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Relative performance of drip irrigation in comparison to conventional methods of irrigation in Indian mustard (*Brassica juncea)* in south-west Haryana

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ABSTRACT

Application of water directly to the root zone through micro-irrigation system can reduce the water, fertilizer and labour requirements by improving their availability and use-efficiency. An experiment was conducted during winter (*rabi*) seasons of 2019–20 and 2020–21 at the research farm of CCS Haryana Agricultural University, Regional Research Station, Bawal, Haryana to study the relative performance of drip irrigation in comparison to conventional methods of irrigation in Indian mustard [*Brassica juncea* (L.) Czern.]. The experiment consisted 7 treatments, viz. two irrigations through flooding (as per state recommendation) at flowering and siliqua formation stage; two irrigations through sprinkler at flowering and siliqua formation stage; three irrigations through sprinkler at flowering, siliqua formation and seed development stage; and 6, 8, 10 and 12 split irrigations were applied from 30 days after sowing (DAS) through drip at 12, 9, 7 and 6 days interval, respectively. Volume of irrigation water under each treatment was same as under recommended practice of two flood irrigations (120 mm). Irrigation applied through drip at 6 days interval in 12 splits and at 7 days interval in 10 splits produced statistically similar seed yield to each other (22.51 and 21.94 q/ha, respectively) and significantly higher than recommended irrigation practice (18.92 q/ha) and sprinkler method of irrigation (18.62 and 19.32 q/ha) during 2019–20. The irrigation through drip in 12 splits (10 mm each) at an interval of 6 days between 30 to100 days after sowing also recorded the highest irrigation water-use efficiency (IWUE) (188 and 181 kg/ha-cm in 2019–20 and 2020–21, respectively). Based on these findings, it can be suggested to apply irrigation in Indian mustard through drip in 12 splits (10 mm depth each) at an interval of 6 days between 30 to100 DAS to get higher yield and water use efficiency.

Keywords: Drip irrigation, Flood irrigation, Indian mustard, Productivity, Sprinkler irrigation, Water use efficiency

Indian mustard [*Brassica juncea* (L.) Czern.] is one of the most important oilseed crops grown in the country. Among edible oilseed crops, rapeseed mustard is the second most important crop after groundnut. The estimated area, production and average yield of rapeseed-mustard in the world was 36.59 million hectares (mha), 72.37 million tonnes (mt) and 1980 kg/ha, respectively, during 2018–19 (DRMR 2023). Further, its area, production and productivity in India was 7.99 m ha, 11.96 mt and 1497 kg/ha, respectively, during 2021–22 (Anonymous 2023). By 2050, India needs to produce 17.84 million tonnes of vegetable oils to meet nutritional fat requirement of its projected population of 1685 million (Hegde 2012). India ranked third after Canada and China in area (19.3%) and production (11.1%) of the global rapeseed-mustard. Non-availability of sufficient irrigation water as per requirements of mustard crop causes moisture stress at critical stages of growth and development. Availability of irrigation water at critical stages of crop is a serious issue particularly in semi-arid areas of the country. To counter this deficit without missing the production targets, adoption of micro-irrigation system seems to be the best option.

The limited available water is applied mainly through check basin method of irrigation, where WUE seldom exceeds 35–40%. Many studies have been done by researchers in past and reported the higher water-use efficiency and crop yield under drip irrigation system as compared to conventional method across the globe (Kumar and Palanisami 2011, Narayanmuthy 2012, Abdelraouf *et al.* 2020, Uddian and Dhar 2020, Mehriya *et al.* 2020).

A large number of studies have been conducted on effect of water stress on rapeseed mustard but the effect of irrigation through different methods of irrigation especially micro-irrigation methods on growth, yield and water use efficiency

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has not been reported adequately. Keeping these facts in view, a field experiment was planned with the hypothesis that micro-irrigation (drip) may help in improving the crop productivity of Indian mustard with improved water use efficiency. Hence, the experiment was conducted to evaluate the effect of micro-irrigation and irrigation scheduling on growth, yield and irrigation water use efficiency of Indian mustard in semi-arid conditions of Haryana.

MATERIALS AND METHODS

The study was carried out at the research farm of CCS Haryana Agricultural University, Regional Research Station, Bawal, Haryana, during winter (*rabi*) seasons of 2019–20 and 2020–21. Soil of the experimental field was light-textured loamy sand, slightly alkaline in reaction (*p*H 8.1), low in organic carbon (0.20%) and nitrogen (112 kg/ha); and medium in available phosphorus (10.5 kg/ha) and potassium (176 kg/ha). The average annual rainfall of this region is about 300–450 mm, which is mostly (about 85%) received between July to September, and remaining (15%) during December-January. The average temperature ranged between 4.5 to 45°. The weather parameters during experiment were recorded at the Meteorological Observatory located at Research Farm, RRS, Bawal (Fig 1 and 2). The rainfall received during 1st year was higher and well distributed (96.7 mm in 7 rainy days) than the 2nd year (67.9 mm in 3 rainy days) of study. During the reproductive phase near the maturity, the average minimum and maximum temperature ranged lower during 1st year (9.4 and 25.8°C, respectively) than 2nd year (14.8 and 31.6°C, respectively) of experimentation except minimum temperature during 9th standard week (12.9°C in 2019–20 and 11.3°C in 2020–21).

The experiment consisting of 7 treatments, viz. two irrigations through flooding (60 mm each) at flowering and siliqua formation stage (T_1); two irrigations (60 mm each) through sprinkler at flowering and siliqua formation stage (T_2); three irrigations (40 mm each) through sprinkler at flowering, siliqua formation and seed development stage (T_3); and 6, 8, 10 and 12 split irrigations between 30–100 DAS (from flower initiation to pod formation stage of crop) through drip at 12, 9, 7 and 6 days interval, respectively (T_4–T_7), was laid out in a randomized block design with 3 replications. Volume of irrigation water under each treatment was same as under recommended practice of two flood irrigations (120 mm). The laterals were placed in alternate rows i.e. 60 cm apart (Lateral to lateral) with dripper at 30 cm with discharge rate of 1.6 litre/h at 1.5 kg/cm^2 pressure. The sprinkler was placed 20 feet spacing having the wetted radius of 10 metre. The discharge rate of sprinkler nozzle was 17.23 to 24.60 litre per minute (lpm) at 2.0 to 4 kg/cm^2. In the experimental field the pressure 2.5 kg/cm^2 was maintained at which the discharge rate of nozzle was 19.40 lpm. The time for irrigation was calculated on the basis of area, depth of irrigation and discharge rate.

Mustard crop variety RH 0725, after pre-sown irrigation, was sown on October 26 and 25 during 2019–20 and 2020–21, respectively. The sowing was done at a row spacing of 30 cm using the seed rate of 5.0 kg/ha. Excess

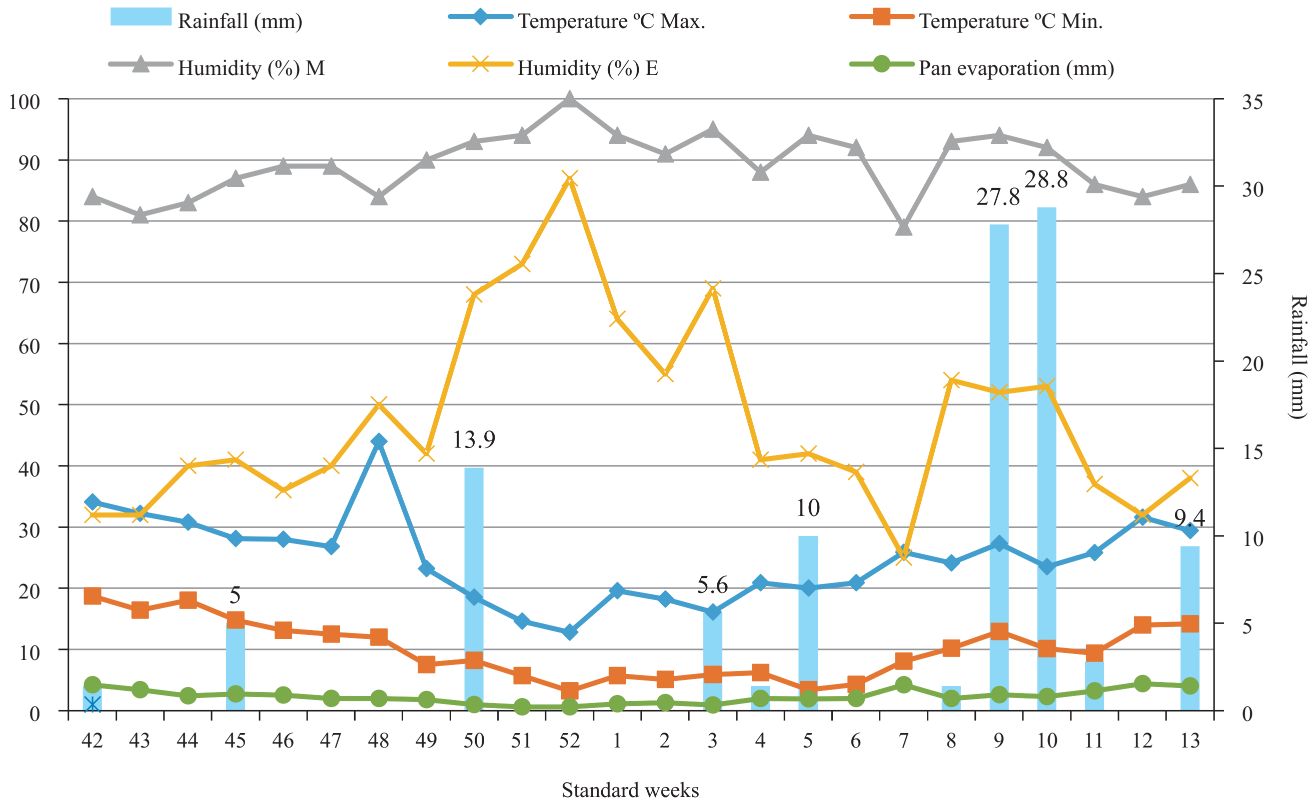

Fig 1 Weather parameters of the study area during the crop period 2019–20.
Note: 42nd week started from 15 October.

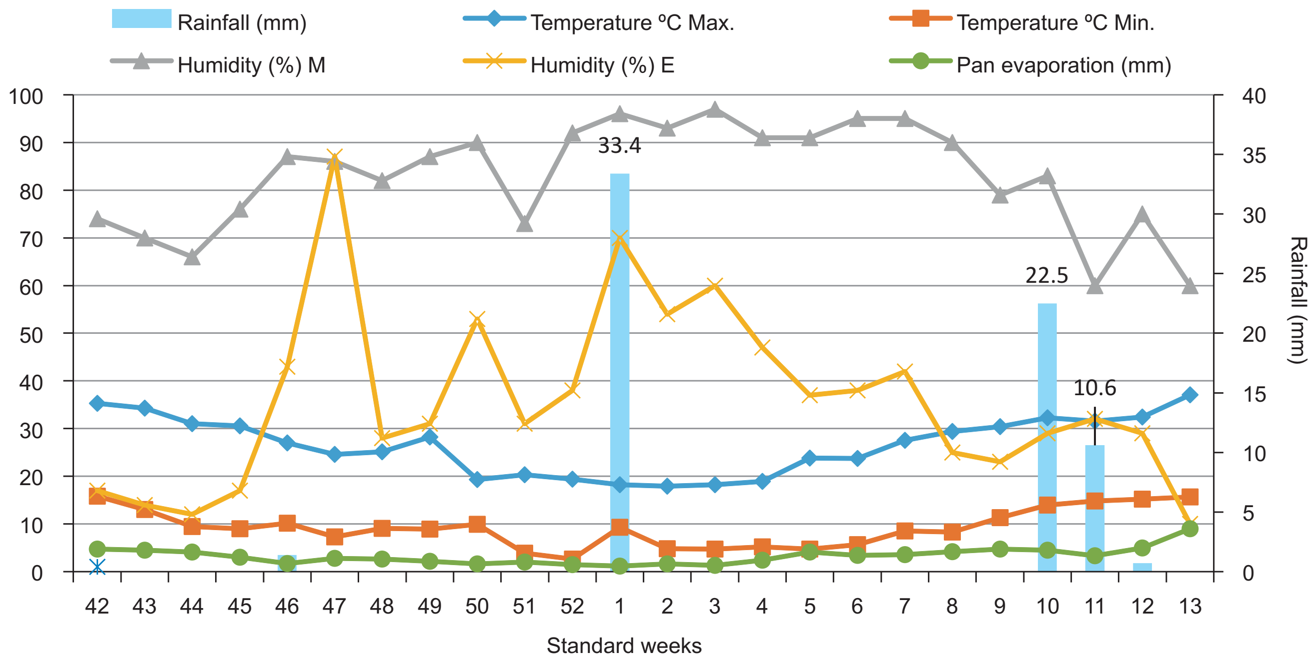

Fig 2 Weather parameters of the study area during the crop period 2020–21.
Note: 42nd week started from 15 October.

plants were removed by thinning at 15 DAS to maintain plant to plant spacing of 10 cm. Gross and net plot size was kept 20.0 m × 3.0 m and 16 m × 2.40 m, respectively. The crop was harvested on March, 19 and 21 during 2019–20 and 2020–21, respectively. All other practices were followed as per recommended package of practices by the State Agricultural University.

Ten plants from each plot were selected randomly and tagged to record growth parameters, viz. plant height, number of primary and secondary branches; and yield attributing characters, viz. number of siliqua/plant, number of seeds/siliqua and 1000-seed weight at harvest. The oil content was also determined during second year of study.

The irrigation water use efficiency (IWUE) in kg/ha-mm for a given treatment was calculated by dividing the seed yield with the respective total consumptive water use for the crop period.

$$\text{IWUE} = \frac{\text{Seed yield (kg/ha)}}{\text{Irrigation water (mm)}}$$

The data were statistically analyzed using 'OPSTAT' (Sheoran *et al.* 1998) software of CCS Haryana Agricultural University, Hisar, Haryana. Significance of treatments was judged with the help of 'F' test at 5% level of significance.

RESULTS AND DISCUSSION

Growth and yield attributes: Plant population and plant height at harvest were found statistically at par in all methods of irrigations and different scheduling of drip irrigation system (Table 1). Number of siliqua/plant and number of seeds/siliqua were significantly increased under drip irrigation method as compared to flooding and sprinkler irrigation. Drip irrigation applied in 10 and 12 splits gave statistically similar values of siliqua/pant and seeds/siliqua which were significantly higher than 6 and 8 splits (Table 1).

Number of branches (primary and secondary) and test weight were found at par in all the treatments, however, numerically higher values were recorded under drip irrigation compared to flooding and sprinkler during both the years. Number of branches/plant and test weight increased with increase in frequencies of split irrigation applied through drip irrigation system. The increase in yield attributes under drip irrigation could be due to continuous irrigation water supply at short intervals which might have escaped the water stress by providing uniform moisture availability during the growth and reproductive phases of crop growth. The water supply at regular interval under micro-irrigation systems shortened intermittent water stress period faced by the crop, thereby improved soil-plant-water relationship and finally yield attributes (Rao *et al.* 2010). Lokhande *et al.* (2019) also reported that check basin irrigation method recorded lower growth and yield parameter as compared to the surface and subsurface drip irrigation method in wheat crop. Sahu *et al.* (2020) found that irrigation scheduling at 60% potential evapotranspiration through drip recorded better growth in terms of plant height (197.06 cm), number of branches (10.28) and plant dry matter (21.36 g/plant), and maximum yield attributes like number of siliqua/plant (314.01), number of seeds/siliqua (16.13) of mustard. Sujatha *et al.* (2023) observed that the drip irrigation at 1.0 ETc recorded significantly higher growth and yield parameters, viz. number of grains, cob diameters, cob weight, grain weight and grain yield of maize crop (75.8 q/ha and 71.4 q/ha, respectively) in comparison to furrow irrigation at 0.8 IW/CPE ratio.

Seed Yield: The results (Table 2) revealed that

Table 1 Growth and yield attributes under different methods and scheduling of irrigation

Treatment	Plant population at harvest (lac.)		Plant height (cm)		No. of primary branches/plant		No. of secondary branches/plant		No. of siliqua/ plant		Test weight (g)		No. of seeds/ siliqua	
	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21
T_1	1.91	1.88	216	186	5.67	4.98	5.67	5.11	211	222	5.17	5.11	12.05	12.07
T_2	1.89	1.89	213	184	5.44	5.01	5.67	5.11	216	223	5.14	5.12	12.04	12.27
T_3	1.93	1.90	216	183	5.67	4.92	5.89	5.11	217	224	5.13	5.12	12.11	12.27
T_4	1.91	1.91	219	189	5.56	5.04	5.67	5.22	217	223	5.16	5.10	12.13	12.67
T_5	1.90	1.90	220	189	5.67	5.08	5.78	5.22	219	225	5.05	5.06	12.23	12.87
T_6	1.91	1.89	224	198	5.89	5.31	6.00	5.44	224	235	5.05	5.06	12.34	13.00
T_7	1.92	1.88	227	200	6.11	5.54	6.33	5.55	227	238	5.01	5.04	12.43	13.47
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	8.0	9	NS	NS	0.22	NS
CV (%)	8.05	6.24	9	5	10.36	8.64	8.93	9.63	2	2	2.11	1.71	3.85	4.20

Treatment details are given under Materials and Methods.

application of irrigation through drip at 6 days interval in 12 splits and 7 days interval in 10 splits produced statistically at par (22.51 q/ha and 21.94 q/ha, respectively) and significantly higher seed yield over the recommended irrigation practice (18.97 q/ha) and sprinkler method of irrigations (18.62 and 19.32 q/ha) during 2019–20. Proper water management through drip irrigation helps the crop in quick utilization of the readily available water and nutrients resulting into higher growth which increases total biomass as well as seed yield of mustard as compared to flood and sprinkler irrigation methods. The results of the study are in close conformity with Rathod *et al.* (2014). Statistically higher stover yield of Indian mustard was recorded under drip irrigation applied in 12 and 10 splits at 6 and 7 days interval as compared to 6 and 8 splits at 9 and 12 days interval, respectively. Mostafa *et al.* (2018) investigated drip irrigation management on wheat crop in clay soils in Egypt where three irrigation intervals of 4, 8 and 12-days treatments were evaluated and found that 8-days interval of irrigation was the most suitable in wheat crop to get maximum yield and water use efficiency.

A micro-irrigation system increased wheat yield under limited water availability by enhancing soil moisture compared to basin irrigation. However, when irrigation water was plentiful, micro-irrigation methods did not increase yields to that extent (Fang *et al.* 2018). The potato crop grown under drip irrigation was compared with furrow irrigation systems on the farmer's field under semi-arid conditions of Punjab, Pakistan and better plant growth, a greater number of tubers/plant and higher crop yield were recorded under drip irrigation system (Malik *et al.* 2020). Singh *et al.* (2022) also concluded that the water application at alternate days with subsurface drip irrigation and at every 3rd days with surface drip irrigation gives better performance to obtain the maximum yield of broccoli grown in the semi-arid region of India. Wonprasaid *et al.* (2023) also reported while comparing irrigation methods in sugarcane crop, the surface drip irrigation produced the highest cane average yield and the lowest in furrow irrigation as the drip irrigation system could maintain the optimal soil water status throughout growing periods.

In the present study sprinkler irrigation either in 2 or 3 splits produced statistically similar yield to recommended practice of 2 irrigations through flooding during both the years. Mila *et al.* (2016) also reported statistically similar yield under two irrigation applied through sprinklers and basin methods.

Water use and water use efficiency: Total water-use was 216.7 and 187.9 mm including 120 mm through irrigation (under all treatments in both years) and 96.7 and 67.9 mm through rainfall received during the crop season of 2019–20 and 2020–21, respectively. It resulted into 19.0 and 13.1% higher IWUE under drip scheduling at 6 days and 15.8 and 11.9% at 7 days interval during 2019–20 and 2020–21, respectively, over recommended irrigation practice (Table 2). The other treatments including 9 and 12 days interval also improved the IWUE. Irrigation

Table 2 Yield, water use efficiency and per cent oil content under different irrigation methods and scheduling of irrigation

Treatment	Seed yield (q/ha)		Stover yield (q/ha)		IWUE (kg/ha-cm)		Per cent Oil content
	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21	(2020–21)
T_1	18.97	19.17	50.17	47.78	158	160	38.7
T_2	18.62	19.30	50.01	46.93	155	161	38.9
T_3	19.32	19.59	51.38	47.12	161	163	38.8
T_4	19.54	19.81	54.34	49.34	163	165	38.9
T_5	20.05	20.12	58.70	52.15	167	168	39.1
T_6	21.94	21.50	65.56	58.56	183	179	39.3
T_7	22.51	21.68	65.89	59.36	188	181	39.3
CD (P=0.05)	1.19	1.55	4.92	5.39	-	-	NS
CV (%)	5.86	4.28	6.85	6.24	-	-	0.96

Treatment details are given under Materials and Methods.

scheduling under micro-irrigation system provided water to the plants more frequently which match with the crop evapotranspiration demand and provide uniform irrigation at critical growth stages resulting in lower water use and higher water use efficiency (Wang *et al.* 2001, Kar *et al.* 2005).

Low water expenses (178.91 mm) and improved water expense efficiency (11.23 kg/ha-mm) were recorded for drip irrigation as compared to farmer's practice under dry moist, sub-humid region of Chhattisgarh (Sahu *et al.* 2020). Malik *et al.* (2020) also reported that drip irrigation exhibited significantly higher IWUE (16.3 kg/m^3) and total WUE (14.1 kg/m^3) under drip as compared to furrow irrigation in potato crop. Similarly in maize crop the irrigation through drip at 1.0 ET_c consumed 28.6% less water but recorded significantly higher water productivity over furrow irrigation (Sujatha *et al.* 2023).

Per cent oil content: The per cent oil content during the second year of experiment did not differ significantly under different treatments (Table 2). There is a slight increase in oil content in drip irrigation as compare to conventional and sprinkler methods. Bhindani *et al.* (2020) also reported that the oil content in Indian mustard increased with increase in application of irrigation water from 1.0 ET_c to 1.2 ET_c under similar dose of nutrient.

Irrigation water management is the key to obtain higher production in areas having water scarcity of good quality underground water as well as low and uncertain rainfall. Drip irrigation system helps in improving the soil moisture conditions around the active root zone, conducive for better growth, yield and water use efficiency. The present study can be concluded that the drip irrigation was superior to sprinkler and flood irrigation in terms of yield and water use efficiency in Indian mustard. Irrigation through drip in 12 splits (10 mm each) from 30 to100 DAS at 6 days' interval produced the highest yield with maximum water-use efficiency resulting into 17% increase in seed yield and water-use efficiency in Indian mustard over flooding and sprinkler irrigation. Based on these results further study on evaluation of drip irrigation under different crop geometry with reducing quantum of irrigation water can be conducted under similar agro-climatic conditions.

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