



# International Journal of Research in Agronomy

E-ISSN: 2618-0618  
P-ISSN: 2618-060X  
© Agronomy  
NAAS Rating (2026): 5.20  
[www.agronomyjournals.com](http://www.agronomyjournals.com)  
2026; 9(8): 1343-1346  
Received: 12-05-2026  
Accepted: 10-06-2026

**SP Maurya**  
Research Scholar, Department of  
Agronomy, RBS College, Bichpuri,  
Agra, Uttar Pradesh, Affiliated to  
Dr. Bhimrao Ambedkar  
University, Agra, Uttar Pradesh,  
India

**SB Singh**  
Professor and Head, Department  
of Agronomy, RBS College,  
Bichpuri, Agra, Uttar Pradesh,  
India

**SK Verma**  
Professor, Department of  
Agronomy, Institute of  
Agricultural Sciences, Banaras  
Hindu University, Varanasi, Uttar  
Pradesh, India

**Shiv Bahadur**  
Assistant Professor, Department of  
Agronomy, CSSS (PG) College,  
Machhara, Uttar Pradesh, India.

## Corresponding Author:

**SP Maurya**  
Research Scholar, Department of  
Agronomy, RBS College, Bichpuri,  
Agra, Uttar Pradesh, Affiliated to  
Dr. Bhimrao Ambedkar  
University, Agra, Uttar Pradesh,  
India

## Effect of nitrogen and hydrogel levels on nutrient concentration and nutrient uptake by wheat (*Triticum aestivum* L.) under climatological-based irrigation schedule

**SP Maurya, SB Singh, SK Verma and Shiv Bahadur**

**DOI:** <https://www.doi.org/10.33545/2618060X.2026.v9.i8q.6428>

### Abstract

A field experiment was conducted during the winter (*rabi*) seasons of 2021-22 and 2022-23 at the Agricultural Research Farm of RBS College, Bichpuri, Agra, to evaluate the effects of nitrogen and hydrogel applications on wheat (*Triticum aestivum* L.) yield and nutrient acquisition in grain and straw under weather-based irrigation scheduling. The study employed a triplicate split-plot design with three irrigation regimes. Main plots consisted of six combinations of three irrigation regimes, viz., 0.50, 0.75, and 1.00 IW/CPE ratios and two nitrogen rates (75% and 100% RDN). Sub-plots included four hydrogel levels viz., control, Pusa hydrogel @ 2.5 kg/ha, 5.0 kg/ha, and 7.5 kg/ha. The irrigation regime at 1.00 IW/CPE ratio, along with 100% RDN and Pusa hydrogel @ 7.5 kg/ha, significantly increased highest nutrient (N, P, and K) concentrations in grain and straw of wheat. The 1.00 IW/CPE irrigation regime resulted in 12.3% and 25.4%, 19.9% and 36.5%, and 13.2% and 27.1% higher N, P, and K uptake over irrigation regimes at 0.75 IW/CPE ratio and 0.50 IW/CPE ratio, respectively. Application of 100% RDN led to increases of 20.0%, 27.2%, and 19.4% in N, P, and K uptake over 75% RDN, respectively. Application of Pusa hydrogel at 7.5 kg/ha significantly improved N, P, and K uptake by 17.2%, 24.6%, and 15.3%, respectively, compared to the control. Under conditions of limited water availability, the combination of 100% RDN and 5.0 kg/ha Pusa hydrogel, with irrigation at a 0.75 IW/CPE ratio, proved comparable in performance.

**Keywords:** Irrigation, Nitrogen, Hydrogel, Water, Wheat, Yield, Protein

### Introduction

Wheat is the most extensively cultivated cereal crop globally. In India, it is a key *rabi* season crop, grown on 32.8 million ha., with a production of 117.9 million tons and a productivity of 3.60 tons/ha. (Anonymous, 2026). The principal wheat producing states viz., Uttar Pradesh, Madhya Pradesh, and Punjab. Wheat is highly nutritious, comprising 60-68% carbohydrates, 8-15% protein, 1.5-2% fat, 2-3% sugar, 2-2.5% cellulose, and 1.5-2% minerals (Singh *et al.*, 2011) <sup>[15]</sup>. It is also rich in amino acids namely niacin and thiamine. The high gluten content in wheat provides the structural framework *i.e.*, necessary for the spongy cellular structure of bread, chapatti, and other baked products (Shewry *et al.*, 2002) <sup>[14]</sup>.

Water management has become increasingly critical and occupies a central role in global political and economic discussions. Water use efficiency remains a significant constraint to achieving agricultural growth, sustainability, and future food security. In India's central zone, monsoon rainfall governs groundwater recharge and water harvesting in ponds, which are subsequently used for irrigation in wheat during the *rabi* season, significantly influencing productivity (Sharma and Solanki, 2025) <sup>[13]</sup>. Understanding groundwater dynamics and its contribution to evapotranspiration under varying water table levels is essential for effective crop irrigation and nutrient management (Singh *et al.*, 2005) <sup>[17]</sup>. Enhancing wheat production remains challenging due to climatic variability, declining soil health, and the increasing incidence of diseases and insect-pest infestations. Addressing these challenges requires integrating innovative technologies that can improve the sustainability of current cropping systems. Notably, advancements such as the use of the irrigation water to cumulative pan evaporation ratio, optimized nitrogen fertilization,

and hydrogel application are receiving increased attention in modern agricultural practices. For irrigation scheduling, a climatological approach utilizing the IW/CPE ratio has proven most effective. This method integrates all relevant weather parameters affecting crop water use and can potentially increase production by 15-20%.

Wheat productivity is influenced by multiple factors, with mineral nutrition, particularly nitrogen, playing a predominant role (Anonymous, 2020). Nitrogen is required throughout the cropping period for growth and development, from the vegetative stage to harvest. Generally, wheat productivity increased with increasing nitrogen and water supply (Mon *et al.* 2016, Tari, 2016) [8, 19] up to a certain threshold, N is both essential for achieving greater wheat yields and susceptible to losses through leaching in heavy rainfall areas and volatilization in arid regions. Consequently, nitrogen use efficiency in wheat is often compromised, resulting in reduced yields and increased environmental impact.

Hydrogels are bio-degradable, three-dimensional, hydrophilic polymeric networks capable of retaining water for extended periods, thereby hydrating crops and gradually releasing water (Kaewpirom and Boonsang, 2006) [6]. Pusa hydrogel, a novel semi-synthetic super-absorbent polymer developed by the Indian Agricultural Research Institute, New Delhi, has proven potential for increasing yields per unit input. This hydrogel exhibits a swelling capacity ranging from a minimum of 350 to over 500 times its own weight in pure water. The swelling ratio of Pusa hydrogel increases with temperature up to 50°C without compromising the polymer matrix structure. Pusa hydrogel enhances crop productivity per unit of available water and nutrients, particularly under moisture stress conditions. It also improves soil physical properties, seed germination, seedling emergence rate, root density, and root growth, thereby enabling plants to withstand prolonged moisture stress (Ekebafe *et al.*, 2011) [15].

## Materials and Methods

The present study was conducted during the winter (*rabi*) seasons of 2021-22 and 2022-23 at Farm of Agricultural Research of R.B.S College, Bichpuri, Agra. The experimental site is located at 27°02' N latitude and 77°09' E longitude, at an altitude of 163 meters above mean sea level. The research farm is classified as North-Western Plain Zone, class II, in terms of land capability. The mean annual rainfall is 628 mm, with July to August being the wettest months. The soil at a depth of 0-15 cm was sandy loam, characterized by an alkaline pH of 8.46, electrical conductivity (EC) of 1.67 dS/m, low organic carbon (0.41%), low available nitrogen (187.31 kg/ha), high available phosphorus (27.68 kg/ha), and also high available potassium (292.02 kg/ha). The experiment was conducted using a split-plot design with three replications, involved 24 treatment combinations. The main-plot treatments consisted three irrigation regimes (0.50, 0.75, and 1.00 IW/CPE ratios) and two nitrogen rates (75% and 100% RDN). The sub-plot treatments included of four hydrogel levels: control (no hydrogel), Pusa hydrogel @ 2.5 kg/ha, 5.0 kg/ha, and 7.5 kg/ha. The doses of recommended nitrogen, phosphorus, and potassium were 150:60:50 kg/ha applied according to the treatments. Full doses of phosphorus and potassium were applied as basal at the time of sowing using di-ammonium phosphate (DAP) and muriate of potash (MOP). Half of the nitrogen dose was applied as basal at the time of sowing by Urea, and the remaining half was applied in two split top-dressings after the first and second irrigations. The wheat variety HD 3086 was sown with seed rate @ 100 kg/ha on 18<sup>th</sup> and 21<sup>st</sup> November during the

2021 and 2022, respectively, in gross plots measuring 4 × 3 m with 20 cm row-to-row spacing and sowing depth of 5 cm. Finally, wheat was harvested manually on 12<sup>th</sup> and 15<sup>th</sup> April during the 2022 and 2023, respectively. All observations were recorded in accordance with standard procedures. After harvest, the crop was sun-drying for one-week time, then bundled, tagged, weighed and transported to the threshing yard. Grain yield was obtained after threshing and converted into t/ha. In laboratory, total N, P, and K contents in wheat grain and straw were determined using standard procedures. N, P and K uptake by grain and straw of wheat was calculated as:

$$\text{Nutrient uptake in grain/straw (kg/ha)} = (\text{Nutrient content in grain/straw (\%)} \times \text{Grain/straw yield (kg/ha)}) / 100$$

All experimental data statistical analysis using a split-plot design following the methods of Gomez and Gomez (1984). Significant differences among treatments were assessed using the 'F' (variance) test and means were separated at  $P < 0.05$  using Fisher's protected least significant difference (LSD test).

## Results and Discussion

**Nutrient content in grain and straw of wheat:** Irrigation at 1.00 IW/CPE ratio resulted in significantly higher nutrient contents (N, P, and K) in both grain and straw compared to irrigation at 0.75 IW/CPE ratio. Adequate water supply facilitates nutrient availability in the soil solution, thereby supporting plant growth and development. The increased N, P, and K contents observed with at 1.00 and 0.75 IW/CPE ratios were attributed to improved solubilization of applied nutrients, leading to greater nutrient availability and uptake. Lower N, P, and K contents under the 0.50 IW/CPE ratio were due to reduced nutrient uptake, resulting from limited root growth and development and insufficient nutrient solubilization in the absence of favourable moisture conditions (Pratap *et al.*, 2024) [10].

Maximum N, P, and K contents in both grain and straw were observed under 100% RDN, which was significantly higher than 75% RDN. This was attributed to increased nutrient availability resulting from an ample and balanced nutrient supply with 100% RDN, aligning with crop requirements throughout the growing period. Lower N, P, and K contents in wheat grain and straw with 75% RDN were due to reduced nutrient availability and uptake, likely caused by imbalanced synchrony between crop demand and N supply.

Application of Pusa hydrogel @ 7.5 kg/ha resulted in higher N, P, and K contents in both grain and straw, significantly surpassing the control but remaining statistically similar to the Pusa hydrogel @ 5.0 kg/ha treatment. This improvement was primarily attributed to increased nutrient uptake, facilitated by hydrogel-retained water in the root zone, which provided continuous moisture and enhanced nutrient solubilization. Lower N, P, and K contents in control were due to insufficient water retention in the root zone, resulting in reduced nutrient uptake and limited root growth and development under moisture-deficit conditions, which disrupted the balance between water and nutrient supply and demand (Barihi *et al.*, 2013, Roy *et al.* 2019) [3, 12].

**N, P, and K uptake by grain and straw of wheat:** Irrigation regimes, nitrogen and hydrogel levels significantly affected N, P, and K uptake by wheat grain and straw during both study years (Verma *et al.*, 2015) [15]. The highest uptake of N, P, and K was observed under the 1.00 IW/CPE irrigation regime, followed by irrigation at 0.75 and 0.50 IW/CPE ratios. The increased nutrient uptake under irrigation at 1.00 IW/CPE regime by frequently supply of water was attributed to higher grain and straw yields.

Lower N, P, and K uptake under irrigation at 0.75 and 0.50 IW/CPE regimes interval led to water stress conditions and lower grain and straw production.

Application of 100% RDN resulted in approximately 20.0%, 27.2%, and 19.4% greater total N, P, and K uptake by grain and straw, respectively, compared to 75% RDN (Patra and Singh, 2018)<sup>98</sup>. The higher grain and straw yields with 100% RDN expedited increased nutrient absorption. Lower yields with 75% RDdN led to reduced N, P, and K uptake by grain and straw (Reena *et al.*, 2017, Kumar *et al.*, 2023)<sup>[11, 7]</sup>.

Application of Pusa hydrogel @ 7.5 kg/ha resulted in the highest N, P, and K uptake by grain and straw, followed by 5.0 kg/ha, 2.5

kg/ha and control. The increased nutrient uptake under the Pusa hydrogel @ 7.5 kg/ha treatment was attributed to the highest grain and straw yields (Singh, 2015). Lower N, P, and K uptake in control was due to reduced grain and straw yields.

In summary, the two-year field investigation proved that irrigating wheat at 1.00 IW/CPE ratio, combined with the application of 100% RDN and Pusa hydrogel @ 7.5 kg/ha, can enhance the grain yield, N, P and K content in grain, N, P and K uptake and quality of wheat. However, under conditions of limited water availability, it can have advocated to wheat cultivation with 100% RDN and Pusa hydrogel @ 5.0 kg/ha under irrigation at 0.75 IW/CPE regime.

**Table 1:** Effect of irrigation regimes, nitrogen and hydrogel levels on N, P and K content in grain and straw of wheat grown during winter (rabi) season

| Treatment                 | N content (%) |         |         |         | P content (%) |         |         |         | K content (%) |         |         |         |
|---------------------------|---------------|---------|---------|---------|---------------|---------|---------|---------|---------------|---------|---------|---------|
|                           | Grain         |         | Straw   |         | Grain         |         | Straw   |         | Grain         |         | Straw   |         |
|                           | 2021-22       | 2022-23 | 2021-22 | 2022-23 | 2021-22       | 2022-23 | 2021-22 | 2022-23 | 2021-22       | 2022-23 | 2021-22 | 2022-23 |
| <b>Irrigation regimes</b> |               |         |         |         |               |         |         |         |               |         |         |         |
| 0.50 IW/CPE ratio         | 1.82          | 1.84    | 0.37    | 0.38    | 0.32          | 0.34    | 0.16    | 0.17    | 0.43          | 0.44    | 1.40    | 1.42    |
| 0.75 IW/CPE ratio         | 1.88          | 1.91    | 0.40    | 0.42    | 0.35          | 0.38    | 0.18    | 0.18    | 0.47          | 0.49    | 1.44    | 1.47    |
| 1.00 IW/CPE ratio         | 1.97          | 2.02    | 0.45    | 0.48    | 0.41          | 0.44    | 0.22    | 0.22    | 0.53          | 0.55    | 1.54    | 1.57    |
| SEm±                      | 0.01          | 0.01    | 0.01    | 0.01    | 0.01          | 0.01    | 0.01    | 0.01    | 0.01          | 0.01    | 0.01    | 0.01    |
| CD (P=0.05)               | 0.04          | 0.05    | 0.02    | 0.02    | 0.02          | 0.02    | 0.02    | 0.02    | 0.04          | 0.04    | 0.03    | 0.03    |
| <b>Nitrogen levels</b>    |               |         |         |         |               |         |         |         |               |         |         |         |
| 75% RDN                   | 1.83          | 1.86    | 0.38    | 0.40    | 0.33          | 0.36    | 0.17    | 0.18    | 0.44          | 0.46    | 1.43    | 1.46    |
| 100% RDN                  | 1.95          | 1.98    | 0.43    | 0.45    | 0.39          | 0.42    | 0.20    | 0.20    | 0.51          | 0.53    | 1.49    | 1.52    |
| SEm±                      | 0.01          | 0.01    | 0.01    | 0.01    | 0.01          | 0.01    | 0.01    | 0.01    | 0.01          | 0.01    | 0.01    | 0.01    |
| CD (P=0.05)               | 0.03          | 0.04    | 0.02    | 0.02    | 0.02          | 0.02    | 0.02    | 0.02    | 0.03          | 0.03    | 0.02    | 0.02    |
| <b>Hydrogel levels</b>    |               |         |         |         |               |         |         |         |               |         |         |         |
| Control                   | 1.84          | 1.87    | 0.39    | 0.41    | 0.34          | 0.36    | 0.17    | 0.17    | 0.45          | 0.47    | 1.44    | 1.46    |
| Pusa hydrogel @ 2.5 kg/ha | 1.87          | 1.90    | 0.40    | 0.42    | 0.36          | 0.39    | 0.18    | 0.18    | 0.47          | 0.49    | 1.46    | 1.49    |
| Pusa hydrogel @ 5.0 kg/ha | 1.93          | 1.96    | 0.41    | 0.43    | 0.37          | 0.40    | 0.19    | 0.20    | 0.49          | 0.50    | 1.47    | 1.50    |
| Pusa hydrogel @ 7.5 kg/ha | 1.93          | 1.97    | 0.42    | 0.44    | 0.37          | 0.41    | 0.20    | 0.20    | 0.50          | 0.51    | 1.48    | 1.51    |
| SEm±                      | 0.01          | 0.01    | 0.01    | 0.01    | 0.01          | 0.01    | 0.01    | 0.01    | 0.01          | 0.01    | 0.01    | 0.01    |
| CD (P=0.05)               | 0.02          | 0.02    | 0.02    | 0.02    | 0.02          | 0.02    | 0.01    | 0.01    | 0.02          | 0.02    | 0.02    | 0.02    |

**Table 2:** Effect of irrigation regimes, nitrogen and hydrogel levels on nutrient uptake by grain and straw of wheat grown during winter (rabi) season

| Treatment                 | N uptake (kg/ha) |         |         |         | P uptake (kg/ha) |         |         |         | K uptake (kg/ha) |         |         |         |
|---------------------------|------------------|---------|---------|---------|------------------|---------|---------|---------|------------------|---------|---------|---------|
|                           | Grain            |         | Straw   |         | Grain            |         | Straw   |         | Grain            |         | Straw   |         |
|                           | 2021-22          | 2022-23 | 2021-22 | 2022-23 | 2021-22          | 2022-23 | 2021-22 | 2022-23 | 2021-22          | 2022-23 | 2021-22 | 2022-23 |
| <b>Irrigation regimes</b> |                  |         |         |         |                  |         |         |         |                  |         |         |         |
| 0.50 IW/CPE ratio         | 84.2             | 89.4    | 17.3    | 18.6    | 15.0             | 16.7    | 7.34    | 8.19    | 19.7             | 21.2    | 64.6    | 68.9    |
| 0.75 IW/CPE ratio         | 98.0             | 104.7   | 20.9    | 23.0    | 18.6             | 21.2    | 9.54    | 10.03   | 24.8             | 27.1    | 75.2    | 80.7    |
| 1.00 IW/CPE ratio         | 109.4            | 118.1   | 25.2    | 28.3    | 22.7             | 26.1    | 12.39   | 13.06   | 29.7             | 32.5    | 85.4    | 91.8    |
| SEm±                      | 2.07             | 2.37    | 0.60    | 0.65    | 0.48             | 0.56    | 0.34    | 0.36    | 0.71             | 0.77    | 1.57    | 1.71    |
| CD (P=0.05)               | 6.53             | 7.47    | 1.90    | 2.05    | 1.52             | 1.76    | 1.08    | 1.15    | 2.23             | 2.44    | 4.95    | 5.40    |
| <b>Nitrogen levels</b>    |                  |         |         |         |                  |         |         |         |                  |         |         |         |
| 75% RDN                   | 87.3             | 92.6    | 18.4    | 20.2    | 15.8             | 17.8    | 8.36    | 8.88    | 21.2             | 23.1    | 68.2    | 72.5    |
| 100% RDN                  | 107.2            | 115.5   | 23.9    | 26.5    | 21.8             | 24.9    | 11.14   | 11.98   | 28.3             | 30.8    | 81.9    | 88.4    |
| SEm±                      | 1.69             | 1.93    | 0.49    | 0.53    | 0.39             | 0.46    | 0.28    | 0.30    | 0.58             | 0.63    | 1.28    | 1.40    |
| CD (P=0.05)               | 5.33             | 6.10    | 1.55    | 1.68    | 1.24             | 1.44    | 0.88    | 0.94    | 1.82             | 1.99    | 4.04    | 4.41    |
| <b>Hydrogel levels</b>    |                  |         |         |         |                  |         |         |         |                  |         |         |         |
| Control                   | 87.8             | 93.5    | 18.7    | 20.6    | 16.2             | 18.0    | 8.19    | 8.73    | 21.7             | 23.7    | 68.6    | 73.1    |
| Pusa hydrogel @ 2.5 kg/ha | 94.2             | 100.8   | 20.4    | 22.6    | 18.2             | 20.8    | 9.23    | 9.88    | 23.9             | 26.3    | 73.3    | 78.6    |
| Pusa hydrogel @ 5.0 kg/ha | 102.1            | 109.3   | 22.1    | 24.5    | 20.0             | 22.8    | 10.33   | 11.06   | 26.0             | 28.2    | 78.1    | 83.8    |
| Pusa hydrogel @ 7.5 kg/ha | 104.7            | 112.8   | 23.3    | 25.7    | 20.6             | 23.8    | 11.26   | 12.03   | 27.3             | 29.6    | 80.4    | 86.2    |
| SEm±                      | 1.61             | 1.76    | 0.44    | 0.48    | 0.41             | 0.53    | 0.25    | 0.26    | 0.52             | 0.64    | 1.25    | 1.35    |
| CD (P=0.05)               | 4.61             | 5.04    | 1.27    | 1.37    | 1.16             | 1.51    | 0.71    | 0.73    | 1.47             | 1.84    | 3.56    | 3.87    |

## References

- Government of India, Directorate of Economics and Statistics, Department of Agriculture, Cooperation and Farmers Welfare. Agricultural statistics at a glance. New Delhi, India: Government of India; 2020.
- Government of India. Unified Portal for Agricultural Statistics (UPAg). New Delhi, India: Government of India; 2026.
- Barihi R, Panahpour E, Beni MH. Super absorbent polymer (hydrogel) and its application in agriculture. *World Sci J*. 2013;1(15):223-228.
- Ekebafé LO, Ogbeifun DE, Okieimen FE. Polymer applications in agriculture. *Biokemistri*. 2011;23(2):81-89.
- Gomez KA, Gomez AA. Statistical procedures for agricultural research. 2nd ed. New York, USA: John Wiley & Sons; 1984. 680 p.
- Kaewpirom S, Boonsang S. Electrical response characterization of poly(ethylene glycol) macromer (PEGM)/chitosan hydrogels in NaCl solution. *Eur Polym J*. 2006;42:1609-1616.
- Kumar B, Shaloo, Bisht H, Meena MC, Dey A, Dass A, et al. Nitrogen management sensor optimization, yield, economics, and nitrogen use efficiency of different wheat cultivars under varying nitrogen levels. *Front Sustain Food Syst*. 2023;7:122-221.
- Mon J, Bronson KF, Hunsaker DJ, Thorp KR, White JW, French AN. Interactive effects of nitrogen fertilization and irrigation on grain yield, canopy temperature and nitrogen use efficiency in overhead sprinkler-irrigated durum wheat. *Field Crops Res*. 2016;191:54-65.
- Patra B, Singh J. Effect of priming, biofertilizers and nitrogen levels on yield and nutrient uptake by wheat. *Int J Curr Microbiol Appl Sci*. 2018;7(7):1411-1417.
- Pratap V, Dass A, Dhar S, Kumari K, Sudhishri S. Precision nitrogen, irrigation and cultivation regimes for enhanced yield and nutrient accumulation in direct seeded rice (*Oryza sativa*). *Indian J Agric Sci*. 2024;94(6):571-576.
- Reena VC, Dhyani SC, Chaturvedi S, Gouda HS. Growth, yield and nitrogen use efficiency in wheat as influenced by leaf colour chart and chlorophyll meter based nitrogen management. *Int J Curr Microbiol Appl Sci*. 2017;6(12):1696-1704.
- Roy T, Kumar S, Chand L, Kadam DM, Bihari B, Shrimali SS, et al. Impact of Pusa hydrogel application on yield and productivity of rainfed wheat in North West Himalayan region. *Curr Sci*. 2019;116(7):1246-1251.
- Sharma KC, Solanki KS. Nitrogen levels and growth regulators effect on wheat (*Triticum aestivum* L.) lodging, productivity and profitability under restricted irrigation in a Vertisols of Central India. *Indian J Agron*. 2025;70(1):13-19.
- Shewry PR, Halford NG, Belton PS, Tatham AS. The structure and properties of gluten: an elastic protein from wheat grain. *Philos Trans R Soc Lond B Biol Sci*. 2002;357(1418):133-142.
- Singh CM, Sharma PK, Kishor P, Mishra PK, Singh AP, Verma R, et al. Impact of integrated nutrient management on growth, yield and nutrient uptake by wheat (*Triticum aestivum* L.). *Asian J Agric Res*. 2011;5(1):76-82.
- Singh SP. Effect of irrigation schedule, mulching and hydrogel on wheat (*Triticum aestivum* L.) [PhD thesis]. Varanasi, Uttar Pradesh, India: Banaras Hindu University; 2015.
- Singh S, Sheoran P, Rana DS, Aulakh PS. Productivity, water use, water use efficiency and economics of rainfed wheat as influenced by supplemental irrigation in lower Shiwaliks of Punjab. *Environ Ecol*. 2005;24(1):119-122.
- Suradkar NS, Parlwar ND, Kakade SU, Deshmukh MR, Sarode SS. Effect of drip fertigation and its interval on growth, yield and economics of wheat (*Triticum aestivum* L.). *J Pharmacogn Phytochem*. 2020;9(5):1918-1921.
- Tari AF. The effects of different deficit irrigation strategies on yield, quality, and water-use efficiencies of wheat under semiarid conditions. *Agric Water Manag*. 2016;167:1-10.
- Verma SK, Singh SB, Prasad SK, Meena RN, Meena RS. Influence of irrigation regime and weed management practices on water use and nutrient uptake in wheat (*Triticum aestivum* L.). *Bangladesh J Bot*. 2015;44(3):437-442.