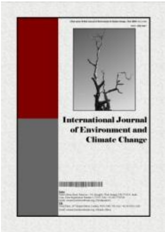

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Heat Unit and Heat Use Efficiency under Different Growing Environments of Mustard Crop (*Brassica juncea* L.)

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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

A field experiment was conducted at Agro-meteorological Research Farm, A.N.D. University of Agriculture & Technology, Kumarganj, Ayodhya, India during 2019-20. The experiment was conducted with Factorial Randomized Complete Block Design and replicated four times with nine treatment combinations consisting of three different sowing times D_1 (31st October) (23.5^oC), D_2 (10th November) (23^oC), and D_3 (20th November) (21^oC) and three varieties V_1 (Bio-902), V_2 (NDR-8501) and V_3 (Varuna). Results showed that higher growth and yield was observed when crop was sown on 31st October than other sowing times. Among the varieties Varuna gave highest growth and maximum yield as compared to other varieties due to fulfillment of congenial Heat unit/GDD, HUE. Maximum heat use efficiency and heat unit requirement from sowing to maturity was obtained when the crop was sown on 31st October while minimum heat use efficiency was obtained when the crop was sown on 20th November. Hence it can be concluded that the best sowing date of mustard is on 31st October in the early sowing. This study may help to select suitable sowing time under climatic condition of eastern Uttar Pradesh.

Keywords: Mustard; sowing time; heat unit; heat use efficiency.

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1. INTRODUCTION

Mustard (*Brassica juncea* L.) is a Latin name 'must'/'mustum' that means "grape juice" and "ardens," which means "hot and scorching" [1]. It is commonly known as toria, rai and laha in India and belongs to the family *Brassicacea*. Mustard is also grown as a source of condiment for the spice trade. The plants grow to be 90-200 centimeters tall, with broad, stalked leaves, slender fruits (pods) that are just 2 to 6.5 cm long, and brown or dark seeds. Mustard is the world's third most important oilseed crop, after soybean (*Glycine max*) and palm oil (*Elaeis guineensis jacq*). The growth rate of area, production and yield of oilseeds increased significantly between 1985 and 1994. Oilseeds account for almost 14% of India's gross cropped area and provide 5% of the country's GNP and 10% of the value of agricultural products. Based on current levels of fats and oils consumption (8.5 kg $Capita^{-1}$ $year^{-1}$) and continuing growth, rapeseed-mustard will contribute 14 million tonnes to meet yearly domestic demand (Directorate of Economics & Statistics, DAC&FW). The prevalent climate of any location regulates crop production and productivity through its parameters viz. temperature, rainfall, light intensity, radiation, and sunshine duration, among other factors. The crop development and growth i.e., phenology, biomass accumulation, leaf area index (LAI) and yield attributes are greatly influenced by the prevailing weather conditions. Mustard is very sensitive to weather and its response varies widely with changes in the growing environment, [2]. Environmental factors of a system may directly influence the growth and productivity of the crops. Mustard is a key winter oilseed crop that is grown all over the world. Cool, dry weather is required for maximum growth and development. Hence climate change may have a substantial impact on its output because weather changes affect its growth [3,4]. In current practice, when the temperature is quite high, the vegetative phase is done, but the temperature is low during blooming, and the temperature and photoperiod steadily increase as the crop matures. Soil temperature directly manipulates the germination rate of seeds and root development of plants. Very high temperature is harmful to root and shoot growth as well as elongation, it may cause lesions of the whole system as well [5,6]. Extreme low temperature impedes intake of nutrients. Soil moisture intake of plants may also stop under very low temperatures. Mustard is primarily grown in temperate areas. In some tropical and subtropical locations, it is also grown as a cold-weather crop. Indian mustard is said to be tolerant of yearly precipitation ranging from 500 to 420 mm, annual temperatures ranging from 6 to 27°C, and pH levels ranging from 4.3 to 8.3. Rapeseed-mustard is a C_3 plant pathway to carbon assimilation. As a result, it exhibits an excellent photosynthetic response at temperature of 15–20°C [7]. The plant achieves maximum CO_2 exchange at this temperature. The black mustard (*rai*) is mostly grown as a rain-fed crop, moderately tolerant to soil acidity, suitable pH value is ranging from 5.5 to 6.8, and can withstand drought in locations with hot days and cool nights. Mustard grows best on well-drained sandy loam soil and requires little water (240–400 mm), making it a good fit for rain-fed cropping systems. Rain-fed crops cover over 20% of the land under these crops [8].

2. MATERIALS AND METHODS

An experiment was conducted during season 2019-2020 at the Agromet Research Farm of Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya (U.P.) India. The farm is located at $26^{\circ}47'$ N latitude and $82^{\circ}12'$ E longitude and an altitude of about 113 m above the mean sea level. The experiment was conducted in a randomized block design (RBD). Nine treatments combination comprised of three growing environment/sowing dates *viz.* crop sown on October 31^{st} (D_1) (23.5°C); crop sown on November 10^{th} (D_2) (23°C) and crop sown on November 20^{th} (D_3) (21°C) respectively along with three varieties *i.e.* Bio-902 (V_1), NDR-8501 (V_2) and Varuna (V_3) were used under present investigation. The field was plowed once with tractor-drawn moldboard plow, twice by cultivator which followed by planking. Fertilizers were applied during the last operation of the field. The crop was fertilized with a uniform dose of nitrogen, phosphorus, and potassium at 120:60:40 kg/ha, respectively. Urea, DAP, and Murate of potash were used as the source of nitrogen, phosphorus, and potassium. Sulfur was applied as per treatment through elemental sulfur**.** Half dose of nitrogen along with a full dose of Phosphorus, Potassium, and Sulfur was applied as basal dressing and remaining dose of nitrogen was top-dressed into two equal splits. 1^{st} split was top-dressed at 30 DAS and 2^{nd} split doze at 45 DAS (pre-flowering stage) of the crop. Sowing was done using different dates as treatment in a row 45 cm apart using a seed rate of 6 kg/ha. Later on, plant spacing of 15 cm was maintained by thinning extra plants.

2.1 Growing Degree Days/ Heat Unit (ºdays)

Growing degree days (GDD) at different phenological stages were calculated by using following formula:

$$GDD = \sum \text{heat unit (HU)}$$

Where,

1, 2, 3, …………….. n is number of days and

$$\text{Heat unit} = \frac{T_{Max.\ Temp.} + T_{Min.\ Temp.}}{2} - \text{Base temp}(T_b).$$

2.2 Heat Use Efficiency (g/m²/ºdays)

Heat use efficiency (HUE) is the dry matter production per unit of heat unit by the crop. Heat efficiency (HUE) may be calculated from the heating unit obtained above as follows Srivastava, *et al.* [9].

$$HUE = \frac{\text{Total dry matter } (g/m^2)}{\text{Heat unit } (^0\text{days})}$$

3. RESULTS AND DISCUSSIONS

3.1 Growing Degree Days/ Heat Unit (ºdays)

Accumulated GDD ranged from (1614.5ºC days) to (1395ºC days). The variety Varuna had the highest heat unit (GDD) demand from sowing to maturity (125 DAS) (1614.5^{o}C days) in the growing environment (31st October), while the variety Bio-902 had the lowest (135DAS) (1395^{o}C days) in the growing environment (20th November). Late sown mustard crop recorded minimum GDD requirement at all the stages. The results are corroborated with Singh, et al. [10] and Srivastava, et al. [8].

3.2 Heat Use Efficiency (g/m²/ºdays)

The highest heat use efficiency and requirement from sowing to maturity were recorded at 0.88g/m²/ºdays for Varuna at 10th November sowing time. While lowest heat use efficiency from sowing to maturity 0.64g/m²/ºdays was observed for Bio-902at late sowing time, 20th November. Late sown varieties recorded minimum heat use efficiency requirement at all the stages. Similar results are reported by Kar and Chakravarty [11] Singh, et al. [12] Khushu, et al. [13] Hundal, et al. [14] and Srivastava, et al. (2011). The plants were harvested at 125 DAS, 130 DAS, and 135 DAS for the first, second, and third of sowing times.

Table 1. Growing degree days/heat unit at different phenophases (˚c days) of mustard as affected by growing environment and varieties

Treatments	Phenophase					
	Emergence	Four Leaf Stage	Flower Initiation	Siliqua Initiation	Pod Development	Maturity
			Bio-902			
31st Oct. (23.5^{o}C)	92.2	180.2	642.25	792.7	975.7	1568.5
10th Nov. (23^{o}C)	117	182.7	569.75	676.2	887.7	1497.7
20th Nov. (21^{o}C)	73.5	148.7	443.25	560	792.7	1395
			NDR-8501			
31st Oct. (23.5^{o}C)	92.2	198.3	653.75	794.7	983.2	1597.4
10th Nov. (23^{o}C)	101	182.7	569.75	676.2	887.7	1497.7
20th Nov. (21^{o}C)	88.2	148.7	443.25	560	792.7	1409.7
			Varuna			
31st Oct. (23.5^{o}C)	111	198.2	642.25	794.5	975.7	1614.5
10th Nov. (23^{o}C)	117	197	569.75	686.7	898.2	1497.7
20th Nov. (21^{o}C)	88.2	163.2	449.5	566.7	792.7	1409.7

Table 2. Heat Use Efficiency (g/m²/ºdays) of Mustard as Affected by Growing Environment and Varieties

Treatments	Heat use efficiency (g/m²/ºdays)			
	30DAS	**60DAS**	**90DAS**	**At Harvest**
		Bio-902		
31st Oct. (23.5°C)	0.11	0.23	0.70	0.50
10th Nov. (23°C)	0.11	0.24	0.69	0.50
20th Nov. (21°C)	0.12	0.23	0.64	0.46
		NDR-8501		
31st Oct. (23.5°C)	0.12	0.28	0.84	0.60
10th Nov. (23°C)	0.12	0.29	0.84	0.60
20th Nov. (21°C)	0.12	0.28	0.77	0.56
		Varuna		
31st Oct. (23.5°C)	0.13	0.28	0.88	0.63
10th Nov. (23°C)	0.12	0.3	0.88	0.63
20th Nov. (21°C)	0.13	0.29	0.80	0.58

4. CONCLUSIONS

Higher growth and yield were observed when the crop was sown on 31st October than that of 10th November and 20th November sowing times, the higher number of branches, dry matter production, yield attributing characters, and yield at maturity. Among the varieties, Varuna was recorded higher growth and yield as compared to other varieties due to fulfillment of congenial Heat unit/GDD, HUE. The Varuna variety had the highest heat use efficiency and heat unit need from sowing to maturation, while Bio-902 had the lowest heat use efficiency from sowing to maturity.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Ahlawat IPS. Rapeseed and Mustard (Book) Division of Agronomy Indian Agricultural Research Institute New Delhi. 2008;110012.10.
2. Tripathi MK. Study of Crop Weather Relationship in Indian Mustard under Different Growing Environments. J. Multidisciplinary Advance Research. 2019; 8(2):36–45.
3. Kumari A, Singh RP, Yeshpal. Productivity, nutrient uptake and economics of mustard hybrid (Brassica juncea) under different planting time and row spacing. Indian J. Agron. 2012;57(1): 61-67.
4. Lallu RS, Baghel VS, Srivastava SBL. Assessment of mustard genotypes for thermo tolerance at seed development stage. Indian J. Plant. Physiol. 2010; 15(10):36-43.
5. Bhuiyan MS, Mondol MRI, Rahaman MA, Alam MS, Faisal AHMA. Yield and yield attributes of rapeseed as influenced by date of planting. Int. J. Sust. Crop Prod. 2008;3(3): 25-29.
6. Panda BB, Bandyopadhyay SK, Shivay YS. Effect of irrigation level, sowing dates and varieties on growth, yield attributes, yield, consumptive water use and water use efficiency of Indian mustard (*Brassica juncea* L.). Indian J. Agriculture Sciences. 2004;74(6):331-342.
7. Shekhawat K, Rathod SS, Premi OP, Kandpal BK, Chauhan JS. Advances in agronomic management of Indian mustard (*Brassica juncea* L.) an overview. Inter. J. Agron. 2012;2012.
   DOI: 10.1155/2012/408284
8. Srivastava AK, Adak T, Chakravarty NVK. Quantification of growth and yield of oilseed Brassica using thermal indices under semi-arid environment. J. Agrometeorology. 2011;13(2):135-140.
9. Singh MP Lallu, Singh NB. Thermal requirement of Indian mustard (*Brassica juncea*) at different phonological stages under late sown condition. Indian J. Plant Physiol. 2014;19(3):238-243.
10. Singh RP, Kumar R, Yeshpal. Yield and quality of Brassica species as influenced by different dates of sowing and varieties. Pantnagar J. Research. 2008;6(1):6-11.
11. Kar G, Chakravarty NVK. Phenological stages and growth dynamics of Brassica as influenced by weather. J. Agrometeoro-logy. 2000;2(1):39-46.

12. Khushu MK, Singh M. Thermal response of mustard under rain-fed condition of Jammu. Environment and Ecology. 2005; 23(3):683-686.

13. Hundal SS, Kaur P, Malikpuri SDS. Radiation use efficiency of mustard cultivars under different sowing dates. J. Agromet. 2004;6(1):70-75.

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