Indian Journal of Agricultural Sciences **93** (2): 169–174, February 2023/Article
https://doi.org/10.56093/ijas.v93i2.119905

Irrigation levels and anti-transpirants impact on performance of Indian mustard (*Brassica juncea*)

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Received: 5 January 2022; Accepted: 4 January 2023

ABSTRACT

A field experiment was conducted during 2017–18 and 2018–19 at Regional Research Station, Bawal, CCS Haryana Agricultural University, Hisar, Haryana to examine the consequences of different levels of irrigation and anti-transpirants application on Indian mustard [*Brassica juncea* (L.) Czern.]. The experiment consisted of 3 irrigation levels (I_1, control; I_2, one irrigation at 40 DAS; I_3, two irrigations at 40 and 75 DAS), and two varieties (V_1, RH-725; V_2, RH-749) in main plots, whereas, 4 anti-transpirants (A_1, control; A_2, PMA @250 ppm at 45 and 90 DAS; A_3, 6% kaolin at 45 and 90 DAS and A_4, PMA @250 ppm + 6% kaolin at 45 and 90 DAS) in sub plots. The experiment was laid out in split plot design with 3 replications. The results revealed that different irrigation levels and anti-transpirants significantly influenced the performance of RH-749 and RH-725 mustard varieties. Yield attributes such as number of siliquae/plant, siliquae length, number of seeds per siliquae, test weight, seed yield/plant and biological yield were recorded significantly higher during both the years. Whereas, in the case of anti-transpirants, highest biological yield and productivity per day of mustard was recorded in A_4 as compared to A_1 but it was at par with A_3 anti-transpirants. Among the varieties, RH-749 performed better compared to RH-725 under different treatments. The interactive between I_3 irrigation level and A_4 anti-transpirants was significantly superioras compared to others. Moreover, mustard yield was found significant and positively correlated with different yield attributes.

Keywords: Anti-transpirants, Irrigation, Mustard, Varieties, Yield

Indian mustard [*Brassica juncea* (L.) Czern.] is foremost essential winter oil seed crop grown in northern state of India. It is cultivated on 6.23 million hectares of area with 9.34 million tonnes production and 1499 kg/ha productivity in India during 2018–19, whereas in Haryana state, crop grown on 0.61 million hectares area and produce 1.25 million tonnes with average productivity of 2058 kg/ha (DAC 2019). The major causes for low yield of mustard are lacking of appropriate agronomic practices like high yield producing variety, irrigation management practices and adoption of other inputs which reduce water losses from leaves such as anti transpirants. Irregular rains and inadequate alternate irrigation sources at maturity, largely affect the final yield. Of the several reasons, non-availability of adequate water at critical stage of crop is the most important one (Pari and Sharma 2006). Therefore, there is need to find out some appropriate solution to fulfil the irrigation requirement of mustard crop. Furthermore, selection of suitable variety for a particular environment is also essential (Mamun *et al.* 2014). Recently, anti-transpirants are used in agricultural field which reduce transpiration rate from plant leaves by reducing the size and number of stomata and gradually hardening them to stress (Kumar *et al.* 2018). Anti-transpirants which minimize transpiration could possibly outcome of higher food production by realizing yield potential of different varieties (Mphande *et al.* 2020). Anti-transpirant foliar spray substantially alleviates plant water stress. By strengthening and activating the plant's defence system and safeguarding the photosynthetic assimilates, these mechanisms increase resilience to drought stress while also boosting the amount of carbohydrates, oil and growth rate (Abdallah *et al.* 2020). The mustard production also significantly increased with an increase irrigation levels to three irrigations compared to the control (Mishra *et al.* 2019). Indian mustard's growth characteristic, yield, and B:C ratio are all improved by irrigation scheduling that includes two irrigations (Maurya *et al.* 2022).The application of anti-transpirants foliar spray may be an option to improve the biometric parameters.

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Keeping above points in view, the present investigation was aimed to evaluate the Indian mustard varieties under different irrigation level and anti-transpirants.

MATERIALS AND METHODS

The experiment was conducted at Regional Research Station, Bawal (latitude 28.1^{0}N and longitude of 76.5^{0}E, 266 m amsl) of Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana during 2017–18 and 2018–19. The climate of the site is arid and semi-arid type. The experimental soil was sandy loam in texture having 78% sand, 12% silt and 10% clay, Typic Ustocherpt in nature.

Treatment details, layout and observation recorded: The experiment consisted 3 irrigation levels (I_1, control; I_2, one irrigation at 40 DAS; I_3, two irrigations at 40 and 75 DAS), and two varieties (V_1, RH-725; V_2, RH-749) in main plots, whereas, four anti-transpirants (A_1, control; A_2, PMA @250 ppm at 45 and 90 DAS; A_3, 6% kaolin at 45 and 90 DAS and A_4, PMA @250 ppm + 6% kaolin at 45 and 90 DAS) in sub plots. The study was laid out in split plot design with 3 replications. Recommended doses of nitrogen (N, 80 kg/ha), phosphorus (P_2O_5,30 kg/ha), potassium (K_2O, 20 kg/ha), zinc sulphate (5 kg/ha) and 40 kg S/ha in the form of gypsum were applied. Experimental plot size was kept to 5 m × 3. 6 m. The *p*H of the experimental soil was alkaline in nature (8.24) having electrical conductivity of 0.19 dS/m. The organic carbon, available nitrogen, available phosphorus and available potassium content were 0.23%, 148 kg/ha, 14.22 kg/ha and 208 kg/ha, respectively. During winter (*rabi*) season of 2017–18 and 2018–19, a pre-sowing irrigation was applied before start of experiment to ensure adequate moisture at the time of planting. Afterword, the field was ploughed twice with the help of discharrow, once with cultivator followed by planking. Layout was done by using rope and hand hoe. Mustard variety RH-749 and RH-725 were sown with row spacing of 30 cm by '*pora'* method with hand plough on 28 October, 2017 and 26 October, 2018. Thinning of extra plant was done 20 days after sowing by hand pulling to obtain the recommended intra-row spacing of 15 cm. For controlling of weed from research field, two hoeing operations were done at 25 DAS and 40 DAS. The mustard crop was harvested on 30 March, 2018 and 28 March, 2019. The 5 plants were selected from each plot for recording yield attributes such as number of siliquae/plant, siliquae length, number of seeds per siliquae, siliquae bearing length (cm) and test weight (recorded at specified growth stages of crop). The harvesting of rows of net plot was done manually. The seed, stover and biological yield was measured plot wise and converted in kg per hectare. Productivity per day was calculated for different treatments by dividing seed yield with crop duration. Harvest index is the ratio of economic yield to the biological yield which was calculated by using the formula given by Donald and Hamblin (1976). Experimental data were statistically analyzed by using the methods of analysis of variance (ANOVA) as described by Gomez and Gomez (1984).

$$\text{Harvest Index (\%)} = \frac{\text{Economic yield (kg/ha)}}{\text{Biological yield (kg/ha)}} \times 100$$

RESULTS AND DISCUSSION

Number of siliquae/plant and length of siliquae: Number of siliquae/plant and length of siliquae (cm) were significantly improved by different treatments during both years (Fig 1). Statistically higher number of siliquae and length of siliquae were observed with I_3 treatment (application of two irrigations at 40 and 75 DAS) followed by I_2 (application of one irrigation at 40 DAS) over I_1 (control). This might be due to increased cell turgidity and photosynthesis which favoured improved leaf area, better allocation of biomass in different plant parts. Significantly higher number of siliquae/plant and length of siliquae were attained with variety RH-749 (V_2) compared to RH-725 (V_1). Likewise, number of siliquae/plant and length of siliquae were positively better with application of PMA @250 ppm + kaolin (6%) at 45 and 90 DAS (A_4) over control (A_1).

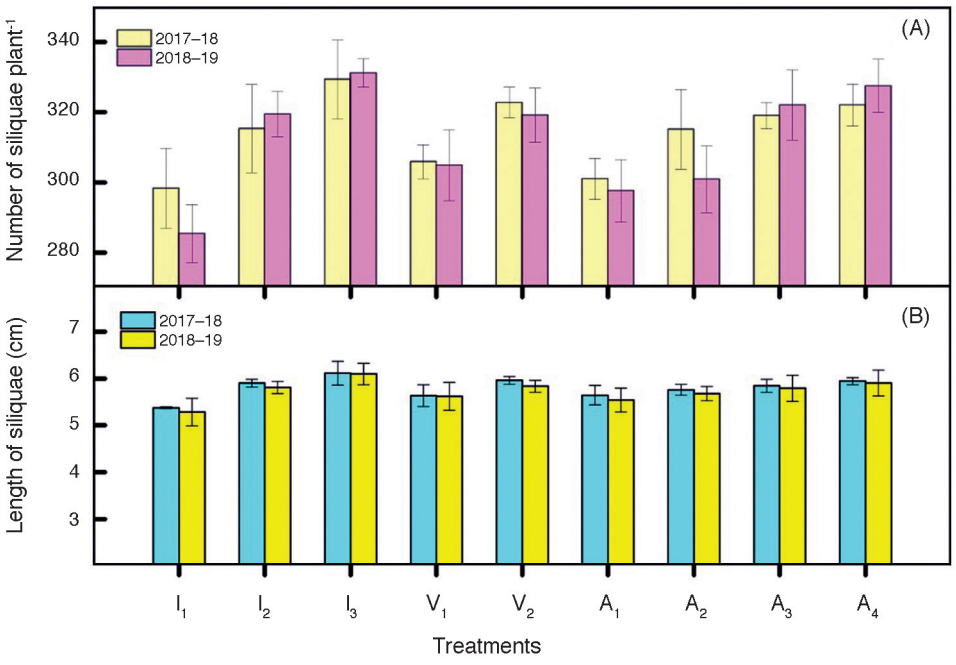

Fig 1 Effect of irrigation levels, varieties and anti-transpirants on (A) number of siliquae/plant and (B) length of siliquae (cm).
(Error bars represent the standard error, indicate significant differences at 0.05)

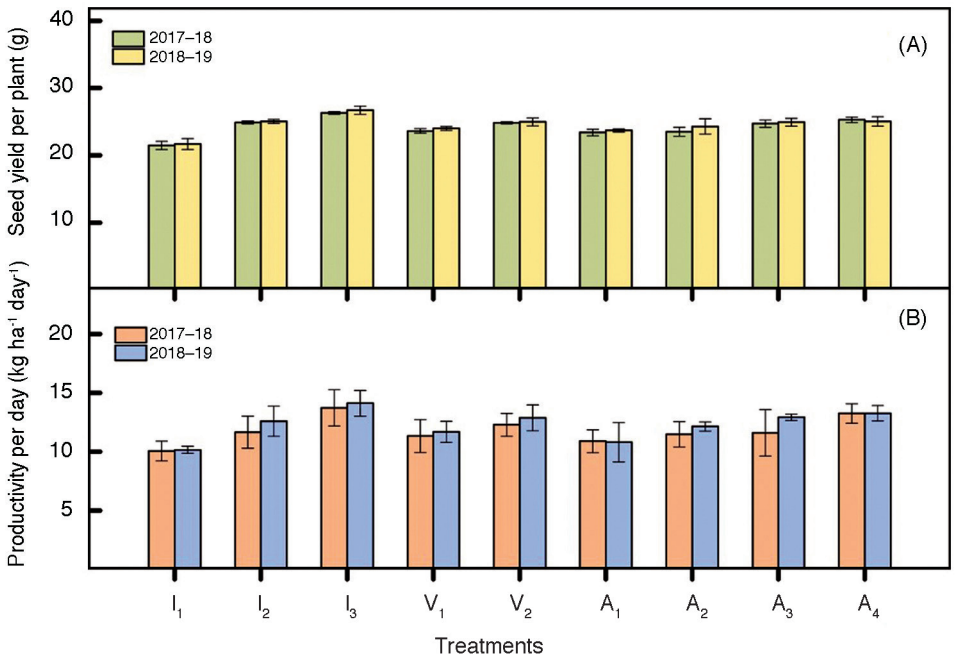

Fig 2 Effect of irrigation levels, varieties and anti-transpirants on (A) seed yield per plant (g) and (B) productivity per day (kg/ha/day).
(Error bars represent the standard error, indicate significant differences at 0.05)

The present findings are also in close confirmation with those observed by Rajput (2012).

Seed yield/plant and productivity/day: Compared to control (I_1) and one irrigation at 40 DAS (I_2), application of two irrigations at 40 and 75 DAS (I_3) recorded significantly higher seed yield per plant (Fig 2). Similarly, highest productivity/day was recorded with application of two irrigations at 40 and 75 DAS (I_3) compared to rest of treatment.This might be due to availability of more soil moisture to root parts and translocation of photosynthates with water towards reproductive part. Similar results have been reported by Hossain *et al.* (2013).

Likewise, variety RH-749 (V_2) recorded statistically higher seed yield/plant compared to RH-725 (V_1), during both the years. However, productivity/day was not influenced significantly by different varieties of mustard. Varieties differed in their response to different treatments due to difference in their genetic behaviour. Better reproductive growth of RH-749 (V_2) is attributed to inherent build up and higher number of siliquae/plant. Application of PMA @250 ppm + kaolin (6%) at 45 and 90 DAS (A_4) had significantly higher seed yield/plant and productivity/day over control (A_1). Foliar sprays markedly increase all growth and yield attributing parameters and relative water content and may reduce transpiration. Similar results also reported by Kumar *et al.* (2018).

Yield attributes: The data pertaining to number of seeds/ siliquae, siliquae bearing length and 1000-seed weightis depicted in Table 1. The irrigation treatment I_3 significantly improved the yield attributing characters compared to I_1 (control). Similar results were also reported by Yadav *et al.* (2010) and Dadhich *et al.* (2015). The number of seeds per siliquae, siliquae bearing length and 1000-seed weight were significantly higher in RH-749 (V_2) as compare to RH-725 (V_1) variety. This was due to better and efficient utilization of water, nutrients and radiation which resulted in enhanced growth and yield attributing characters. Similar findings were also reported by Khajuria *et al.* (2017). Similarly, application of anti-transpirants (A_4, PMA @250 ppm + kaolin, 6%) at 45 and 90 days after sowing recorded significantly higher number of seeds per siliquae, siliquae bearing length and 1000-seed weight than A_1, A_2 and A_3 treatments. Anti- transpirants helps in minimizing the water losses from the leaves and helped in curtailing the stress effect (Badukale *et al.* (2015).

Seed, stover and biological yield: Seed, stover and biological yield of mustard was significantly influenced by irrigation levels (Table 1). During 2017–18 and 2018–19, seed yield with application of two irrigations at 40 and 75 DAS (I_3) increased by 18.3% and 14.0% over I_2 and 39.8% and 43.0% over I_1, respectively. The notable improvements in seed and stover yield as well as biological yield were obtained due to successive increase in number of irrigations from I_1 to I_3 at different phenological stages. The better response of yield under I_3 treatment might be due to sufficient soil moisture status at plant growth and development and, diversion of translocate towards storage sites. These results are also confirmed by Verma *et al.* (2014). Seed yield with RH-749 (V2) increased by 11.9% and 13.4% over RH-725 (V_1), respectively during both the years. Similar results have reported by Datta *et al.* (2012). Marked effect of various anti-transpirants was noted on yield but did not exhibit any influence on harvest index. Seed yield, stover and biological yield was recorded significantly higher with application of PMA @250 ppm + kaolin (6%) at 45 and 90 DAS (A_4) as compared to A_1 treatment and it was at par with both application of kaolin (6%) at 60 and 90 DAS (A_3), during both the years. The application of anti-transpirants increase yield through water balance in different crop parts and improve overall growth and seed development (Kumar *et al.* 2017).

Interactive effect of irrigation levels and anti-transpirants on yield and productivity of mustard: Interaction effect between levels of irrigation and anti-transpirants showed their significance on seed yield, stover yield and productivity per day (Table 2). The significantly higher seed, stover yield and productivity per day were recorded with

Table 1 Effect of irrigation levels, varieties and anti-transpirants on yield attributes and yield of Indian mustard

Treatment	Number of seeds per siliquae		Siliquae bearing length (cm)		1000-seed weight (g)		Seed yield (kg/ha)		Stover yield (kg/ha)		Biological yield (kg/ha)		Harvest index (%)	
	2017–18	2018–19	2017–18	2018–19	2017–18	2018–19	2017–18	2018–19	2017–18	2018–19	2017–18	2018–19	2017–18	2018–19
Irrigation levels (I)														
I_1	13.4	13.2	66.2	68.7	4.56	4.59	1395	1413	4072	4215	5467	5629	25.3	25
I_2	14.6	14.4	71.9	73	5.9	5.79	1649	1772	5253	5299	6902	7071	23.9	24.9
I_3	15.6	15.4	74.5	76.7	6.26	6.1	1950	2021	5605	5899	7555	7920	25.6	25.3
S.Em.±	0.2	0.1	0.8	1.2	0.09	0.16	68.8	80.9	75.2	44.2	100.7	85.4	0.9	0.9
CD (P=0.05)	0.5	0.4	2.6	3.8	0.29	0.5	216.7	255	236.9	139.2	317.3	269.2	NS	NS
Varieties (V)														
V_1	14.3	14.2	69.6	71.2	5.46	5.28	1571	1626	4871	5069	6442	6695	24.3	24.1
V_2	14.8	14.5	72.1	74.4	5.69	5.7	1758	1845	5083	5206	6840	7051	25.6	26
S.Em.±	0.1	0.1	0.7	1	0.08	0.13	56.2	66.1	61.4	36.1	82.2	69.8	0.7	0.7
CD (P=0.05)	0.4	0.3	2.1	3.1	0.24	0.4	177	208.2	193.4	113.7	259	219.8	NS	NS
Anti-transpirants (A)														
A_1	14.2	13.8	68	68.6	5.24	5.16	1517	1510	4602	4958	6119	6469	24.5	23.1
A_2	14.3	14.1	69.2	72.6	5.42	5.37	1619	1712	4888	5088	6507	6800	25.1	25.2
A_3	14.6	14.7	72.6	74.5	5.68	5.48	1641	1832	5092	5171	6733	7003	24.3	25.9
A_4	15	14.8	73.7	75.5	5.95	5.96	1880	1887	5326	5333	7207	7221	26	25.9
S.Em.±	0.2	0.2	1.4	0.8	0.17	0.18	58.6	68	93.7	63.2	116.4	81.5	0.7	0.8
CD (P=0.05)	0.51	0.52	4	2.3	0.47	0.52	168.1	195	268.7	181.1	333.8	233.8	NS	NS

Treatment details are given under Materials and Methods.

Table 2 Effect of interaction between levels of irrigation and anti-transpirants on seed yield, stover yield and productivity per day of Indian mustard

Treatment		2017–18					2018–19				
		Anti-transpirants (A)									
		A_1	A_2	A_3	A_4	Mean	A_1	A_2	A_3	A_4	Mean
		Seed yield (kg/ha)									
Irrigation levels (I)	I_1	1123	1577	1456	1422	1395	1222	1669	1374	1388	1413
	I_2	1576	1489	1673	1857	1649	1718	1562	1865	1944	1772
	I_3	1853	1790	1794	2361	1950	1591	1904	2257	2329	2021
	Mean	1517	1619	1641	1880		1510	1712	1832	1887	
	S.Em.±			102					118		
	CD (P=0.05)			291					338		
		Stover yield (kg/ha)									
Irrigation levels (I)	I_1	3958	3900	4319	4111	4072	4292	4111	4167	4292	4215
	I_2	4743	5243	5139	5889	5253	4875	5292	5431	5597	4215
	I_3	5104	5521	5817	5979	5605	5708	5861	5917	6111	5299
	Mean	4602	4888	5092	5326		4958	5088	5171	5333	5899
	S.Em.±			162					109		
	CD (P=0.05)			465					314		
		Productivity per day (kg/ha/day)									
Irrigation levels (I)	I_1	8.1	11.3	10.5	10.3	10	8.8	11.8	10.1	9.9	10.1
	I_2	11.4	10.6	11.7	12.9	11.7	12.3	11.2	13.2	13.7	12.6
	I_3	13.2	12.6	12.6	16.6	13.7	11.3	13.4	15.6	16.2	14.1
	Mean	10.9	11.5	11.6	13.2		10.8	12.1	12.9	13.3	
	S.Em.±			0.7					0.9		
	CD (P=0.05)			2.1					2.5		

Treatment details are given under Materials and Methods.

application of two irrigations at 40 and 75 DAS (I_3) along with PMA @250 ppm + kaolin (6%) at 45 and 90 DAS (A_4), during 2017–18 and 2018–19 and was statistically at par with treatment combinations of I_3A_3 only during 2018–19. It might be because effective irrigation was available throughout crucial growth stages. It must ensure that the crop's root zone has an adequate amount of moisture, that various nutrients are absorbed, and plant growth traits are generally improving. The complex interactions between its components, which are impacted by the growth cycle during vegetative stages and reflected during productive phases, may be the cause. Anti transpirants also helps plants to survive in stress condition and synergistic the effect of different irrigation levels. Similar results were reported by Kumar *et al.* (2017).

Relationship of different yield attributes with seed yield of mustard crop: The correlation analysis (Table 3) indicates that seed yield (kg/ha) was significantly and positively correlated with yield attributing characters, viz. number of siliquae/plant (0.89 and 0.72), length of siliquae (0.79 and 0.64), number of seeds per siliquae (0.77 and 0.71), siliquae bearing length (0.82 and 0.71), test weight (0.65 and 0.73) and seed yield per plant (0.81 and 0.70), respectively during 2017–18 and 2018–19. The highly significant and positive correlation established between seed yield and yield attributes confirm the above findings by Verma *et al.* (2014).

Based on the findings of this study, it is stated that the higher yield and yield traits could be obtained when mustard crop is grown with two irrigations, each at 40

Table 3 The values of correlation coefficient 'r' between seed yield and yield attributes

Character	Seed yield (kg/ha)	
	Correlation coefficient 'r'	
	2017-18	2018-19
Number of siliquae/plant	0.89**	0.72**
Length of siliquae (cm)	0.79**	0.64**
Number of seeds per siliquae	0.77**	0.71**
Siliquae bearing length (cm)	0.82**	0.71**
1000-seed weight (g)	0.65**	0.73**
Seed yield per plant (g)	0.81**	0.70**

*=Significant at 5% level; **=Significant at 1 % level.

and 75 DAS. The variety RH-749 proved to be better as compared to RH-725 in terms of all yield traits. Whereas, application of PMA @250 ppm + kaolin (6%) at 45 and 90 DAS (A_4) recorded significantly higher yield and yield parameters during both years of experimentation. It may be concluded that maximum seed yield can be achieved by sowing the mustard variety RH-749 along with application of two irrigations at 40 and 75 DAS and PMA @250 ppm + kaolin (6%) at 45 and 90 DAS on loamy sand soils. Findings suggest that, further research should be done to study the responses of mustard crop to different levels of irrigations, varieties and anti transpirants under different environmental conditions.

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