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Evaluation of Temperature Modification in Open Top Chambers in Mustard Cultivars and its Effect on Yield and Percentage Content of Nitrogen and Sulfur

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present study was conducted during *rabi* season in the your of 2021-22. The experiments were conducted in open top chambers established in the research area of Department of Environmental Science, College of Agriculture, RVSKVV, Gwalior have uniform topography and adequate drainage conditions. The trial was laid out in a two way factor anova with three replications. It was consisting of five elevated/ambient temperature viz., ambient in OTC, ambient+1^{o}C, ambient+1.5^{o}C, ambient+2^{o}C, Open field (control) and two mustard cultivars at varied crop geometry i.e., RVM2

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(45x10 cm & 25x20 cm) and Giriraj (45x10 cm & 25x20 cm). The result of the study indicated that significantly higher no. of siliqua per plant, no. of seed per siliqua, length of siliqua (cm), 1000 seed weight (g), total biomass (q/ha), seed yield (q/ha), harvest index (%), nitrogen content (%) and sulfur content (%) was obtained at ambient +1°C which were significantly superior over rest of the ambient temperature and open field control (OTCs) conditions. Maximum no. of siliqua per plant, no. of seed per siliqua, length of siliqua (cm), 1000 seed weight (g), total biomass (q/ha) and seed yield (q/ha) was observed with mustard cultivar of Giriraj (45x10 cm) except harvest index (%) and sulfur content (%), respectively.

Keywords: Sandy clay loam; ambient temperature; RVM2; Giriraj; open top chamber (OTC).

1. INTRODUCTION

Indian mustard [*Brassica juncea* (L.) czernj & coss] is known as Rai, Raya or Laha which is belonging to the family *Brassicaceae*. Mustard is an important *Rabi* season oilseed crop which belongs to family crucifereae (*Brassicaceae*) and genus *Brassica*. It is identified by the presence of conduplicate cotyledons (i.e. cotyledons folded longitudinally around the radicle) and/or a two-segmented fruit (siliqua), containing seeds in one or both segments and, if present, only Commonly known as hair, crop brassicas includes a variety of plants grown as vegetables, fodder, or as a source of oil and spices. There was a big expansion in the area under oilseeds in Rajasthan, Madhya Pradesh and Chhattisgarh. Rapeseed and mustard are major contributors to the increase in oilseeds area during this rabi season. The area under mustard in Madhya Pradesh is 1.23 million hectares which is about 5.5% of total net sown area. The production is 1.69 million tones with yield of 1376 kg/ha [1].

Application of sulphur was reported to increase yield attributes and yield of Indian mustard [2,3], which also has a significant effect on oil, fatty acid [4] and glucosinolates content in mustard seed [5]. The relative proportions of individual glucosinolates viz. sinigrin (allyl isothiocyanate), gluconapin (3-butenyl glucosinolate) and progoitrin (2-hydroxy-3-butenyl glucosinolate) are influenced by sulphur application [6]. Sulfur Fertilizer: Among the oilseed crops, rapeseed and mustard require the most sulfur. Sulfur promotes oil synthesis. It is an important component of seed proteins, amino acids, enzymes, glucosinolates and is essential for chlorophyll formation. Sulfur increased mustard yield by 12 to 48% under irrigation and by 17 to 124% under rainfed conditions. In terms of agricultural efficiency, each kg of sulfur increases the yield of mustard by 7.7 kg. Canola-4 and Hyola-401 have 3% more oil content than hybrid "PGSH-51" due to the effect of different doses of nitrogen and sulfur.

Due to its hardy nature and ability to thrive well under poor conditions of fertility and moisture, it is generally grown as a rain-fed crop, with a low average yield. Mustard is a crop of tropical and temperate regions. The temperature requirement ranges from 0.5-3.0ºC (min) to 35-40ºC (max) with an optimum temperature of 20-35ºC. Oil yields are enhanced by cool temperatures, dry weather and a good amount of bright sunlight. Oil yields are enhanced by cool temperatures, dry weather and a good amount of bright sunlight. Mustard requires high temperature (20ºC-32ºC) for vegetative growth and cool temperature with clear sky during reproductive growth and maturity.

The production potential of Indian mustard can be fully exploited under these conditions with appropriate agricultural practices and varieties. The major mustard producing districts in Madhya Pradesh are Bhind, Morena, Shivpuri, Gwalior, Neemuch and Mandla. In Bhind district, mustard crop is grown in an average area of 180546 thousand hectares and production of 175.5 thousand tonnes and it accounts for 24 percent area and 27 percent production of mustard in Madhya Pradesh. Since Madhya Pradesh has large area under mustard, the present investigation is an attempt to analyze the effect of high temperature on seed yield and growth parameters of Brassica varieties under elevated temperature.

2. MATERIALS AND METHODS

The present investigation was conducted in open top chambers (OTCs) located in the Department of Environmental Sciences, College of Agriculture, Gwalior having similar topography and adequate drainage conditions during the Rabi season of the year 2021-22. Gwalior is located in the Gird Zone in Madhya Pradesh, India at 26'13' North latitude and 76'14' East longitude with an elevation of 211.52 meters above sea level. The region falls under semi-arid subtropical climate, with extreme weather

conditions with hot and dry summers and cold winters, which is also affected by passing climate change patterns. Generally, monsoon arrives during the last week of June to the first week of July. Annual rainfall ranges from 700 to 800 mm, most of which occurs during the last June to the first fortnight of September. The maximum temperature during summers goes up to 45-46ºC and the minimum temperature goes up to 3.8ºC during winters.

Open Top Chamber (OTC) is made with high quality multilayer UV protected 90% light transparent polycarbonate sheet 4-5 mm thickness and galvanized iron and high grade aluminum channels, circular type structure, the upper part of the chamber is covered for experimental purpose. It is kept partially open. These chambers are designed for carbon dioxide (CO_2), ozone (O_3) and temperature elevation features. It is also integrated with meteorological parameters, soil sensors, wireless communication and web based (GPRS) SCADA technology.

In the present experiment, four open top chambers of 4.7 m diameter and one control plot were selected in the research farm of the Department of Environmental Sciences, Climate Change Project Unit, College of Agriculture, Gwalior. Mustard varieties RVM2 and Giriraj were grown in chambers in different crop geometries (45x10 cm and 25x20 cm) as well as under natural conditions. For the present study the first open top chamber (OTCs) was maintained with ambient temperature, the second with ambient + 1ºC, the third with ambient + 1.5ºC, the fourth with ambient + 2ºC. To maintain the temperature level as part of the research work, the temperature was maintained in all the chambers with the help of infrared heaters with automation system. Two plots were laid out in each OTC of $2m^2$ area and there were 3 replications in each $2m^2$ area, each containing 8 plants of Mustard varieties. Plants were tagged for samples from each plot and each chamber. Observations of plant growth at harvest stages were recorded. Plants were marked and tagged for data. The yield was measured at the harvesting stage and all the plants were harvested from each plot of $2m^2$ area to record the yield and quality parameters. Statistical analysis of the data was performed using two-way factor analysis with replication to test the significance of elevated temperatures at 1% and 5% significance levels.

3. RESULTS AND DISCUSSION

3.1 Yield parameters and Nitrogen %, Sulfur Content at Harvest

Data was recorded in no. of siliqua/plant, no. of seed / siliqua, length of siliqua (cm), 1000 seed weight (g), total biomass (q/ha), seed yield (q/ha), harvest index (%), nitrogen (%) and sulfur content (%) as affected by ambient/elevated temperature and mustard cultivars have been presented in Table 1.

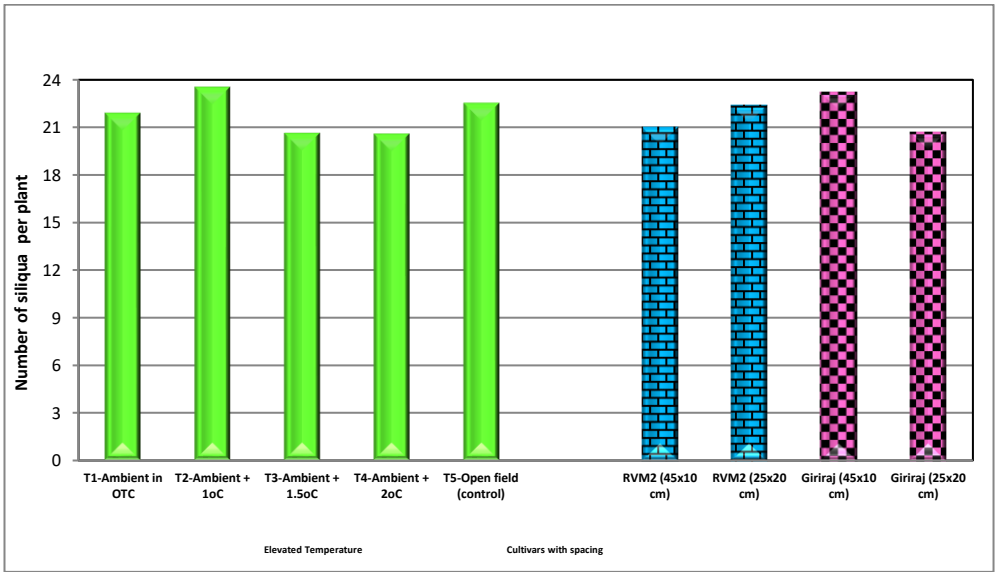

Fig. 1. Number of siliqua per plant of mustard cultivars varied crop geometry as influenced by elevated temperature at harvest stages

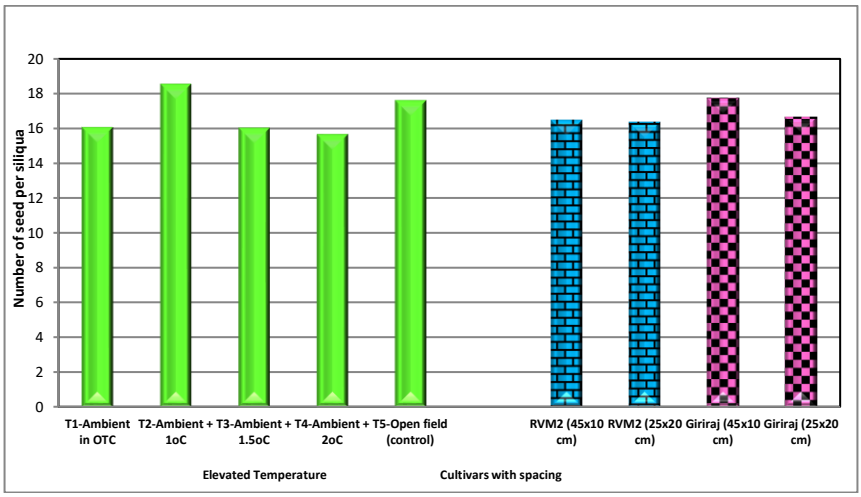

Fig. 2. Number of seed per siliqua of mustard cultivars varied crop geometry as influenced by elevated temperature at harvest stages

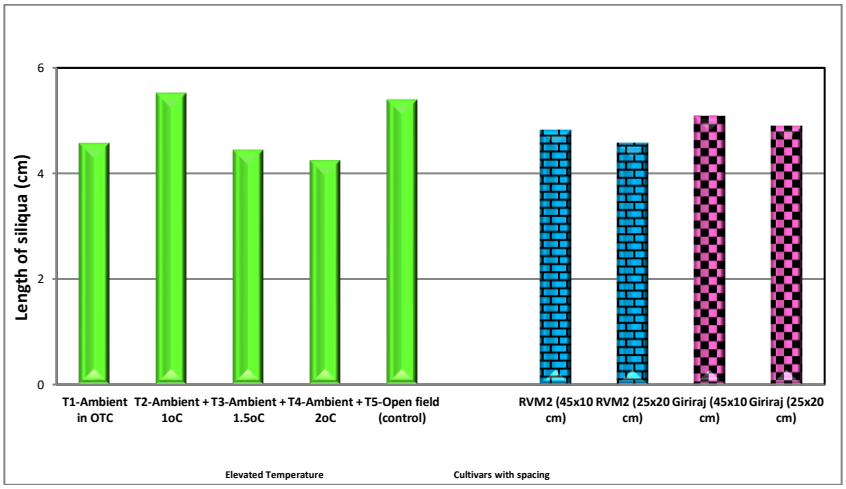

Fig. 3. Length of siliqua (cm) of mustard cultivars varied crop geometry as influenced by elevated temperature at harvest stages

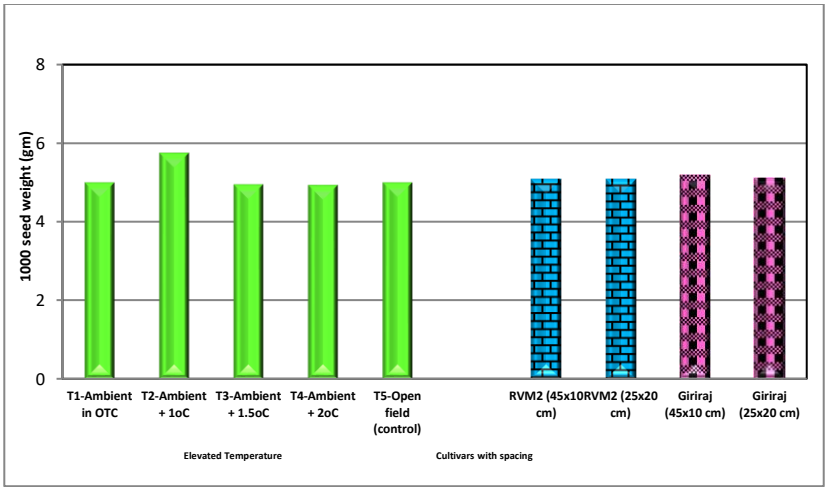

Fig. 4. 1000 seed weight (gm) of mustard cultivars varied crop geometry as influenced by elevated temperature (at harvest stages)

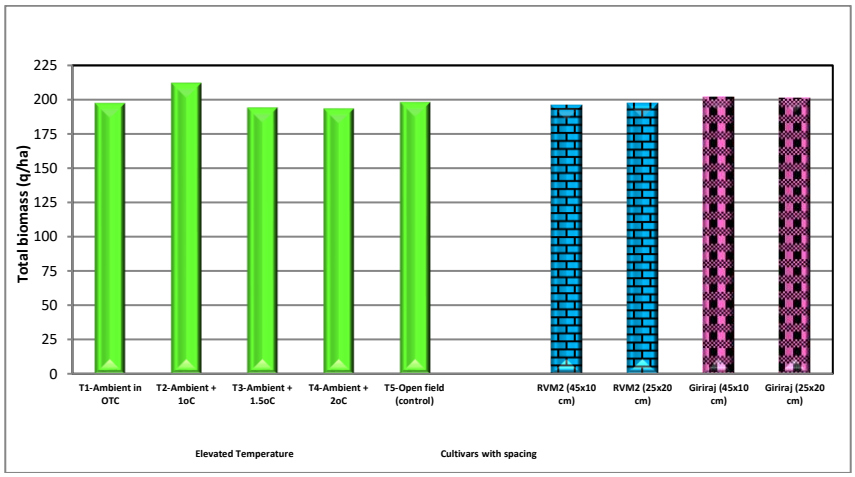

Fig. 5. Total biomass (q/ha) of mustard cultivars varied crop geometry as influenced by elevated temperature (at harvest stages)

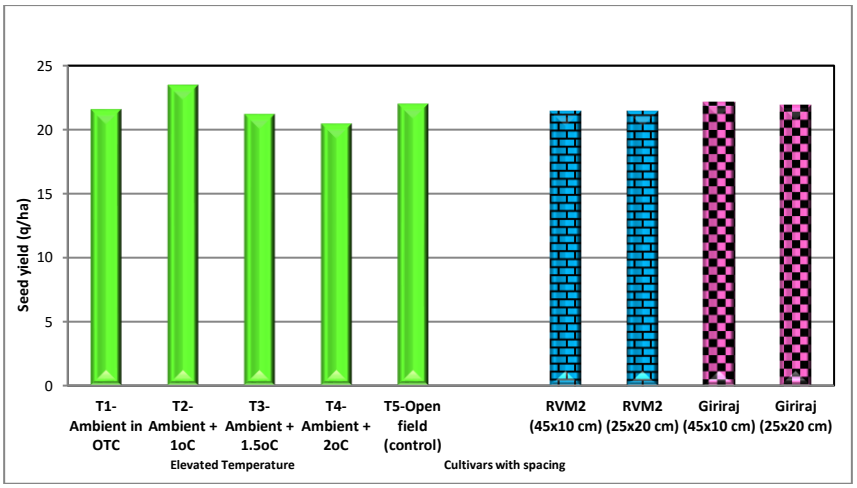

Fig. 6. Seed yield (q/ha) of mustard cultivars varied crop geometry as influenced by elevated temperature at harvest stages

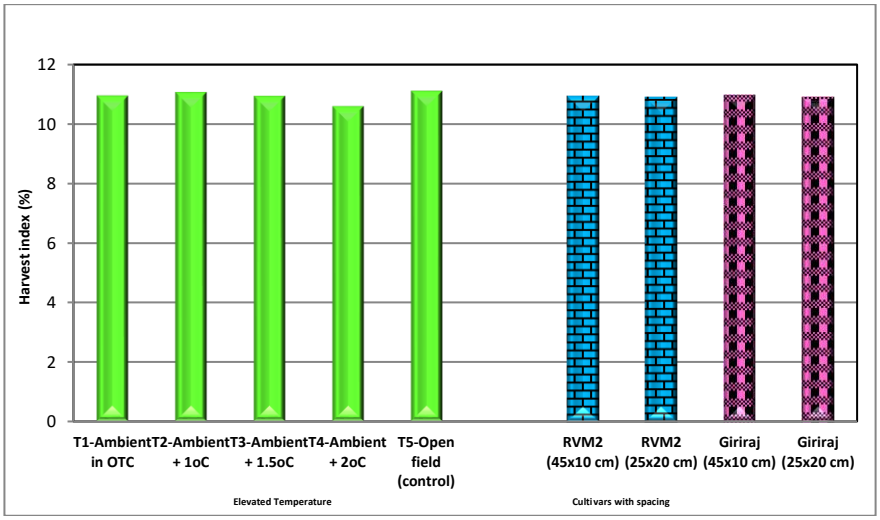

Fig. 7. Harvest index (%) of mustard cultivars varied crop geometry as influenced by elevated temperature (at harvest stages)

Table 1. Yield attributes and seed yield of mustard cultivars varied crop geometry as influenced by elevated temperature (at harvest stages)

Elevated Temperature	No. siliqua /plant	No. of seed/ siliqua	Length of siliqua (cm)	1000 seed weight (g)	Total biomass (q/ha)	Seed yield (q/ha)	Harvest index (%)	Nitrogen content (%)	Sulfur content (%)
T1-Ambient in OTC	154.33	16.10	4.58	4.99	197.45	21.58	10.94	1.75	15.38
T2-Ambient + 1^{o}C	160.88	18.58	5.53	5.74	212.20	23.47	11.05	2.08	15.67
T3-Ambient + 1.5^{o}C	152.30	16.05	4.45	4.94	194.05	21.19	10.92	1.72	15.16
T4-Ambient + 2^{o}C	150.88	15.68	4.25	4.92	193.35	20.45	10.58	1.69	14.99
T5-Open field (control)	154.33	17.63	5.40	4.99	198.23	22.01	11.10	1.80	15.65
S.E.(m)+	**0.322**	**0.166**	**0.063**	**0.018**	**1.150**	**0.207**	**0.114**	**0.011**	**0.139**
CD (at 0.05%)	**0.921**	**0.475**	**0.181**	**0.052**	**3.292**	**0.593**	**0.326**	**0.033**	**0.399**
Cultivars with spacing									
RVM2 (45x10 cm)	153.84	16.46	4.82	5.07	196.02	21.44	10.93	1.78	15.20
RVM2 (25x20 cm)	153.32	16.38	4.56	5.09	197.08	21.47	10.89	1.84	15.34
Giriraj (45x10 cm)	155.88	17.74	5.08	5.19	201.82	22.12	10.96	1.86	15.55
Giriraj (25x20 cm)	155.12	16.64	4.90	5.11	201.30	21.92	10.89	1.75	15.39
S.E.(m)+	**0.288**	**0.148**	**0.057**	**0.016**	**1.028**	**0.185**	**0.102**	**0.010**	**0.125**
CD (at 0.05%)	**0.823**	**0.425**	**0.162**	**0.046**	**2.945**	**0.530**	**NS**	**0.029**	**NS**

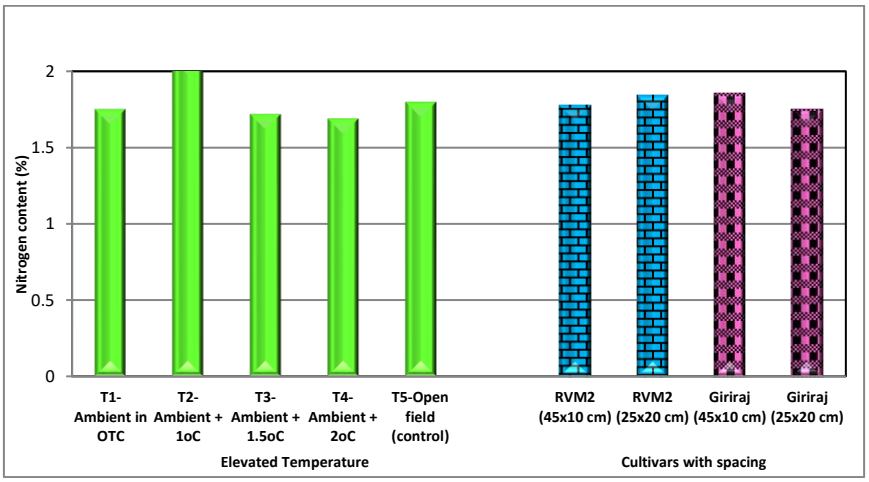

Fig. 8. Nitrogen content (%) of mustard cultivars varied crop geometry as influenced by elevated temperature (at harvest stages)

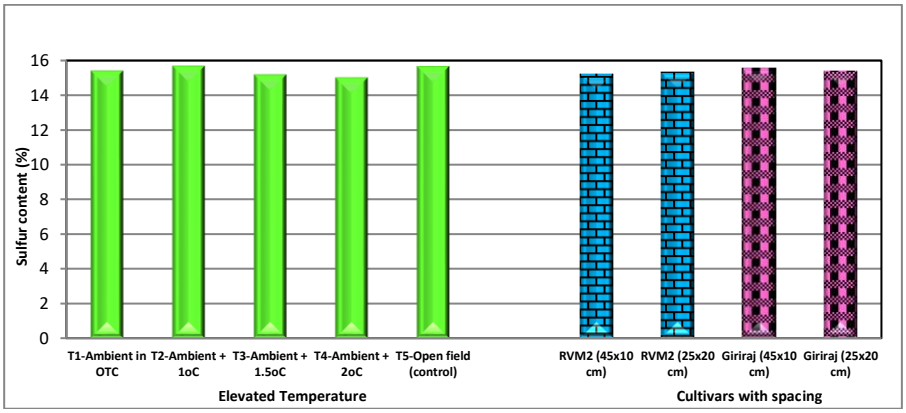

Fig. 9. Sulfur content (%) of mustard cultivars varied crop geometry as influenced by elevated temperature (at harvest stages)

The elevated temperature level with ambient+1^{o}C attained significantly higher values of no. of siliqua (160.88 siliqua/plant), no. of siliqua (150.68 siliqua/plant), length of siliqua (5.53 cm), 1000 seed weight (5.74 g), total biomass (212.20 q/ha), seed yield (23.47 q/ha) and harvest index (11.05%), respectively. The ambient+2^{o}C recorded the significant reduction in the values of no. of siliqua, no. of seed/siliqua, length of siliqua,1000 seed weight, total biomass, seed yield and harvest index of mustard cultivars compared to ambient/elevated temperature conditions and control plot, respectively. These results are also in conformity with the findings of Angadi et al*.* [7], Dhanuja et al*.* [8], Kaur et al*.* [9], Sharma (2020) and Macova et al*.* [10].

The mustard cultivars at varied crop geometry (RVM2 and Giriraj) also exhibited significant differences on the yield and quality attributes at harvest stages. The mustard cultivars Giriraj (45x10 cm) performed best and highest values of no. of siliqua (155.88 siliqua/plant), length of siliqua (5.08 cm), 1000 seed weight (5.11 g), total biomass (201.82 q/ha), seed yield (22.12 q/ha) under all mustard cultivars at varied crop geometry, respectively. A perusal of data showed that harvest index percentage was non-significant due to the mustard cultivars at varied crop geometry. Similar results were also observed by Angadi et al*.* [7], Dhanuja et al*.* [8], Kaur et al*.* [9], Sharma (2020) and Macova et al*.* [10].

The highest values of quality parameters of mustard cultivars as nitrogen content percent and sulfur content percent were recorded significantly highest with elevated temperature level ambient+1^{o}C. Among mustard cultivars (Giriraj 45x10 cm) at varied crop geometry

performed best and recorded the highest values of nitrogen content and sulfur content percentage at harvest stages. Similar results were also observed by Patel et al. [2] and Kumar et al. [3].

4. CONCLUSION

The revealed that diverse geometric differential response was observed among mustard cultivars (RVM2 and Giriraj) under changing climate scenario. Mustard cultivars have depicted significant variation with respect to growth and yield aspects under *Rabi* season 2021 at elevated temperature conditions and Giriraj performed as well as compared to RVM2. However, elevated temperature (ambient + 1^0C) lead to increased growth and development. It can be concluded from the research work that if the average temperature of the earth increases by 1^oC in future, there will be no significant impact on the growth of mustard cultivars RVM2 and Giriraj.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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