical stage approach is familiar among farmers due to its simplicity, requiring no technical knowledge, skills, or instruments. While it may have a less scientific approach compared to factors like IW/CPE ratio or soil moisture depletion, its practical utility makes it popular. Certain stages of crop growth and development are particularly sensitive to soil moisture stress, known as moisture-sensitive periods. Ensuring adequate soil moisture during these periods is essential for the normal development of wheat at all growth stages, achievable through timely irrigation scheduling (Parihar and Tiwari, 2003) [10].

The significance of irrigation management has heightened with the introduction of dwarf wheat cultivars across the country. Optimal irrigation facilities are essential for achieving maximum yields across different wheat varieties. In Uttar Pradesh, a general recommendation of 4-5 irrigations is made, with the possibility of increasing to 5-6 irrigations depending on climatic conditions and underground water table levels.

Materials and Methods

The study was conducted on wheat crops during the rabi seasons over two consecutive years, 2012-13 and 2013-14, at the Agronomy Research Farm of N.D. University of Agriculture and Technology, located in Narendra Nagar, Ayodhya, India (24.40-26.60 N, 82.10-83.90 E, with an altitude of 113 m above mean sea level). The climate in the region is characterized as warm humid subtropical, with cool, dry winters extending from November to February. The recorded total rainfall during the winter seasons of 2012-13 and 2013-14 was 85.6 mm and 56.2 mm, respectively. The total evaporation rate was highest in the month of April during both experimental seasons.

The soil in the experimental field was identified as silt loam with a pH of 8.21 and 8.20, Electric Conductivity (EC) of 0.34 and 0.32 dSm-1, low organic carbon content (0.35% and 0.38%), and medium levels of available nitrogen (109.40 and 115.40 kg ha^{-1}), phosphorus (15.82 and 17.60 kg ha^{-1}), and potassium (245.20 and 251.47 kg ha^{-1}) during the consecutive years of 2012-13 and 2013-14. The weekly maximum and minimum temperatures ranged from 41.1 to 2.10 °C and 39.2 to 5.90 °C, respectively, in 2012-13 and 2013-14. Relative humidity was highest during the crop season of 2012-13 in the 4th week of December at 82.5 percent, while in 2013-14, it was lowest in the 2nd week of December at 87.9 percent.

The experimental design consisted of 18 treatment combinations involving three varieties and two irrigation levels in the main plots, and three fertility sources in the subplots, laid out in a split-plot design with three replications. Each treatment combination was randomly allocated in each block plot, following the treatments presented in Table 1.

Following the harvest of rainy-season crops, the experimental field underwent preparation, including pre-sowing irrigation, ploughing with a tractor-drawn soil turning plough, and subsequent cross-harrowing and planking to achieve favorable soil tilth. As per the specific treatments, fertilizers such as Urea, Di-Ammonium Phosphate, and Muriate of Potash were applied. The remaining half dose of nitrogen, administered through urea, was top-dressed in two equal doses. Crop sowing was carried out manually in rows spaced at 20 cm apart and at a depth of 4-5 cm.

Irrigation was scheduled based on the Irrigation Water/Crop Potential Evapotranspiration (IW/CPE) ratio. Weed control was implemented using Sulfosulfuron herbicide at a rate of 25 gm a.i. ha^{-1} as a post-emergence application after 30 days after sowing (DAS). Other recommended agricultural practices were diligently followed. The crop was assessed in terms of yield attributes, including the number of shoots (running meter), length of spike, grains per spike, grain weight per spike, 1000-grain weight, grain yield, straw yield, and harvest index. Additionally, evaluations were made for gross returns, net returns, benefit-cost ratios, consumptive use of water, and water use efficiency.

Data on plant growth attributes were recorded at 30, 60, and 90 days after sowing (DAS), as well as at the harvest stage. Yield attributes were documented at crop maturity. Standard procedures were employed for the chemical analysis of soil and plant samples. Statistical analysis of the collected data utilized the analysis of variance (ANOVA) technique as described by Panse and Sukhatme (1978) [16]. To assess significant differences between the means of two treatments, the critical difference (C.D.) was determined using the formula cited in Cochran and Cox (1959) [17].

Table 1: Details of the treatments used in experiment

A	Main plot (varieties × moisture regimes)	Symbol used
a.	**Varieties**	
i	NW-2036	V_1
ii	PBW-373	V_2
iii	HUW-234	V_3
b.	**Moisture regimes**	
i.	Irrigation at 0.8 IW/CPE ratio	M_1
ii.	Irrigation at 1.0 IW/CPE ratio	M_2
B.	**Sub plot-nutrient supply system**	
i	100% NPK through chemical fertilizers (150:60:40 kg NPK ha^{-1})	F_1
ii	50% N+ 50% N through FYM	F_2
iii	50% N + 50% N neem cake	F_3

Note: Farm yard manure (FYM) contains 0.5% nitrogen. Applied on oven dry basis. Neem cake contains 5.22 % nitrogen.

Results and Discussion

Effect of moisture regime

Yield and its attributes

Yield attributes, which play a crucial role in determining overall yield, are a consequence of the plant's vegetative development. All yield-related characteristics, including the number of spikes per square meter, spike length, number of grains per spike, and weight of grains per spike, were significantly influenced by changes in the moisture regime. The maximum values for these attributes were observed under the 1.0 Irrigation Water/Crop Potential Evapotranspiration (IW/CPE) ratio compared to the 0.8 IW/CPE ratio. This difference was attributed to favorable vegetative growth and development resulting from receiving adequate moisture throughout the entire growth period.

Under conditions of sufficient moisture, plant height and leaf area index reached their maximum values, contributing to the highest yield attributes, likely due to an increase in the photosynthetic activity of leaves. Additionally, the wetter conditions led to a higher uptake of potassium, enhancing the translocation of photosynthates from source to sink. Conversely, the minimum yield attributes were recorded under the 0.8 IW/CPE ratio, as plants struggled to extract sufficient water and nutrients under poor moisture conditions, resulting in compromised growth and yield attributes. These findings align closely with previous studies by Bandyopadhyay (1997) [1] and Khatri *et al*. (2001) [8].

Yield is the outcome of the coordinated interaction between growth characteristics and yield attributes. Grain and straw yield were significantly influenced by different moisture regimes, with the highest grain yield observed under a moisture regime of 1.0 Irrigation Water/Crop Potential Evapotranspiration (IW/CPE) ratio. This can be attributed to the availability of adequate moisture, contributing to improved growth parameters and yield attributes. The collective determination of crop productivity relies on the vigor of vegetative growth and yield attributes. Enhanced vegetative growth, combined with higher yield attributes, led to increased grain and straw yields. Conversely, the lowest grain yield was recorded under the 0.8 IW/CPE ratio due to inadequate moisture supply during the growth period. Insufficient moisture during critical stages resulted in reduced yield attributes, leading to poor grain and straw yields. Similar results have been reported by Khatri *et al*. (2001) [8] and Behara *et al*. (2002) [2].

Harvest index, representing the ratio of grain to straw yield, was not significantly influenced by different moisture levels. This may be attributed to the fact that adequate moisture under the higher moisture regime increased both grain and straw yield proportionally (Pal *et al*. 1996) [9].

Water use efficiency (WUE) was notably affected by various moisture regimes. The highest water use efficiency, recorded at 207.68 kg/ha/cm, was observed under 3 irrigations at the 0.8 IW/CPE ratio. This could be due to the fact that under lower moisture regimes, plants yielded more per unit of water consumed. Chavan and Power (1988) [5] also reported a decrease in water use efficiency with increasing irrigation levels and an increase with decreased irrigation levels. These findings align with those of Behera *et al*. (2002) [2] and Seren *et al*. (2004) [13].

Table 2: Effect of wheat varieties, moisture regimes and nutrient supply system on number of shoots per running meter

Treatment	No. of shoots (running meter)							
	30 DAS		60 DAS		90 DAS		At harvest	
	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14
Varieties								
NW- 2036	41.11	41.62	71.21	73.05	73.76	75.29	70.86	72.39
PBW-373	41.91	42.43	72.62	74.49	75.22	76.78	72.32	73.88
HUW-234	37.88	38.35	65.57	67.26	67.92	69.33	65.02	66.43
S.Em±	0.78	0.82	1.41	1.41	1.43	1.44	1.31	1.31
CD at 5%	2.45	2.57	4.43	4.43	4.49	4.52	4.11	4.11
Moisture regimes (IW/CPE Ratio)								
0.8	39.09	39.58	67.69	69.43	70.11	71.57	67.21	68.67
1.0	41.51	42.02	71.92	73.77	74.49	76.04	71.59	73.14
S.Em±	0.64	0.67	1.15	1.15	1.17	1.17	1.07	1.07
CD at 5%	2.01	2.10	3.61	3.61	3.66	3.67	3.36	3.36
Fertilizers levels (kg ha^{-1})								
F_1	41.51	42.02	72.62	74.47	75.19	76.74	72.29	73.84
F_2	38.69	39.17	67.18	68.91	69.58	71.02	66.68	68.12
F_3	40.70	41.21	69.61	71.42	72.13	73.65	69.23	70.75
S.Em±	0.70	0.71	1.16	1.23	1.281	1.30	72.29	73.84
CD at 5%	2.02	2.06	3.35	3.56	3.700	3.74	66.68	68.12

Table 3: Influence of wheat cultivars, moisture levels, and nutrient delivery methods on the number of spikes per square meter, spike length, grains per spike, grain weight per spike, and test weight (in grams).

Treatment	No. of spikes m^{-2}		Length of spike (cm)		No. of grain spike^{-1}		Weight of Grain/Spike (g)		Test weight(g)	
	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14
Varieties										
V_1	225.07	230.67	8.22	8.42	36.45	37.07	1.95	2.00	36.35	36.40
V_2	293.53	300.83	8.52	8.50	41.76	42.76	2.17	2.23	37.38	37.82
V_3	206.77	211.91	8.02	8.17	34.13	34.87	1.71	1.76	35.02	35.32
S.Em±	5.17	5.05	0.193	0.20	1.03	1.10	0.03	0.04	0.70	0.70
CD at 5%	16.23	15.86	NS	NS	3.23	3.45	0.09	0.13	NS	NS
Moisture regime										
M_1	232.33	238.14	7.86	7.91	36.10	36.98	1.86	1.91	35.93	36.13
M_2	251.25	257.46	8.64	8.81	38.79	39.48	2.03	2.08	36.57	36.89
S.Em±	4.22	4.12	0.16	0.16	0.84	0.90	0.03	0.03	0.57	0.57
CD at 5%	13.25	12.94	0.50	0.50	2.64	2.82	0.09	0.09	NS	NS
Fertilizers levels (kg ha^{-1})										
F_1	258.05	263.21	8.67	8.82	39.29	40.11	2.08	2.14	37.00	37.30
F_2	231.07	236.84	7.93	8.00	36.05	36.63	1.84	1.88	35.73	35.97
F_3	236.26	243.35	8.15	8.27	36.98	37.95	1.90	1.97	36.02	36.27
S.Em±	3.96	4.08	0.16	0.17	0.95	0.95	0.03	0.04	0.62	0.63
CD at 5%	11.43	11.77	0.48	0.50	2.73	2.73	0.09	0.10	NS	NS

Impact of nutrient supply sources

Yield-related factors such as the number of spikes per square meter, spike length, grains per spike, and grain weight per spike exhibited their maximum values when 100% Recommended Dose of Fertilizer (RDF) was applied through inorganic fertilizers, as compared to 50% nitrogen substitution by organic sources. The application of various nutrient sources led to an increase in dry matter accumulation in assimilating organs, subsequently enhancing yield attributes. These findings align with the results reported by Deshmukh *et al*. (1995) [6].

The recommended nitrogen dosage through fertilizer significantly influenced both grain and straw yields. The highest grain yield was achieved with the treatment of 100% RDF through inorganic fertilizers, followed by 50% Replacement of Nitrogen (RDN) along with 50% nitrogen through fertilizers or organic sources like Farm Yard Manure (FYM) or Neem Cake, respectively. Conversely, the lowest grain yield was recorded under the treatment of 50% nitrogen through FYM (37.50 q/ha). Chemical fertilizers not only increased the production of photosynthates but also facilitated their translocation from source to sink, ultimately resulting in increased spike density, spike length, and grains per spike, all positively correlated with grain yield. This could be attributed to the slower release of nitrogen from organic sources compared to the faster release from chemical fertilizers. These results are consistent with the findings of Chardra *et al*. (2004) [4].

Nutrient supply, specifically 100% RDF through inorganic fertilizers, led to higher nutrient content in both grain and straw compared to other treatments. This is likely due to the adequate availability of nitrogen, phosphorus, and potassium with the use of chemical fertilizers, stimulating plant metabolism, and facilitating the rapid conversion of synthesized carbohydrates into proteins. Similar outcomes were reported by Patel *et al*. (1995) [11] and Hedge (1998) [7].

The highest nitrogen uptake in both grain and straw was observed under the treatment of 100% RDN through inorganic fertilizers, followed by 50% RDN along with 50% nitrogen through FYM or Neem Cake. This could be attributed to the easy nutrient availability in nitrogen fertilizer plots, making plants more capable of nutrient absorption. These findings are consistent with the results reported by Rathwa *et al*. (2018) [12].

Varieties

Similarly, significant differences were observed among the varieties in terms of yield-contributing characteristics. The variations in growth, development, and yield can likely be attributed to the unique characteristics of each variety. Genetic traits inherent in different varieties may contribute to the observed differences in plant growth, development, and overall yield. Similar findings regarding the influence of varieties on these factors were also reported by Brijkishor (1998) [3].

Among the wheat cultivars included in the experiment, PBW-373 has emerged as more promising compared to NW-2036 and HUW-234. PBW-373 exhibited higher values for nutrient uptake, primarily attributed to its superior grain and straw yields, leading to increased nutrient uptake as the nutrient contents were not significantly affected.

Table 4: Impact of wheat varieties, moisture levels, and nutrient supply systems on wheat grain yield, straw yield, and harvest index.

Treatment	Grain yield (q/ha)		Straw yield (q/ha)		Harvest index	
	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14
Varieties						
V_1	34.19	35.04	46.64	47.71	42.27	42.28
V_2	38.70	39.61	52.36	54.08	42.48	42.33
V_3	32.41	33.22	43.47	44.38	42.72	42.82
S.Em±	0.89	0.76	0.98	0.98	-	-
CD at 5%	2.79	2.39	3.08	3.08	-	-
Moisture regime						
M_1	33.70	34.53	45.81	46.96	42.41	42.40
M_2	36.50	37.38	49.17	50.49	42.57	42.55
S.Em±	0.73	0.62	0.80	0.80	-	-
CD at 5%	2.29	1.95	2.51	2.51	-	-
Fertilizers levels (kg ha^{-1})						
F_1	37.50	38.23	50.04	50.90	42.91	42.93
F_2	33.52	34.34	45.98	47.26	42.14	42.11
F_3	34.28	35.29	46.45	48.01	42.43	42.39
S.Em±	0.71	0.64	0.90	0.96	-	-
CD at 5%	2.05	1.84	2.61	2.77	-	-

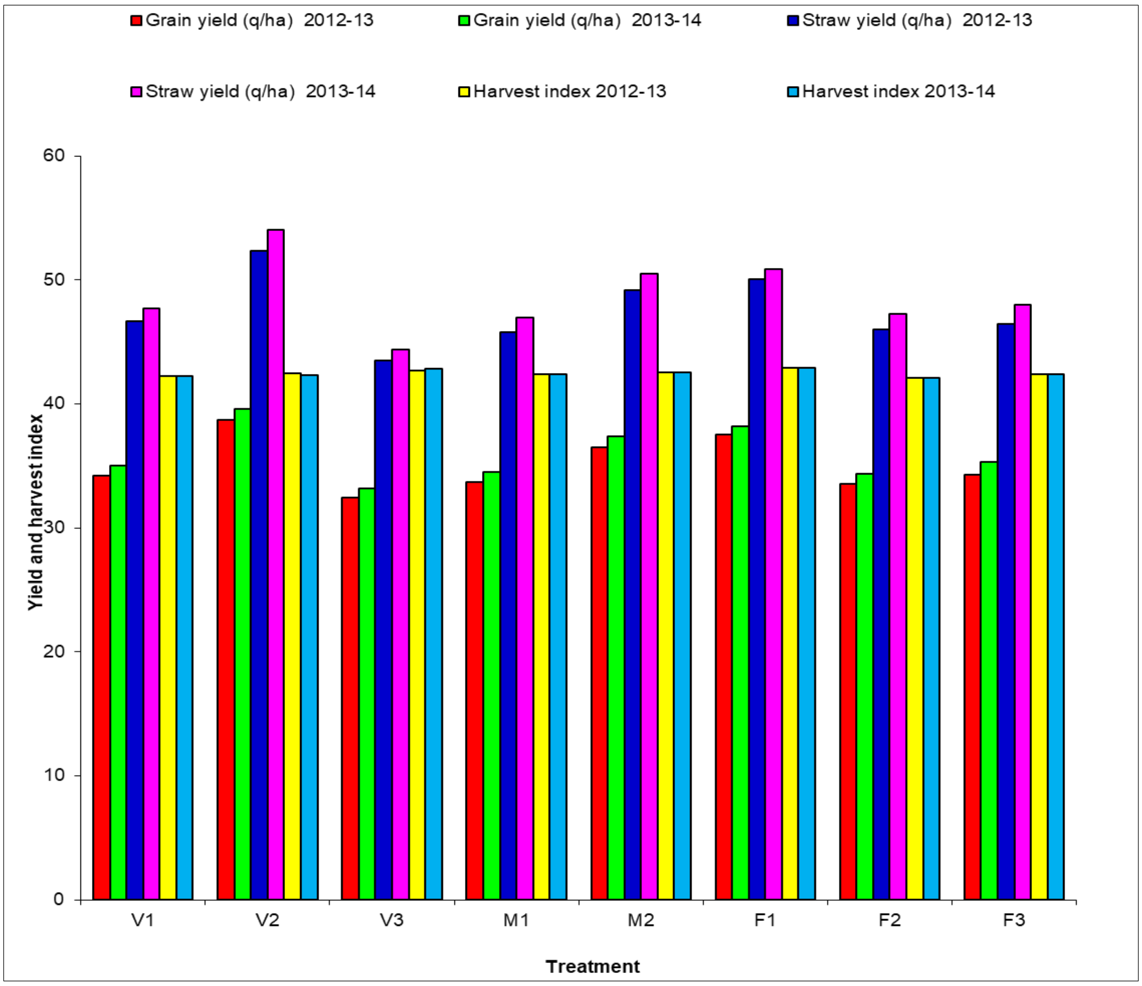

Fig 4: Effect of moisture regimes, and nutrient supply system on grain and straw yield and harvest index of wheat varieties.

Economic Aspects

Differences in the cost of cultivation were observed, attributed to variations in the variety cost, moisture regimes, and nutrient sources. The costs increased with higher levels of moisture regimes and changes in nitrogen sources. Variations in grain and straw yield, along with cultivation costs, contributed to variations in net returns and returns per rupee invested, as depicted in Table 5.

The wheat variety PBW-373, coupled with a moisture a regime of 1.0 Irrigation Water/Crop Potential Evapotranspiration (IW/CPE) ratio and a nutrient level of 100% Recommended Dose of Fertilizer (RDF), demonstrated the highest net return and Benefit-Cost (B:C) ratio. This outcome is mainly attributed to a higher gross income coupled with lower cultivation costs. Similar results were reported by Yadav and Verma (1991) [15], supporting the economic advantages of such combinations.

Table 5: presents the Water Use Efficiency (WUE) and Economic Analysis of wheat under the influence of various treatment combinations.

Treatment combination	Water use efficiency		Cost of cultivation (Rs. ha^{-1})		Gross income Rs.ha^{-1}		Net return(Rs. ha^{-1})		Benefit : Cost ratio	
	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14
$V_1M_1F_1$	125.30	143.73	28622	31775	62968	68442	34346	36668	1.20	1.15
$V_1M_1F_2$	120.22	138.57	36101	39017	60805	66446	24704	27430	0.68	0.70
$V_1M_1F_3$	125.45	145.30	47902	50818	63262	69504	15360	18686	0.32	0.37
$V_1M_2F_1$	121.87	136.63	29422	32705	74808	81311	45386	48606	1.54	1.49
$V_1M_2F_2$	102.83	115.87	36901	39947	63638	69592	26737	29645	0.72	0.74
$V_1M_2F_3$	102.55	116.14	48702	51748	63316	69704	14614	17956	0.30	0.35
$V_2M_1F_1$	141.68	162.24	28622	31775	70928	77110	42306	45335	1.48	1.43
$V_2M_1F_2$	134.98	155.38	36101	39017	68117	74677	32016	35660	0.89	0.91
$V_2M_1F_3$	142.47	164.86	47902	50818	71724	78954	23822	28136	0.50	0.55
$V_2M_2F_1$	126.66	142.10	29422	32705	78114	85100	48692	52396	1.65	1.60
$V_2M_2F_2$	115.76	130.28	36901	39947	71641	78635	34740	38689	0.94	0.97
$V_2M_2F_3$	116.49	131.77	48702	51748	71585	78937	22883	27190	0.47	0.53
$V_3M_1F_1$	118.79	136.24	28622	31775	59452	64658	30830	32883	1.08	1.03
$V_3M_1F_2$	114.16	131.58	36101	39017	57472	62811	21371	23794	0.59	0.61
$V_3M_1F_3$	118.75	137.55	47902	50818	59579	65422	11677	14605	0.24	0.29
$V_3M_2F_1$	115.54	129.54	29422	32705	70567	76741	41145	44037	1.40	1.35
$V_3M_2F_2$	97.64	110.03	36901	39947	60116	65651	23215	25705	0.63	0.64
$V_3M_2F_3$	97.08	109.93	48702	51748	59613	65482	10911	13734	0.22	0.22

Conclusions

Based on the findings from the experiment, it can be concluded that the cultivation of the wheat variety PBW-373, combined with a moisture regime of 1.0 Irrigation Water/Crop Potential Evapotranspiration (IW/CPE) ratio and fertilization with 150 kg N/ha through inorganic fertilizers, demonstrated superior performance in terms of growth and yield-contributing characteristics, overall yield, and economic considerations. Additionally, the combination of Wheat variety PBW-373 with 0.8 IW/CPE and a nutrient supply system consisting of 50% Replacement of Nitrogen (RDN) and Neem cake recorded higher Water Use Efficiency (WUE).

The treatment combination of Wheat variety PBW-373, 1.0 IW/CPE, and Recommended Dose of Fertilizer (RDF) at 100% (150:60:40 NPK kg/ha) consistently resulted in the maximum grain yield, highest net returns (Rs. 48,692/ha and Rs. 52,396/ha), and a Benefit-Cost (B-C) ratio of 1.65 and 1.60 during both experimental years. Therefore, it can be affirmed that the treatment combination involving Wheat variety PBW-373, a moisture regime of 1.0 IW/CPE, and nutrient supply at 150:60:40 NPK kg/ha (RDF 100%) proved significantly superior in terms of grain yield, straw yield, and overall economic returns compared to the other treatment combinations across both years.

References

1. Bandyopadhyay PK. Effect of irrigation schedule on evapo-transpiration and water use efficiency of winter wheat (*Triticum aestivum* L). Indian J Agron. 1997;42(1):90-93.
2. Behera B, Sharma HC, Panda PK. Effect of plant population and sulphur levels on root growth, seed yield and moisture use efficiency of mustard varieties under rainfed conditions. Indian J Soil Conserv. 2002;30(2):161-165.
3. Brijkishor. To assess the performance of newly developed strains of wheat under zero tillage condition with varying nitrogen levels. M.Sc. (Ag.) thesis submitted to N.D.U.A & T., Kumarganj, Faizabad; c1998.
4. Chandra, Kumar K, Halepyati AS, Desai BK, Pujari BT. Influence of organics, micronutrients and methods of application on yield and yield attributes of wheat under irrigation. Karnataka J Agric Sci. 2004;17(1):5-9.
5. Chavan DR, Pawar RK. Dry matter accumulation pattern of wheat as influenced by irrigation levels based on pan evaporation. J Maharashtra Agric Univ. 1988;13(2):180-182.
6. Deshmukh PD, Kharchi SG, Zade KD. Efficiency of organic sources with fertilizers in wheat crop. Ann Plant Physiol. 1995;9(1):59-63.
7. Hegde DM. Long term sustainability of productivity in rice (*Oryza sativa*)-wheat (*Triticum aestivum* L.) system in sub-humid ecosystem through integrated nutrient supply. Indian J Agron. 1998;43(2):189-198.
8. Khatri RS, Goel AC, Malik PK. Water use and application efficiency in bed flat sowing of wheat in rice-wheat system under different irrigation level. Crop Res. 2001;21(2):20-23.
9. Pal SK, Kaur J, Thakur R, Verma UN, Singh MK. Effect of irrigation, seedling date and fertilizer on growth and yield of wheat. Indian J Agron. 1996;41(3):386-389.
10. Parihar SS, Tiwari RB. Effect of irrigation and nitrogen levels on yield, nutrient uptake and water use of late-sown wheat (*Triticum aestivum* L.). Indian J Agron. 2003;48(2):103-107.
11. Patel DN, Patel SK, Karelia GN. INM in Pearlmillet (*Pennisetum glaucum*) wheat (*T. aestivum* L.) cropping system. Indian J Agron. 1995;40(2):266-268.
12. Rathwa PG, Mevada K, Ombase KC, Dodiya CJ, Bhadu V, Purabiya VS, *et al*. Integrated Nitrogen Management through Different Sources on Growth and Yield of Wheat (*Triticum aestivum* L.). J Pure Appl Microbiol. 2018;12:905-911.
13. Saren BK, Dey S, Mandal D. Effect of irrigation and sulphur on yield attributes productivity, consumptive use, and consumptive use efficiency of wheat (*Triticum aestivum* L.). Indian J Agric Sci. 2004;74(5):257-261.
14. Singh BP, Mundra MC, Gupta SC, Singh RP. Integrated nutrient management in predominant cropping system in Haryana through participatory approach. Indian J Agron. 2004;49(3):135-139.
15. Yadav GL, Verma JK. Effect of irrigation regime, nitrogen and zinc fertilization on growth and yield of late-sown wheat (*T. aestivum* L.). Indian J Agron. 1991;36:50-56.
16. Panse VG, Sukhatme PV. Statistical Methods for Agricultural Workers. ICAR, New Delhi; c1978. p. 68-75.
17. Cochran WG, Cox GM. Experimental designs (Asia Publishing House); c1959.