



Effect of nutrient management in various irrigation schedules on water and nutrient use efficiency in mustard

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ABSTRACT: A field experiment was conducted at R.B.S. College, Bichpuri, Agra during the crop season of 2021-22 and 2022-23 to study the effect of irrigation schedules and nutrient management on water and nutrient use efficiency in Indian mustard (*Brassica juncea* var. RH-725). The experiment was carried out in split plot design with three replications. The treatments consisted of three schedules of irrigation in the main plots and four nutrient management practices in sub-plots. The results showed that, irrigation applied treatments consume more water during the crop period as compared to no irrigated treatment and maximum water use efficiency ($8.90 \text{ kg ha}^{-1} \text{ mm}^{-1}$) was achieved in one irrigation applied at 35 DAS stage, which was significantly higher than two irrigations applied at 35 & 60 DAS stages. The successive increase in nutrients levels from 50% to 100% NPKS significantly improved the water use efficiency which is inversely related in case of nutrient use efficiency. The crop sown with two irrigations at 35 and 60 DAS and application of 50% NPKS + 1% foliar spray of thio urea at flowering stage observed significantly maximum nutrient use efficiency ($21.55 \text{ kg seed kg nutrients}^{-1}$) over rest of the other treatment combinations.

Key words: Irrigation schedules, nutrient use efficiency, thio urea, water use efficiency.

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I. INTRODUCTION

Indian mustard [*Brassica juncea* (L.) Czern & Coss.] is an important *rabi* oilseed crop of Chambal region i.e. northern Madhya Pradesh and adjoining Rajasthan and Utter Pradesh which grown in various sequences under rainfed as well as limited irrigated conditions. Mustard crop needs approx 200 to 400 mm of irrigation water. At critical periods, the crop is extremely vulnerable to water stress. The most critical stages of irrigation in mustard farm are the pre-flowering stage and siliquae formation stage which needs 15% soil moisture by volume in the root zone. Water-use efficiency can be improved with balanced and proper nutrition and applying irrigation at proper crop stage. Irrigation at maximum branching and pod development stages has given yield gains of 25- 70%. Among these two, pod development stage was found most critical and irrigation at this stage gives higher yields [1]. Irrigation scheduling or frequency has effect on the yield parameters and as well quality parameters of any crop. Therefore, a suitable irrigation schedule is needed to avoid high or recurrence of water system and how much water is required which is upon such factors as soil texture or type, cultivar, season, precipitation rate and illnesses. Lower and higher supply of water through irrigation both results affect the production because water use efficiency with its frequency play an important role in mustard crop production. After irrigation, nutrients application in form of chemical fertilizers is the second most important input for crop growth and development [2]. There are many reports that fertilizers enhance water productivity, but the efficacy of fertilizers depends on the availability of soil moisture. Water stress and nutrient deficiency are two major constraints that influence rapeseed and mustard crop production under semi-arid regions of Northern India One of the primary constraints for low productivity of rapeseed and mustard is the unavailability of adequate irrigation water. Irrigation and nutrient application are fundamentally linked, with optimal levels of both boosting water use efficiency (WUE) and nutrient use efficiency (NUE) by ensuring nutrients are available when and where plants need them, preventing losses like leaching, and improving overall yield; however, too much water or fertilizer can decrease efficiency, making precise, coordinated management crucial. It is well-known that there is a positive correlation among irrigation, fertilizer application and the

productivity of the crop. Keeping in view the present study was carried out with different nutrient management practices in various irrigation schedules.

II. MATERIALS AND METHODS

The experiment was conducted during rabi season of 2021-2022 and 2022-23 at, Raja Balwant Singh College research Farm Bichpuri, Agra (U. P.). The experimental soil was coarse in texture (sandy loam) with pH 7.9 and organic carbon 4.29 g kg⁻¹. Available N, P, K and S were 185.0, 16.3, 232.4 and 16.8 kg ha⁻¹, respectively. The experiment was laid out in split plot design with three replications and twelve treatment combinations in which three irrigation scheduling (i.e. no irrigation, one irrigation at 35 DAS, two irrigation at 35 and 60 DAS stages) constituted in main plot and four nutrient management treatments (control, 50% NPKS+ foliar spray of 1% Thio urea at 45 DAS, 75% NPKS+ foliar spray of 1% Thio urea at 45 DAS and 100% NPKS) in sub plot. The seed of mustard variety RH-725 @ 5 kg/ha was used for sowing in the experiment. The sowing was done in rows at 40 cm apart behind the proper field preparation. The experimental mustard crop was fertilized uniformly with 80 kg N, 40 kg P₂O₅, 20 kg K₂O and 30 kg S /ha through urea, DAP, MOP and bentonite sulphur, respectively. Half dose of the nitrogen along with full dose of phosphorous, potash and sulphur was applied at the time of sowing as basal. The remaining dose of nitrogen was top dressed after first irrigation at 35 days after sowing of the crop. Thinning was done after two weeks of sowing to maintain plant to plant spacing of 10 cm. during cropping period, total rainfall received was more (126.8 mm) during first year (2021-22) as compared (84.7 mm) to second year (2022-23). The nutrient use efficiency in kg seed per kg nutrient was calculated by dividing the seed yield with the respective nutrient applied of the crop and water use efficiency (WUE) in kg ha⁻¹ mm⁻¹ was calculated by dividing the seed yield with the respective total consumptive use of water during the crop period.

III. RESULT AND DISCUSSION

3.1: Consumptive use of water

Data presented in table 1 revealed that the consumptive water use was higher in irrigated treatments as compared to no irrigated treatment. Mean data revealed that irrigation applied treatments consume higher water during the crop period as compared to no irrigated treatment. The effect of irrigation scheduling on consumptive use of water increased with increasing number of irrigation up to two and maximum value was noted with two irrigation at 35 & 60 DAS treatment which was higher as compared to one irrigation at 35 DAS treatment. This was expected because irrigation increased the available water in the soil profile under two irrigations and evaporation was at potential rate due to availability of more the soil moisture than the crop irrigated only at one time. [3] and [4]. Different nutrient management practices show difference in consumptive use of water and was it found in the range of 251.32 to 258.27 and 246.40 to 253.56 mm during Ist and IInd years of experimentation. It is clear from results that increasing the levels of NPKS from 50 to 100 % increased the value of consume water and maximum was observed with 100% NPKS treatments. (Table-1).

3.2: Water use efficiency

Maximum water use efficiency (6.40 kg ha⁻¹ mm⁻¹) was achieved in one irrigation applied at 35 DAS stage, which was higher than two irrigations applied at 35 & 60 DAS stages, mainly due to conservative water use, which indicates the efficient water use at lower frequency of irrigation. The increase in evapo-transpiration and infiltration losses due to more water application might be the owing to increasing number of irrigation resulted in to higher consumptive use the probably the increase in seed yield was more as the compared to amount of water used for total biomass production which might have increased water use efficiency under one irrigation at 30-35 DAS as compared two irrigations. These results are in consonance with those of [3] and [5],

It is clear from results (Table 2) that the successive increase in nutrients levels from 50% to 100% NPKS significantly improved the water use efficiency. Highest WUE (6.84 kg ha⁻¹ mm⁻¹) were seen with 100% NPKS. The superiority of this treatment over rest of the treatments might be the ascribed to higher seed yield coupled with more proportionate increase in seed yield due to higher availability of the major nutrients to crop under 100% NPKS and improved transpiration efficiency. These results are in close conformity with those of [6] and [7].

3.3: Nutrient use efficiency:

Data on efficiency parameters (Table-2) revealed that irrigation applied treatments show significantly higher nutrient use efficiency as compared to no irrigated treatment. Maximum value (12.75 kg seed kg nutrients⁻¹) of NUE was noted with two irrigation at 35 & 60 DAS treatment which was statistically higher as compared to one irrigation at 35 DAS and no irrigation treatment. Application of one irrigation at 35 DAS also observed significantly higher nutrient use efficiency as compared to no irrigated treatment. This result was partially close with the findings of [7].

Different nutrient management practices treatment show significant difference in nutrient use efficiency and increasing the levels of NPKS from 50 to 100 % decreased the nutrient use efficiency significantly and maximum value was observed with 50% NPKS + 1% foliar spray of thio urea treatment which is inversely related. This may be attributed to losses of nutrients in form of leaching and fixation at higher levels and therefore to the fact that yield of mustard did not increase with the same proportion as the nutrient application. These results are in conformity with those of [8], and [9] .

3.4: Interaction effect of irrigation scheduling and nutrient management practices on NUE

Nutrient use efficiency was observed in the range of 0.00 to 21.55 kg seed kg nutrients⁻¹ under different treatment combinations of irrigation scheduling and nutrient management practices treatment (Table-3) in which under each irrigation schedule, application of 50% NPKS + 1% foliar spray of thio urea at flowering stage (F₂) resulted higher nutrient use efficiency over 75% NPKS + 1% foliar spray of thio urea and 100% NPKS treatments. Similarly, under each nutrient management practice, two irrigations at 35 and 60 DAS produced significantly higher nutrient use efficiency as compared to other irrigation schedule at 35 DAS. Thus, the crop sown with two irrigations at 35 and 60 DAS and application of 50% NPKS + 1% foliar spray of thio urea at flowering stage (I₂ X F₂) observed significantly maximum nutrient use efficiency (21.55 kg seed kg nutrients⁻¹) over rest of the other treatment combinations.

IV. CONCLUSION:

On the basis of experimental findings it is clear that irrigation applied treatments consume more water during the crop period as compared to no irrigated treatment and maximum water use efficiency (6.84 kg ha⁻¹ mm⁻¹) was achieved in one irrigation applied at 35 DAS stage, which was significantly higher than two irrigations applied at 35 & 60 DAS stages. The successive increase in nutrients levels from 50% to 100% NPKS significantly improved the water use efficiency which is inversely related in case of nutrient use efficiency.

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Table- 1: Effect of different treatments on total water use by mustard

Treatments	Soil water storage (mm)						Irrigation applied* (mm)		Rainfall (mm)		Total water use (mm)	
	Before sowing		After harvest		Soil water available							
	A		B		C=(A-B)		D		F		G= C+D+F	
	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23

Irrigation schedules (I)												
I ₀ : No irrigation	51.62	89.04	20.86	22.67	72.48	111.71	0.0	0.0	126.8	84.7	199.28	196.41
I ₁ : One irrigation (At 35 DAS)	51.62	89.04	29.12	28.64	80.74	117.68	50.0	50.0	126.8	84.7	257.54	252.38
I ₂ : Two irrigations (At 35 & 60 DAS)	51.62	89.04	30.08	30.02	81.70	119.06	100.0	100.0	126.8	84.7	308.5	303.76
Mean	51.62	89.04	26.69	27.11	78.31	116.15	50.0	50.0	126.8	84.7	255.11	250.85
Nutrient management (F)												
F ₁ : Control	51.62	89.04	22.9	22.66	74.52	111.7	50.0	50.0	126.8	84.7	251.32	246.4
F ₂ : 50% NPKS + Thio urea (1%)	51.62	89.04	26.24	26.18	77.86	115.22	50.0	50.0	126.8	84.7	254.66	249.92
F ₃ : 75% NPKS + Thio urea (1%)	51.62	89.04	27.77	29.82	79.39	118.86	50.0	50.0	126.8	84.7	256.19	253.56
F ₄ : 100% NPKS	51.62	89.04	29.85	29.78	81.47	118.82	50.0	50.0	126.8	84.7	258.27	253.52
Mean	51.62	89.04	26.69	27.11	78.31	116.15	50.0	50.0	126.8	84.7	255.11	250.85

Table - 2 : Effect of Irrigation scheduling and nutrient management on nutrient and water use efficiency in mustard

Treatment	Nutrient use efficiency (kg seed / kg nutrient)			Water use efficiency (kg ha ⁻¹ mm ⁻¹)		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
Main Treatments - Irrigation scheduling (I)						
I ₀ : No irrigation	7.78	7.47	7.63	5.79	5.70	5.75
I ₁ : One irrigation (At 35 DAS)	10.60	11.26	10.93	6.17	6.64	6.40
I ₂ : Two irrigations (At 35 and 60 DAS)	12.61	12.88	12.75	6.11	6.32	6.22
S.E m.±	0.22	0.24	0.16	0.07	0.12	0.07
C.D. (5%)	0.88	0.94	0.54	0.26	0.47	0.22
Sub-plot treatment - Nutrient management (F)						
F ₁ : Control	0.00	0.00	0.00	4.84	4.97	4.91
F ₂ : 50% NPKS+ foliar spray of Thio urea (1%) at flowering stage	18.03	18.36	18.19	6.02	6.19	6.10
F ₃ : 75% NPKS+ foliar spray of Thio urea (1%) at flowering stage	13.17	13.37	13.27	6.53	6.74	6.64
F ₄ : 100% NPKS	10.13	10.42	10.27	6.70	6.99	6.84
S.E m.±	0.17	0.23	0.17	0.11	0.11	0.09
C.D. (5%)	0.50	0.68	0.50	0.32	0.32	0.26
Interaction (I x F)	S*	S*	S*	NS	NS	NS

Table 3: Interaction effect of irrigation scheduling and nutrient management on nutrient use efficiency in mustard (pooled basis)

Nutrient management	Irrigation scheduling (I)			
	I ₀ : No irrigation	I ₁ : One irrigation at 35 DAS	I ₂ : Two irrigations at 35 & 60 DAS	F- Mean
F ₁ : Control	0.00	0.00	0.00	0.00
F ₂ : 50% NPKS + Thio urea (1%)	13.66	19.37	21.55	18.19
F ₃ : 75% NPKS + Thio urea (1%)	9.52	13.75	16.55	13.27
F ₄ : 100% NPKS	7.33	10.60	12.89	10.27
I - Mean	7.63	10.93	12.75	
	F within I (F x I)		I within F (I x F)	
S.E m.±	0.25		0.30	
C.D. (5%)	0.70		0.88	