



Growth and productivity of gobhi sarson (*Brassica napus*) cultivars under diverse sowing environments

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ABSTRACT

The sowing date of oilseed [winter (*rabi*) season] crop changes from year to year based on the harvesting of the preceding sown (rainy (*kharif*) season) crop in the northern regions of India, which exposes the crop to varying weather situations. So, to investigate the impact of sowing environments on growth, yield attributes and yield of gobhi sarson (*Brassica napus* L.) cultivars, an experiment was conducted with the 3 sowing environments and 3 cultivars under sub-tropical conditions of Jammu during the winter (*rabi*) season of 2018–19 and 2019–20. The pooled data of two years revealed that the early sown gobhi sarson crop recorded significantly highest growth parameters (plant height, leaf area index and dry matter accumulation) and yield attributes (number of primary and secondary branches/plant, siliquae/plant and seeds/siliqua) as compared to the delayed sown crop. With the result (source sink relationship), significantly higher seed yield was recorded under the first sowing environment (1758 kg/ha) sown crop, while significant reduction to the extent of 27.66% and 66.95% was recorded with delayed sowing, D₂ (1377 kg/ha) and D₃ (1053 kg/ha), respectively. The cultivar GSL-1 recorded significantly higher plant height, LAI, dry matter, primary and secondary branches/plant, siliquae/plant, seeds/siliqua, followed by ONK-1 and DGS-1, resulting in significantly higher yield of GSL-1 (1493 kg/ha) over DGS-1 (1262 kg/ha) but at par with ONK-1 (1432 kg/ha).

Keywords: Cultivars, Gobhi sarson, Growth, Sowing environments, Yield

The current annual production of edible oilseeds in India is only about 35–40% of the domestic requirements, and the shortfall is filled by imports of about 13.45 million tonnes of vegetable oil worth ₹81682 crores (Anonymous 2022) despite being the largest cultivator of the oilseed in the world. Rapeseed-mustard is one of the major oilseed crops, traditionally grown everywhere in the country due to its high adaptability in conventional farming system. In India, the rapeseed-mustard was grown on an area of 6.86 million ha, with a production of 9.12 million tonnes and a productivity of about 1.33 t/ha during 2019–20, while, in J&K, the area under oilseed crops was 47.24 thousand ha with production and productivity of about 54.28 thousand tonnes and 1149 kg/ha in 2018–19, respectively (Anonymous 2021). Being a thermo and photosensitive crop, the productivity of mustard is largely governed by prevailing weather conditions throughout the life cycle of crop (Meena *et al.* 2021). Among various weather parameters, temperature is the prime determinant of crop

growth and development as it regulates the physiological, chemical and biological processes of the oilseed rape (Sharma *et al.* 2021). The change in crop weather conditions faced by the crop at various growth stages with the change in sowing environment is bound to affect the productivity of the crop in any place. The optimum sowing time is an important agronomic factor and non-monetary input that significantly describes the potential yield of the crop in any region by creating an ideal environmental condition for better growth and higher productivity (Khajuria *et al.* 2017). Being a thermo-sensitive crop, choice of suitable cultivars for different sowing time further gets prime importance. Selection of non-recommended varieties for particular location is the main reason for low productivity of rapeseed-mustard in sub-tropical regions of Jammu division (Ajrawat *et al.* 2013). Keeping in view the above facts, the present study was carried out to optimize the suitable sowing environment and cultivar for maximizing the yield of the oilseed crop in the sub-tropics of Jammu region.

MATERIALS AND METHODS

The experiments were conducted at the research farm of the agrometeorology section, Sher-e-Kashmir University of Agricultural Sciences and Technology-Jammu, Chatha, J&K during two consecutive winter (*rabi*) seasons 2018–19

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and 2019–20. The site lies at 32°40'N latitude, 74°82' longitude and at an altitude of 293 m amsl, which represents sub-tropical Indo-Gangetic plain in western Himalayan agro-climatic zone lying under foothill lands of Shivalik in India. The meteorological data of both the years (*rabi*, 2018–19 and 2019–20) for different weather parameters of the entire crop growing period of the gobhi sarson crop were taken from Agrometeorological observatory, situated at 20 m distance from the experimental field (Fig 1). The crop growing period of various cultivars of gobhi sarson sown under different sowing environment varies between 42nd to 15th Standard Meteorological Weeks (SMW) and 42nd to 13th SMW during *rabi* season 2018–19 and 2019–20, respectively. The total rainfall received during entire crop growing period were 291.6 mm and 416.8 mm during *rabi*, 2018–19 and 2019–20, respectively. The highest average weekly maximum temperature of 33.8°C was recorded in the 15th SMW (April) and the lowest average weekly minimum temperature of 1.7°C was recorded in the 52nd SMW (December) with average morning and evening relative humidity of 90.80 and 48.00%, respectively during

rabi 2018–19, but the mean weekly maximum temperature recorded to 29.3°C in the 43rd SMW (October), while the lowest minimum temperature of about 4.8°C was recorded in the 6th SMW (February) and average morning and evening relative humidity were 89.40% and 57.80% during *rabi* 2019–20 (Fig 1).

Site description and methodology: The soil of the experimental site was sandy loam in texture and was analyzed by Bouyoucous Hydrometer method (Piper 1966), normal in reaction (*pH* 7.60) and safer range of electrical conductivity (0.15 dS/m) measured by glass electrode *pH* meter and EC meter in 1:2.5 soil:water ratio (Jackson 1973), low in organic carbon (0.41%) by using dichromate oxidation method (Walkley and black 1934), low in available nitrogen (219.5 kg/ha) determined by alkaline potassium permanganate method (Subbiah and Asija 1956), medium in available phosphorous (14 kg/ha) and potassium (132.46 kg/ha) estimated by sodium bicarbonate method (Olsen *et al.* 1954) and ammonium acetate extraction method (Jackson 1973), respectively. The experiment was laid out in factorial randomized block design keeping combinations of three sowing environment (20th October, 30th October and 9th November) and (16th October, 30th October and 14th November) in 2018 and 2019, respectively along with three cultivars (GSL-1, ONK-1 and DGS-1). Seeds (5 kg/ha) were sown at specified distance between the rows (45 cm) and plants (10 cm) in 3 cm depth in furrows by Kera method for all the cultivars. The crop was supplemented with 60 kg/ha nitrogen (N), 40 kg/ha phosphorus (P₂O₅) and 20 kg/ha potassium (K₂O). Seeds (5 kg/ha) were sown at specified distance between the rows (45 cm) and plants (10 cm) in 3 cm depth in furrows by Kera method for all the cultivars. Need based plant protection measures were adopted to protect the crop from insect pests and diseases. For weed management, uniform application pendimethalin @1 l/ha as pre-emergence was done on the same day after sowing with the help of knapsack sprayer using a spray volume of 500 l/ha. The parameters studied during study were growth characteristics, yield attributing characters and yield. Plant height was recorded by selecting and tagging five random plants within the area of each net plot and height was measured with meter scale from soil surface to apex of the plant and the mean values thus worked out are presented in centimeters (cm). For the leaf area

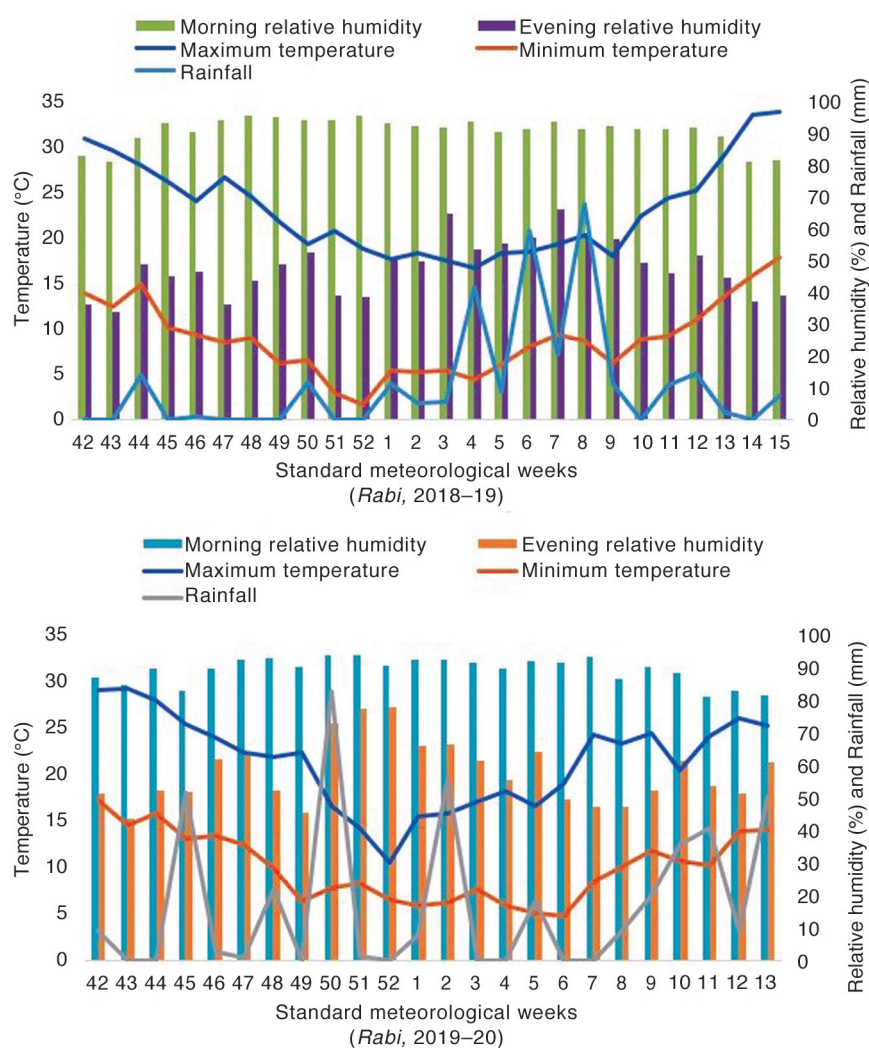


Fig 1 Weekly weather data of temperature (°C), relative humidity (%), and rainfall (mm) during the entire growing period of gobhi sarson in *rabi*, 2018–19 and 2019–20.

For the leaf area

index, half running metre row length plants were uprooted and the leaf area of all leaves was measured separately with a leaf area metre (MODEL: LAMETRE-211). In present study, the LAI of 90 DAS has been taken into consideration as maximum LAI was observed at this growth stage. The leaf area worked out per plant was divided by the ground area occupied by plants to find out leaf area index (Watson 1947).

$$\text{Leaf area index (LAI)} = \frac{\text{Leaf area (cm}^2\text{)}}{\text{Land area (cm}^2\text{)}}$$

Further, these plant samples were sun-dried and thereafter shifted in an oven to dry at temperature of $65 \pm 5^\circ\text{C}$ till a constant weight was achieved for dry matter accumulation. The dry matter recorded for the half meter row length was multiplied with total number of plants/m² in each treatment and expressed as dry weight in g/m² at physiological maturity of the crop. Total number of primary branches, secondary branches and number of siliquae obtained from the five randomly selected plants from all the treatments were counted and mean of five plants was expressed as the number of primary branches per plant, number of secondary branches per plant and number of siliquae per plant. The seeds of 20 siliquae taken randomly from the 5 randomly selected plants in all treatments were averaged to calculate number of seeds per siliqua. From the individual plot, the produce was harvested from net plot area; sun dried for 3–4 days, subsequently threshed manually and cleaned. The seeds thus obtained were weighed and expressed as seed yield in kg/ha. After proper drying the produce and prior to threshing of the net plot area, the total biological yield (seed + stover) obtained from the net plot was recorded and expressed in kg/ha. Stover yield per net plot was worked out from each treatment by subtracting total seed weight from the total biological weight. The stover yield thus obtained was weighed and expressed in kg/ha. Harvest index was calculated as (Nichiporovich 1967):

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

Statistical analysis: Analysis of variance was performed to evaluate the influence of sowing environments and cultivars on growth characteristics, yield attributes and yield along with their interaction. The statistical analysis of the data was done by using OP STAT software developed by CCSHAU, Hisar for both the years separately. The difference between means was compared with Fisher's least significant difference test (LSD) at 5% probability level ($P=0.05$). Since the trends in results were similar during both the years, the data was pooled.

RESULTS AND DISCUSSION

Impact of sowing environments and cultivars on growth characteristics: The various growth parameters, viz. plant height, leaf area index and dry matter accumulation differ significantly with respect to sowing environment and cultivars as the pooled data presented in Table 1 revealed that the crop sown under first sowing environment

Table 1 Effect of sowing environments on plant height, LAI and dry matter accumulation of gobhi sarson cultivars (pooled data of 2 years)

Treatment	Plant height (cm)	Leaf area index (90 DAS)	Dry matter accumulation (g/m ²)
<i>Sowing environments (D)</i>			
First sowing environment (D ₁)	190.17	5.14	809.08
Second sowing environment (D ₂)	184.18	4.59	651.75
Third sowing environment (D ₃)	170.00	3.50	511.67
SEm (±)	1.33	0.07	4.54
CD (P=0.05)	3.98	0.23	13.72
<i>Cultivars (V)</i>			
GSL-1 (V ₁)	184.60	4.64	709.61
ONK-1 (V ₂)	183.04	4.42	662.03
DGS-1 (V ₃)	176.70	4.18	600.85
SEm (±)	1.33	0.07	4.54
CD (P=0.05)	3.98	0.23	13.72

Interaction: Non significant, SEm: Standard error mean, CD: Critical difference

recorded significantly tallest plant height of about 190.17 cm followed by the second sowing environment (184.18 cm) and third sowing environment (170.00 cm) at maturity. Similar results were obtained in case of leaf area index and dry matter accumulation. Maximum leaf area index of the crop was recorded at 90 DAS and the crop sown of first sowing environment (5.14) recorded significantly higher LAI as compared to the second environment (4.59) and third environment (3.50) sown crop. Moreover, significantly higher dry matter accumulation was observed under first sowing environment (809.08 g/m²) sown crop in comparison to crop sown on second sowing environment (651.75 g/m²) and third sowing environment (511.67 g/m²) at maturity. This was due to the fact that the late-sown crop experienced relatively low temperatures, resulting in delayed germination and a shorter time span for growth and development. On the contrary, early sowing had resulted in improved nutrient availability to plants for efficient utilisation under favourable conditions, resulting in improved carbohydrate conversion for enhancing cell division and cell elongation. The variation in mean temperature at different developmental stages caused a reduction in leaf expansion and the number of leaves per plant during the early stages of crop reducing leaf area index. Due to unfavourable environmental conditions, the late-sown crop's short plant height and reduced leaf area resulted in less dry matter accumulation of the crop sown on the third sowing environment. Similar findings had also been reported by Keerthi *et al.* (2017)

The different cultivars also differ significantly with respect to plant height, leaf area index and dry matter

Table 2 Effect of sowing environments on yield attributes of gobhi sarson cultivars (pooled data of 2 years)

Treatment	No. of plants/m ²	Primary branches/plant	Secondary branches/plant	Siliquae/plant	Seeds/silique	Test weight (g)
<i>Sowing environments (D)</i>						
First sowing environment (D ₁)	20.22	5.20	13.25	159.95	19.16	3.05
Second sowing environment (D ₂)	20.00	4.47	11.60	150.25	18.21	3.02
Third sowing environment (D ₃)	19.94	3.95	9.95	127.70	16.73	2.94
SEm (±)	-	0.09	0.14	1.23	0.16	-
CD (P=0.05)	NS	0.27	0.43	3.70	0.49	NS
<i>Cultivars (V)</i>						
GSL-1 (V ₁)	20.28	4.79	12.15	150.87	18.55	3.07
ONK-1 (V ₂)	20.06	4.59	11.75	147.28	18.14	3.00
DGS-1 (V ₃)	19.83	4.24	10.90	139.75	17.42	2.93
SEm (±)	-	0.09	0.14	1.23	0.16	-
CD (P=0.05)	NS	0.27	0.43	3.70	0.49	NS

Interaction, Non-significant (NS); SEm, Standard error mean; CD, Critical difference

accumulation as presented in Table 1. The data revealed that cultivar GSL-1 recorded significantly higher growth parameters (plant height, leaf area index and dry matter accumulation) followed by the cultivar ONK-1 and DGS-1. It might be due to their genetic constitution of *Brassica* species and similar types of results were reported by Kumar *et al.* (2017).

Impact of sowing environments and cultivars on yield attributing characters: There was non-significant difference on number of plants/m² with respect to sowing environments and cultivars and data (Table 2) reveals different sowing environments failed to bring any significant difference with respect to no. of plant/m², but numerical difference was observed as first sowing environment sown crop recorded numerically higher number of plants (20.22) followed by second sowing environment (20.00) and third sowing

environment (19.94) sown crop. Similarly, test weight did not differ significantly with the sowing environments but numerical higher values of test weight was observed in first sowing environment (3.05 g) sown crop followed by the crop sown on second sowing environment (3.02 g) and third sowing environment (2.94 g). On contrary, other yield attributing characters differ significantly with different sowing environments as crop sown under first sowing environment recorded significantly higher no. of primary branches per plant (5.20), no. of secondary branches per plants (13.25), no. of siliquae per plant (159.95) and no. of seeds per silique (19.16) as compared to second environment and third environment sown crop due to translocation of more photosynthates from source to sink and longer reproductive phase with favourable temperature conditions under early sowing as compared to delayed sowing. Similar

Table 3 Effect of sowing environments on seed, biological and stover yield of gobhi sarson cultivars (pooled data of 2 years)

Treatment	Seed yield (kg/ha)	Biological yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)
<i>Sowing environments (D)</i>				
First sowing environment (D ₁)	1758	7833	6075	22.4
Second sowing environment (D ₂)	1377	6351	4974	21.6
Third sowing environment (D ₃)	1053	4907	3854	21.4
SEm (±)	16.91	92.10	88.70	-
CD (P=0.05)	51.14	278.50	268.22	NS
<i>Cultivars (V)</i>				
GSL-1 (V ₁)	1493	6684	5191	22.3
ONK-1 (V ₂)	1432	6529	5097	21.9
DGS-1 (V ₃)	1262	5877	4615	21.4
SEm (±)	16.91	92.10	88.70	-
CD (P=0.05)	51.14	278.50	268.22	NS
<i>Interaction (D×V)</i>	S	NS	NS	NS

S, Significant; NS, Non-significant; SEm, Standard error mean; CD, Critical difference

results substantiate with the findings of Kumari *et al.* (2012), Khajuria *et al.* (2017) and Meena *et al.* (2017).

Among cultivars, yield attributing characters did not differ significantly with respect to no. of plants and test weight but numerical higher values with respect to no. of plants/m² were obtained by GSL-1 followed by ONK-1 and DGS-1. On contrary, other yield attributing characters differ significantly with cultivars, as cultivar GSL-1 recorded significantly higher no. of primary branches per plant (4.79), no. of secondary branches per plant (12.15), no. of siliquae per plant (150.87) and no. of seeds per siliqua (18.55) as compared to cultivar DGS-1 but found at par with the cultivar ONK-1 (Table 2). The varietal difference in several yield attributes may be attributed as inherent variation due to their genetic makeup. Singh *et al.* (2015) and Meena *et al.* (2017) also reported varietal difference in yield attributes.

Impact of sowing environments and cultivars on yield: The seed yield recorded under different treatments is presented in Table 3 which revealed that the seed yield differed significantly with sowing environments and cultivars as the crop sown on first sowing environment (D₁: 1758 kg/ha) produced significantly highest seed yield as compared to the crop sown on second (D₂: 1377 kg/ha) and third sowing environment (D₃: 1053 kg/ha) whereas among cultivars, GSL-1 (1493 kg/ha) produced significantly higher seed yield than the DGS-1 (1432 kg/ha) but was at par with ONK-1 (1262 kg/ha). The biological and stover yield also differed significantly with the sowing environments and cultivars (Table 3). The first environment sown crop produced significantly highest biological and stover yield (7833 and 6075 kg/ha, respectively) followed by the crop sown on second environment (6351 and 4974 kg/ha, respectively) and third sowing environment (4907 and 3854 kg/ha, respectively), while among cultivars, GSL-1 recorded significantly higher biological and stover yield (6684 and 5191 kg/ha, respectively) than DGS-1 (5877 and 4615 kg/ha, respectively) but was found at par with ONK-1 (6529 and 5097 kg/ha, respectively). However, the interaction between sowing environments and cultivars showed that the seed yield of gobhi sarson cultivars differ significantly with diverse sowing environments (Fig 2). All cultivars sown under first sowing environment produced significantly higher seed yield than cultivars sown on second and third sowing environment. The cultivar GSL-1 (V₁) sown under the first sowing environment (D₁) recorded significantly higher seed yield of about 1885 kg/ha as compared to other treatment combinations (D×V). Moreover, under third sowing environment, ONK-1 (1165 kg/ha) produced significantly higher seed than DGS-1 (950 kg/ha) but was at par GSL-1 (1043 kg/ha) (Fig 2).

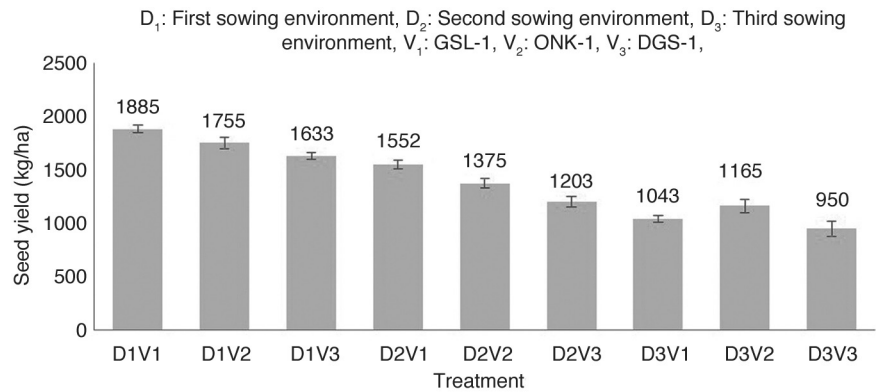


Fig 2 Interaction effect of sowing environments on seed yield of gobhi sarson cultivars (pooled data of 2 years).

The decrease in yield per hectare with delay in sowing occurred primarily due to the lower biomass build-up which resulted in reduced bearing capacity owing to slower growth on account of lower temperatures during early vegetative growth phase leading to reduced seed filling span (reproductive stage) and sink strength (siliqua number). Furthermore, due to unfavourable temperature conditions during delayed sowing, decreased photosynthetic translocation towards reproductive portions and early maturity led to a decrease in the number of siliquae/plant shortening of the siliqua filling period. High temperatures accelerated quick maturity due to accumulation of more heat units in lesser days, which decreased the seed yield under delayed sowing. Similar findings had also been reported by Kumari *et al.* (2012) and Khajuria *et al.* (2017). Harvest index did not differ significantly with sowing environments and cultivars due to similar ratio of seed with stover yield among different sowing environments and cultivars (Keerthi *et al.* 2017, Khajuria *et al.* 2017).

The findings of this study can be safely summarised by stating that the sowing environments have a significant impact on the growth characteristics, yield attributes and yield of the gobhi sarson crop. The crop sown up to 20th October performed significantly better in terms of growth traits (plant height, leaf area index and dry matter accumulation), which improves the yield-attributing characters (branches/plant, siliquae/plant, and seeds/silqua), thus, resulting in significantly higher yield (seed, biological and stover). Thereafter, the growth and yield of the crop were significantly reduced with the successive delay in sowing by 10–15 days. Among cultivars, GSL-1 recorded significantly higher growth, yield attributing characters and yield followed by ONK-1 and DGS-1. Hence, based on the present study, it can be concluded that the cultivar GSL-1 can be sown up to 20th October for getting higher growth and productivity under sub-tropical area of Jammu region.

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