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# Growth and Yield Response of different Indian Mustard [*Brassica juncea* (L.)] varieties to Irrigation Scheduling

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**ABSTRACT: The field experiment to study the response of various mustard varieties to different irrigation scheduling treatments through critical growth stage approach was conducted during *Rabi* season of year 2019-20 at Integrated Farming System research Unit farm in Banda University of Agriculture and Technology, Banda (U.P. - 210001) India. The experiment was laid out in strip plot design with three replications. Four irrigation scheduling treatments [*viz.* $I_0$: No Irrigation, $I_1$: One Irrigation at Rosette stage, $I_2$: One Irrigation at Pod formation and $I_3$: Two Irrigations ($1^{st}$ at Rosette + $2^{nd}$ at Pod Formation)] were allocated to horizontal plots; whereas two mustard varieties (*viz.* NRCHB-101 and PM-28) were sown in vertical plots. Higher growth attributing characters at different crop stages and at harvest *viz.* plant height, number of primary & secondary branches, leaf area index, plant dry matter, crop growth rate, relative growth rate and net assimilation rate and yield (grain yield, straw yield, biological yield and harvest index) along with B: C ratio were recorded under treatment irrigating the crop for two times during rosette and pod formation. NRCHB-101 was observed maximum growth attributing characters and yield in compared to PM-28 at all growth stages.**

**Keywords**: Mustard, irrigation scheduling, growth attribute, variety and yield.

## INTRODUCTION

India is the third largest producer of rapeseed-mustard after Canada, China and contributing to around 11 % of world's total production. Rapeseed-mustard are the important oilseed crops and also one of the second largest oilseed crops in India. Globally around 36.59 million hectares area is under Rapeseed and mustard along with 72.37 million tonnes production and 1980 kg $ha^{-1}$ productivity during 2018-19. India account for 19.8 % and 9.8% of the total acreage and production (USDA). In India around 6.23 million hectare area is under Rapeseed and mustard along with 8.6 million tonnes production and 1346 kg/ha productivity (source DRMR). Rapeseed and mustard is cultivated in majority of states of the country, Rajasthan (44.97 %), Haryana (12.44 %), Madhya Pradesh (11.32%) Uttar Pradesh (10.60 %), and West Bengal (7.53 %) during (2014-15 to 2018-19) (source DRMR). In India, out of rapeseed-mustard, Indian mustard [*Brassica juncea* (L.)] is a predominant crop and covers more than 90% area of mustard. After soybean and palm oil, it is third important oilseed in the world. In Indian mustard oil contain varies from 37 to 42 percent with 38-57 % eruric acid, 27% oleic acid and seed & oil are used as condiment in the preparation of pickles, curries, vegetables, hair oils, medicines and manufacture of greases. The oil cake is used as feed for animals and manure (5.1 % N, 1.8% $P_2O_5$ and 1.1 % $K_2O$). Oil cake or meal has high nutritional values in animal diet. Leaves of the young plants are used as green vegetables and green stem leaves are a good source of green fodder for cattle. In tanning industry, mustard oil is used for softening of leather.

Rapeseed – mustard crops in India are grown in diverse agro climatic conditions ranging from north-eastern /north –western hills to down south under irrigated /rain fed timely/late sown, saline and mixed cropping (Gupta *et al*., 2020). Rapeseed and mustard is crops of tropical as well as temperate zones and require somewhat cool and dry weather for proper growth. They require a fair supply of soil moisture during the growing period and a dry clear weather at the time of maturity. Cool temperature, clear dry weather with plentiful of bright sun shine accompanied with sufficient soil moisture increase the oil yield. In India grown in *Rabi* season from September – October to February – March.

Soil moisture is the most limiting factor for crop cultivation in Bundelkhand, as usual as dry land. Due to the scarcity and unavailability of irrigation water, production of Mustard is lower than average productivity of the country (Kullu *et al.,* 2018). The knowledge of proper irrigation scheduling is important for the efficient utilization of irrigation water. Irrigation water must be applied at the proper time and in the right volume to achieve maximum crop output. Because of the higher evaporation demand of the atmosphere and little rainfall, mustard irrigation requirements are substantially higher when the crop is cultivated in water-stressed and arid places. Moisture stress occurs at critical growth and development stages when sufficient irrigation water is not available to meet the needs of the mustard crop. Irrigation is necessary for the proper growth of mustard during three important stages: rosette, pre-flowering, and pod production. Application of two irrigations at pre-flowering + grain filling stage of mustard significantly increases growth and yield attributing characters (Singh *et al.,* 2018). However, number of irrigation depends on soil water content in the root zone soil, soil and climatic condition, and varieties (Chauhan and Singh, 2004). Appropriate water management with irrigation scheduling on the basis of critical growth stage approach will be the best option for increasing water productivity under stressed environment. Soil moisture in a specified root zone depth is depleted to a particular level (which is different for different crops), it is to be replenished by irrigation. (Rizk and Sherif 2014). More favorable irrigation regimes maintained under regular watering results in higher soil moisture content in rhizosphere promoting cellular activity of enlargement, expansion and multiplication with synergistic impact on leaf water potential, stomatal conductance and photosynthetic activity (Rana *et al.,* 2019). It is also enhances the availability of different nutrients to the crop plants (Verma *et al.,* 2018).

Variety of the crop decides its growth and yield potential under specific agro-climate along with efficient resource utilization. Therefore, exploring appropriate varieties for higher yield in dryland condition is also having tremendous scope. Improved varieties have higher moisture use efficiency as compared to local varieties and can be adopted for efficient moisture use. The old and degenerated varieties due to their low yield potential and other factors like maturity, shattering habit, poor response to fertilizers and irrigation and susceptibility to insect-pest and diseases have poor productivity as compared to improved varieties of the region (Yamben *et al.*, 2020). Selection of improved varieties are important for producer to achieve high crop yield by improving the fertilizer use efficiency and water use efficiency. Improved cultivars and hybrids offers better genetic makeup, ensures uniform germination and emergence maintaining optimum plant stand, higher survival under temperature stress during vegetative phase, resistance to major pests and diseases and efficient translocation and assimilation of assimilates which ultimately results in improved growth, yield contributing characters and productivity of mustard (Rana *et al.,* 2019).

## MATERIALS AND METHODS

The research field was located at the Integrated Farming SystemFarm, Banda University of Agriculture and Technology, Banda -210001, Uttar Pradesh, India during *Rabi* season 2019-20, is situated between latitude 24° 53' and 25° 55'N and longitudes 80° 07' and 81° 34' E and having an altitude of 168m above sea level. This region falls under agro climatic zone- 8 (Central Plateaus & Hills Region) of India. Meteorological data recorded during cropping season, showed that the mean maximum temperature varies from 21.5 to 30.4 °C and the minimum temperature varies from 10.2 to 17.8°C. Relative humidity ranged from 44 to 61% during the cropping period. Average wind speed was recorded 3.98 km $h^{-1}$ during experiment period. During the period of experimentation total 14.3 mm rainfall in three rainy days received at trail location. Whereas, total evapotranspiration was 351.5 mm, which provided favourable conditions for crop growth. Initial soil fertility status of field experiment revealed soil pH 7.94, electrical conductivity 0.20 $dSm^{-1}$, organic carbon 0.57 %, available sulphur 12.35 mg $kg^{-1}$, available nitrogen 252 kg $ha^{-1}$, available phosphorus 21.04 kg $ha^{-1}$, available potassium 273.8 kg $ha^{-1}$. The experiment was laid out in strip plot design with three replications. Four irrigation scheduling treatments *viz.* no irrigation, one irrigation at rosette stage, one irrigation at pod formation stage and two irrigations ($1^{st}$ at Rosette + $2^{nd}$ at Pod Formation) were allocated in vertical plots; whereas horizontal plots consisted two varieties *viz.* NRCHB-101 and PM-28.

The experimental field was ploughed criss - cross with a tractor drawn disc and dry weeds as well as stubbles were removed. The field was again ploughed by rotavator and finally planking was done to obtain a good soil tilth. The seed are sown on 09/10/2019 by hand equally in the furrows and instantly after the sowing of seed furrow is cover by the soil. Seed of Indian mustard has sown in row to row distance of 45cm and plant to plant distance is maintained about 10 - 15cm with 4 to 5 cm depth. 5 kg seed sufficient for one hectare. A uniform dose of phosphorus (60 kg $P_2O_5$ $ha^{-1}$), potassium (60 kg $K_2O$ kg $ha^{-1}$), half dose of nitrogen (60 kg N $ha^{-1}$) and (40 sulphur kg $ha^{-1}$) through di-ammonium phosphate, muriate of potash, urea and alimental sulphur was applied below the seeds at the time of sowing of crop, respectively. Remaining half dose of nitrogen (60 kg N $ha^{-1}$) was applied as top dressing in the form of urea. Thinning of extra plant in the rows was done at 20 days after the sowing by hand pulling to maintain the plant spacing. Two hand

weeding were done for weed free crop field. First weeding has done at 25 DAS second wedding at 40 DAS. To protect crop from aphids (*Lipaphis erysimi*), Imidacloprid (17.8 SL) @ 1 ml per 2.5 Litter was sprayed during flowering to pod formation stage.

All the growth and yield attributing characters were recorded with the standard methodology at different growth stages of the crop. Various growth indices were estimated with the formulae as per mentioned below-

**Leaf area index**

$$LAI = \frac{\text{Total leaf area of plant}}{\text{Ground area}}$$

**Crop growth rate**

$$CGR\ (g\ m^{-2}\ day^{-1}) = \frac{W2 - W1}{t2 - t1}$$

Where, $W_1$ and $W_2$ are dry weight ($gm^{-2}$) at first and second taken at times $t_1$ and $t_2$ respectively.

**Relative growth rate**

$$RGR\ (g\ day - 1) = \frac{\log W2 \quad \log W1}{t2 - t1}$$

Where, $W_1$ and $W_2$ are dry weight ($g\ m^{-2}$) at times $t_1$ and $t_2$ respectively.

**Net assimilation rate**

$$NAR\ (g\ m^{-2} day^{-1}) = \frac{W2 - W1}{t2 - t1}\left(\frac{\log L2 - \log L1}{L2 - L1}\right)$$

Where, $W_1$ and $W_2$ are dry weight ($g\ m^{-2}$) at times $t_1$ and $t_2$ respectively.$L_1$ and $L_2$ are Leaf area at times $t_1$ and $t_2$ respectively.

**Harvest Index**

$$Harvestindex(\%) = \frac{\text{Economic Yield}}{\text{BiologicalYield}} \times 100$$

Where, Economic yield = seed yield ($q\ ha^{-1}$); Biological yield = seed yield + straw yield ($q\ ha^{-1}$)

Recorded data was analyzed using appropriate method of 'Analysis of Variance (ANOVA)' given by Gomez and Gomez (1984).

## RESULTS AND DISCUSSION

*A. Effect of treatments on growth attributing characters*

Tallest plants at harvest were recorded with two irrigations (1st at Rosette + 2nd at Pod Formation) in comparison to no irrigation, one irrigation at rosette and one irrigation at pod formation stages (Table 1). It might be due to the supply of adequate moisture during critical growth stages. Ray *et al.* (2014); Tavassoli *et al.* (2020) have correlated the availability of sufficient moisture in crop root zone and uptake of various nutrients and relative increase in plant growth attributes. Similar results have also been reported by Singh *et al.* (2018). Effect of varieties on plant height was found to be non- significant at all the stages of crop growth.

**Table 1: Effect of treatments on growth attributing characters.**

| Treatment | Plant height (cm) at harvest | Dry matter accumulation ($g\ m^{-2}$) at harvest | Leaf area index | | | No. of branches ($plant^{-1}$) at harvest | |
|---|---|---|---|---|---|---|---|
| | | | 30 DAS | 60 DAS | 90 DAS | Primary | Secondary |
| **Irrigation scheduling** | | | | | | | |
| $I_0$: No Irrigation | 185.93 | 621.29 | 0.82 | 3.31 | 1.86 | 7.40 | 15.77 |
| $I_1$: One Irrigation at Rosette stage | 191.37 | 712.32 | 0.83 | 3.83 | 2.13 | 8.71 | 17.97 |
| $I_2$: One Irrigation at Pod formation | 190.23 | 710.33 | 0.82 | 3.29 | 2.16 | 7.53 | 15.89 |
| $I_3$: Two Irrigations (1st at Rosette + 2nd at Pod Formation) | 195.27 | 785.36 | 0.82 | 3.85 | 2.45 | 8.97 | 19.03 |
| **SE±** | 0.63 | 18.36 | 0.01 | 0.07 | 0.06 | 0.31 | 0.52 |
| **CD (at 5%)** | 1.89 | 55.34 | NS | 0.23 | 0.18 | 0.84 | 1.55 |
| **CV %** | 6.36 | 8.65 | 1.52 | 2.03 | 1.85 | 2.19 | 3.51 |
| **Variety** | | | | | | | |
| $V_1$: NRCHB-101 | 190.19 | 712.65 | 0.83 | 3.69 | 2.27 | 7.97 | 17.73 |
| $V_2$: PM-28 | 191.21 | 702.42 | 0.81 | 3.45 | 2.03 | 8.33 | 16.59 |
| **SE±** | 0.56 | 18.20 | 0.01 | 0.08 | 0.07 | 0.35 | 0.51 |
| **CD (at 5%)** | NS | NS | NS | 0.22 | 0.19 | NS | NS |
| **CV %** | 6.46 | 8.72 | 1.5 | 2.00 | 1.90 | 2.2 | 3.5 |
| **Mean** | 190.70 | 707.32 | 0.82 | 3.57 | 2.15 | 8.15 | 17.16 |
| **Interaction Effect** | NS | NS | NS | NS | NS | NS | NS |

Application of two Irrigations (1st at Rosette + 2nd at Pod Formation) at harvest was produced significantly maximum dry matter 785.36 $gm^{-2}$ as compared to other control. One irrigation each at rosette and pod formation stages were found to be at par with each other. The superior vegetative growth and morphological parameters *viz.* plant height, LAI, number of branches with two Irrigations (1st at Rosette + 2nd at Pod Formation) were further reflected into higher plant dry matter accumulation at harvest which was earlier reported by Kumar *et al.* (2020), Sarma and Das (2016) in mustard crop.It was found that the effect of varieties on dry matter accumulation was non-significant at all the growth stages of crop.

Higher LAI at 60 and 90 DAS was found with two irrigation (1st at Rosette + 2nd at Pod Formation). However, irrigating the crop once at rosette stage was found at par with two irrigations (1st at Rosette + 2nd at Pod Formation) at 60 DAS. One irrigation each at rosette and pod formation stages at 90 DAS were found to be at par with each other. Which might be due to sufficient moisture availability. Such effect of irrigation regimes on LAI was also reported earlier by Verma *et al.* (2018). Effect of varieties on leaf area index was

found to be non-significant at 30 DAS. However, NRCHB-101 was recorded significantly maximum LAI as compared to PM-28 at 60 and 90 DAS (Table 1).

Significantly highest number of primary and secondary branches at harvest were recorded under two irrigations (1st at Rosette + 2nd at Pod Formation) over the treatments no irrigation and one irrigation at pod formation (Table 1). Lowest number of primary and secondary braches were observed under no irrigation treatment. However, scheduling one irrigation at rosette stage was found at par with two irrigations (1st at Rosette + 2nd at Pod Formation) at all growth stages. Sufficient moisture in crop root zone and uptake of various nutrients and relative increase in plant growth attributes result as a result increases number of branches. Ahamed *et al.* (2019); Hossain *et al.* (2013). Effect of varieties on number of branches was found to be non- significant at all the growth stages of crop.

*B. Effect of treatments on growth rates and photosynthetic efficiency*

It was found that the effect of various irrigation scheduling treatments on CGR, RGR and NAR at 30 DAS was non- significant. Significantly higher crop growth rate at 30 to 60 DAS, 60 to 90 DAS and 90 DAS to at harvest was observed in treatment two irrigations (1st at Rosette + 2nd at Pod Formation) over no irrigation and one irrigation at pod formation treatment. However, it was on par with treatment one irrigation at rosette at all the growth stages. At 30 – 60 DAS significantly higher relative growth rate was found in one irrigation at rosette stage as compared to no irrigation and one irrigation at pod formation stages. During 60 to 90 DAS and 90 DAS to harvest treatment one irrigation at pod formation stage was superior; which was on par with two irrigations at rosette and pod formation. Two irrigations (1st at Rosette + 2nd at Pod Formation) was resulted in significantly superior net assimilation rate during 30 to 60 DAS over all the other treatments (Table 2). However, during 60 to 90 DAS treatment one irrigation at pod formation stage was found superior. The superior vegetative growth and morphological parameters *viz.* plant height, LAI, number of branches with two Irrigations (1st at Rosette + 2nd at Pod Formation) were further reflected into crop growth indices *viz.* CGR, RGR and NAR; which was earlier reported by Sarma and Das (2016); Hasanuzzaman (2008); Ahamed *et al.* (2019) in mustard crop. In case variety the effect of varieties on CGR, RGR and NAR were found to be non- significant at all the growth stages of crop.

**Table 2: Effect of treatments on growth rates and photosynthetic efficiency.**

| Treatment | CGR (g m$^{-2}$ day$^{-1}$) | | | | RGR (g day$^{-1}$) | | | | NAR (g m$^{-2}$day$^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0-30 DAS | 30-60 DAS | 60-90 DAS | 90 DAS to Harvest | 0- 30 DAS | 30- 60 DAS | 60- 90 DAS | 90 DAS to Harvest | 0- 30 DAS | 30-60 DAS | 60-90 DAS |
| **Irrigation scheduling** | | | | | | | | | | | |
| $I_0$: No Irrigation | 1.64 | 9.63 | 4.57 | 4.87 | 0.0564 | 0.0279 | 0.0049 | 0.0039 | -0.172 | 2.34 | 0.79 |
| $I_1$: One Irrigation at Rosette stage | 1.62 | 11.09 | 5.40 | 5.63 | 0.0562 | 0.0298 | 0.0051 | 0.0040 | -0.158 | 2.45 | 0.81 |
| $I_2$: One Irrigation at Pod formation | 1.67 | 9.67 | 6.20 | 6.14 | 0.0567 | 0.0277 | 0.0063 | 0.0043 | -0.176 | 2.36 | 1.00 |
| $I_3$: Two Irrigations (1st at Rosette + 2nd at Pod Formation) | 1.65 | 11.26 | 6.85 | 6.42 | 0.0565 | 0.0297 | 0.0062 | 0.0041 | -0.174 | 2.50 | 0.96 |
| **SE±** | 0.03 | 0.27 | 0.22 | 0.25 | 0.0003 | 0.0005 | 0.0003 | 0.0002 | 0.009 | 0.04 | 0.02 |
| **CD (at 5%)** | NS | 0.82 | 0.64 | 0.76 | NS | 0.0016 | 0.0009 | NS | NS | 0.13 | 0.07 |
| **CV %** | 1.31 | 3.26 | 2.10 | 2.37 | 1.08 | 1.92 | 1.03 | 1.01 | 1.12 | 1.22 | 1.04 |
| **Variety** | | | | | | | | | | | |
| $V_1$: NRCHB-101 | 1.63 | 10.47 | 5.87 | 5.77 | 0.0563 | 0.0290 | 0.0057 | 0.0041 | -0.159 | 2.37 | 0.87 |
| $V_2$: PM-28 | 1.66 | 10.35 | 5.65 | 5.75 | 0.0565 | 0.0287 | 0.0055 | 0.0040 | -0.182 | 2.46 | 0.91 |
| **SE±** | 0.03 | 0.23 | 0.25 | 0.26 | 0.0003 | 0.0005 | 0.0003 | 0.0002 | 0.009 | 0.07 | 0.03 |
| **CD (at 5%)** | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| **CV %** | 1.34 | 3.27 | 2.22 | 2.40 | 1.09 | 1.93 | 1.02 | 1.00 | 1.14 | 1.20 | 1.03 |
| **Mean** | 1.64 | 10.41 | 5.75 | 5.76 | 0.0564 | 0.0288 | 0.0056 | 0.0041 | -0.170 | 2.41 | 0.89 |
| **Interaction Effect** | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

*C. Effect of treatments on yield and economics*

Increment in growth attributing characters were ultimately reflected in yield attributing characters viz. pod plant$^{-1}$, pod length, grain pod$^{-1}$ and test weight; Crop yield attributes are further reflected into grain and straw yield; which was found highest (22.32 q ha$^{-1}$, 70.05 q ha$^{-1}$, respectively) with application of two irrigations (1st at Rosette + 2nd at Pod Formation). Similarly, highest Harvest Index (24.16) was observed in treatment two irrigations (1st at Rosette + 2nd at Pod Formation) as compared to other treatments (Table 3). Lowest grain yield (17.62 q ha$^{-1}$), straw yield (62.27q ha$^{-1}$) and Harvest Index (22.06) were recorded under no

irrigation treatment. Such effect of irrigation scheduling on yield attributing characters and yield of mustard have been earlier reported by Ahamed *et al.* (2019); Begum *et al.* (2018); Sivran *et al.* (2018).

Maximum cost of cultivation (28521 ₹ $ha^{-1}$) was recorded under two irrigations (1st at Rosette + 2nd at Pod Formation) and minimum cost of cultivation (24149 ₹ $ha^{-1}$) recorded under no irrigation control. The cost of cultivation was high because more number of irrigation which increases the cost of cultivation of corresponding treatments. Maximum gross return (93759 ₹ $ha^{-1}$), net return (65238 ₹ $ha^{-1}$) and benefit cast ratio (2.29) were recorded under two irrigations (1st at Rosette + 2nd at Pod Formation). Whereas, minimum gross return (74014 ₹ $ha^{-1}$), net return (49864 ₹$ha^{-1}$) and benefit cast ratio (2.06) recorded under no irrigation control. Gross return, net return and benefit cast ratio were more due to higher production grain yield of Indian mustard crop. The effect of irrigation scheduling on economics of mustard has been also described earlier by various scientists; Piri *et al.* (2011); Barick *et al.* (2020); Ray *et al.* (2014).

Increased grain yield of NRCHB-101 has been further reflected in higher harvest index (23.63), gross monetary return (86950 ₹ $ha^{-1}$), net monetary return (60426 ₹ $ha^{-1}$), B: C ratio (2.28) and crop water use efficiency (5.89) as compared to PM-28 (Basavanneppa and Kumar 2020; Kashyap *et al.,* 2017).

**Table 3: Effect of treatments on yield and economics.**

| Treatment | Grain yield (q $ha^{-1}$) | Straw yield (q $ha^{-1}$) | Biological yield (q $ha^{-1}$) | Harvest index(%) | Cost of cultivation (₹ $ha^{-1}$) | Gross return (₹ $ha^{-1}$) | Net return (₹ $ha^{-1}$) | B:C Ratio |
|---|---|---|---|---|---|---|---|---|
| **Irrigation scheduling** | | | | | | | | |
| $I_0$: No Irrigation | 17.62 | 62.27 | 79.89 | 22.06 | 24149 | 74014 | 49864 | 2.06 |
| $I_1$: One Irrigation at Rosette stage | 20.35 | 67.38 | 87.73 | 23.19 | 26412 | 85482 | 59070 | 2.24 |
| $I_2$: One Irrigation at Pod formation | 20.24 | 66.23 | 86.47 | 23.40 | 26747 | 85018 | 58271 | 2.18 |
| $I_3$: Two Irrigations (1st at Rosette + 2nd at Pod Formation) | 22.32 | 70.05 | 92.38 | 24.16 | 28521 | 93759 | 65238 | 2.29 |
| **SE±** | 0.36 | 0.64 | 0.88 | - | - | - | - | - |
| **CD (at 5%)** | 1.08 | 1.92 | 2.66 | - | - | - | - | - |
| **CV %** | 10 | 12 | 13 | - | - | - | - | - |
| **Variety** | | | | | | | | |
| $V_1$: NRCHB-101 | 20.70 | 67.10 | 87.58 | 23.63 | 26524 | 86950 | 60426 | 2.28 |
| $V_2$: PM-28 | 19.57 | 65.87 | 85.66 | 22.85 | 26390 | 82186 | 55796 | 2.11 |
| **SE±** | 0.36 | 0.64 | 0.88 | - | - | - | - | - |
| **CD (at 5%)** | 1.09 | NS | NS | - | - | - | - | - |
| **CV %** | 10 | 12 | 13 | - | - | - | - | - |
| **Mean** | 20.14 | 66.48 | 86.62 | - | - | - | - | - |
| **Interaction Effect** | NS | NS | NS | - | - | - | - | - |

## CONCLUSION

The current study concludes that irrigation scheduling with two irrigations (first at rosette stage and second during pod formation stage) improves the growth attribute, yield and B: C ratio of Indian mustard. Similarly mustard variety NRCHB-101 shows better performance in terms of growth as compared to variety PM-28.

## FUTURE SCOPE

Water is the most limiting factor for crop production in dryland agriculture. Appropriate water management with irrigation scheduling on the basis of critical growth stage approach will be the best option for increasing water productivity under stressed environment. Selection of improved varieties are important for producer to achieve high crop yield by improving the fertilizer and water use efficiency.

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**Conflicts of Interest**. None.

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