

Original Research Article

EFFECT OF IRRIGATION SCHEDULING AT DIFFERENT PHENOLOGICAL PHASES ON GROWTH AND YIELD OF MUSTARD (*Brassica juncea* L.) IN NORTHERN TELANGANA

ABSTRACT

A field experiment was conducted during *rabi*, 2021-22 at Agricultural college, Jagtial to investigate the effect of irrigation scheduling at different phenological phases on growth and yield of mustard. The experiment was laid out in randomized complete block design with twelve treatments and replicated thrice. Treatments include two irrigations each at vegetative and flowering stage (T₁), two irrigations each at vegetative and silique development (T₂), two irrigations each at flowering and silique development (T₃), three irrigations each at vegetative, flowering and silique development (T₄), three irrigations each at vegetative, pre-flowering and silique development (T₅), three irrigations each at pre-flowering, silique initiation and silique development (T₆), four irrigations each at vegetative, pre-flowering, flowering and silique development (T₇), four irrigations each at vegetative, pre-flowering, flowering and silique initiation (T₈), four irrigations each at vegetative, pre-flowering, silique initiation and silique development (T₉), four irrigations each at pre-flowering, flowering, silique initiation and silique development (T₁₀), five irrigations each at vegetative, pre-flowering, flowering, silique initiation and silique development (T₁₁) and scheduling of irrigation at IW/CPE ratio of 1.0 (T₁₂). The results of the experiment revealed that maximum plant height (146), LAI (0.89), dry matter accumulation (416 g m⁻²), number of siliques plant⁻¹ (124), number of filled seeds silique⁻¹ (13.65), seed yield (1113 kg ha⁻¹) and stover yield (2224 kg ha⁻¹) were recorded with five irrigations each at vegetative, pre-flowering, flowering, silique initiation and silique development (T₁₁). However, it was on par with irrigation scheduled at IW/CPE ratio of 1.0 (T₁₂).

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Keywords: Mustard; irrigation scheduling; Dry matter accumulation; Seed yield

INTRODUCTION

Oilseeds are immensely significant to the Indian economy, contributing 5% of India's GDP and 10% of the value of agricultural products. Oilseeds are India's second most important agricultural commodity after grains, accounting for roughly 13.5 percent of the country's total cropped area [1]

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Mustard (*Brassica juncea* L.) belong to the family Cruciferae. The seed contains 40-45% oil and 20-25% protein. The seed and oil of mustard are used as a condiment in the preparation of pickles, flavoring curries and vegetables as well as for cooking and frying purposes. Mustard oil is utilised in a variety of industrial applications, while the oil cake is used as cattle feed and manure and the green leaves are used as a vegetable and green fodder [2]. Indian mustard has recently gained popularity among farmers due to its adaptability to both irrigated and rainfed environments, as well as its appropriateness for both single and mixed cropping. Furthermore, it provides a larger return because to its low production cost and low water consumption. It has a greater potential to boost the supply of edible oil from domestic production because it is a major winter season oilseed crop with the advantage of grown under stored soil moisture.

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Optimum crop yield is not possible without the timely application and right amount of irrigation water. Since rainfall during *rabi* is inadequate and unpredictable, mustard requires supplemental irrigation for its proper growth and development otherwise; the crop may suffer from water stress and reduce ultimately the yield[1]. Scheduling of irrigation during critical stages could boost the growth, yield and water productivity of mustard. Hence the present study was conducted to determine the performance of mustard under different irrigation schedules at phenological stages

2. MATERIALS AND METHODS

The current investigation was carried out at College Farm, Agricultural College, Jagtial, Professor Jayashankar Telangana State Agricultural University. The farm is geographically situated at 18° 50'37.0" N latitude and 78° 57'00.6" E longitude with an altitude of 243.4 m above mean sea level. The soil of the experiment field was sandy clay loam in texture. The cultivar under study was Pusa Mustard-25 at a seed rate is around 5kg ha⁻¹. The applied dose of fertilizer for the cultivar i.e., 135 N, 250 P₂O₅ and 65 K₂O kg ha⁻¹. Half of the nitrogen, entire P and K are applied as basal at the time of sowing, remaining nitrogen applied just before flowering stage.

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Plant height was measured from the base of the plant to the tip of the shoot before scheduling the irrigation and the average height was expressed in cm. Representative plant samples were collected from the border rows by the destructive sampling method and collected plant samples were shade dried for one day, discarding the roots, followed by oven drying at 60°C for 48 hours till a constant weight was attained. These dried samples are weighed and dry matter accumulation expressed in g m⁻². Leaf area is measured by using the “Biovis Leaf Area meter” at various growth stages and expressed as cm² plant⁻¹ then LAI was calculated by dividing leaf area with unit ground area. Tagged plants, which were utilised for recording the plant height were, additionally utilised for counting the number of siliquae plant⁻¹ present on branches and average siliquae plant⁻¹ at harvest was worked out. The mean number of seeds siliquae⁻¹ was calculated from twenty randomly chosen siliquae from five tagged plants were counted out of total siliquae. A thousand seeds were counted from the weighed sample and weight of 1000 seeds was recorded as the test weight. Plants from the net plot area (3.6 m X 3 m) were harvested, threshed, sun dried and winnowed separately. The yield obtained from each net plot was measured in grams and later converted to kg ha⁻¹.

The data obtained analysed statistically by Analysis of Variance utilizing Randomized Block Design [3]. Statistical difference (CD) will be tested by applying F test at 0.05 level of probability.

3. RESULTS AND DISCUSSION

3.1 PLANT HEIGHT (cm)

Observation of experimental data revealed that there was no significant difference in plant height when irrigation scheduled at vegetative stage (table 1). Plant height assumes significant part in the capture of light and sun-oriented radiation. Plant height is determined by cell division, cell enlargement and cell differentiation all of which requires sufficient water.

Plant height at flowering stage ranges from (56 to 85 cm). Treatment with 5 irrigations each at vegetative, pre-flowering, flowering, silique initiation and silique development (T₁₁) had the highest plant height (85 cm) and it was on par with treatments T₅ to T₁₂. While, the lowest plant height (56 cm) recorded in treatments with two irrigations each at flowering and silique development (T₃) in turn, it was on par with treatments provided two irrigations at vegetative and silique development (T₃) and two irrigations at vegetative and flowering stage (T₁).

Significantly higher plant height (140 cm) at silique development was observed in treatments when irrigation imposed at IW/CPE ratio of 1.0 which was on par with treatment (T₈ to T₁₁). The lower

plant height (97cm) was recorded in treatments provided with two irrigations at vegetative and siliqua development (T₂) due to moisture stress during flowering stage and siliqua stage which was on par with treatment (T₃) when irrigated each at flowering and siliqua development (107cm).

At harvest the highest plant height was seen in treatment with an IW/CPE ratio of 1.0 (T₁₂) in turn, it was on par with treatments (T₈ to T₁₁). While, the treatment with two irrigations each at vegetative and siliqua development (T₂) had the lowest plant height (102cm) which was on par with treatment (T₃) when irrigated each at flowering and siliqua development (Table 1).

The increased plant height with increasing number of irrigations might be due to increased water availability has caused progressive tissue initiation and cell expansion which may aided in nutrient mobilization and thereby making plant physiologically more active. Similar findings were reported with Yadav *et al.* [4], Mila *et al.*[5], Verma *et al.*[6], Chaudari *et al.*[7] and Rathore *et al.*[8].

3.2 LEAF AREA INDEX

Leaf area index increased progressively throughout different stages of the crop growth up to flowering, after which it began to decline. Mustard LAI growth trend might be linked to the plant's regular typical growth pattern, and the increase in LAI could be the consequence of the cumulative effect of increased leaf number and leaf growth as the plant ages. The decline in LAI was caused by the drying and fall of leaves when the senescence period began. Irrigation scheduled during vegetative has no significant different among treatments. It is evident from the data presented in Table 2.

When irrigation was set at an IW/CPE ratio of 1.0, a higher LAI (3.67) was observed during the flowering stage. However, it is at par with T₅, T₇, T₈, T₉, and T₁₁. Increased water availability at critical stages resulted in better nutrient uptake, cell growth and division, higher photosynthetic activity and thus resulted in superior growth indices. These results were in line with Puppala *et al.* [9].

While, two irrigations each at flowering and siliqua development (T₃) results in much lower LAI (2.01) which was on par with treatments (T₂) with two irrigations each at vegetative and flowering stages (2.33). Water shortages have notably repressed leaf development through decrease of relative leaf turgidity. Similar results were reported with Verma *et al.*[6] and Tamboli *et al.*[10].

3.3 DRY MATTER ACCUMULATION (g m^{-2})

After respiration and anabolic processes, photosynthates accumulate as dry matter. A perusal of data summarized in Table 3, showed a consistent increase in dry matter accumulation up to siliqua development and then at slower rate till harvest. Data collected on dry matter accumulation at vegetative stage had no significant difference between treatments.

At flowering stage, irrigation scheduling at 1.0 IW/CPE (T_{12}) resulted in significantly higher dry matter accumulation (46.23 g m^{-2}), which was on par with treatments ($T_5, T_7, T_8, T_9, T_{11}$) with 43.67, 42.38, 43.13, 42.67, 42.45 g m^{-2} respectively. Treatment with two irrigations at flowering and siliqua development (T_3) had lower dry matter accumulation (25.33 g m^{-2}) due to lack of water availability during vegetative stage, which resulted in protoplasm dehydration, which decreased turgor potential and turgor-driven physiological processes and it was on par with the treatment (T_3) provided two irrigations at vegetative and siliqua development (29.33 g m^{-2}).

Treatments with irrigation imposed at an IW/CPE ratio of 1.0 had significantly higher dry matter accumulation (336.27 g m^{-2}) at siliqua development, which was on par with treatment (T_{11}) provided with five irrigations each at vegetative, pre-flowering, flowering, siliqua initiation and siliqua development (333.33 g m^{-2}). While, lower dry matter accumulation (158.67 g m^{-2}) was attained in treatments provided with two irrigations at vegetative and siliqua development (T_2) due to moisture stress throughout flowering stage and siliqua initiation stage.

At harvest, dry matter accumulation ranges from (420.33 to 198.33 g m^{-2}), irrigation scheduling at IW/CPE ratio of 1.0 (T_{12}) results in significantly higher dry matter accumulation (420.33 g m^{-2}) and it was on par with treatments (T_{11}) with five irrigations each at vegetative, pre-flowering, flowering, siliqua initiation and siliqua development (416.67 g m^{-2}). It could be due to adequate and appropriate water supply to plants, which increased cell turgidity and cell enlargement as well as meristematic activity resulted in increased photosynthesis and bio mass accumulation. These results were in agreement with experimental findings of Puppala *et al.* (2019). While, the lowest dry matter (198.33 g m^{-2}) was observed in treatment that received two irrigation each at vegetative and siliqua development (T_2) due to devoid of water during flowering stage and siliqua initiation stage results in dehydration of protoplasm which results in decreased the turgor potential and turgor driven physiological processes such as cell division and cell elongation which affect the plant growth and eventually the total dry matter accumulation (Tyagi and Upadhyay [11]. Similar results were reported with Piri *et al.* [12], Verma *et al.* [13] and Rana *et al.* [14].

3.4 Yield attributes

Number of irrigations at different phenophases had a considerable impact on yield attributes of mustard (Table 4). Among the different irrigation scheduling treatments, highest number of siliqua plant⁻¹ (135.67), number of seed siliqua⁻¹ (13.88) in mustard were recorded with irrigation scheduled at 1.0 IW/CPE which in turn, on par with treatment (T₁₁) provided with 5 irrigations each at vegetative, pre-flowering, flowering, siliqua initiation and siliqua development stages (124.80 and 13.65 respectively). It is due to frequent irrigation application reduced water stress in the soils and generated a favourable environment for the plants in respect of water availability, providing congenial conditions for the growth and development of high number of siliqua plant⁻¹ and number of filled seeds siliqua⁻¹.

However, the highest test weight (5.65 g) was recorded with treatment (T₁₁) with five irrigations each at vegetative, pre-flowering, flowering, siliqua initiation and siliqua development stages. This might be due to higher photosynthesis and translocation of assimilates towards reproductive structures owing to adequate soil moisture. While, treatment (T₂) provided with two irrigations each at vegetative and siliqua development stage had lowest number of siliqua plant⁻¹ (63.00), number of filled seed siliqua⁻¹ (10.43) and test weight (4.46 g) which was on par with treatment (T₁) with two irrigations each at vegetative and siliqua development. These findings were in accordance with Shivran *et al.* [15], Yadav *et al.* [16], Tripathi *et al.* [17], Rayet *et al.* [18] and Nautilya *et al.* [19].

3.5 SEED YIELD

Yield is the result of coordinated interplay of growth characters and yield attributes. Significantly the highest seed yield (1143 kg ha⁻¹) was obtained with irrigation scheduled at IW/CPE ratio of 1.0 (T₁₂) which was on par with treatment (T₁₁) that received five irrigations each at vegetative, pre-flowering, flowering, siliqua initiation and siliqua development stages (1113 kg ha⁻¹) and the lowest seed yield (431 kg ha⁻¹) when irrigated twice each at vegetative and siliqua development. Data pertaining to seed and stover yield represented in Table 5.

Seed yield is the function of dry matter and yield attributes of plant which have increased dramatically as the number of irrigations increased. This could be because it also be linked to increased photosynthates and photosynthetic translocation to reproductive structures in the mustard crop's rhizosphere due to adequate soil moisture. Adequate supply of moisture in soil helps in proper utilization of plant nutrients, resulting in proper growth

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and high yield. Whereas, irrigation imposed each at vegetative and siliqua development produced the lowest plant height, filled siliqua plant⁻¹, number of seed siliqua⁻¹ and 1000-seed weight due to devoid of moisture throughout the flowering and siliqua initiation stage. These findings were in agreement with Hossain *et al.* [20], Dadich *et al.* [21], Singh and Thenua [22] and Shivran *et al.* [23].

3.6 STOVER YIELD

The stover yield grew substantially as number of irrigations increased. This rise was attributed to increased moisture availability, which resulted in a better nutritional environment during critical growth phases of the crop, resulting in improved vegetative growth. Irrigation with an IW/CPE ratio of 1.0 (T₁₂) resulted in the maximum stover output (2372 kg ha⁻¹) which was a par with treatment (T₁₁) in which imposed five irrigations each at vegetative, pre-flowering, flowering, siliqua initiation and siliqua development stage (2224 kg ha⁻¹). Lower stover yield noticed in treatment (T₂) when irrigation scheduled each at vegetative and siliqua development. It might be due to extended moisture stress during flowering period.

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UNDER PEER REVIEW

Table 1: Plant height(cm) of mustard as influenced by irrigation scheduling at different phenophases**Comment [A13]:** write down the data source and year

Treatments	Plant height (cm)			
	Vegetative	Flowering	Siliqua development	Harvest
T ₁ Two irrigations at Vegetative and Flowering stage	5.51	64.61	114.00	119.70
T ₂ Two irrigations at Vegetative and Siliqua development	6.47	64.67	97.93	102.72
T ₃ Two irrigations at Flowering and Siliqua development	6.69	56.67	107.60	112.98
T ₄ Three irrigations at Vegetative, Flowering and Siliqua development	5.77	73.94	117.67	123.55
T ₅ Three irrigations at Vegetative, Pre-flowering and Siliqua development	5.92	87.77	122.87	129.01
T ₆ Three irrigations at Pre-flowering, Siliqua initiation and Siliqua development	6.70	84.26	124.60	130.83
T ₇ Four irrigations at Vegetative, Pre-flowering, Flowering and Siliqua development	5.57	86.67	128.07	134.47
T ₈ Four irrigations at Vegetative, Pre-flowering, Flowering and Siliqua initiation	6.97	83.27	131.60	138.16
T ₉ Four irrigations at Vegetative, Pre-flowering, Siliqua initiation and Siliqua development	6.45	85.29	131.33	137.90
T ₁₀ Four irrigations at Pre-flowering, Flowering, Siliqua initiation and Siliqua development	6.43	77.69	136.40	143.13
T ₁₁ Five irrigations at Vegetative, Pre-flowering, Flowering, Siliqua initiation and Siliqua development.	6.50	85.92	139.80	146.79
T ₁₂ Scheduling of irrigation at IW/CPE ratio of 1.0	5.85	84.33	140.67	147.70
SEm±	0.555	2.991	3.831	3.522
CD @ 5%	1.612	8.828	11.309	10.396
CV (%)	15.408	6.647	5.335	4.672

Table 2: LAI of mustard as influenced by irrigation scheduling at different phenophases**Comment [A14]:** write down the data source and year

Treatments	Leaf area Index (LAI)			
	Vegetative	Flowering	Silique development	Harvest
T ₁ Two irrigations at Vegetative and Flowering stage	0.95	2.43	1.40	0.48
T ₂ Two irrigations at Vegetative and Silique development	0.92	2.33	1.13	0.42
T ₃ Two irrigations at Flowering and Silique development	0.88	2.01	1.28	0.52
T ₄ Three irrigations at Vegetative, Flowering and Silique development	0.79	2.54	1.57	0.59
T ₅ Three irrigations at Vegetative, Pre-flowering and Silique development	0.97	3.46	1.91	0.71
T ₆ Three irrigations at Pre-flowering, Silique initiation and Silique development	0.94	2.80	1.98	0.74
T ₇ Four irrigations at Vegetative, Pre-flowering, Flowering and Silique development	0.93	3.36	1.94	0.72
T ₈ Four irrigations at Vegetative, Pre-flowering, Flowering and Silique initiation	0.89	3.42	2.16	0.73
T ₉ Four irrigations at Vegetative, Pre-flowering, Silique initiation and Silique development	0.86	3.38	1.97	0.80
T ₁₀ Four irrigations at Pre-flowering, Flowering, Silique initiation and Silique development	0.91	2.95	2.21	0.83
T ₁₁ Five irrigations at Vegetative, Pre-flowering, Flowering, Silique initiation and Silique development.	0.87	3.36	2.38	0.89
T ₁₂ Scheduling of irrigation at IW/CPE ratio of 1.0	0.90	3.67	2.40	0.89
SEm±	0.056	0.135	0.042	0.016
CD @ 5%	0.163	0.397	0.124	0.046
CV (%)	10.776	7.838	3.901	3.899

Table 3: Dry matter production (g m⁻²) of mustard as influenced by irrigation scheduling at different phenophases**Comment [A15]:** write down the data source and year

Treatments	Dry matter production (g m ⁻²)			
	Vegetative	Flowering	Siliqua development	harvest
T ₁ Two irrigations at Vegetative and Flowering stage	5.77	30.67	196.53	224.33
T ₂ Two irrigations at Vegetative and Siliqua development	5.60	29.33	158.67	198.33
T ₃ Two irrigations at Flowering and Siliqua development	5.35	25.33	179.47	245.67
T ₄ Three irrigations at Vegetative, Flowering and Siliqua development	4.82	32.00	220.36	275.45
T ₅ Three irrigations at Vegetative, Pre-flowering and Siliqua development	5.87	43.67	267.73	334.67
T ₆ Three irrigations at Pre-flowering, Siliqua initiation and Siliqua development	5.73	35.33	277.33	346.67
T ₇ Four irrigations at Vegetative, Pre-flowering, Flowering and Siliqua development	5.63	42.38	272.27	340.33
T ₈ Four irrigations at Vegetative, Pre-flowering, Flowering and Siliqua initiation	5.43	43.13	302.51	345.33
T ₉ Four irrigations at Vegetative, Pre-flowering, Siliqua initiation and Siliqua development	5.25	42.67	276.27	378.13
T ₁₀ Four irrigations at Pre-flowering, Flowering, Siliqua initiation and Siliqua development	5.52	37.20	310.40	388.00
T ₁₁ Five irrigations at Vegetative, Pre-flowering, Flowering, Siliqua initiation and Siliqua development.	5.29	42.45	333.33	416.67
T ₁₂ Scheduling of irrigation at IW/CPE ratio of 1.0	5.45	46.23	336.27	420.33
SEm±	0.341	1.698	5.876	7.346
CD @ 5%	0.990	5.014	17.344	21.683
CV (%)	10.776	7.838	3.900	3.901

Table 4: Yield attributes of mustard as influenced by irrigation scheduling at different phenophases**Comment [A16]:** write down the data source and year

Treatments	Number of Siliqua plant ⁻¹	Number of filled seeds siliquae ⁻¹	Test weight(g)
T ₁ Two irrigations at Vegetative and Flowering stage	75.33	10.87	4.76
T ₂ Two irrigations at Vegetative and Siliqua development	63.00	10.43	4.46
T ₃ Two irrigations at Flowering and Siliqua development	84.07	11.24	4.92
T ₄ Three irrigations at Vegetative, Flowering and Siliqua development	88.67	11.47	5.21
T ₅ Three irrigations at Vegetative, Pre-flowering and Siliqua development	101.00	11.97	5.17
T ₆ Three irrigations at Pre-flowering, Siliqua initiation and Siliqua development	110.33	12.18	5.49
T ₇ Four irrigations at Vegetative, Pre-flowering, Flowering and Siliqua development	94.40	11.51	5.24
T ₈ Four irrigations at Vegetative, Pre-flowering, Flowering and Siliqua initiation	98.67	11.59	5.44
T ₉ Four irrigations at Vegetative, Pre-flowering, Siliqua initiation and Siliqua development	112.67	12.18	5.55
T ₁₀ Four irrigations at Pre-flowering, Flowering, Siliqua initiation and Siliqua development	116.27	12.28	5.64
T ₁₁ Five irrigations at Vegetative, Pre-flowering, Flowering, Siliqua initiation and Siliqua development.	124.80	13.65	5.65
T ₁₂ Scheduling of irrigation at IW/CPE ratio of 1.0	135.67	13.88	5.54
SEm±	4.168	0.270	0.238
CD @ 5%	12.303	0.796	0.702
CV (%)	7.190	3.913	7.834

Table 5: Yield (kg ha⁻¹) of mustard as influenced by irrigation scheduling at different phenophases

TREATMENTS	Seed yield(kg ha ⁻¹)	Stover yield(kg ha ⁻¹)
T ₁ Two irrigations at Vegetative and Flowering stage	546	1113
T ₂ Two irrigations at Vegetative and Siliqua development	431	923
T ₃ Two irrigations at Flowering and Siliqua development	582	1161
T ₄ Three irrigations at Vegetative, Flowering and Siliqua development	618	1300
T ₅ Three irrigations at Vegetative, Pre-flowering and Siliqua development	653	1297
T ₆ Three irrigations at Pre-flowering, Siliqua initiation and Siliqua development	831	1591
T ₇ Four irrigations at Vegetative, Pre-flowering, Flowering and Siliqua development	728	1488
T ₈ Four irrigations at Vegetative, Pre-flowering, Flowering and Siliqua initiation	765	1577
T ₉ Four irrigations at Vegetative, Pre-flowering, Siliqua initiation and Siliqua development	902	1907
T ₁₀ Four irrigations at Pre-flowering, Flowering, Siliqua initiation and Siliqua development	968	1945
T ₁₁ Five irrigations at Vegetative, Pre-flowering, Flowering, Siliqua initiation and Siliqua development.	1113	2224
T ₁₂ Scheduling of irrigation at IW/CPE ratio of 1.0	1143	2372
SEm±	33	59
CD @ 5%	97	175
CV (%)	7.4	6.5

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4. CONCLUSIONS

The present investigation found that deficit and optimum irrigation schedules had a substantial impact on growth, yield attributes and yield of mustard. It is concluded that irrigation scheduled with five irrigations each at vegetative, pre-flowering, flowering, siliqua initiation and siliqua development results in highest seed output. Further, under limited water supply, schedule four irrigations each during pre-flowering, flowering, siliqua initiation, and siliqua development, if three irrigations are available schedule at pre-flowering, siliqua initiation and siliqua development for higher growth and yield of mustard in Northern Telangana Zone

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