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Impact of irrigation and nitrogen management practices on growth characters of wheat (*Triticum aestivum* L.)

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Abstract
A field experiment was conducted to study the effect of irrigation and nitrogen management on growth of wheat during two consecutive *rabi* seasons of years 2017-18 and 2018-19, respectively. The experiment was laid out in split plot design with four water management practices in main plot *viz*. Without irrigation (control), Irrigation at main shoot and 1 tillers (Z_{21}) + Flag leaf sheath extending (Z_{41}) + Early milk (Z_{73}), Irrigation at 4th leaf unfolded (Z_{14}) + 1st node detectable (Z_{31}) + Anthesis 50% (Z_{65}) and Irrigation at 1st node detectable (Z_{31}) + First spikelet of inflorescence just visible (Z_{50}) + Late milk (Z_{77}) and four nitrogen levels *viz*. Control, 60 kg N ha^{-1},120 kg N ha^{-1} and 180 kg N ha^{-1}. The results reported that the higher growth parameters *viz*. plant height, number of tillers, shoot dry matter accumulation, crop growth rate, relative growth rate and chlorophyll content were recorded under irrigation application of Z_{14}, Z_{31} & Z_{65}. However irrigation application of Z_{14}, Z_{31} & Z_{65} was statistically at par with Z_{21}, Z_{41} & Z_{73} during both the experimental years. Among the nitrogen levels, 180 kg N ha^{-1} recorded higher growth parameters which were at par with 120 kg N ha^{-1}.

Keywords: Spikelets, Infloescence, Zadoks, irrigation and nitrogen

Introduction
Indian mustard (*Brassica juncea* L.) is an important *Rabi* oilseed crop extensively grown as rainfed crop in India. Mustard oil meets the one third of edible oil requirement of the country, to meet these needs the country highly depends on imports of vegetable oil. Import of vegetable oils during July 2019 is up by 26% to 14.12 lakh tones as compared to 11.19 lakh tones in July 2018, according to data compiled by the Solvent Extractors' Association of India (SEA). There is a need to decrease the Import of vegetable oils by expanding the area under oil seed crops. It is important to increase the yields of mustard crop by improving the available germplasm lines, for that we need to know various yield contributing characters and the relationship among them and with the seed yield. In this experiment, we studied correlation or mutual association among different yield contributing characters and the direct and indirect effects also estimated through path coefficient analysis. The inter-relationship between the yield components will be helpful to a breeder to assess the nature, extent and direction of selection pressure on characters.

Material and Methods
Wheat is one of the leading food crops of world farming and occupies significant position among the cultivated cereals (Waines and Hegde, 2003) [25]. Cultivation of wheat has been the symbolic of green revolution that is why some times green revolution is also termed as Wheat revolution. In India, wheat is the second most important staple cultivated food after rice and consumed by nearly 65% of the Indian population (Mishra *et al*., 2005) [15] and rank first in dietary shares in northern India represented by Gangetic plains. India is the second largest wheat producer 99.70 million tonnes next only to China 121.72 million tonnes and covers the largest area under wheat cultivation (29.58 m ha), which is about 13.77% of the world wheat area 217 million hectare (Agricultural Statistics at a glance, 2018) [1]. While, Uttar Pradesh occupied an area 9.54 million hectare and production 32.75 million tonnes but the average productivity 3432 kg ha^{-1} is much lower than Punjab 5183 kg ha^{-1} and Haryana 4925 kg ha^{-1} (Agricultural Statistics at a Glance, 2019) [2]. The availability of wheat has increased from about 79 g^{-1} capita^{-1} day to more than 185 g^{-1} capita^{-1} day despite the doubling of the

population since 1961 (Bhardwaj *et al*., 2010) [4] population. However, the productivity of the crop in the Uttar Pradesh is lower than the potential yield. The wheat productivity is highly variable within different agro-ecologies of India, due to variable climatic conditions, moisture stress, genotypes, imbalance fertilizer use, seeding time and practices and other management practices (Kantwa *et al*., 2015) [9]. Moreover, it is grown mainly in light textured soils with low water holding capacity, poor nitrogen, phosphorus and organic matter contents resulting in poor growth and yield. Wheat compares well with other important cereals in its nutritive value.

At present, more than 60 per cent of wheat area is irrigated, of which about 50 per cent receive only one to two irrigations. So, there is need to improve irrigation efficiency through optimization of irrigation water under conditions of limited water availability (Chauhan and Yada, 2012) [6]. Water stress experienced by a wheat crop during growth stages is known to have cumulative effects expressed as a reduction in total biomass as compared to well-watered conditions (Mirbahar *et al*., 2009) [14]. Water shortage is becoming the most important limiting factor for wheat production. Under such situation, the deficit irrigation becomes more important in recent years as there is continuous decrease in available fresh water that can be used by agricultural production (Cai and Rosegrant, 2003) [5]. Thus, it become relevant to identifying growth stages of a particular cultivar under local conditions of climate and soil fertility allows irrigation scheduling to maximize crop yield and to enable the most efficient use of scarce water resources (Panda *et al.*, 2003) [18].

After irrigation, nitrogen is the second most important input for growth and development of wheat crop (Lenka *et al.*, 2009) [10]. Nitrogen (N) is often the most limiting nutrient in crop production and N accumulation dynamics in crops therefore often closely follow biomass growth patterns (Drinkwater and Snapp, 2007) [7] and to enhances the water productivity (Pandey *et al.*, 2001) [19]. The response to Nitrogen not only depends upon amount but also optimum time of its application. However, information regarding irrigation and nitrogen management in wheat production is meager in Uttar Pradesh.

S However, information regarding irrigation and nitrogen management in wheat production in Uttar Pradesh is lacking. Keeping in view the above discussed facts of sufficient information and sparce related research, the present investigation was undertaken to find out the effect of irrigation and nitrogen management practices on growth of wheat in Varanasi conditions.

Material and Methods

The experiment was conducted during two consecutive *rabi* seasons of years 2017-18 and 2018-19, respectively at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, situated at latitude of 25° 18' North and longitude of 83° 03' East, with altitude of 128.93 meters above the mean sea level. The total rainfall experienced during the crop growth season was 9.4 mm in 2017-18 and 29.4 mm in 2018-19.Soil of the experiment field had sandy loam in texture, slightly alkaline in reaction, low in electrical conductivity, low in organic carbon, available nitrogen and medium in available phosphorus and potassium.

The experiment was laid out in split plot design with three replications assigning four irrigation management practices comprising of [I_0 (Without irrigation (control)), I_1 (Irrigation at main shoot and 1 tillers (Z_{21}) + Flag leaf sheath extending (Z_{41}) + Early milk (Z_{73})), I_2 (Irrigation at 4th leaf unfolded (Z_{14}) + 1st node detectable (Z_{31}) + Anthesis 50% (Z_{65})) and I_3 (Irrigation at 1st node detectable (Z_{31}) + First spikelet of inflorescence just visible (Z_{50}) + Late milk (Z_{77})] in main plot. Each main plot was further divided into four sub plots to accommodate sub plot treatments *i.e*. nitrogen levels [N_0 (Control), N_1 (60 kg N ha^{-1}), N_2 (120 kg N ha^{-1}) and N_3 (180 kg N ha^{-1})]. Thus a total of 16 treatment combinations were tested in the study and were replicated thrice. Wheat variety HUW-234 was used for test crop. The treatments were allocated randomly to each plot. Crop was fertilized with 60 and 50 kg ha^{-1} of P and K. Treatment wise the half quantity of nitrogen and entire dose of phosphorus and potassium were applied as basal. While, the rest half dose of nitrogen was top dressed in two equal splits, first 25% at main shoot and 1 tillers (Z_{21}) and second 25% at first node detectable (Z_{31}). Each main plot was surrounded by a buffer of 1.5 m width whereas subplot was surrounded by 0.5 m width to protect the plots from accidental irrigation and gain of water through seepage. The volume of irrigation water was calculated as per treatments by using Parshall flume. The treatments were replicated three times. Irrigation and nitrogen management were done as per treatment. Other crop management practices were followed as per the recommendation of the area. The data relating to each character were analyzed as per the procedure of analysis of variance and significance was tested by "F" test (Gomez and Gomez 1984) [8].

Results and Discussions

Effect of irrigation management on growth characters

Irrigation management practices influenced significantly almost all the growth parameters *viz*, plant height, number of tillers, shoot dry matter accumulation at harvest stage (Table 1). Irrigation application of I_2 (Z_{14}, Z_{31} & Z_{65}) recorded highest values during both the experimental years for plant height (98.24 and 104.49 cm), number of tillers (99.60 and 106.69 m^{-2}) and shoot dry matter accumulation (303.00 and 316.67 g m^{-1} row length) over different irrigation management practices. However, I_2 (Z_{14}, Z_{31} & Z_{65}) was significantly at par with I_1 (Z_{21}, Z_{41} & Z_{73}) for all the growth parameters. Increase in crop growth characters of wheat under irrigation schedules of I_2 (Z_{14}, Z_{31} & Z_{65}) was due to ample supply of irrigation water to crop during growth period and thereby the better growth of crop which helped in the supply of sufficient photosynthates at the grain filling stage. These results are in accordance with those reported by Narolia *et al.* (2016) [16].

The data on crop growth rate, relative growth rate and chlorophyll content in leaves are presented in Table 4.2. Significantly higher crop growth rate (15.18 and 16.00 g m^{-1} day^{-1}), relative growth rate (0.0120 and 0.0130 g g^{-1} day^{-1}) and leaf area index (4.53 and 4.66) was also noted under irrigation application of I_2 (Z_{14}, Z_{31} & Z_{65}) during both the experimental years. Increase in crop growth rate and relative growth rate may be due to higher shoot dry matter accumulation. These results are in close agreement with those reported by Mahmood *et al.* (2002) [12]; Patel (2014) [21]; Patel and Patel (2016) [20].

Effect of nitrogen management on growth characters

Among the nitrogen management treatments (Table 1), application of N_3 (180 kg N ha^{-1}) recorded significantly higher plant height (98.13 and 105.69 cm), no. of tillers (100.27 and

108.69 m^{-1} row length) and shoot dry matter accumulation (336.00 and 357.92 g m^{-1} row length) during *rabi*, 2017-18 and 2018-19, respectively. However, N_2 (120 kg N ha^{-1}) was statistically at par with N_3 (180 kg N ha^{-1}) in case of plant height and number of tillers.

The data on crop growth rate, relative growth rate and chlorophyll content in leaves are presented in Table 4.2. Significantly higher crop growth rate (16.55 and 19.57 g m^{-1} day^{-1}), relative growth rate (0.0108 and 0.0123 g g^{-1} day^{-1}) and leaf area index (4.71 and 4.90) was also noted under nitrogen application of N_3 (180 kg N ha^{-1}) during both the experimental years. However, N_3 (180 kg N ha^{-1}) was statistically at par with N_2 (120 kg N ha^{-1}) during both the years. Whereas, relative growth rate during first experimental year could not reach the level of significance.

Increasing level of nitrogen up to 180 kg ha^{-1}, plant maintained greater height, more number of tillers and assimilated higher amount of dry matter almost at all the stages of crop growth supporting the well-established fact that nitrogen sufficiency results into vigorous growth of plants. Increase in number of tillers due to application of nitrogen at all growth stages has also been reported by Waraich *et al.* (2002) [27] and Mattas *et al.* (2011) [13].

Shoot dry matter accumulation of plants is the final outcome of photosynthetic activities. A significant increase in plant dry matter at different stages of growth due to higher nitrogen dose which leads to higher biomass production as at that time nitrogen requirement is higher and partitioned for biomass production efficiency of chlorophyll which influence the photosynthetic efficiency and formation of other nitrogen compounds. Similarly this type of result was also reported by Ahmad *et al.* (2012) [3]. It not only acts as catalysts and substrate for plant growth but can also be considered as stimuli for oriented growth and development of plant due to its involvement in certain regulatory functions at cellular level. Beneficial effects of nitrogen application on growth of wheat have been reported by several workers *viz.* Sain (2000) [22]; Nehra *et al.* (2001) [17]; Singh *et al.* (2009) [24]. Similar results were obtained by Wang *et al.* (2010) [26]; Lifeng *et al.* (2011) [11] and Singh *et al.* (2013) [23].

Table 1: Effect of irrigation and nitrogen management on growth characters of wheat at harvest

Treatments	Plant height (cm)		No. of tillers m^{-1} row length		Shoot dry matter accumulation (g m^{-1} row length)	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
Irrigation management						
I_0 (Control)	88.23	91.07	82.00	86.19	252.83	276.08
I_1 (Z_{21}, Z_{41} & Z_{73})	96.70	101.44	92.80	100.72	289.50	302.08
I_2 (Z_{14}, Z_{31} & Z_{65})	98.24	104.49	99.60	106.69	303.00	316.67
I_3 (Z_{31}, Z_{50} & Z_{77})	94.56	98.52	89.10	99.22	285.67	294.33
S.Em±	1.70	1.45	2.66	2.52	6.41	5.47
LSD (*p*=0.05)	5.90	5.01	9.19	8.72	22.17	18.93
Nitrogen management						
N_0 (Control)	88.09	88.27	77.33	86.47	208.92	215.83
N_1 (60 kg N ha^{-1})	94.53	98.96	89.27	96.17	267.50	290.17
N_2 (120 kg N ha^{-1})	96.97	102.61	96.63	101.50	318.58	325.25
N_3 (180 kg N ha^{-1})	98.13	105.69	100.27	108.69	336.00	357.92
S.Em±	1.19	1.22	2.06	2.22	3.75	4.86
LSD (*p*=0.05)	3.46	3.57	6.00	6.49	10.95	14.19

Table 2: Effect of irrigation and nitrogen management on crop growth rate, relative growth rate and leaf area index of wheat

Treatments	Crop growth rate (g m^{-1} day^{-1}) at 90 DAS to at harvest		Relative growth rate (g g^{-1} day^{-1}) at 90 DAS to at harvest		Leaf area index (LAI) at 90 DAS	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
Irrigation management						
I_0 (Control)	12.83	14.37	0.0080	0.0091	3.59	3.78
I_1 (Z_{21}, Z_{41} & Z_{73})	12.19	14.66	0.0105	0.0125	4.11	4.32
I_2 (Z_{14}, Z_{31} & Z_{65})	15.18	16.00	0.0120	0.0130	4.53	4.66
I_3 (Z_{31}, Z_{50} & Z_{77})	12.40	15.09	0.0103	0.0129	4.06	4.34
S.Em±	0.35	0.32	0.0006	0.0002	0.08	0.02
LSD (*p*=0.05)	1.21	1.09	0.0021	0.0008	0.29	0.07
Nitrogen management						
N_0 (Control)	10.36	9.95	0.0100	0.0122	3.40	3.59
N_1 (60 kg N ha^{-1})	12.03	13.62	0.0098	0.0115	3.89	4.12
N_2 (120 kg N ha^{-1})	13.67	16.97	0.0102	0.0116	4.28	4.50
N_3 (180 kg N ha^{-1})	16.55	19.57	0.0108	0.0123	4.71	4.90
S.Em±	0.36	0.20	0.0003	0.0002	0.05	0.02
LSD (*p*=0.05)	1.06	0.59	NS	0.0005	0.16	0.07

Conclusions

From the above overall study, it is recommended that to obtain higher growth attributes of wheat should be grown under irrigation application of I_2 (Z_{14}, Z_{31} & Z_{65}) with 180 kg N ha^{-1} under ago-climatic conditions of Varanasi region of Eastern Uttar Pradesh.

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