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Effect of irrigation scheduling and nitrogen management on yield and yield attributes of wheat

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Abstract
A field experiment was carried out in a loamy sand soil at Rajasthan Agricultural Research Institute, Durgapura during *Rabi* seasons of 2021-22 and 2022-23 to study the effect of irrigation scheduling and nitrogen management on yield and yield attributes of wheat. Wheat (cv. Raj 4083) was grown in a split plot design with four irrigation scheduling (0.6 IW/CPE, 0.8 IW/CPE, 1.0 IW/CPE & at critical growth stages) as main factor and five nitrogen management strategies (Control, 100% RDN through FYM, 50% RDN through FYM + 2 foliar spray of nano urea, 100% RDN through chemical fertilizer & 50% RDN through chemical fertilizer + 2 foliar spray of nano urea) as subplot factor. It was observed that number of effective tillers/m^2, number of spikes/plant, number of grains/spike, weight of spike/plant, test weight and yield of wheat was statically higher with an irrigation scheduling 1.0 IW/CPE. The maximum yield attributes and grain yield of wheat was recorded with 100% RDN through chemical fertilizer over other doses of nitrogen.

Keywords: Irrigation scheduling, nitrogen, wheat, yield & yield attributes

Introduction
Wheat [*Triticum aestivum* (L.) emend. Fiori & Paol.] is the most important staple food crop of the world and emerged as the backbone of India's food security. It is one of the most important and remunerative *Rabi* cereal crop of India not only in terms of acreage, but also in terms of its versatility for adoption under wide range of crop growing situations. In India, major wheat growing states are UP, Punjab, Haryana, M.P., Rajasthan and Bihar. Wheat productivity is highly variable within different agro-ecologies of India, due to variable climatic conditions, genotypes, seeding time and practices and other management practices (Kantwa *et al*., 2015) [6]. Though current wheat production in India is sufficient to meet its demand, but it has to be increased to 140 million tons per annum by 2050 (Vision 2050, IIWBR, Karnal, 2015) [18]. Among the various constraints of its lower productivity in semi-arid region are less availability and poor quality of irrigation water, imbalances fertilization with deficiencies of some macro and micro nutrients, erratic nature of climate and poor soil physical conditions. Besides these, soils are course textured and have poor organic matter content, low water receptivity, excessive permeability and sharp increase in soil strength upon drying are also important factors associated with low production.
Irrigation and fertilizer are the forerunners of modern agricultural technologies and high crop yields can be harvested only when all the technologies are applied in optimum levels. Irrigation water is the limiting factor in arid to semi-arid region and day-by-day, the availability of irrigation water is becoming scarce because of increasing demand from domestic and industrial sectors jeopardizing the future food security of India. As wheat is being highly irrigation intensive crop with a requirement of 300 to 500 mm, needs assured irrigation to get optimum yield. This crop being highly sensitive to water stress, produces substantially low yield under water restricted environment and gives significantly higher yield with supplemental irrigation (Bandyopadhyay *et al*., 2010 and Pardhan *et al*., 2014) [3, 12].
Besides, water management practices, focus on nutrient management also play important role in improving crop productivity, nutrient uptake and nutrient use efficiency. Among all the essential nutrients, nitrogen is the major macronutrients that required for plant growth and development. Nitrogen is the integral part of amino acid, nucleic acid, chlorophyll, proteins and an important component of energy molecule *i.e.* ATP and ADP. Since Nitrogen plays an important role in various physiological process of the plants both deficiency and excess cause significant reduction in the yield.

Materials and Methods

The field experiment was conducted at Research Farm, Rajasthan Agricultural Research Institute, Durgapura, Jaipur (75º47′ E, 26º5′ N) in 2021-22 and 2022-23. The soil of the experimental field is a loamy sand, in which the pre-sowing topsoil (0–20 cm) contained 0.21% organic matter, 135.71 kg ha^{-1} available N, 20.79 kg ha^{-1} available P, and 219.06 kg ha^{-1} available K. The organic carbon was measured by Walkley and Black's rapid titration method, available N was measured by the Alkaline $KMnO_4$ method, available P was measured by the Olsen's method, and available K was measured by the Flame photometric method. The total amounts of precipitation in the wheat-growing period of the two-year experiments were 37.6 and 73.9 mm, respectively. Wheat (cv. Raj 4083) was grown in a split plot design with four levels of irrigation *viz*., 0.6 IW/CPE, 0.8 IW/CPE, 1.0 IW/CPE & at critical growth stages as main plot factors and five nitrogen management strategies *viz*., control, 100% RDN through FYM, 50% RDN through FYM + 2 foliar spray of nano urea, 100% RDN through chemical fertilizer & 50% RDN through chemical fertilizer + 2 foliar spray of nano urea as sub plot factors.

The number of spikes bearing tillers was counted in five randomly selected one-meter row length at harvest and their average was taken as the number of effective tillers per meter row length. Number of spike/plant from randomly selected plant were taken from each plot. Five spike from each plot were taken and threshed. The cleaned grains were counted and average number of grains/spike was worked out. The weight of spike from five selected plants were collected and weighed. The average weight was worked out and expressed as weight of spikes/plant (g). One thousand seeds were counted from each sample drawn from the finally winnowed and cleaned produce of each plot and their weight was recorded as test weight in gram. The total biomass harvested from each net plot was threshed and cleaned. The grains so obtained were weighed in kg/plot and then converted into kg/ha.

Results and Discussion

Different irrigation scheduling and nitrogen management treatments significantly increased the yield attributes (number of spike/plant, number of effective tillers/m^2, number of grains/spike, weight of spike and test weight) and yield (grain yield, straw yield and biological yield) of wheat (Table 1, 2 and 3) in both the years of study as well as in pooled analysis.

Effect of irrigation scheduling

Among the irrigation treatments, 1.0 IW/CPE produced the maximum number of effective tillers/m^2, number of spikelets/spike, number of grains/spike, weight of spikes/plant, test weight whereas 0.6 IW/CPE produced the lowest. This is because of optimum availability of water at crop growth that provides all available nutrients from the soil. Besides this, it maintained chlorophyll content in leaves of wheat and plant remain stay-green for longer period of time that helped higher photosynthesis of crop through better assimilation of carbon from atmosphere that favors the growth and more number of yield attributes. Kaur and Mahal (2016) [7] also reported that significantly higher number of spike of wheat was recorded with irrigation schedule of 1.0 IW/CPE ratio as compared with 0.8 and 0.6 IW/CPE ratio.Similar findings were also observed by Verma *et al.* (2017) [17] and Sagar *et al.* (2018) [14], Choudhary *et al.* (2020) [5] and Pal *et al.* (2020a) [11].

The highest grain (3896 kg/ha), straw (6063 kg/ha) and biological (9959 kg/ha) yield was attained at 1.0 IW/CPE on pooled basis whereas the lowest grain straw and biological yield was obtained from plots treated at 0.6 IW/CPE. Higher grain yield under this treatment might be the result of cumulative effect of improvement in growth and yield attributes such as effective tillers, number of grains/spike, spike weight and test weight. It was also found that, sufficient moisture in the soil profile under higher irrigation frequency, plant nutrients particularly nitrogen, phosphorus and potassium were more available and might have translocated to produce more dry matter. Secondly, higher yield with higher levels of irrigation might be due to its key role in root development by reducing mechanical resistance of soil, higher transpiration, greater nutrient uptake and more photosynthesis due to metabolic activities in plant. The results of present experiment were closely supported by Kumawat *et al.* (2022) [9], Singh *et al.* (2022) [15] and Sisodiya *et al.* (2022) [16].

Effect of nitrogen management

Among the nitrogen treatments, the maximum number of effective tillers/m^2, number of grains/spike, weight of spikes/plant, test weight were observed under 100% RDN through chemical fertilizer whereas minimum values were recorded under control. The increase in yield attributes under application of nitrogen through chemical fertilizers may be explained due to increase in growth in terms of plant height, dry matter accumulation and number of tillers/plant number of tillers which might provide better sites for spike formation and grain development. With the application of nitrogen through chemical fertilizers, the tissue differentiations, meristematic activity and the development of floral primordial might have been enhanced, causing greater production of flowers which latter developed to spikes. Nitrogen application induced greater translocation of photosynthesis from leaves via stem to sink site. Similar to present research findings, Agrawal *et al.* (2018) [1] in wheat and Neelam *et al.* (2018) [10] in barley also revealed that yield attributes (*viz*., number of effective tillers/m^2, spike length, grains/ear and grain weight/ear)was recorded significantly higher with application of 100% RDN through inorganic source.

The application of 100% RDN through chemical fertilizer increased the yield% over control. Application of 100% RDN through chemical fertilizers also registered higher values of number of effective tillers/m^2, number of spike/plant, number of grains/spike, weight of spike/plant, test weight, grain yield (3888 kg/ha), straw yield (6193 kg/ha), biological yield (10081 kg/ha). The increase in yield due to application of nitrogen may be attributed to cumulative effect of increase in number of effective tillers and grains/spike. It might be also due to improved availability of nitrogen in root zone. The increase in straw yield with application of nitrogen could be partly attributed to its direct influence on dry matter production of each vegetative part and indirectly through increased morphological parameters of growth. Since, biological yield is a function of grain and straw yield representing vegetative and reproduction growth of crop. Kishore *et al.* (2022) [8] found that the application of 100% RDN and 6 t FYM/ha produced maximum grain yield and straw yield of barley. In a another study, Rathwa *et al.* (2022) [13] stated that application of 75% RDN through chemical +

25% N through FYM recorded significantly highest grain yield and straw yield of wheat. Our results are in close agreement with the results of earlier researchers *i.e.* Chandana *et al.* (2021) [4] and Balveer *et al*. (2022) [2].

Table 1: Effect of Irrigation scheduling and nitrogen management on yield attributes of wheat

Treatments	Number of effective tillers/m^2			Number of spike/plant		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
Irrigation scheduling						
0.6 IW/CPE	241.85	253.56	247.71	2.44	2.56	2.50
0.8 IW/CPE	270.96	294.60	282.78	2.73	2.97	2.85
1.0 IW/CPE	300.12	337.69	318.90	3.03	3.41	3.22
At critical growth stages	296.14	329.74	312.94	2.99	3.33	3.16
S.Em±	6.62	8.00	5.19	0.07	0.08	0.05
CD (5%)	22.89	27.67	15.99	0.23	0.28	0.16
Nitrogen management						
Control	244.18	257.52	250.85	2.46	2.60	2.53
100% RDN through FYM	269.98	292.87	281.42	2.72	2.95	2.84
50% RDN through FYM + 2 foliar spray of nano urea	273.02	299.46	286.24	2.75	3.02	2.89
100% RDN through chemical fertilizer	302.31	339.33	320.82	3.05	3.42	3.24
50% RDN through chemical fertilizer + 2 foliar spray of nano urea	296.85	330.30	313.58	2.99	3.33	3.16
S.Em±	6.69	7.94	5.19	0.07	0.08	0.05
CD (5%)	19.29	22.87	14.67	0.19	0.23	0.15

Table 2: Effect of Irrigation scheduling and nitrogen management on yield attributes of wheat

Treatments	Number of grains/spike			Weight of spike/plant (g)			Test weight (g)		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
Irrigation scheduling									
0.6 IW/CPE	32.09	32.32	32.21	5.60	6.52	6.06	34.75	35.06	34.91
0.8 IW/CPE	33.19	33.54	33.36	6.13	7.12	6.63	35.35	36.04	35.70
1.0 IW/CPE	36.14	37.17	36.66	6.76	8.08	7.42	38.19	39.39	38.79
At critical growth stages	35.95	36.76	36.36	6.66	7.87	7.27	37.93	38.97	38.45
S.Em±	0.72	0.83	0.55	0.13	0.16	0.11	0.71	0.81	0.54
CD (5%)	2.51	2.87	1.70	0.46	0.57	0.32	2.45	2.81	1.66
Nitrogen management									
Control	31.65	31.91	31.78	5.62	6.54	6.08	34.88	35.06	34.97
100% RDN through FYM	33.85	34.29	34.07	6.17	7.18	6.68	35.63	36.19	35.91
50% RDN through FYM + 2 foliar spray of nano urea	33.93	34.54	34.24	6.23	7.23	6.73	36.13	37.24	36.69
100% RDN through chemical fertilizer	36.20	37.09	36.64	6.73	8.09	7.41	38.21	39.45	38.83
50% RDN through chemical fertilizer + 2 foliar spray of nano urea	36.09	36.90	36.49	6.69	7.96	7.32	37.93	38.88	38.41
S.Em±	0.72	0.78	0.53	0.14	0.18	0.11	0.77	0.89	0.59
CD (5%)	2.08	2.25	1.50	0.41	0.52	0.32	2.22	2.55	1.66

Table 3: Effect of Irrigation scheduling and nitrogen management on yield of wheat

Treatments	Yield (kg/ha)								
	Grain yield (kg/ha)			Straw yield (kg/ha)			Biological yield (kg/ha)		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
Irrigation scheduling									
0.6 IW/CPE	3025	3081	3053	4541	4837	4689	7565	7918	7742
0.8 IW/CPE	3373	3544	3458	5158	5503	5330	8531	9047	8789
1.0 IW/CPE	3778	4014	3896	5908	6218	6063	9686	10231	9959
At critical growth stages	3661	3867	3764	5695	6058	5876	9356	9925	9640
S.Em±	78	76	54	121	123	86	175	156	117
CD (5%)	269	264	168	418	427	266	607	539	361
Nitrogen management									
Control	3033	3115	3074	4418	4622	4520	7450	7737	7594
100% RDN through FYM	3332	3474	3403	5121	5480	5300	8452	8954	8703
50% RDN through FYM + 2 foliar spray of nano urea	3456	3632	3544	5244	5572	5408	8699	9203	8951
100% RDN through chemical fertilizer	3777	4000	3888	6010	6376	6193	9787	10376	10081
50% RDN through chemical fertilizer+ 2 foliar spray of nano urea	3699	3911	3805	5834	6219	6027	9533	10131	9832
S.Em±	66	58	44	121	138	91	137	167	108
CD (5%)	189	167	124	347	397	258	396	480	305

Conclusion

The irrigation scheduling at 1.0 IW/CPE ratio gave significantly higher yield and yield attributes, of wheat and it was being at par with irrigation at critical growth stages. The application of 100% RDN through chemical fertilizer, recorded significantly higher yield and yield attributes of wheat and it was being at par with 50% RDN through chemical fertilizer + 2 foliar spray of nano urea. Among the different treatment combinations, significantly higher grain, straw and biological yield of wheat was obtained by irrigation scheduling at 1.0 IW/CPE ratio with application of 100% RDN through chemical fertilizer.

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