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Effect of drip-fertigation levels on *gobhi sarson* (*Brassica napus*) performance under Punjab conditions

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ABSTRACT

A field experiment was conducted to study the effect of drip irrigation and fertigation levels on performance of *gobhi sarson* (*Brassica napus* L.) during *rabi* 2016–18. The results revealed that application of irrigation through drip at 100% of CPE ($I_{1.0}$) recorded highest values for growth components, viz. periodic plant height, dry matter accumulation and leaf area index than $I_{0.8}$ (80% of CPE) and $I_{0.6}$ (60% of CPE). Maximum seed and oil yield were recorded at $I_{1.0}$, which was statistically *at par* with $I_{0.8}$ but significantly higher than $I_{0.6}$ and absolute control. Utilization of water-soluble fertilizers through drip at 100% RDF ($F_{1.0}$) recorded highest growth components along with seed and oil yield than that produced by 80 and 60% RDF ($F_{0.8}$ and $F_{0.6}$). Among treatment combinations, drip-fertigation at $I_{1.0}$ or $I_{0.8}$ with $F_{1.0}$ or $F_{0.8}$ significantly enhanced seed and oil yield of *gobhi sarson* than absolute control (flood irrigation and manual application of RDF).

Keywords: Drip irrigation, Fertigation, *Gobhi sarson*, Oil yield, Seed yield

Rapeseed-mustard (*Brassica* spp.) is an important source of edible vegetable oil in India. Globally, India ranks 2nd after Canada in acreage (19.81%) and 4th after Canada, China and European Union in its production (10.37%). Despite the increase in availability of edible oil in the country from 8.80 (2015–16) to 11.35 million tonnes (2019–20), the import has increased up to 13.60 million tonnes during 2019–20 (Anonymous 2021).Thus, a huge gap exists between demand and supply of oilseeds and to meet this gap, refinement of prevailing set of technology and management of available resources are highly desirable.

Among the seven edible oilseed crops cultivated in India, rapeseed-mustard accounted for the most important one after soybean during 2019–20 with area, production and productivity of 6.86 million ha, 9.12 million tonnes and 1331 kg/ha, respectively (Anonymous 2021). While Punjab occupies an area of 30.5 thousand ha with total production of 46.5 thousand tonnes and 1524 kg/ha productivity, during 2018-19 (Anonymous 2020). Owing to high yield potential and compatibility with diverse agro-climatic conditions, *gobhi sarson* (*Brassica napus* L.) among *Brassica* species emerged as a popular oilseed crop in Punjab and other northern states. Although Punjab is an irrigated state, but faulty and defective practices with poor irrigation scheduling resulted in low crop and water productivity. Himanshu *et al.* (2012) revealed that the overall efficiency of various surface irrigation methods is considerably very low (33%) and about 67% of water got wasted due to seepage, evapo-transpiration and poor water application technology. Correspondingly, a large portion (10-15%) of land is also wasted in bunds and water channels (Kushwah and Dwivedi 2013). Thus, drip irrigation evolved as an agronomically efficient water and nutrient delivery system for cultivating various crops. This system delivers water and nutrients directly into the root zone of crop plants in a right and required amount with timely preciseness and minimum evaporation losses. In view of this, an experiment was conducted during *rabi* 2016–18 to study the effect of drip-fertigation levels on the performance of *gobhi sarson* cv. GSC 7 under semi-arid and sub-tropical conditions of Punjab.

MATERIALS AND METHODS

The present study was conducted at the Research Farm, Department of Agronomy, Punjab Agricultural University, Ludhiana, Punjab ($30^0$54' N latitude and 75^0 48' E longitude) during *rabi* 2016–17 and 2017–18. Soil of the experimental field was loamy sand in texture with 7.3 pH, 0.34% available organic carbon, 184.0, 22.0, 21.5 and 341.2 kg/ha available N, P, S and K, respectively. The experiment was conducted in randomized complete block design (RCBD) with combination of three drip irrigation levels based on cumulative pan evaporation (CPE), i.e. 100, 80 and 60% of CPE ($I_{1.0}$, $I_{0.8}$, $I_{0.6}$) and three fertigation levels, i.e. 100, 80 and 60% of RDF (recommended dose

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of fertilizers) ($F_{1.0}$, $F_{0.8}$, $F_{0.6}$) with one absolute control (flood irrigation and manual application of RDF). The *gobhi sarson* cv. GSC 7 was sown manually using 3.75 kg/ha seed with inter-row and intra-row spacing of 45 and 10 cm, respectively. The sowing was done on 7th November and 27th October during 2016–17, respectively.

Drip irrigation treatments were started one month after sowing and thereafter scheduled at 6 days interval. Volume of irrigation water applied was equal to CPE of the respective treatments. The rainfall and pan-evaporation data were obtained from Department of Agrometeorology and Climate Change, PAU, Ludhiana. In absolute control plot, application of flood irrigation was done thrice, i.e. 30 days after sowing (DAS), end December and end February. Fertigation levels were started at 15 DAS and applied through water-soluble fertilizers such as urea, mono-ammonium phosphate and elemental sulphur in ten splits at 6 days interval. In absolute control, half N and full P_2O_5 were applied as basal dose and the remaining N was applied with first irrigation. Periodic observations on growth components were recorded at 30 days interval till harvest. Seed and stover yield were obtained from net plot area and expressed as t/ha. Seed oil content was determined by Nuclear Magnetic Resonance Analyser (dry) extraction method. To estimate N, P and S content in seed and stover, Micro Kjeldahl's Distillation Method, Vanado-phospho-molybdate yellow colour method and Turbid Metric method were used, respectively. Whereas, K was estimated using flame photometer.

Data were analysed using SAS software (9.3, SAS Institute Ltd, USA) and the comparisons were done at 5% level of significance.

RESULTS AND DISCUSSION

Growth components: The growth components of *gobhi sarson* cv. GSC 7 were significantly influenced by drip irrigation and fertigation levels. Drip irrigation at $I_{1.0}$ recorded maximum plant height, dry matter accumulation (DMA) and leaf area index (LAI) at 60, 90, 120 DAS and at harvest, which was *at par* with $I_{0.8}$ but higher than $I_{0.6}$ (Fig 1). Irrigation levels $I_{1.0}$ and $I_{0.8}$ recorded 6.5 and 4.8% taller plants and 56.0 and 48.7% higher DMA and 21.8 and 19.3% higher LAI at 90 DAS than $I_{0.6}$, respectively (pooled). Correspondingly, fertigation treatment $F_{1.0}$ obtained maximum plant height, DMA and LAI followed by $F_{0.8}$ and $F_{0.6}$. The treatments $F_{1.0}$ and $F_{0.8}$ noted 5.7 and 4.0% taller plants than $F_{0.6}$ at 90 DAS, respectively. Enhancement in growth components at higher levels of drip-fertigation might be due to regular supply of water and water-soluble fertilizers through drip irrigation at optimum growth stages that increased their absorption by the crop and resulted in higher production of photosynthates and their translocation to sink (Sahoo *et al.* 2018).

Treatment combination $I_{0.6}F_{0.6}$ and absolute control resulted in lower plant height, DMA and LAI. This might be due to the stress caused by lesser availability of moisture and nutrients at this level because of application of lower dose of water and fertilizers (Sinha *et al.* 2017). Furthermore, lower growth components in recommended practice (absolute control) might be due to less frequent application of irrigation water that too at longer intervals resulted in poor uptake of water and nutrients and hence, reduced growth.

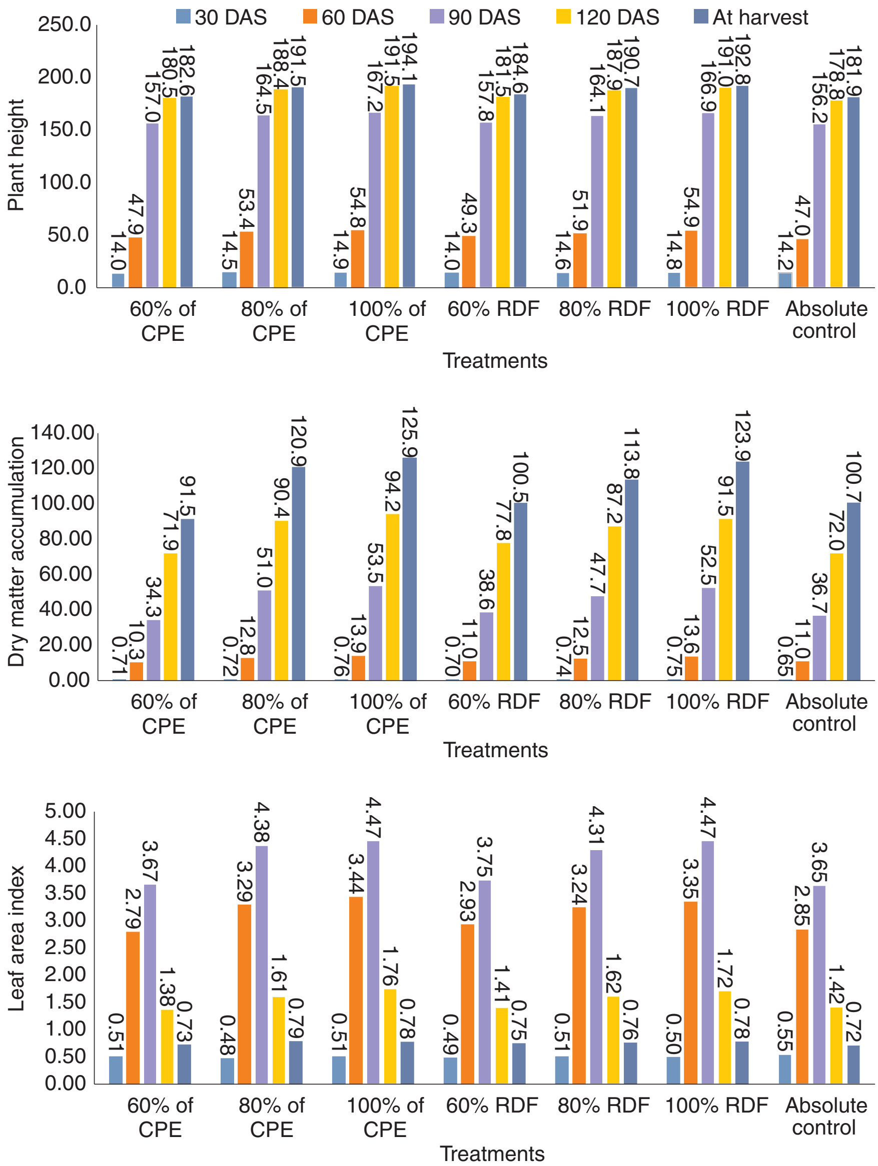

Fig 1 Effect of drip irrigation and fertigation levels on periodic plant height (cm), DMA (q/ha) and LAI of *gobhi sarson* (mean of 2 years).

Table 1 Effect of drip irrigation and fertigation levels on yield and quality of *gobhi sarson* during *rabi* 2016–17 and 2017–18

Fertigation levels (F)	2016-17					2017-18				
	Irrigation levels (I)				Absolute control (AC)	Irrigation levels (I)				Absolute control (AC)
	$I_{0.6}$	$I_{0.8}$	$I_{1.0}$	Mean		$I_{0.6}$	$I_{0.8}$	$I_{1.0}$	Mean	
Seed yield (t/ha)										
$F_{0.6}$	1.64	1.78	1.83	1.75	1.74	1.77	2.09	2.17	2.01	1.92
$F_{0.8}$	1.76	2.09	2.18	2.01		2.02	2.41	2.49	2.31	
$F_{1.0}$	1.82	2.15	2.24	2.07		2.07	2.46	2.54	2.36	
Mean	1.74	2.01	2.08			1.95	2.32	2.40		
CD (P=0.05)	I=0.11 F=0.11 I×F=NS I×F v/sAC=0.14					I=0.15 F=0.15 I×F=NS I×F v/s AC= 0.18				
Stover yield (t/ha)										
$F_{0.6}$	5.94	6.38	6.72	6.35	6.49	7.06	7.74	8.13	7.64	7.56
$F_{0.8}$	6.18	6.92	7.47	6.86		7.63	8.31	8.73	8.22	
$F_{1.0}$	6.50	7.43	7.71	7.21		7.65	8.56	8.94	8.38	
Mean	6.20	6.91	7.30			7.45	8.20	8.60		
CD (P=0.05)	I=0.64 F=0.64 I×F=NS I×F v/s AC= NS					I=0.62 F=0.62 I×F=NS I×F v/s AC= NS				
Harvest Index										
$F_{0.6}$	22.1	21.9	21.4	21.8	21.1	20.3	21.2	21.1	20.9	20.3
$F_{0.8}$	22.3	23.3	22.6	22.7		21.0	22.5	22.1	21.9	
$F_{1.0}$	22.0	22.5	22.5	22.3		21.4	22.4	22.1	22.0	
Mean	22.1	22.5	22.1			20.9	22.0	21.8		
CD (P=0.05)	I= NS F= NS I×F=NS I×F v/s AC= NS					I=NS F=NS I×F=NS I×F v/s AC= NS				
Oil content (%)										
$F_{0.6}$	41.4	40.8	41.1	41.1	40.2	40.8	40.3	40.7	40.6	40.4
$F_{0.8}$	40.7	40.7	38.9	40.1		40.0	39.5	38.8	39.4	
$F_{1.0}$	39.9	38.3	38.7	39.0		39.6	39.4	38.7	39.2	
Mean	40.7	39.9	39.6			40.2	39.8	39.4		
CD (P=0.05)	I=NS F=1.58 I×F=NS I×F v/s AC=NS					I=NS F=0.83 I×F=NS I×F v/s AC=NS				
Oil yield (t/ha)										
$F_{0.6}$	0.681	0.725	0.753	0.720	0.698	0.723	0.842	0.885	0.817	0.781
$F_{0.8}$	0.718	0.854	0.846	0.802		0.810	0.953	0.965	0.909	
$F_{1.0}$	0.724	0.822	0.866	0.804		0.820	0.972	0.982	0.925	
Mean	0.708	0.800	0.822			0.785	0.922	0.944		
CD (P=0.05)	I=0.059 F=0.059 I×F=NS I×F v/s AC =0.073					I=0.069 F=0.069 I×F=NS I×F v/s AC=0.085				
Protein content (%)										
$F_{0.6}$	17.9	18.2	18.0	18.0	18.6	17.9	18.3	18.0	18.1	18.5
$F_{0.8}$	19.1	19.5	19.6	19.4		18.9	19.6	20.0	19.5	
$F_{1.0}$	20.7	20.9	21.1	20.9		21.1	20.9	20.4	20.8	
Mean	19.2	19.5	19.6			19.3	19.6	19.5		
CD (P=0.05)	I=NS F=0.3 I×F=NS I×F v/s AC =0.5					I=NS F=0.6 I×F=NS I×F v/s AC =0.8				
Protein yield (t/ha)										
$F_{0.6}$	0.295	0.323	0.329	0.316	0.323	0.318	0.383	0.392	0.364	0.357
$F_{0.8}$	0.336	0.409	0.427	0.391		0.382	0.473	0.497	0.451	
$F_{1.0}$	0.377	0.448	0.472	0.432		0.437	0.516	0.517	0.490	
Mean	0.336	0.394	0.409			0.379	0.457	0.469		
CD (P=0.05)	I=0.022 F=0.022 I×F=NS I×F v/s AC =0.026					I=0.035 F=0.035 I×F=NS I×F v/s AC =0.043				

Table 2 Effect of drip irrigation and fertigation levels on N, P, K and S content of *gobhi sarson* seed and stover during *rabi* 2016–17 and 2017–18

Fertigation levels(F)	Seed										Stover									
	2016-17					2017-18					2016-17					2017-18				
	Irrigation levels (I)				Absolute control (AC)	Irrigation levels (I)				Absolute control (AC)	Irrigation levels (I)				Absolute control (AC)	Irrigation levels (I)				Absolute control (AC)
	$I_{0.6}$	$I_{0.8}$	$I_{1.0}$	Mean		$I_{0.6}$	$I_{0.8}$	$I_{1.0}$	Mean		$I_{0.6}$	$I_{0.8}$	$I_{1.0}$	Mean		$I_{0.6}$	$I_{0.8}$	$I_{1.0}$	Mean	
N content (%)																				
$F_{0.6}$	2.87	2.91	2.87	2.89	2.98	2.87	2.93	2.89	2.90	2.96	0.57	0.65	0.65	0.62	0.66	0.58	0.60	0.60	0.59	0.61
$F_{0.8}$	3.05	3.13	3.14	3.11		3.02	3.14	3.19	3.12		0.86	0.88	0.96	0.90		0.73	0.74	0.88	0.77	
$F_{1.0}$	3.32	3.34	3.38	3.35		3.38	3.35	3.26	3.33		1.04	1.06	1.08	1.06		0.99	1.01	1.01	1.01	
Mean	3.08	3.13	3.13			3.09	3.14	3.11			0.82	0.86	0.90			0.77	0.78	0.83		
CD (P=0.05)	I=NS F=0.06 I×F=NS I×F v/s AC =0.08					I=NS F=0.10 I×F=NS I×F v/s AC =0.12					I=NS F=0.1 I×F=NS I×F v/s AC =0.12					I=NS F=0.08 I×F=NS I×F v/s AC =0.10				
P content (%)																				
$F_{0.6}$	0.38	0.38	0.37	0.38	0.37	0.37	0.37	0.36	0.37	0.373	0.12	0.12	0.12	0.12	0.12	0.11	0.13	0.12	0.12	0.12
$F_{0.8}$	0.39	0.40	0.41	0.40		0.39	0.40	0.41	0.39		0.12	0.13	0.13	0.13		0.13	0.13	0.13	0.13	
$F_{1.0}$	0.39	0.43	0.41	0.41		0.40	0.41	0.41	0.41		0.13	0.14	0.14	0.13		0.13	0.13	0.13	0.13	
Mean	0.39	0.401	0.40			0.39	0.39	0.39			0.12	0.13	0.13			0.12	0.13	0.13		
CD (P=0.05)	I=NS F=0.02 I×F=NS I×F v/s AC =0.02					I=NS F=0.02 I×F=NS I×F v/s AC =0.02					I=NS F=NS I×F=NS I×F v/s AC =NS					I=NS F=NS I×F=NS I×F v/s AC =NS				
K content (%)																				
$F_{0.6}$	0.16	0.15	0.17	0.16	0.16	0.16	0.15	0.16	0.16	0.15	1.86	1.90	1.85	1.87	0.60	1.83	1.83	1.81	1.82	0.88
$F_{0.8}$	0.15	0.17	0.17	0.16		0.14	0.17	0.16	0.16		1.86	1.91	1.92	1.90		1.88	1.91	1.93	1.91	
$F_{1.0}$	0.15	0.16	0.17	0.16		0.16	0.16	0.17	0.16		1.84	1.90	1.94	1.90		1.89	1.95	1.94	1.92	
Mean	0.15	0.16	0.17			0.15	0.16	0.16			1.85	1.90	1.90			1.87	1.90	1.89		
CD (P=0.05)	I=NS F=NS I×F=NS I×F v/s AC =NS					I=NS F=NS I×F=NS I×F v/s AC =NS					I=NS F=NS I×F=NS I×F v/s AC =NS					I=NS F=NS I×F=NS I×F v/s AC =NS				
S content (%)																				
$F_{0.6}$	0.45	0.46	0.46	0.46	0.43	0.46	0.46	0.46	0.46	0.44	0.18	0.18	0.18	0.18	0.17	0.18	0.18	0.18	0.18	0.17
$F_{0.8}$	0.46	0.47	0.46	0.46		0.47	0.46	0.46	0.46		0.18	0.19	0.18	0.18		0.18	0.18	0.18	0.18	
$F_{1.0}$	0.50	0.49	0.51	0.50		0.49	0.50	0.50	0.50		0.18	0.19	0.19	0.19		0.18	0.18	0.19	0.19	
Mean	0.47	0.47	0.47			0.47	0.47	0.47			0.18	0.19	0.19			0.18	0.18	0.19		
CD (P=0.05)	I=NS F=0.01I×F=NS I×F v/s AC =0.01					I=NS F=0.01 I×F=NS I×F v/s AC =0.01					I=NS F=NS I×F=NS I×F v/s AC =NS					I=NS F=NS I×F=NS I×F v/s AC =NS				

Seed and stover yield: Drip fertigation considerably improved seed and stover yield of *gobhi sarson* (Table 1) compared to crop irrigated by conventional flood irrigation and manual application of fertilizers. In case of irrigation levels, maximum seed and stover yield were observed at $I_{1.0}$, which was statistically *at par* with $I_{0.8}$ and 19.5, 15.5 and 23.1, 19.0% higher than $I_{0.6}$ during 2016-17 and 2017-18, respectively. Likewise, $F_{1.0}$ resulted in maximum seed and stover yield followed by $F_{0.8}$, $F_{0.6}$ and absolute control. This could be due to the production of maximum LAI and DMA at higher doses (Fig 1), which resulted in higher seed yield. Moreover, higher drip irrigation and fertigation levels meant greater availability of water and water-soluble nutrients at the root zone of crop plants (Kumar *et al.* 2021).

Oil and protein content: Drip irrigation treatments did not show any significant difference in oil and protein content of the crop. Whereas, fertigation at $F_{0.6}$ produced 2.5, 5.4 and 3.0, 3.6% higher oil content than $F_{0.8}$ and $F_{1.0}$ during both the years, respectively (Table 1). Further, it was observed that oil content decreased with each successive increment in fertilizer doses. Thus, there is an inverse relationship between oil content and fertilizer doses, particularly nitrogen (Premi *et al*. 2013). Maximum protein content was obtained at $F_{1.0}$ which was statistically similar with $F_{0.8}$ but 16.1, 7.7% and 14.9, 7.7% higher than $F_{0.6}$ during 2016–17 and 2017–18, respectively. Likewise, Rathke *et al.* (2005) observed that high oil content in *Brassica* is generally correlated with low crude protein content and vice versa.

Oil and protein yield were determined by multiplying the per cent oil and protein content with the seed yield, respectively. Maximum oil and protein yield were obtained by drip irrigation at $I_{1.0}$, which was statistically indistinguishable from $I_{0.8}$ but significantly better than $I_{0.6}$ during both of the years, respectively. Sahoo *et al.* (2018) also reported 18.9% upsurge in sunflower oil when crop was irrigated through drip rather than furrow due to higher oil content and seed yield. Among fertigation levels, $F_{1.0}$ was statistically at par with $F_{0.8}$. However, it was observed that $F_{1.0}$ and $F_{0.8}$ produced 11.9, 11.7 and 13.2, 11.3% higher oil yield than $F_{0.6}$ during 2016-17 and 2017-18, respectively (Table 1). Although the oil content in seed decreased with the application of fertilizers specifically nitrogen, but oil yield increased significantly, indicating that oil yield was governed by the seed yield of *gobhi sarson* rather than its per cent oil content. Similarly, Daneshvar *et al.* (2008) observed that as the N rate increased, seed oil percentage decreased and seed oil yield increased significantly. Further, fertigation at $F_{1.0}$ recorded significantly higher protein yield than $F_{0.8}$ followed by $F_{0.6}$. While, $F_{0.8}$ produced significantly higher protein yield as compared to $F_{0.6}$. This trend was similar for both the crop seasons.

N, P, K and S content in seed and stover: The N, P and S content in seed were not significantly influenced by any of the drip irrigation level but fertigation had a substantial effect on these parameters (Table 2). Fertigation at $F_{1.0}$ produced maximum N and S content in seed and was significantly higher than $F_{0.8}$, $F_{0.6}$ and absolute control during 2016–17 and 2017–18, respectively. Maximum P content in seed was also reported at $F_{1.0}$, which was statistically *at par* with $F_{0.8}$ but significantly better than $F_{0.6}$ and absolute control. Similarly, in *gobhi sarson* stover maximum N content was recorded at $F_{1.0}$ which was 17.8, 70.9 and 31.2, 71.2% higher than $F_{0.8}$ and $F_{0.6}$ during 2016–17 and 2017–18, respectively. Increased dose of fertilizers at higher fertigation levels might have resulted in its greater accumulation in seed and stover as compared to lower doses. This might be due to application of fertilizers in water-soluble form through drip that provided nutrients in readily available form throughout the crop growth stages that resulted in greater nutrient uptake and their accumulation in the seeds and stover as compared to absolute control, where mostly nutrients were applied as basal. The K content in seed and stover were not significantly influenced by any drip irrigation and fertigation level, because the soil was high in available potassium and no potassic fertilizer was applied.

From the present investigation, it can be concluded that all drip irrigation and fertigation levels significantly improved growth and yield of *gobhi sarson* than absolute control (flood irrigation and manual application of RDF) except $I_{0.6}F_{0.6}$ (under dose of irrigation and fertilizers). Although drip-fertigation at $I_{1.0}$ or $I_{0.8}$ with $F_{1.0}$ or $F_{0.8}$ significantly enhanced seed, oil and protein yield of *gobhi sarson*, but $I_{1.0}F_{1.0}$ was statistically *at par* with $I_{0.8}F_{0.8}$ for all these components. Thus, $I_{0.8}F_{0.8}$ evolved as an efficient schedule with saving of irrigation water and fertilizers over $I_{1.0}F_{1.0}$ without any significant reduction in seed and oil yield.

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