



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
NAAS Rating (2026): 5.20
www.agronomyjournals.com
2026; 9(6): 1252-1255
Received: 11-04-2026
Accepted: 14-05-2026

Madan Mohan Dandotiya
School of Agriculture Science,
Vikrant University, Gwalior,
Madhya Pradesh, India

Sachin Kumar Singh
Professor and Dean, School of
Natural and Applied Science,
Vikrant University, Gwalior,
Madhya Pradesh, India

Hirdesh Kumar
Professor and Dean, School of
Natural and Applied Science,
Vikrant University, Gwalior,
Madhya Pradesh, India

Arun Sahu
Professor and Dean, School of
Natural and Applied Science,
Vikrant University, Gwalior,
Madhya Pradesh, India

Arun Yadav
Professor and Dean, School of
Natural and Applied Science,
Vikrant University, Gwalior,
Madhya Pradesh, India

Naveen Kumar Singh
Professor and Dean, School of
Natural and Applied Science,
Vikrant University, Gwalior,
Madhya Pradesh, India

Corresponding Author:
Madan Mohan Dandotiya
School of Agriculture Science,
Vikrant University, Gwalior,
Madhya Pradesh, India

Effect of irrigation and fertilizer on yield and water use efficiency in mustard (*Brassica juncea* L.) on alluvial soil of Madhya Pradesh

Madan Mohan Dandotiya, Sachin Kumar Singh, Hirdesh Kumar, Arun Sahu, Arun Yadav and Naveen Kumar Singh

DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i6p.5859>

Abstract

A field experiment was conducted at experimental farm, Agriculture Research and Development Centre Sakatpura Gwalior, (Madhya Pradesh), during *Rabi* season of 2025-26 on alluvial soil to study the effect of irrigation and fertilizer on yield and water use efficiency in mustard. The experiment was laid out in split plot design with three replications. The treatments consisted of three irrigation schedules in main plots and four different doses of fertilizers in sub-plots. The results showed that, irrigated treatments show significantly higher growth and yield parameters as compared to no irrigation treatment and its trend under various irrigation scheduling were in increasing order as no irrigation < one irrigation at branching stage < two irrigations at branching and siliqua formation stage. Application of NPKS at different levels (50, 75 and 100%) with foliar spray of 1% ZnSO₄ at flowering stage recorded significantly higher yield and water use efficiency as compared to control treatment. In case of nutrient use efficiency the trend was reverse and maximum use efficiency was observed with 50% NPKS + 1% foliar spray of zinc sulphate treatment.

Keywords: Irrigation, Mustard, NPKS, zinc sulphate and water use efficiency.

Introduction

The rapeseed-mustard production was 72.41 million tones during 2022–23 in the global which contributing 12.1% to the total oilseed output, with cultivation spanning 67 countries across continents (FAOSTAT, 2023) ^[4]. India plays a crucial role, ranking 2nd in area and 3rd in productivity, contributing 27.8% to its oilseed industry despite an average yield of 12.58 q ha⁻¹, below the global 19.96 q ha⁻¹. (Indian Ecological Society, 2023). Mustard crop grown on alluvial soil under rainfed as well as limited irrigated conditions. Water stress can affect growth, development and physiological processes of the plant which can reduce biomass and ultimately grain and oil yield due to reduction of number and size of the seeds. Crops receiving only two irrigations at pre-flowering and pod-filling stages produced 33% more seed than non-irrigated crops. Increase in the amount of water supply by increasing the number of irrigations augmented the leaf water potential, stomatal conductance, light absorption, and leaf area index (LAI) which ultimately increased growth and yield attributes (Garnayak *et al.*, 2000 and Ray *et al.*, 2015) ^[5, 12] of mustard crop. 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 levels under various irrigation schedules.

Materials and Methods

The field experiment was conducted at experimental farm, Agriculture Research and Development Centre Sakatpura Gwalior, (Madhya Pradesh), during *Rabi* season of 2025-26. The soil was sandy clay loam in texture with normal pH 7.88. Status of soil organic carbon and available Nitrogen is

low whereas available phosphorus and potassium found in medium category. The experiment was laid out in Split plot design in which three main treatments of irrigation and four sub treatments of fertilizers levels in three replication. The experimental crop was sown (DRMR IJ-31 -Giriraj) with a seed rate of 5 kg per ha and row spacing of 40 cm were maintained. Recommended doses of fertilizers were 80 kg N, 40 kg P, 20 kg K and 30 kg S per ha. Full dose of Phosphorus, potassium & sulphur and half dose of nitrogen were applied at basal dose. Remaining half dose of nitrogen was top dressed after 1st irrigation. Yield parameters were recorded at harvest and harvest index was computed with the ratio of economic yield to the total biological yield. Economical parameters were calculated by appropriate formula as per current market rates. 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. Whereas water use efficiency in kg ha⁻¹ mm⁻¹ was calculated by dividing the seed yield with the respective total consumptive water use for the crop period.

Results and Discussion

Effect of irrigation and fertilizers on growth and yield attributes parameters

The crop grown with irrigated treatments show significantly higher value of all growth parameters and yield attributes parameters as compared to no irrigation treatment (Table-1). The trend in these parameters under various irrigation scheduling were in descending order as two irrigation at branching (30-35 DAS) & silique formation stage > one irrigation at branching (30-35 DAS) stage > no irrigation. Maximum value was recorded with two irrigation which was significantly higher with one irrigation

treatment. Irrigation application might have increased the availability of nitrogen to the plant at early growth stages and nitrogen being an essential constituent of nucleic acid, protoplasm and protein, play a fundamental role in metabolism, growth, development, reproduction and transmission of heritable characters, so the number of secondary branches also increased by this condition under irrigation regime. These results were in conformity with those of Kumar and Dhillon (2023) ^[6].

Application of NPKS at different levels (50, 75 and 100%) along with foliar spray of 1% ZnSO₄ at flowering stage recorded significantly higher growth and yield attributes parameters as compared to control treatment. Maximum value was noted with 100% NPKS+ foliar spray of 1% ZnSO₄ at flowering stage treatment which was significantly higher over 50 & 75% NPKS + foliar spray of 1% ZnSO₄ at flowering stage. Such improvement in growth and yield attributes parameters was owing to increased availability of nutrients. Several workers have reported the positive response of mustard with fertilizer application (Reager *et al.*, 2006, and Bharti *et al.* 2022) ^[13, 2].

Effect of irrigation and fertilizers on yield parameters

It is clear from results (table-2) that irrigated treatments show significantly higher seed yield as compared to no irrigation treatment and its trend was in increasing order as no irrigation < one irrigations < two irrigations. Maximum seed yield (1846.2 kg ha⁻¹) was observed with treatment of two irrigations at branching and silique formation stage which was 18.48 and 65.46 per cent significantly higher as compared to one irrigation at branching and no irrigation treatments, respectively. Treatment of one irrigation also recorded 39.66 per cent significantly higher seed yield as compared to no irrigation treatment.

Table 1: Effect of irrigation and nutrient management on growth and yield attributes parameters at harvest of mustard

Treatments	Growth parameters		Yield attributes parameters			
	Plant height (cm)	Number of branches	Number of siliquae (plant ⁻¹)	Length of siliquae (cm)	Number of seeds (Siliqua ⁻¹)	Weight of seeds (g plant ⁻¹)
Main plot treatments: Irrigation scheduling (I)						
I ₀ : No irrigation	193.64	22.11	171.4	4.59	10.78	10.14
I ₁ : One irrigation: At branching stage (35-40 DAS)	199.80	23.81	257.0	4.99	11.74	10.95
I ₂ : Two irrigations: At branching and silique formation stage	206.18	24.26	293.4	5.43	12.39	11.82
S.E m.±	0.53	0.11	3.6	0.05	0.07	0.11
C.D. (5%)	2.09	0.44	14.2	0.18	0.26	0.42
Sub plot treatment: Fertilizer management (F)						
F ₁ : Control	188.94	21.53	187.1	4.36	10.67	9.60
F ₂ : 50% NPKS + foliar spray of 1% ZnSO ₄ at flowering stage	198.93	23.23	236.4	4.93	11.54	10.84
F ₃ : 75% NPKS + foliar spray of 1% ZnSO ₄ at flowering stage	203.90	24.00	263.8	5.25	11.99	11.51
F ₄ : 100% NPKS+ foliar spray of 1% ZnSO ₄ at flowering stage	207.72	24.83	275.0	5.48	12.35	11.93
S.E m.±	1.13	0.24	3.7	0.06	0.11	0.10
C.D. (5%)	3.35	0.71	10.9	0.19	0.33	0.29

Table 2: Effect of irrigation and nutrient management on yield, quality and efficiency parameters in mustard

Treatments	Yield parameters		Quality parameters		Efficiency parameters	
	Seed yield (kg ha ⁻¹)	Stover yield (kg ha ⁻¹)	Oil content (%)	Oil yield (kg ha ⁻¹)	Nutrient use efficiency (kg seed / kg nutrient)	Water use efficiency (kg ha ⁻¹ mm ⁻¹)
Main plot treatments: Irrigation scheduling (I)						
I ₀ : No irrigation	1115.8	2859.2	40.66	453.86	7.49	9.16
I ₁ : One irrigation: At branching stage (35-40 DAS)	1558.3	3802.9	41.17	642.37	10.58	9.40
I ₂ : Two irrigations: At branching and silique formation stage	1846.2	4073.2	41.30	763.72	12.63	8.61
S.E m.±	29.5	47.9	0.09	12.73	0.26	0.13
C.D. (5%)	115.8	188.1	0.35	49.96	1.01	0.51

Sub plot treatment: Fertilizer management (F)						
F ₁ : Control	1096.7	2954.8	40.63	445.93	0.00	6.69
F ₂ : 50% NPKS + foliar spray of 1% ZnSO ₄ at flowering stage	1470.6	3527.4	41.02	603.81	17.30	8.88
F ₃ : 75% NPKS + foliar spray of 1% ZnSO ₄ at flowering stage	1672.2	3845.9	41.20	689.99	13.12	10.00
F ₄ : 100% NPKS + foliar spray of 1% ZnSO ₄ at flowering stage	1787.8	3985.6	41.33	740.20	10.52	10.67
S.E m.±	20.7	75.7	0.09	7.83	0.19	0.14
C.D. (5%)	61.6	225.0	0.27	23.27	0.58	0.40

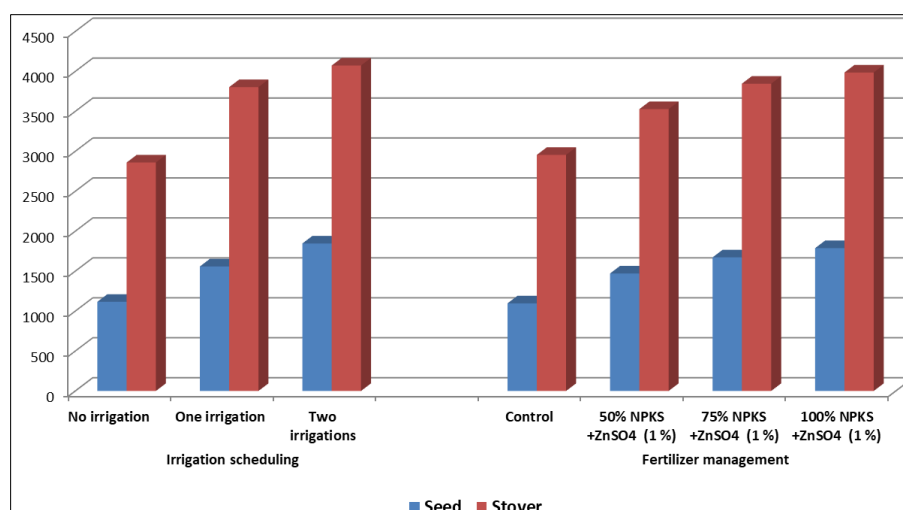


Fig 1: Seed and stover yield (kg ha⁻¹) of mustard as influenced by irrigation and fertilizer management

The significant improvement in the mustard seed yield might be the cumulative effect of significant improvement in the value of yield attributes like number of siliquae per plant, number of seeds/silique and test weight. Bharati and Prasad (2002) [1] and Piri *et al.* (2019) [10] also reported an increase in seed yield of mustard due to irrigation. Similar trend was also noted in stover yield of mustard. Under different nutrient management, maximum seed yield (1787.8 kg ha⁻¹) was noted with 100% NPKS + foliar spray of 1% ZnSO₄ at flowering stage treatment which was significantly higher as compared to other all other treatments. Similar trend was also noted in stover yield of mustard (Fig -1). The higher yield with 100% NPKS + foliar spray of 1% ZnSO₄ at flowering stage might be attributed to higher yield components like siliquae/plant, and test weight that improved with the application of sulphur through ZnSO₄ in this crop. Increase in seed yield with an increase in the rate of NPKS application has also been reported by Paliwal and Singh (2014) [9] and Meena *et al.* (2024) [8].

Effect of irrigation and fertilizers on quality parameters

Maximum oil content (41.30%) was observed with two irrigation treatment which was comparable with one irrigation treatment but both treatments show significantly higher oil content as compared to no irrigation treatment. Oil yield was also recorded the same pattern with different irrigation schedules treatment. This may be due to the fact that adequate supply of moisture helps in the greater uptake of nitrogen which in turn resulted in higher protein content in seed. These findings are in close conformity with the observations made by Kumar *et al.* (2022) [7]. In the case of different fertilizer treatment, oil content in mustard seed was found in the range of 40.63 to 41.33% and maximum value (41.33%) was found with 100% NPKS + foliar spray of 1% ZnSO₄ at flowering stage treatment but at par with 75% NPKS + foliar spray of 1% ZnSO₄ at flowering stage treatment. This may be because ZnSO₄ was found more efficient in increasing the oil content of the seeds possibly due to intensive participation of sulphur in glucoside synthesis. Application of ZnSO₄ to plants

enhanced the formation of acetyl co-enzyme- A, a precursor compound for the synthesis of long chain fatty acid resulting in increase in oil content which ultimately led to greater oil recovery. These findings are in close conformity with the observations made by Paliwal and Singh (2014) [9].

Effect of irrigation and fertilizers efficiency parameters

Nutrient use efficiency

Data on efficiency parameters (Table-2) revealed that irrigation applied treatments show higher nutrient use efficiency as compared to no irrigated treatment. Maximum nutrient use efficiency (12.63 kg seed kg nutrients⁻¹) noted with two irrigations at branching and silique formation stages which was statistically higher as compared to one irrigation and no irrigation. Application of one irrigation at branching stage also observed significantly higher nutrient use efficiency as compared to no irrigated treatment. This result was partially close with the findings of Yadav *et al.* (2010) [16]. It is clear from results (table-2) that increasing the levels of NPKS from 50 to 100% decreased the nutrient use efficiency significantly and maximum use efficiency was observed with 50% NPKS + 1% foliar spray of zinc sulphate treatment. 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 Yadav *et al.* (2010) [16] and Rakesh and Banik (2016) [11].

Water use efficiency

Under different irrigation schedule, water use efficiency was observed in the range of 8.61 to 9.40 kg ha⁻¹ mm⁻¹. Maximum water use efficiency (9.40 kg ha⁻¹ mm⁻¹) was achieved in one irrigation applied at branching stage, which was significantly higher with two irrigation applied at branching and silique formation stage 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 owing to increasing number of irrigation resulted into higher consumptive use probably the increase in seed yield was more as 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 Das and Ray (2003)^[3] and Shivran *et al.* (2018)^[15]. Maximum water use efficiency ($10.67 \text{ kg ha}^{-1} \text{ mm}^{-1}$) was found with 100% NPKS + foliar spray of 1% ZnSO_4 at flowering stage

which was significantly superior as compared to rest of other nutrient management treatments. The superiority of this treatment over rest of the treatments might be ascribed to higher seed yield coupled with more proportionate increase in seed yield due to higher availability of major nutrients to crop under 100% NPKS and improved transpiration efficiency. These results are in close conformity with those of Roul *et al.* (2006)^[14] and Yadav *et al.* (2010)^[16].

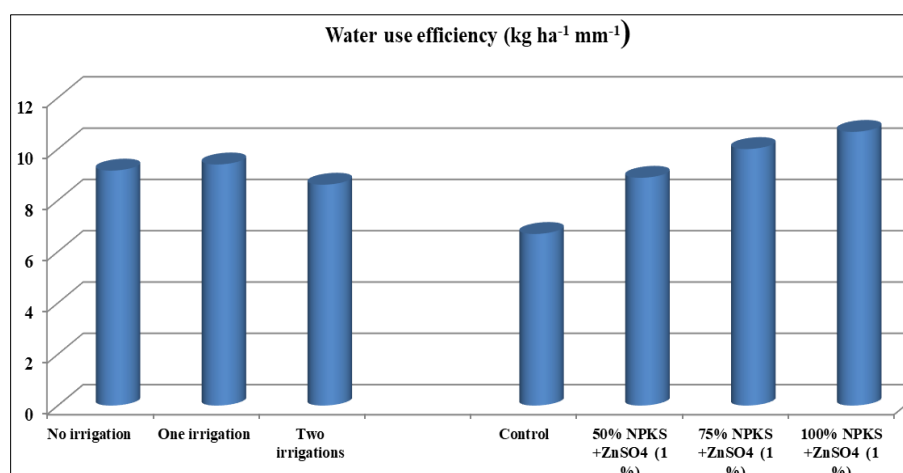


Fig 2: Water use efficiency in mustard as influenced by irrigation and fertilizer

Conclusion

The mustard crop grown with two irrigations at branching and siliqua formation stages along with the application of 100% NPKS + foliar spray of 1% ZnSO_4 at flowering stage produced maximum seed and oil yield as well as maximum water use efficiency in alluvial soil of Madhya Pradesh.

References

1. Bharati V, Prasad UK. Irrigation and sulphur on yield and nutrient uptake of Indian mustard. *Journal of Farming Systems Research and Development*. 2002;8(1):97-98.
2. Bharti V, Lal K, Prasad SS, Dwivedi DK, Kumar R, Chodhary CS. Assessment of nutrient and biofertilizers for productivity enhancement of Indian mustard (*Brassica juncea* L.). *The Pharma Innovation Journal*. 2022;11(5):1283-1287.
3. Das LK, Ray MR. Response of different irrigation schedules on consumptive use, water use efficiency and crop coefficient value of mustard crop. *Environment and Ecology*. 2003;21(1):143-145.
4. Food and Agriculture Organization of the United Nations. Global rapeseed-mustard production statistics 2022-23. FAOSTAT. 2023.
5. Garnayak LM, Singh NA, Singh S, Paikaray. Effect of irrigation and nitrogen on growth, yield and nutrient uptake by late-sown brassica oil seeds. 2000;45(2):371-378.
6. Kumar D, Dhillon BS. Effect of irrigation schedules on productivity, quality and water use of Indian mustard (*Brassica juncea*) under staggered sowing in Northwest India. *Indian Journal of Agronomy*. 2023;68(2):199-204.
7. Kumar Y, Ram Niwas, Dipak. Effect of irrigation and sowing time on growth and yield of Indian mustard (*Brassica juncea* L.) in central plain zone of U.P. *The Pharma Innovation Journal*. 2022;11(7):2143-2146.
8. Meena S, Shivran AC, Dhaker DL, Karthik R, Meena BR. Effect of irrigation scheduling and thiourea on productivity of Indian mustard [*Brassica juncea* (L.) Czern & Coss]. *Journal of Oilseeds Research*. 2024;41(3-4):161-167.
9. Paliwal A, Singh JP. Response of mustard to potassium with other nutrients on yield and quality. *The Bioscan*. 2014;9(2):649-652.
10. Piri MMN, Tavassoli A, Rastegaripour F. Effect of irrigation intervals and sulphur fertilizer on growth analyses and yield of *Brassica juncea*. *Advanced Journal of Microbiology Research*. 2019;13(5):1-7.
11. Rakesh S, Banik GC. Effect of sulphur levels and sources on growth, yield and quality of mustard in terai region of West Bengal. *Annals of Plant and Soil Research*. 2016;18(2):152-155.
12. Ray D, Bandhopadhyay P, Dutta D, Jana PK. Studies on growth, water use efficiency and crop coefficient of mustard under limited irrigation. *Research on Crops*. 2015;4(2):178-181.
13. Reager ML, Sharma SK, Yadav RS. Yield attributes, yield and nutrient uptake of Indian mustard (*Brassica juncea*) as influenced by nitrogen levels and its split application in arid western Rajasthan. *Indian Journal of Agronomy*. 2006;51(3):213-216.
14. Roul PK, Sarawgi SK, Shrivastava GK, Kumar D. Effect of integrated nutrient management techniques on productivity, nitrogen uptake, N use efficiency, economics and energetics of rice (*Oryza sativa*)-Indian mustard (*Brassica juncea*) sequence. *Indian Journal of Agronomy*. 2006;51(3):170-173.
15. Shivran H, Kumar S, Tomar R, Chauhan GV. Effect of irrigation schedules on productivity and water use efficiency in Indian mustard (*Brassica juncea* L.). *International Journal of Chemical Studies*. 2018;6(4):15-17.
16. Yadav RP, Tripathi ML, Trivedi SK. Yield and quality of Indian mustard (*Brassica juncea*) as influenced by irrigation and nutrient levels. *Indian Journal of Agronomy*. 2010;55(1):56-59.