



Effect of irrigation scheduling and nitrogen management on growth and development of Indian mustard (*Brassica juncea*)

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ABSTRACT

A field experiment was conducted during winter (*rabi*) seasons of 2019–20 and 2020–21 at Agronomy Farm, Anand Agricultural University, Anand, Gujarat to assess the influence of irrigation scheduling and nitrogen management on crop growth and development of Indian mustard [*Brassica juncea* (L.) Czern]. The experiment was planned using split-plot design where treatments replicated thrice. The main plots were allotted with 3 irrigation levels, viz. irrigation at 0.6 IW/CPE ratio (I_1), irrigation at 0.8 IW/CPE ratio (I_2) and irrigation at 1.0 IW/CPE ratio (I_3) and in sub-plots 5 nitrogen management treatments, viz. 100% RDN through chemical fertilizer (N_1); 100% RDN through vermicompost (N_2); 75% RDN through chemical fertilizer + 25% RDN through vermicompost (N_3); 50% RDN through chemical fertilizer + 50% RDN through vermicompost (N_4) and 25% RDN through chemical fertilizer + 50% RDN through vermicompost + Bio NPK Consortium @1.0 litre/ha (N_5) were practised. The results showed that, growth traits of mustard, viz. height of plant, dry matter accumulation, crop growth rates, leaf area and leaf area index were significantly enhanced by scheduling irrigation at 0.8 IW/CPE ratio and application of 50% RDN through chemical fertilizer + 50% RDN through vermicompost among nitrogen management treatments. Hence, mustard growth and development can be significantly improved by application of irrigation at 0.8 IW/CPE ratio and 50% RDN through chemical fertilizer + 50% RDN through vermicompost.

Keywords: Irrigation, Mustard, Nitrogen management, Plant growth, Vermicompost

Indian mustard [*Brassica juncea* (L.) Czern] is third important oilseed crop in the world after soybean and groundnut, India occupies first position in area and third in production of mustard after China and Canada. It is major winter (*rabi*) oil seed crop in northern India. In India, being major essential oilseed crop it contributes about 27.8% to India's oilseed economy. In current contest, it necessitates new suitable agro techniques to enhance the crop productivity in a sustainable manner. Among the varying agronomic inputs, improved cultivar or hybrids are important options for enhancing the production and productivity. Water is very precious and scarce input during winter, its efficient utilization is quite necessary. Efficient usage of water for irrigation aims at the utilization of available water resources to the maximum possible advantages in the crop production. Among the several recognized criteria of irrigation scheduling, the climatological approach (IW/

CPE ratio) is very useful. More favorable irrigation regimes maintained as per crop need results in higher soil moisture in root zone promoting cellular activity like enlargement, cell expansion and multiplication and creating synergistic impact on water potential of cell and stomatal conductance ultimately on photosynthetic activity (Rana *et al.* 2019). Optimum nutrient dose and their source play significant role in enhancing the productivity of crops. The increasing use of NPK fertilizers has no doubt remarkably increase the food production but prolonged cultivation of crops using chemical fertilizers alone causes decline in organic matter content due to accelerated oxidation at high temperature in the rainfed ecosystem has resulted great reduction in soil fertility. Hence, integrated use of both organic (bulky organic manures) and inorganic nutrient sources of plant nutrients might be good option for sustaining crop productivity along with enhancing soil fertility (Haque and Ali 2020). It is well-known that there is a positive correlation among fertilizer application, irrigation and the productivity. Considering these facts, field trail was designed to evaluate the effect of irrigation scheduling and various nitrogen application options on crop growth and development of mustard.

MATERIALS AND METHODS

The present experiment was conducted during winter

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(*rabi*) seasons of 2019–20 and 2020–21 at Agronomy Farm, Anand Agricultural University, Anand, Gujarat. The experimental field was having loamy sand soil, low in organic C, low in soil available nitrogen and medium in available P_2O_5 and high in available K_2O having pH of 7.84. The experiment was executed in split-plot design with fifteen treatment combinations, three irrigation levels in main plot and in sub plots five treatments of nitrogen management (N) were applied. Three irrigation levels were allocated to main plots, viz. irrigation scheduled at 0.6 IW/CPE ratio (I_1), irrigation at 0.8 IW/CPE ratio (I_2) and Irrigation at 1.0 IW/CPE ratio (I_3) and 5 nitrogen management treatments, viz. 100% RDN through chemical fertilizer (N_1); 100% RDN through vermicompost (N_2); 75% RDN through chemical fertilizer + 25% RDN through vermicompost (N_3); 50% RDN through chemical fertilizer + 50% RDN through vermicompost (N_4); 25% RDN through chemical fertilizer + 50% RDN applied through vermicompost + Bio NPK Consortium @1.0 l/ha (N_5) in sub-plots. 50 kg N/ha and 50 kg P/ha was recommended to mustard in this region. Nitrogen was provided in the form of urea (46% N) and vermicompost (1.7% N) according to treatments and phosphorus was supplied through SSP (16% P) fertilizer as a basal dose to all plots. For nitrogen, in case of inorganic fertilizer treatments N was scheduled in two splits first as basal dose and second at branching stage, while vermicompost was applied as basal dose and Bio NPK consortium was applied along with vermicompost as per treatments. Other agronomic operations were followed as per the standard packages of practices to raise the mustard crop except irrigation scheduling and nitrogen management. GDM 4 (Gujarat Dantiwada Mustard 4) seeds were used for sowing which was spaced at 45×10 (cm²) to maintain optimum population. Different crop growth and development parameters like plant height, dry matter accumulation, leaf area were documented at varied growth stages of mustard crop and the experimental data was analyzed for further interpretation. Average value of five plants per treatment was recorded, to observe the mustard dry weight at 30, 60 and 90 days of sowing (DAS).

Absolute growth rate (AGR) and crop growth rate (CGR) were derived using dry matter values and expressed as g/day and g/m²/day respectively (Hunt 1978). The formula for AGR and CGR are as follow:

$$AGR = \frac{W_2 - W_1}{t_2 - t_1}$$

$$CGR = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{1}{P}$$

where, W_1 and W_2 are dry weights (g) at time intervals t_1 and t_2 respectively; P is ground area (m²).

Leaf area was documented using an electronic leaf area meter. Leaf area index was calibrated as (Watson 1947):

$$LAI = \frac{\text{Leaf Area}}{\text{Land Area}}$$

The experimental data was subjected for F-test to

evaluate the significant disparity between treatment means taken at 5% probability level.

RESULTS AND DISCUSSION

Effect of irrigation: The two-year experiment results revealed that growth attributes of mustard steadily increased with the advancement of crop growth stages from 30 days after sowing (DAS) and peaked at 90 DAS (Table 1). The irrigation effect was non-significant on plant height at 30 DAS. Significantly higher plants were observed at 60 DAS and at harvest under I_2 (0.8 IW: CPE ratio) whereas, shortest plants were seen in treatment I_1 (0.6 IW: CPE ratio). The marked increase in plant height under treatments I_2 and I_3 might be attributed to ample supply of available soil moisture when plant needed for plant to its favorable growth process like active meristematic growth, cell division and cell elongation resulting enhanced plant height. These can be comparable to results of Haque and Ali (2020).

The response of dry matter accumulation (DMA) to irrigation scheduling had considerable effect at 60 and 90 DAS (Table 1). Significantly maximum dry matter content was observed under treatment I_2 and least DMA was reported under treatment I_1 during individual years and in pooled basis respectively. Significantly higher DMA was observed in treatment I_2 and I_3 over I_1 which might be frequent supply and optimum amount of soil moisture as plant needed for plant root system development which in turn improves the soil water intake, nutrient uptake, translocation and metabolic processes in the plant body along with increased photosynthesis process ultimately growth of plant. Our results are in line with findings of Bindhani *et al.* (2020) and Puppala *et al.* (2021).

Absolute growth rate (AGR) and crop growth rate (CGR) data of mustard showed that, there is increasing trend at 0–60 DAS thereafter decreased from 60 DAS in both years (Table 2). The both AGR and CGR significantly varied during 30–60 DAS and 60–90 DAS (on pooled basis). Higher AGR and CGR values were reported under treatment I_2 at all crop growth stages. Singh *et al.* (2008) and Yadav *et al.* (2010) reported the similar results. A proper soil moisture supply increased the plant growth; development got evident in the form of higher plant height and enhanced DMA resulting in higher absolute growth rate and crop growth rate.

Significant response of irrigation on Leaf area (LA) was observed in our experiment, subsequently leaf area index (LAI) of mustard also showed significant effect to irrigation schedules. During both years of experiment, there was increased progress in leaf area and leaf area index up to 0–60 DAS then it declined at the phase of 60–90 DAS (Table 3). Significantly higher LA and LAI was recorded in I_2 during 30–60 DAS and 30–60 DAS and lower values were observed in treatment I_1 . The results were parallel with findings of Garg *et al.* (2001). The optimum irrigation scheduling had appreciable effect on plant shoot growth as evident in plant height accumulating higher branches and leaves which may be result of better nutrient availability

Table 1 Effect of irrigation scheduling and nitrogen management on growth parameters of mustard

Treatment	Plant height at 30 DAS (cm)			Plant height at 60 DAS (cm)			Plant height at harvest (cm)			Dry matter accumulation at 30 DAS (g/plant)			Dry matter accumulation at 60 DAS (g/plant)			Dry matter accumulation at 90 DAS (g/plant)		
	2019–20	2020–21	Pooled	2019–20	2020–21	Pooled	2019–20	2020–21	Pooled	2019–20	2020–21	Pooled	2019–20	2020–21	Pooled	2019–20	2020–21	Pooled
<i>Irrigation levels (I)</i>																		
I ₁	29.7	30.1	29.9	121.5	122.3	121.9	156.6	150.4	153.5	7.40	8.03	7.71	19.1	20.1	19.6	30.5	31.4	30.9
I ₂	31.5	32.0	31.8	138.4	139.4	138.9	179.5	174.3	177.9	7.70	8.33	8.01	23.4	25.4	24.4	35.7	37.4	36.5
I ₃	31.9	32.4	32.2	136.2	137.4	136.8	176.2	172.4	174.3	7.33	7.97	7.65	21.0	22.6	21.8	32.3	33.7	33.0
SEm±	0.72	0.72	0.51	3.02	3.17	2.19	3.87	4.14	2.84	0.18	0.18	0.13	0.52	0.54	0.37	0.74	0.86	0.57
LSD (P≤0.05)	NS	NS	NS	12	12	7	15	16	9	NS	NS	NS	2.02	2.10	1.21	2.91	3.39	1.85
<i>Nitrogen management (N)</i>																		
N ₁	31.4	31.8	31.6	121.7	121.4	121.5	161.7	155.7	157.7	7.41	7.97	7.69	19.4	20.9	20.1	31.1	32.3	31.7
N ₂	30.5	31.1	30.8	128.0	128.9	128.5	164.4	157.6	161.0	7.26	7.95	7.60	19.7	21.4	20.6	31.7	32.9	32.3
N ₃	30.5	31.9	30.7	135.9	137.1	136.5	177.3	172.0	174.6	7.69	8.23	7.96	22.1	23.8	22.9	33.7	35.1	34.4
N ₄	31.8	32.2	32.0	142.1	143.5	142.8	181.0	177.9	179.2	7.73	8.42	8.08	23.1	25.2	24.1	34.5	35.9	35.3
N ₅	31.1	31.6	31.3	133.6	134.6	134.1	171.7	166.9	168.8	7.31	7.97	7.64	21.5	22.2	21.8	33.1	34.3	33.7
SEm±	0.69	0.69	0.49	3.51	3.77	2.58	3.53	3.76	2.58	0.18	0.19	0.13	0.51	0.54	0.37	0.65	0.82	0.52
LSD (P≤0.05)	NS	NS	NS	10	11	9	10	11	7	NS	NS	0.37	1.50	1.56	1.06	1.91	2.39	1.49
Interaction (I × N)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Treatment details are given under Materials and Methods.

Table 2 Effect of irrigation scheduling and nitrogen management on Absolute Growth Rate and Crop Growth Rate of mustard

Treatment	AGR 0-30 DAS (g/day)		AGR 30-60 DAS (g/day)		AGR 60-90 DAS (g/day)		CGR 0-30 DAS (g/m ² /day)		CGR 30-60 DAS (g/m ² /day)		CGR 60-90 DAS (g/m ² /day)						
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21					
<i>Irrigation levels (I)</i>																	
I ₁	0.25	0.27	0.26	0.39	0.40	0.40	0.38	0.38	3.66	3.96	3.81	5.76	5.97	5.86	5.62	5.56	5.59
I ₂	0.26	0.28	0.27	0.52	0.55	0.41	0.40	0.41	3.80	4.11	3.96	7.75	8.42	8.09	6.10	5.92	6.01
I ₃	0.24	0.27	0.26	0.46	0.47	0.37	0.37	0.37	3.62	3.93	3.78	6.76	7.22	6.99	5.55	5.50	5.53
SEm±	0.01	0.01	0.004	0.01	0.01	0.01	0.01	0.01	0.09	0.09	0.06	0.20	0.21	0.14	0.11	0.17	0.10
LSD (P≤0.05)	NS	NS	NS	0.05	0.05	0.03	NS	0.02	NS	NS	NS	0.77	0.81	0.47	NS	NS	0.34
<i>Nitrogen management (N)</i>																	
N ₁	0.25	0.27	0.26	0.40	0.43	0.42	0.39	0.38	3.66	3.94	3.80	5.91	6.40	6.15	5.82	5.63	5.72
N ₂	0.24	0.26	0.25	0.42	0.45	0.43	0.40	0.38	3.58	3.92	3.75	6.16	6.66	6.41	5.91	5.70	5.80
N ₃	0.26	0.27	0.27	0.48	0.52	0.50	0.39	0.38	3.80	4.06	3.93	7.12	7.70	7.41	5.72	5.60	5.66
N ₄	0.26	0.28	0.27	0.51	0.56	0.54	0.38	0.36	3.82	4.16	3.99	7.59	8.28	7.94	5.62	5.33	5.48
N ₅	0.24	0.27	0.25	0.47	0.47	0.47	0.39	0.41	3.61	3.94	3.77	7.02	6.97	7.00	5.72	6.05	5.89
SEm±	0.01	0.01	0.003	0.02	0.02	0.01	0.03	0.04	0.09	0.09	0.06	0.27	0.29	0.20	0.47	0.56	0.37
LSD (P≤0.05)	NS	NS	0.01	0.05	0.06	0.04	NS	NS	NS	NS	0.18	0.79	0.83	0.56	NS	NS	NS
Interaction (I × N)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Treatment details are given under Materials and Methods.

Table 3 Effect of irrigation scheduling and nitrogen management on different growth indices of mustard

Treatment	Leaf area at 30 DAS (cm ²)			Leaf area at 60 DAS (cm ²)			Leaf area at 90 DAS (cm ²)			LAI at 30 DAS			LAI at 60 DAS			LAI at 90 DAS		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
<i>Irrigation levels (I)</i>																		
I ₁	295	302	299	775	793	784	590	608	599	0.66	0.67	0.66	1.72	1.75	1.73	1.30	1.34	1.33
I ₂	311	318	314	986	1014	1000	786	811	798	0.69	0.70	0.70	2.18	2.24	2.21	1.73	1.79	1.76
I ₃	315	321	318	856	878	867	647	668	657	0.70	0.72	0.70	1.90	1.94	1.91	1.43	1.48	1.45
SEm±	6	8	5	19	23	15	19	17	13	0.01	0.01	0.01	0.04	0.04	0.03	0.04	0.04	0.03
CD (P=0.05)	NS	NS	NS	76	89	49	73	67	41	NS	NS	NS	0.11	0.13	0.07	0.11	0.10	0.06
<i>Nitrogen management (N)</i>																		
N ₁	290	295	292	812	831	822	614	632	623	0.64	0.66	0.64	1.79	1.84	1.82	1.36	1.40	1.37
N ₂	302	309	306	843	867	855	647	669	658	0.67	0.69	0.67	1.87	1.91	1.90	1.43	1.48	1.45
N ₃	316	323	319	894	916	905	719	741	730	0.70	0.72	0.70	1.99	2.03	2.00	1.60	1.64	1.61
N ₄	320	328	324	930	958	944	725	751	738	0.70	0.73	0.72	2.06	2.12	2.09	1.60	1.66	1.63
N ₅	308	313	310	882	904	893	667	685	676	0.69	0.69	0.69	1.96	2.00	1.97	1.48	1.51	1.49
SEm±	7	7	5	17	23	14	17	16	12	0.01	0.01	0.01	0.04	0.04	0.03	0.04	0.03	0.03
CD (P=0.05)	NS	NS	NS	50	67	41	50	47	33	0.04	0.04	0.03	0.10	0.15	0.09	0.10	0.10	0.07
Interaction (I × N)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Treatment details are given under Materials and Methods.

and number of metabolic processes occurring in the plant which enhances plant shoot growth.

Effect of nitrogen management: The nitrogen (N) management options, significantly influenced the height of plant at 60 DAS and at harvest (Table 1). At every crop growth stage N_4 treatment reported taller plants compared to nitrogen management levels however remained on par with N_3 and N_5 treatments at 60 DAS and at harvest in both years, on pooled basis they are on par with N_3 . Treatment N_1 reported shorter plants. Application of 50% RDN through chemical fertilizer + 50% RDN through vermicompost had enhanced plant height which might be quite obvious due to simultaneous supply of macro as well as micro nutrients through organic and inorganic sources, which improve soil physical and biological properties. Thus, favorable influence of nutrients to produce larger cells with thinner cell walls increased cell division and cell elongation process, which ultimately increased the plant height. The present result can be comparable with study of Kumar *et al.* (2018).

Similarly, DMA of mustard reported a significant influence at 30 DAS (pooled basis), 60 and 90 DAS during individual years and when data was pooled (Table 1). Significantly higher accumulation of dry matter at 60 and at 90 DAS was found in N_4 , however N_2 accumulated lowest dry matter at 30 DAS and under N_1 at 60 and 90 DAS. Pooled data showed that increment of dry matter under N_4 was by 5.9%, 9.6% and 11.3% at 30, 60 and 90 DAS respectively as compared to lowest values (N_2 at 30 DAS and N_1 at 60 and 90 DAS, respectively). Higher DMA in treatment receiving 50% RDN through chemical fertilizer + 50% RDN through vermicompost might be attributed to combined application of both vermicompost along with chemical fertilizer which accelerated the microbial activity, the availability of the native nutrients, nutrients uptake and nutrient use efficiency which enhances plant metabolic processes, dry matter accumulation through photosynthesis ultimately resulting in higher plant growth and development. The results can be supported by findings of Lepcha *et al.* (2015).

Nitrogen management treatments had significantly enhanced the AGR and CGR values of mustard during 0–30 DAS (pooled) and 30–60 DAS (Table 2). The increase in growth rate in terms of AGR and CGR was observed during 0–60 DAS then it started to decline. Statistically AGR and CGR values were significantly higher in treatment N_4 at 0–30 DAS (pooled) and at 60 DAS. Reddy and Singh (2018) also reported the similar results. The enhanced AGR and CGR values with 50% RDN through chemical fertilizer + 50% RDN through vermicompost treatment that is combination of inorganic and organic fertilizer treatment could be due to higher growth and DMA at early stage of mustard due to fast and easy supply of nitrogen from urea, optimum and constant release from vermicompost throughout growth period.

Application of N through both chemical fertilizer and organic source significantly given higher leaf area and

Index, lower values are found with application of 100% RDN through chemical fertilizer (Table 3). Our results are in agreement with the results of Mondal *et al.* (2015). Inorganic and organic combination resulted adequate and balanced nitrogen supply by greater mobilization to growing parts at the initial stage which enhanced photosynthesis, higher levels of auxin, metabolic activity and cell division leading to synthesizing more food in the leaves which due to leaf expansion number of leaves ultimately higher leaf area LAI.

The two years of experiment indicates that the growth and development of mustard in term of plant height, dry matter accumulation, leaf area, LAI, AGR and CGR could be significantly increased with scheduling of irrigation at 0.8 IW/CPE ratio and 50% RDN through chemical fertilizer + 50% RDN through vermicompost. Thus providing good quality irrigation water at proper time and optimum quantity in conjunction with supply of ample of nutrients at the crop required stage will augment the crop vegetative growth in turn help in increment of plant yield attributes and yield. Proper nutrient supply and source will help in maintenance of soil fertility and soil health. Hence these irrigation and N management practices may help to enhance the growth and productivity of mustard crop in long run.

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