The Pharma Innovation Journal 2023; 12(10): 1979-1983

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(10): 1979-1983

www.thepharmajournal.com
Received: 25-08-2023
Accepted: 30-09-2023

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Effect of irrigation scheduling and zinc fertilization on yield and water productivity of irrigated wheat (*Triticum aestivum* L.)

Neroju Manasa, Navjot Rana and K Vamshi Krishna

Abstract
A field experiment entitled "Effect of Irrigation Scheduling and Zinc Fertilization on Yield and Water Productivity of Irrigated Wheat" was conducted in agricultural research farm of Lovely Professional University, Punjab. The investigation was laid out in split plot design with three replications, aimed to study the impact of irrigation and zinc on wheat crop. The design consisted of three irrigation treatments *viz.*, Irrigation at CRI + Late Tillering + Flowering (I_1), Irrigation at CRI + Late Jointing + Milking (I_2) and Irrigation at CRI + Flowering + Dough (I_3) and three zinc treatments 100% RDZ (25 kg ha^{-1}), 50% RDZ (12.5 kg ha^{-1}) and 25% RDZ (6.5 kg ha^{-1}). When compared to all other treatments, Irrigation at CRI + Late Jointing + Milking +100% RDZ were shown to have significantly higher levels of other parameters like effective tillers, grain yield, straw yield and no of leaves. However, compared to other treatments, it has the highest B:C ratio of 1.88. According to these findings, wheat crop agronomic traits responded more significantly in plots treated with irrigation at CRI + Late Jointing + Milking + 100% RDZ. Hence due to the identical agro-climatic conditions and soil characteristics, it was recommended that irrigation at CRI + Late Jointing + Milking + 100% RDZ might be beneficial for increasing wheat yield.

Keywords: Zinc, plant height, effective tillers, grain yield, straw yield, water productivity

Introduction
Wheat (*Triticum aestivum* L.) is the second most significant rabi cereal crop in India after rice, and the primary source of nutrition for over half the world's population. Wheat also contributes significantly to the nation's economy. Wheat is one of the most extensively consumed grain crops, not only in India but around the world as well. It is grown in a variety of climatic zones, though mainly under irrigation conditions. Production of wheat during 2019-2020 is estimated at record 107.18 Mt (agri exchange.apeda.gov.in). It is higher by 3.58 Mt as compared to wheat production during 2018-19 and is higher by 11.02 Mt and the average wheat production is 96.16 Mt. Uttar Pradesh holds the prime position in wheat production (30.30 MT) followed by Punjab (16.11 MT) and Madhya Pradesh (13.13 MT) which accounts 32.77 percent (agri exchange.apeda.gov.in) of total wheat production in India. In Uttar Pradesh, the eastern U.P. contributes about 30% wheat grain production of the state. Due to its high sensitivity to moisture stress, wheat is typically grown as a rainfed crop in many parts of the region, particularly in the semi-arid regions of central and peninsular India, even though the percentage of all India's irrigated area planted with wheat has increased from 34% in 1950–1951 to 93.4% in 2013–2014 (Directorate of Economics and Statistics, 2016).

In Madhya Pradesh, the area covered by irrigated wheat has significantly increased in recent years. In addition to one irrigation every sowing, farmers in this area also apply irrigation to wheat 4 or 5 times. The most crucial factor in maintaining the productivity of the wheat crop, assuming the upcoming water shortage, is the careful management of irrigation water. For wheat to produce its maximum potential yield, water is necessary at every stage of development, from germinating seeds to plant maturity (Kumar *et al.*, 2014) [1]. One of the good agronomic management techniques is efficient water management, which enhances the wheat crop's ability to utilise water effectively (Singh *et al.*, 2012) [2]. Many workers have recommended that scheduling wheat irrigation conveniently based on pan evaporation Angadi and Janawade 2001) [3]. Although the phases of the soil and plants are not taken into account in this method, they stated that scheduling irrigation based on pan evaporation is easy, quick, and convenient.

Micronutrient deficiency in plants is a global problem that has recently become more serious. One third of the worldwide people suffers from zinc deficiency, which is common in India and causes between 50% and 75% of birth defects in pregnant women and between 40% and 75% of birth defects in children (Dhingra *et al*., 2009) [4]. All people, plants and animals (Broadley *et al*., 2007) [6] require zinc to survive. In the developing world, cereal crops are crucial for meeting daily caloric needs, yet they naturally contain very little zinc in their grains (Cakmak *et al*., 2010) [5]. One person needs 15 mg of zinc per day for good nutrition, however our dietary grains only contain 15–35 mg of zinc/kg, and only 13–35% of that amount is available. Therefore, there is a significant difference between daily intake and requirements, and our dietary grains should have 40 to 60 mg of zinc/kg.

The experiment has been designed with the following objectives

1. To study how wheat growth, production, and quality are affected by irrigation timing and zinc management.
2. To assess how wheat's water productivity is affected by the timing of irrigation and zinc fertilisation.
3. To research how a treatment affects the health of the soil.
4. To estimate the treatments of the economics.

Materials and Methods

This experiment was conducted at the research farm of the Lovely Professional University's Department of Agronomy in Phagwara, Kapurthala district, during the rabi session of 2021. The research farm is located in the sub-tropical region of the central plains of Punjab State's agroclimatic zone. At a height of 252 metres above mean sea level, the farm is exactly located between the geographic coordinates of 31^0 22' 31.81" North latitude and $75^0$23'03.02" East latitude. Average value of temperature (maximum and minimum) during the field experimental period of November 2021- April 2022 have been 24 °C & 14 °C. A split block design with three replications was used for the study's layout. There were three irrigation treatments and three zinc treatments in the experiment design. The field was ploughed and irrigated prior to sowing. After the initial tillage, the area was divided into 27 distinct plots, each measuring 5m x 4m size. At the time of sowing, the required levels of fertilizers were applied in the recommended doses. The appropriate nutrient rates (N, P, and K @ 150, 60, and 60 kg ha-1) were applied using urea, SSP, and MOP. A basal dose of zinc was applied using zinc sulphate $ZnSO_4$ just prior to seeding wheat, while nitrogen was applied in two splits, half at sowing and half at 30 days after sowing. SSP and MOP were applied at the time of sowing. The variety PBW 824 seeds were sown by dibbling method in between the rows by using wheat seed at the rate of 100 kg/ha with a spacing of 22.5 cm on 9 November, 2021. Furrows were used for line sowing, and a wooden marker was used to open them at a distance of 22.5 cm between each row, furrows were then quickly covered after sowing. Plant protection measures and irrigations, whenever required were provided in same manner for all the treatments. Regular biometric data were collected at intervals of 30DAS, 60DAS, and 90 DAS, while yield attributes were recorded right before crop harvest. The crop was carefully inspected for maturity signs including golden yellow spikes, lower leaf drying, and upper leaf yellowing before being harvested.

On April 4, 2022, after around 98 percent of the grains hardened, the crop was harvested and the grains were then tied in labelled bundles. Harvested crop bundles were weighed and sun-dried for two to three days to bring the moisture content down to a level suitable for threshing. The grains from each net plot were weighed after being threshed and cleaned separately in accordance with the treatment. Using the statistical method of (ANOVA), the research data on crop growth, dry matter, and yield parameters were analysed.

Results and Discussion

Soil parameters

The soil sample, which was randomly collected from the trial area, was discovered to be sandy loam, with a pH of 7.52. The pH of the experimental plot's soil was measured using a pH metre after soil samples were taken, dried in the shade, using a pH metre, create a buffer with a pH of 7 and 4. The soil's electrical conductivity on the experimental area is 0.33 (ds m^1), and the EC (Electrical conductivity) of the soil is measured using an EC metre. By using the chromatic acid quick titration method, the amount of organic carbon that is readily available in the soil of the experimental plot is 0.31 (%). The Kjeldahal method (1956) was used to calculate the amount of available nitrogen in the soil of the experimental plot, which was 194.28 Kg/ha. According to the Olsen's approach, the experimental plot's available phosphorus level is 16.12 Kg/ha. According to the Flame photometer method, the amount of potassium that was readily available was 216.11 Kg/ha.

Growth parameters

The present study's results indicated that plant growth parameters including plant height, number of tillers were significantly influenced by the irrigation stages and zinc treatment. Plant height and number of leaves of wheat at 30, 60 and 90 DAS has been presented in the Table 1. At 30 DAS, there was no significant influence of irrigation stages and zinc treatment on the plant height. However, at 30 D AS among Irrigation levels treatments Irrigation at CRI + Late Jointing + Milking (I_2) had the maximum plant height and no of tillers that was followed by the treatment Irrigation at CRI + Flowering + Dough (I_3). Among zinc levels 100% RDZ (Zn_1) had the maximum plant height and no of tillers that was followed by the treatment 50% RDZ (Zn_2). The highest plant growth is due to there are growth regulators like gibberellins, kinetin, and indole-3-acetic acid that are available to stimulate growth and give plants the capacity to tolerate environmental stresses, which may be the reason why the massively taller plants were identified in the zinc treatment application. Similar findings were observed by Gopal *et al*., (2012) [7] and Jan *et al*., (2013) [7]. The application of irrigation during flowering resulted in the production of the greatest number of productive tillers. Additionally, it might be stimulated by improved moisture regimes and higher nutrient supply. Similar result was noticed by Yadav *et al*., (2002) [8].

Table 1: Effect of irrigation scheduling and zinc levels on plant height and no of tillers

Treatments	Plant height (cm)			No of tillers per plant	
	30 DAS	60 DAS	90 DAS	60 DAS	90 DAS
Irrigation stages					
Irrigation at CRI + Late Tillering + Flowering (I_1)	11.63	37.63	75.85	4.18	6.15
Irrigation at CRI + Late Jointing + Milking (I_2)	14.72	41.78	78.94	6.74	5.58
Irrigation at CRI + Flowering + Dough (I_3)	13.10	39.93	77.29	5.67	7.42
CD 5%	0.69	0.64	0.12	0.38	0.79
S.Ed (±)	0.17	0.16	0.03	0.09	0.19
Zinc levels					
100% RDZ (Zn_1)	14.53	41.43	78.73	7.85	10.33
50% RDZ (Zn_2)	13.21	39.45	77.47	7.62	9.33
25% RDZ (Zn_3)	11.70	38.44	75.88	5.68	7.33
CD 5%	0.38	0.54	0.25	0.36	0.26
S.Ed (±)	0.12	0.17	0.08	0.11	0.08
Interaction					
CD 5%	NS	0.89	0.38	NS	0.56
S.Ed (±)	0.23	0.29	0.12	0.19	0.24

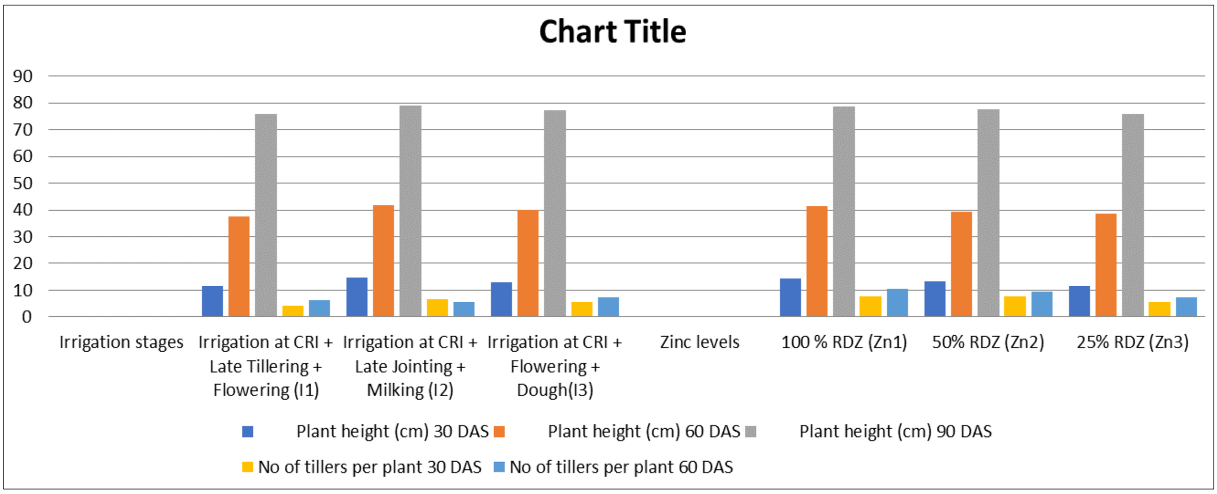

Fig 1: Effect of irrigation scheduling and zinc levels on plant height and no of tillers

Yield attributes

Data on the yield attributes revealed that irrigation and zinc treatments had a significant impact on the grain yield, straw yield, and harvest index. The yield attributes of wheat have been presented in Table 2. Among the irrigation treatments Irrigation at CRI + Late Jointing + Milking (I_2) and at zinc levels the 100% RDZ (Zn_1) recorded maximum grain yield The interaction effect of irrigation schedule and zinc treatments on wheat grain production was determined to be significant, according to a critical analysis of the data. Higher grain production is the cause of the increased weight of grains per ear. In this experiment, irrigation during milking may have helped the grain accumulate more photosynthates in contrast to other treatments, which saw decreased nutrient availability and lower photosynthetic rates. Wheat grain production was improved by zinc additions of up to 0.04 percent. A crucial role for zinc was identified in the plant biomass. Cakmak *et al*., (2008) [9] reported similar results for the highest grain yield. The straw yield statistical data is similar to grain yield. In terms of dry matter, better vegetative crop growth obviously led to better straw yields, which may be the reason for higher straw yields under irrigation schedules with the best levels of water supply. Similar outcomes were reported by Narolia *et al*., (2016) [10].

Table 2: Effect of irrigation scheduling and zinc levels on grain, straw, biological yield and harvest index of wheat

Treatments	Grain yield (Kg/ha)	Straw yield (Kg/ha)	Biological yield (Kg/ha)	Harvest index (%)
Irrigation schedule				
Irrigation at CRI + Late Tillering + Flowering (I_1)	2887.37	4822.11	7764.90	36.22
Irrigation at CRI + Late Jointing + Milking (I_2)	4201.21	5022.86	9224.07	45.26
Irrigation at CRI + Flowering + Dough (I_3)	3251.44	4965.52	8216.96	38.77
CD 5%	271.87	NS	194.77	2.73
SE (m)±	67.43	NS	48.11	0.67
Zinc levels				
100% RDZ (Zn_1)	4508.89	4986.63	9495.52	47.45
50% RDZ (Zn_2)	3316.96	4938.66	8311.05	39.22
25% RDZ (Zn_3)	2514.17	4885.20	7399.37	33.57
CD 5%	121.42	NS	152.02	1.26
SE (m)±	38.97	NS	48.79	0.41

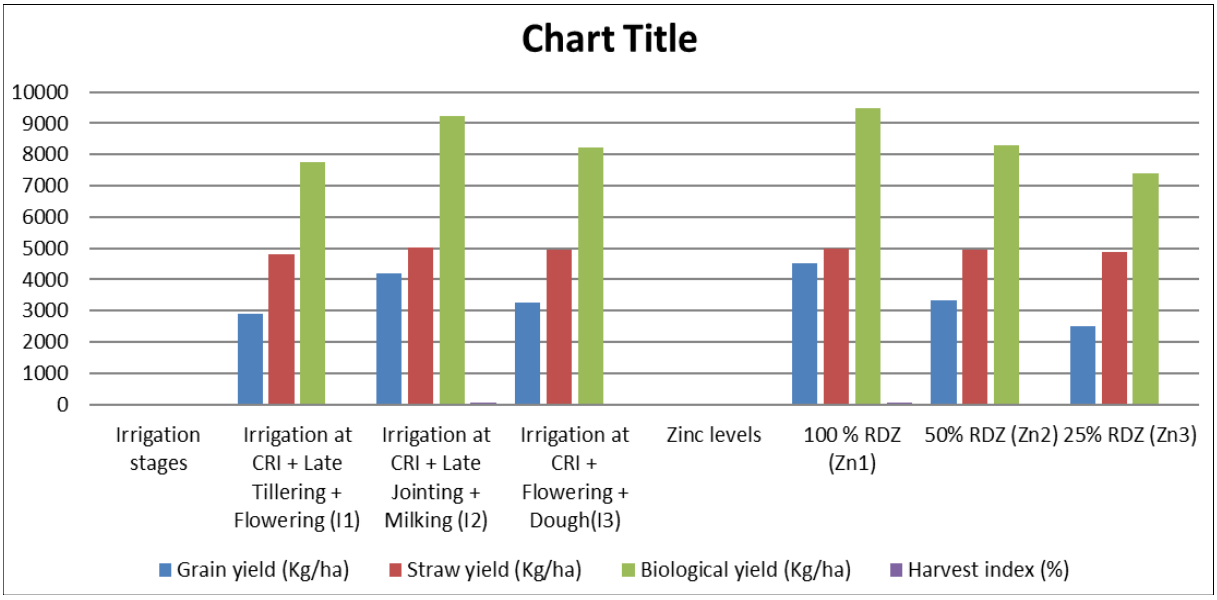

Fig 2: Effect of irrigation scheduling and zinc levels on grain, straw, biological yield and harvest index of wheat

Water use efficiency

The wheat crop's water use efficiency was measured during experiment. At irrigation stages the water use efficiency of Irrigation at CRI + Late Tillering + Flowering (I_1) had the maximum water use efficiency whereas at zinc treatment 25% RDZ (Zn_3) had the maximum water use efficiency. With increasing irrigation levels, the water use efficiency in terms of grain yield per unit of water consumed increased. The combination of irrigation scheduling at CRI, late jointing, and milking may have contributed to the increase in yield in WUE. This may have led to a longer reproductive phase with a larger photosynthetic surface and reproductive storage capacity to accommodate more gross photosynthates, which was advantageous for grain development and yield. Mishra and Kushwaha (2016) [11] also agreed with this result.

Consumptive use

Among the irrigation treatments Irrigation at CRI + Late Jointing + Milking (I_2) and at zinc levels the 100% RDZ (Zn_1) recorded maximum consumptive use of water. Different irrigation schedules have an effect on the average water consumption. The results also showed that the application of various zinc levels had a negligible impact on mean water consumption.

Table 3: Shows Treatments, Water use efficiency (Kg ha^{-1} mm) and Consumptive use (mm)

Treatments	Water use efficiency (Kg ha^{-1} mm)	Consumptive use (mm)
Irrigation schedule		
Irrigation at CRI + Late Tillering + Flowering (I_1)	14.29	202
Irrigation at CRI + Late Jointing + Milking (I_2)	12.17	345
Irrigation at CRI + Flowering + Dough (I_3)	13.21	246
CD 5%	0.76	5.26
SE (m)±	0.25	1.30
Zinc Levels		
100% RDZ (Zn_1)	14.97	301
50% RDZ (Zn_2)	15.07	220
25% RDZ (Zn_3)	15.14	166
CD 5%	0.78	7.67
SE (m)±	0.24	2.46

Conclusion

The findings of "Effect of Irrigation Scheduling and Zinc Fertilization on Yield and Water Productivity of Irrigated Wheat (*Triticum aestivum L.*)" study indicated that zinc levels and irrigation stages both increased growth parameters. At irrigation the Irrigation at CRI + Late Jointing + Milking (I_2) and at zinc levels 100% RDZ(Zn_1) directly impact the development and growth of wheat. Additionally, the maximum grain and straw yield was observed Irrigation at CRI + Late Jointing + Milking (I_2) and 100% RDZ(Zn_1) comparing to other treatments. It can be concluded that irrigation and Zn optimization can increase wheat grain yield in areas with similar environmental factors to the experimental site.

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