Original Research Article

Effect of Irrigation Scheduling and Varieties on Yield & Yield Attribute and Profitability of Indian Mustard [*Brassica juncea* (L.)]

ABSTRACT

An agronomic investigation 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 IFS research Unit farm in Banda University of Agriculture and Technology, Banda (U.P.-210001). 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 yield attributing characters at different crop stages and at harvest *viz*. pod plant^{-1}, pod length, grain pod^{-1} and test weight and yield (grain yield, straw yield, biological yield and harvest index) along with crop water use efficiency were recorded under treatment irrigating the crop with two times during rosette and pod formation. Similarly maximum gross return (93759 INR ha^{-1}), net return (65238 INR ha^{-1}) and benefit cast ratio (2.29) were recorded under two irrigations (1^{st} at Rosette + 2^{nd} at Pod Formation). NRCHB-101 was observed maximum yield attributing characters and yield in compared to PM-28.

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

INTRODUCTION

After Canada and China, India is the world's third largest producer of rapeseed-mustard, accounting for roughly 11% of global production. Rapeseed and mustard are key oilseed crops in India, and they are also one of the second largest oilseed crops.

Rapeseed and mustard are grown on 36.59 million hectares worldwide, with 72.37 million tonnes produced and 1980 kg ha^{-1} productivity in 2018-19. India accounts for 19.8% of total area and

9.8% of total production, respectively (USDA, 2018). In India, rapeseed and mustard are grown on 6.23 million hectares, producing 8.6 million tonnes and yielding 1346 kg ha^{-1} (DRMR, 2019). 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. Indian mustard oil contains 37 to 42 % eruric acid, 27 %oleic acid, and is used as a condiment in pickles, curries, vegetables, hair oils, pharmaceuticals, and grease manufacturing. Animal feed and manure are both made from oil cake (5.1 % N, 1.8 % P_2O_5 and 1.1 % K_2O). The nutritional value of oil cake or meal in the diet of animals is very high. Green stem leaves are a rich source of green feed for cattle, while young plant leaves are eaten as green vegetables. Mustard oil is commonly used to soften leather in the tanning industry.

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). It is critical to understand correct irrigation scheduling in order to make the most optimal use of irrigation water. To get the best crop yield, irrigation water must be applied at the right time and in the right amount. Mustard irrigation requirements are significantly higher when the crop is grown in water-stressed and desert areas due to the higher evaporation demand of the atmosphere and little rainfall. Moisture stress occurs when irrigation water is insufficient to meet the mustard crop's needs during critical growth and development stages. Mustard requires irrigation at three critical periods of development: 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).

The crop's variety determines its growth and yield potential in a given agro-climate, as well as efficient resource utilization. Exploring optimal cultivars for increased yield in dryland conditions so has a lot of potential. Improved varieties, when compared to local types, have a greater moisture use efficiency and can be used to save water. 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). Improved cultivars and hybrids have a better genetic makeup, which ensures uniform germination and emergence, optimal plant stand, higher survival under temperature stress during the vegetative phase, resistance to major pests and diseases, and efficient translocation and assimilation of assimilates, all of which lead to improved mustard growth, yield contributing characters, and productivity (Rana *et al.*, 2019).

MATERIALS AND METHODS

The research field was located at the IFS Farm, Banda University of Agriculture & Technology, Banda -210001, Uttar Pradesh, India during *Rabi* season 2019-20, is situated between latitude 24^{o} 53′ and 25^{o} 55′ N and longitudes 80^{o} 07′ and 81^{o} 34′ E and having an altitude of 168 m 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 was 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 10-15 cm with 4 to 5 cm depth with seed rate of 5 kg h^{-1}. 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*), Monocrotophos (36SL) @ 1.5 ml L^{-1} was sprayed during flowering to pod formation stage.

The filled pods from previously tagged plants were used for counting the total number of pods at harvest and their average was worked out to record number of pods per plant for each net plot. Randomly selected ten pods were used for counting the number of seeds per pod. Length of 10 randomly selected pod was measured and average was calculated and expressed in cm as length of pod. The weight of grains net plot was threshed and cleaned separately and the grain yield recorded in kilogram per net plot and converted into quintal per hectare. After threshing weight of stem and chaff $plot^{-1}$ were recorded and added treatment-wise.

Harvest index was calculated by the formula (Donald, 1962)

$$\text{Harvest index (\%)} = \frac{\text{Economic Yield}}{\text{Biological Yield}} \times 100$$

Where,

Economic yield = seed yield (q ha^{-1})

Biological yield = seed yield + straw yield (q ha^{-1})

Crop water use efficiency is the yield of the crop per unit of water lost through evapotranspiration (ET) of the crop.

$$\text{Crop water use efficiency} = \frac{\text{Yield}}{\text{ET}}$$

From the representative sample of each plot one thousand seeds were counted and weighed to record 1000-seed weight in gram. The cost of cultivation for individual treatment was work out by taking into the cost of all the agronomical cultural operations are using from preparatory tillage to harvest of mustard crop and including the cost of input like seed, fertilizers use to treatment. Gross return was worked out by multiplying grain and straw yield separately under various treatment combinations with their existing market prices.

Gross return = Total income from grain and straw yields

Net return was calculated by subtracting the cost of cultivation from the gross return of the individual treatment combination.

Net return = Gross return - Cost of cultivation

Benefit: Cost ratio (B: C) was calculated using the formula as given

$$\text{Benefit Cost Ratio (B: C)} = \frac{\text{Net Return}(₹\ \text{ha}^{-1})}{\text{Cost of Cultivation}\ (₹\ \text{ha}^{-1})}$$

RESULTS AND DISCUSSION

Response to irrigation scheduling

The data on days to 50% flowering as affected by irrigation scheduling and varieties is presented in (Table 1). Considerable delay to attain 50% flowering was observed in treatments application of two irrigations (1^{st} at Rosette + 2^{nd} at Pod Formation) and one irrigation at rosette stage as compared to no irrigation and one irrigation at pod formation stage, which might be due to the increase in vegetative phase of the crop under sufficient soil moisture. Similar result has been also reported by (Shivay *et al*., 2004). The effect of irrigation scheduling on yield attributing characters viz. pod plant^{-1}, pod length, grain pod^{-1} and test weight; which were Significantly recorded higher (586.53, 5.81cm, 15.73 and 4.96g, respectively) with two irrigations (1^{st} at Rosette + 2^{nd} at Pod Formation). Increment in growth attributing characters were ultimately reflected in yield attributing characters. Similarly, (Sarma and Das, 2016). All these yield attributes were recorded lowest in treatment no irrigation; which might be due to the scarcity of soil moisture and relative stress effects on crop. The effect of irrigation scheduling on yield attributing characters have been also reported earlier by (Meena *et al.*, 2015) and (Ahamed *et al.*, 2019). Highest water use efficiency (6.35 kg $ha^{-1}mm^{-1}$) was recorded in application of two irrigations (1^{st} at Rosette + 2^{nd} at Pod Formation); which might be due to the relative availability of water during vegetative and reproductive stages of crop and its further utilization for assimilation and translocation of photosynthetes to produce higher grain yield. Lowest water use efficiency was observed in treatment no irrigation (5.01 kg $ha^{-1}mm^{-1}$); which might be due to moisture stress during various growth stages of crop.

Perusal of data presented in (Table 2) crop yield attributes are further reflected into grain, straw yield and harvest index. Significantly highest grain yield (22.32 q ha^{-1}) was observed in treatment two irrigations (1^{st} at Rosette + 2^{nd} at Pod Formation). It was 26.67, 9.68 and 10.27 percent higher over no irrigation, one irrigation at rosette and one irrigation at pod formation, respectively and highest straw yield (70.05 q ha^{-1}) was observed in treatment two irrigations (1^{st} at Rosette + 2^{nd} at Pod Formation). It was 12.49, 3.96 and 5.76 percent higher over no irrigation, one irrigation at rosette and one irrigation at pod formation, respectively. Similarly, highest Harvest Index (24.16) was observed in treatment two irrigations (1^{st} at Rosette + 2^{nd} at Pod Formation) as compared to other treatments. 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) and (Shivran *et al.*, 2018). Maximum cost of cultivation (28521 ₹ ha^{-1}) was recorded under two irrigations (1^{st} at Rosette + 2^{nd} at Pod Formation) and minimum cost of cultivation (24149 INR 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 INR ha^{-1}), net return (65238 INR ha^{-1}) and benefit cast ratio (2.29) were recorded under two irrigations (1^{st} at Rosette + 2^{nd} at Pod Formation). Whereas, minimum gross return (74014 INR ha^{-1}), net return (49864 INR 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; (Barick *et al.*, 2020) and (Ray *et al.*, 2014).

Response to varieties

Data showed in (Table 1) Significantly NRCHB-101 attained 50% flowering earlier than PM-28; which might be due to its considerably short crop duration. Similar result has been also reported by (Shivay *et al.*, 2004). Yield attributing characters *viz.* pod plant^{-1}, pod length, grain pod^{-1} and test weight; which were recorded higher (546.33, 5.82 cm, 14.36 and 4.62 g, respectively) with variety NRCHB-101 as compared to PM-28; which was also reflected in comparatively higher grain yield (20.70 q ha^{-1}). It might be due to the better suitability and performance of NRCHB-101 under specific agro-climate of the region where experiment was conducted (Singh *et al.*, 2020) and (Kashyap *et al.*, 2017). Increased grain yield of NRCHB-101 has been further reflected in higher harvest index (23.63), gross monetary return (86950 INR ha^{-1}), net monetary return (60426 INR ha^{-1}), B: C ratio (2.28) and crop water use efficiency (5.89) as compared to PM-28 (Table 2). Similar results also reported earlier by (Basavanneppa and Kumar, 2020) and (Yambem *et al.*, 2020).

CONCLUSION

It can be concluded from the present investigation that irrigation scheduling practice with two irrigation (first at rosette and second pod formation stage) increases the yield attributes and yield of mustard. Similarly mustard variety NRCHB-101 shows better performance in terms of yield attributes and yield as compared to variety PM-28 in Bundelkhand region. Two Irrigations (1st at Rosette + 2nd at Pod Formation) and variety NRCHB-101 are increases water use efficiency, net monetary income and B: C ratio in mustard crop.

Table 1. Effect of irrigation scheduling and varieties on yield attributing characters & crop water use efficiency in Indian mustard

Treatment	Days to 50% flowering	No. of pod plant^{-1}	Length of pod (cm)	No. of grain pod^{-1}	Test weight (g)	Crop water use efficiency (kg ha^{-1}mm^{-1})
Irrigation Scheduling						
I_0 : No Irrigation	50.2	472.34	5.23	12.02	3.80	5.01
I_1: One Irrigation at Rosette stage	51.4	549.61	5.46	13.30	4.26	5.62
I_2: One Irrigation at Pod formation	50.1	545.07	5.66	14.07	4.47	5.93
I_3: Two Irrigations (1st at Rosette + 2nd at Pod Formation)	51.5	586.53	5.81	15.73	4.96	6.35
SE±	0.38	8.52	0.13	0.36	0.13	0.14
CD (at 5%)	1.1	25.6	0.52	1.06	0.40	0.43
CV %	4.23	9.24	2.10	2.56	1.23	1.20

Variety						
V_1: NRCHB-101	49.2	546.33	5.82	14.36	4.62	5.89
V_2: PM-28	52.4	530.45	5.26	13.2	4.12	5.57
SE±	0.40	8.2	0.16	0.34	0.13	0.14
CD (at 5%)	1.2	NS	0.50	1.02	0.41	NS
CV %	4.33	9.12	2.15	2.39	1.20	1.25
Interaction Effect	NS	NS	NS	NS	NS	NS

Table 2. Effect of irrigation scheduling and varieties on Yield & economics in Indian mustard

Treatment	**Grain yield (q ha^{-1})**	**Straw yield (q ha^{-1})**	**Biological yield (q ha^{-1})**	**Harvest Index (%)**	**Cost of cultivation (INR ha^{-1})**	**Gross return (INR ha^{-1})**	**Net retur (INR 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	--	--	--	--	--
Interaction Effect	NS	NS	NS	--	--	--	--	--

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