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# Effect of Irrigation Scheduling and Integrated Nutrient Management on Soil Moisture, Water Productively and Soil Fertility in Wheat

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**ABSTRACT: A field experiment was conducted during *rabi* 2020-21 and 2021-22 at Agriculture research farm, RNTU, Raisen, entitled "Effect of irrigation scheduling and integrated nutrient management on soil moisture, water productively and soil fertility". The treatments combination consists of two factors such as irrigation scheduling and integrated nutrient management practices. The treatment were: Factor A: Irrigation scheduling ($I_0$-CRI, late, Jointing, and milking stage, $I_1$-CRI, late jointing, flowering and milking stage, $I_2$-Irrigation with (0.8 IW/CPE) and $I_3$-Irrigation with (1.0 IW/CPE) and Factor B: Integrated nutrient management practices ($F_0$-100% RDF+$ZnSO_4$ 30 kg, $F_1$-75% RDF +25% RDN through FYM+$ZnSO_4$ 25 kg/ha, $F_2$-50% RDF+50% RDN through FYM +$ZnSO_4$ 20 kg/ha and $F_3$-100 kg+25% RDN through FYM+$ZnSO_4$ 15 kg/ha). The experiment was laid out in split plot design with three replications. The results revealed that the irrigation levels and nutrient management treatments did not influence significant variation on moisture content at sowing of wheat crop during both the years of experiment (2020-21 and 2021-22). Significant difference was observed with irrigation levels on water use efficiency (13.16 and 13.21 kg/ha/mm) and water productivity (1.74 and 1.39 kg/$m^3$) in wheat during 2020-21 and 2021-22, respectively. Application of F3 gave highest water use efficiency (10.14 and 9.88 kg/ha/mm) and water productivity (1.66 and 1.12 kg/$m^3$) which was significantly superior over other treatments. The highest available nitrogen of 96.48 and 97.28 kg/ha and phosphorus of 55.23 and 57.29 kg/ha during 2020-21 and 2021-22 were recorded with $I_0$. Potassium was maximum (421.54 and 419.65 kg/ha during 2020-21 and 2021-22, respectively) under the treatment $I_2$ (Irrigation with 0.8 IW/CPE). Among fertility grades, maximum available nitrogen of 112.89 and 114.67 kg/ha were recorded under the treatment $F_0$ (100% RDF + $ZnSO_4$ 30 kg) and maximum phosphorus of 56.68 and 57.12 kg/ha were recorded under the treatment $F_1$ (75% RDF + 25% RDN through FYM + $ZnSO_4$ 25kg/ha) during 2020-21 and 2021-22. However, the maximum potassium was recorded under $F_2$ (50% RDF + 50% RDN through FYM + $ZnSO_4$ 20 kg/ha) in 2020-21 and $F_3$ (100 kg + 25% RDN through FYM + $ZnSO_4$ 15 kg/ha) in 2021-22.**

**Keywords:** Irrigation scheduling, INM, water productivity and soil fertility.

## INTRODUCTION

Wheat (*Triticum aestivum* L.) is very important staple and remunerative *Rabi* crops, cultivated in almost all the countries of the world. Among major wheat producing countries, India ranked second next to china with regards to its production in world (Agriculture Sectors National Portal). It is the second most important cereal crop after rice in India, and grown under diverse agro climatic conditions.

Water scarcity has become a global problem with a significant impact on agricultural production (Eck *et al.*, 2020). According to the most recent report (The world bank, 2020), irrigation covers more than 20% of global cultivated lands and contributes to more than 40% of global total food production. Agricultural irrigation consumes the most water, but it yields the lowest return per unit of water when compared with other economic sectors (Monaghan *et al.*, 2013). However, traditional irrigation methods, such as flood irrigation, result in less water productivity. There have been many irrigation methods developed to increase WP throughout the world, including furrow and drip irrigation (Zhang *et al.*, 2021).

Farmyard manure rich in organic matter can be supplemented with NPK fertilizers. Although, it is costlier than chemical fertilizers on nutrient basis but other beneficial effects which it has on soil can compensate for the added cost. It not only provides most of the essential plant nutrients but also improves soil structure through binding effect on soil aggregates. Cation exchange capacity, water holding capacity, fertilizer use efficiency, microbial activity and nutrient availability in soil also get improved due to FYM. Vermicompost has also been advocated as a good organic manure for use in integrated nutrient management practices in field crops.

The integrated approach of nutrient supply by chemical fertilizers along with organic manures and bio fertilizers is gaining importance and balanced INM involving lower doses of organic materials is needed on priority to enhance the nutrient use efficiency of native and applied nutrients for restoring soil fertility (Aulakh and Grant 2008). The use of organic manures dates back to the beginning of settled agriculture but after the introduction of wide spread use of mineral fertilizers, organic manures were thought of as a secondary source of nutrients. However, with increasing awareness on soil health and sustainability in agriculture, organic manures and many diverse organic materials have gained importance as components of integrated plant nutrient management. FYM is the major source of organic manure. Application of organic manures not only improves the soil organic carbon for sustaining the soil physical quality but also increases plant nutrients. In this context, FYM and vermicompost are of paramount importance for application in food crops. Addition of organic material to the soil such as farm yard manure (FYM) helps in maintaining soil fertility and productivity. It increases soil microbiological activities, plays key role in transformation, recycling and availability of nutrients to the crop. It also improves the physical properties like soil structure, porosity, reduces compaction and crusting and increases water holding capacity of soil.

## MATERIAL AND METHODS

A field experiment was conducted at the agriculture research farm, Faculty of Agriculture, RNTU, Raisen (23.134273° North latitude and 77.564305° East longitude) during two consecutive *rabi* season of 2020-2021 and 2021-22. The treatments were arranged in split plot design consisting of two factors such as irrigation scheduling and integrate nutrient management practices (Table 1) with three replications. The fertility status of soil of the experiment soil was categorized as low concerning organic carbon (0.34%) having 215.22, 19.12 and 215.21 kg/ha were available mineral N, P and K, respectively. The total rainfall of 131.30 mm was received during the wheat crop growth period of first year (2020-21), was higher (46.30 mm) than second year (2021-22). Distribution of rainfall in terms of qualitative was somehow uniform in second year while quantitatively it was more during second year of crop period.

The unit plot size was 4.0 m × 5.0 m. Altogether 48 plots were included in the field experimentation. The wheat was direct line sown at the spacing of 20 cm × 3 cm during *rabi* season. Crop was raised with best possible management practices. After to harvesting, top soil samples were collected from a depth of 0-15 cm representative locations of the experimental site, mixed thoroughly and bulked into a composite sample, which was subjected to physico-chemical analysis following standard laboratory procedures after grinding and sieving through a 2 mm mesh sieve.

**Available nitrogen (kg/ha).** Available nitrogen in soil was determined by adapting the alkaline permanganate method of Subbiah and Asija (1956).

**Available phosphorus (kg/ha).** The phosphorus content of soil was estimated by extraction procedure as described by Olsen *et al.* (1954). The absorbance of blue color was read after 10 minutes, on spectrophotometer at 660 nm wavelength.

**Available potassium (kg/ha).** The available potassium was extracted with neutral normal ammonium acetate with flame photometer (Jackson, 1973).

**Available Zn (kg/ha).** Available Zinc content was determined by using atomic Absorption Spectrophotometry given by Lindsay and Norvell (1978), expressed in mg kg $^{-1}$.

**Soil moisture contents.** Soil samples were drawn with the help of a screw auger from the depth 15 cm for determining moisture content at sowing, just before each irrigation and 72 hrs. After each irrigation and just before crop harvest. The samples drawn from the experimental unit in the morning hours were weighed and labeled in separate aluminum boxes. These boxes were oven dried for 48 hrs. At 105°C and weighed to calculate soil moisture on oven dry weight basis.

$$\text{Soil moisture content (\%)} = \frac{\text{Wt. of box with wet soil} - \text{Wt. of the box with oven dried soil}}{\text{Wt. of the box with oven dried soil}} \times 100$$

**Water use efficiency.** Water use efficiency was worked out here which was treated as water use efficiency. Water expense efficiency (WEE) was a grain yield produced per unit of water or expensed which was total water applied and effective rainfall.

$$\text{WUE (kg/ha/mm)} = \frac{\text{Grain yield (kg/ha)}}{\text{Total water received (mm)}} \times 100$$

**Table 1: Treatment details.**

| | | |
|---|---|---|
| (A) Irrigation levels – 04 | | |
| $I_0$ | : | CRI, late, Jointing, and milking stage |
| $I_1$ | : | CRI, late jointing, flowering and milking stage |
| $I_3$ | : | Irrigation with (0.8 IW/CPE) |
| $I_4$ | : | Irrigation with (1.0IW/CPE) |
| (B) Integrated nutrient management practices – 04 | | |
| $F_0$ | : | 100% RDF (120:60:40) +$ZnSO_4$ 30kg |
| $F_1$ | : | 75% RDF +25% RDN Through FYM+$ZnSO_4$ 25kg/ha |
| $F_2$ | : | 50% RDF+50% RDN Through FYM +$ZnSO_4$ 20kg/ha |
| $F_3$ | : | 100kg+25% RDN Through FYM+$ZnSO_4$ 15kg/ha |

## RESULTS AND DISCUSSION

*A. Effect of treatments on soil moisture content*

Data pertaining the moisture content at sowing (%) under different moisture regimes is presented in Table 2 revealed that effect of moisture regime had not significantly influenced on moisture content at sowing (%). However, the maximum moisture content at sowing 40.16 and 41.26 (%) was recorded under the irrigation at 1.0 IW/CPE ratio ($I_3$) followed by irrigation at 0.8 IW/CPE ratio ($I_2$) of wheat crop, respectively both year data. The similar results reported by Liu et al., (2007). Data reveal that the different fertility levels did not affect significantly on the moisture content at sowing (%). However, maximum moisture content at sowing 41.64 and 41.72 (%) was noted with ($F_3$) 100kg+25% RDN through FYM+$ZnSO_4$ 15kg/ha, followed by ($F_1$) (75% RDF +25%RDN through FYM+$ZnSO_4$ 25kg/ha, ($F_2$) 50%RDF+50% RDN through FYM +$ZnSO_4$ 20kg/ha and the minimum moisture content at sowing 40.69 and 41.18 (%) under the treatment $F_0$ (100%RDF +$ZnSO_4$ 30kg). during the years of experimentation, respectively. The similar results reported by Liu *et al.* (2007). The interaction effect between different moisture regimes and different fertility levels on moisture content at sowing (%) was not found significant.

*B. Effect of treatments on water use efficiency and water productivity*

The perusal data on water use efficiency (kg $ha^{-1}$ $mm^{-1}$) and water productivity (kg $m^{-3}$) is presented in Table 2. The variations in water use efficiency and water productivity due to main effects of various moisture regimes and fertility levels under late sown condition of wheat during both the years. The data pertaining maximum water use efficiency (13.16 and 13.21 kg $ha^{-1}$ $mm^{-1}$) and water productivity (1.74 and 1.39 kg $m^{-3}$) was recorded under the irrigation at CRI, late, Jointing, and milking stage followed by irrigation at (0.8 IW/CPE) and irrigation at 1.0IW/CPE of wheat crop, respectively both year data. This might be due to the fact that under lower moisture regimes, plant yielded more per unit of water consumed. Water use efficiency decrease with increasing the irrigation levels. These finding are reported by Sarwar *et al.* (2010); Rajanna *et al*. (2017). The data pertaining maximum water use efficiency (10.14 and 9.88 kg $ha^{-1}$ $mm^{-1}$ during 2020-21 and 2021-22, respectively) and water productivity (1.66 kg $m^{-3}$ during 2020-21 only) was recorded under the treatment $F_2$ (50% RDF+50% RDN through FYM + $ZnSO_4$ 20 kg/ha).

*C. Effect of treatments on status of soil fertility*

During the period of study, irrigation scheduling and integrated nutrient management had a significant effect on available soil nutrients in the soil (Table 3). Maximum available N and P was recorded in the treatments where irrigation was applied at CRI, Late jointing and milking stage ($I_0$). This treatment showed maximum nutrient content as more nutrients were absorbed by the plants in other irrigation treatments. Similarly, integrated of inorganic, organic manures and Zinc sulphate application resulted in maximum available N, P, K and Zn content in the soil at initial stages and at harvest. It might be due to less solubility of nutrients in the soil as well as reduced uptake of nutrients by the plants (Choudhry *et al.*, 1992; Yaseen, 1999). Maximum soil content of K (421.54 and 419.65 kg $ha^{-1}$) after harvest of crop was found in treatment where $I_2$ (Irrigation with 0.8 IW/CPE) was applied during successive years of trials. The increase in K soil may be due to the positive interaction of K and Zn (Keram *et al*., 2012; Alloway, 2004).

Integrated application of nutrients also had a significant impact on the available nitrogen, phosphorus and potassium content in the soil (Table 3). Among fertility grades, maximum available nitrogen of 112.89 and 114.67 kg/ha were recorded under the treatment F0 (100% RDF + $ZnSO_4$ 30 kg) followed by treatment $F_1$ (50% RDF + FYM @ 5.0 t/ha) where 99.68 kg per ha of available nitrogen was recorded and maximum phosphorus of 56.68 and 57.12 kg/ha were recorded under the treatment $F_1$ (75% RDF +25% RDN through FYM + $ZnSO_4$ 25kg/ha) followed by treatment $F_0$ (100% RDF + $ZnSO_4$ 30kg) where 55.79 kg per ha of available phosphorus was recorded during 2020-21 and 2021-22. However, the maximum potassium was recorded under $F_2$ (50% RDF+50% RDN through FYM +$ZnSO_4$ 20 kg/ha) in 2020-21 and $F_3$ (100 kg+25% RDN through FYM+$ZnSO_4$ 15 kg/ha) in 2021-22.

**Table 2: Effect of moisture conditions and fertility grades on soil moisture parameters in grain of wheat.**

| **Treatments** | **Moisture content at sowing (%)** | | **Water use efficiency (kg $ha^{-1}$ $mm^{-1}$)** | | **Water productivity (kg $m^{-3}$)** | |
|---|---|---|---|---|---|---|
| **Moisture conditions (I)** | **2020-21** | **2021-22** | **2020-21** | **2021-22** | **2020-21** | **2021-22** |
| $I_0$ | 37.41 | 38.28 | 13.16 | 13.21 | 1.74 | 1.39 |
| $I_1$ | 37.82 | 38.91 | 12.82 | 12.41 | 1.62 | 1.27 |
| $I_2$ | 38.99 | 39.53 | 12.64 | 11.96 | 1.54 | 1.19 |
| $I_3$ | 40.16 | 41.26 | 9.69 | 9.53 | 1.29 | 0.98 |
| **SEm±** | **1.14** | **0.91** | - | - | - | - |
| **CD (P=0.05)** | **NS** | **NS** | - | - | - | - |
| **Fertility grades (F)** | | | | | | |
| $F_0$ | 40.69 | 41.18 | 9.86 | 9.77 | 1.63 | 1.12 |
| $F_1$ | 41.23 | 41.64 | 9.39 | 9.28 | 1.51 | 1.05 |
| $F_2$ | 40.26 | 40.89 | 10.14 | 9.88 | 1.66 | 1.08 |
| $F_3$ | 41.64 | 41.72 | 9.17 | 9.21 | 1.43 | 1.03 |
| **SEm±** | **1.15** | **0.96** | - | - | - | - |
| **CD (P=0.05)** | **NS** | **NS** | - | - | - | - |

**Table 3: Effect of moisture conditions and fertility grades on available soil nutrients.**

| Treatments | Available N (Kg per hectare) | | Available $P_2O_5$ (kg/ha) | | Available $K_2O$ (Kg/ha) | |
|---|---|---|---|---|---|---|
| **Moisture conditions (I)** | **2020-21** | **2021-22** | **2020-21** | **2021-22** | **2020-21** | **2021-22** |
| $I_0$ | 96.48 | 97.28 | 55.23 | 57.29 | 356.48 | 349.24 |
| $I_1$ | 82.14 | 74.59 | 41.89 | 42.28 | 402.16 | 404.69 |
| $I_2$ | 90.62 | 89.38 | 50.75 | 54.93 | 421.54 | 419.65 |
| $I_3$ | 85.29 | 84.67 | 42.64 | 42.62 | 392.69 | 387.42 |
| **SEm±** | **11.23** | **10.45** | **2.93** | **2.11** | **19.8** | **17.23** |
| **CD (P=0.05)** | **22.46** | **21.82** | **8.42** | **6.74** | **36.45** | **32.47** |
| **Fertility grades (F)** | | | | | | |
| $F_0$ | 112.89 | 114.67 | 55.79 | 56.83 | 391.24 | 382.58 |
| $F_1$ | 99.68 | 98.75 | 56.68 | 57.12 | 409.69 | 396.47 |
| $F_2$ | 96.89 | 98.46 | 54.45 | 56.29 | 426.64 | 418.62 |
| $F_3$ | 92.86 | 91.64 | 51.64 | 52.47 | 423.18 | 422.83 |
| **SEm±** | **12.14** | **11.96** | **3.12** | **3.09** | **18.64** | **17.23** |
| **CD (P=0.05)** | **20.65** | **21.28** | **8.86** | **7.79** | **31.47** | **29.48** |

## CONCLUSIONS

Based on two year of experimentation, the irrigation at CRI, late, Jointing, and milking stage in wheat was obtained superior for WUE, water productivity and available N and P. Application of 50% RDF+50% RDN through FYM +$ZnSO_4$ 20 kg/ha recorded the maximum WUE and water productivity. However, the maximum available nitrogen was recorded under the treatment $F_0$ (100% RDF+$ZnSO_4$ 30 kg) and maximum phosphorus was recorded under the treatment $F_1$ (75% RDF +25% RDN through FYM+$ZnSO_4$ 25 kg/ha).

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