

STUDIES ON HEAT UNIT AND HEAT USE EFFICIENCY UNDER DIFFERENT GROWING ENVIRONMENT OF MUSTARD CROP (*Brassica juncea* L.)

ABSTRACT

A field experiment was conducted during 2019-20 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 time D₁ (31st October) (23.5°C), D₂ (10th November) (23°C) and D₃ (20th November) (21°C) and three varieties V₁ (Bio-902), V₂ (NDR-8501) and V₃ (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 number of 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 crop was sown on 31st October while minimum heat use efficiency was obtained when the crop was sown on 20th November from sowing to maturity of crop. From Hence it can be concluded that the result, the best sowing date of mustard is on 31st October in the early sowing. This study may help to understand and select suitable sowing time under climatic condition of eastern Uttar Pradesh.

Keywords: Mustard, Sowing time, Heat unit, Heat use efficiency.

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Introduction:

Mustard (*Brassica juncea* L.) is a Latin name 'must'/'mustum' that means "grape juice" and "ardens," which means "hot and scorching" (Ahlawat, 2008). It is commonly known as toria, rai and laha in India and belongs to 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 centimeters 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 Betweenbetween 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). As a result, in total edible oil availability the proportion of imported edible oils declined from 26.72% in 1985 to 2.17% in 1993, thereby India became almost self-sufficient in edible oil production (Nair.....add year and also give reference in reference section). The prevalent climate of any location regulates agricultural 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

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prevailing weather conditions. [Mustard is very sensitive to weather and its response varies widely with change in growing environment, \(Tripathi, 2019\).](#) 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 changes in weather affect its growth. 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 for root and shoot growth as well as elongation, it may cause lesion of the whole system as well. Extreme low temperature impedes intake of nutrients. Soil moisture intake of plants may also stop under very low temperature. 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 C₃ plant pathway in relation to carbon assimilation. As a result, it exhibits an excellent photosynthetic response at temperatures of 15–20°C (Shekhawat, 2012). The plant achieves maximum CO₂ 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 it 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 (Shekhawat, 2012).

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°47' N latitude and 82°12' E longitude and at an altitude of about 113 meter above the mean sea level. The experiment was conducted in randomized block design (RBD). Nine treatments combination comprised of three growing environment/sowing dates *viz.* crop sown on October 31st (D₁) (23.5°C); crop sown on November 10th (D₂) (23°C) and crop sown on November 20th (D₃) (21°C) respectively along with three varieties *i.e.* Bio-902 (V₁), NDR-8501 (V₂) and Varuna (V₃) were used under present investigation. The field was ploughed once with tractor drawn mould board plough, twice by cultivator which followed by planking. Fertilizers were applied during last operation of 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. Sulphur was applied as per treatment through elemental sulphur. Half dose of nitrogen along with full dose of phosphorus, potassium and sulphur were applied as basal dressing and remaining dose of nitrogen was top dressed into two equal splits. 1st split was top dressed at 30 DAS and 2nd splits doze at 45 DAS (pre flowering stage) of the crop. Sowing was done using different dates as treatment in row 45 cm apart using seed rate of 6 kg/ha. Later on plant spacing of 15 cm was maintained by thinning extra plants.

Growing degree days/ Heat unit (°days):

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

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

Where,

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

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

Heat use efficiency (g/m²/°days):

Heat use efficiency (HUE) is the dry matter production per unit of heat unit by the crop. Heat efficiency (HUE) may be calculated from heat unit obtained above as following Srivastava, *et al.* (2011).—

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

Results and discussions:

Growing degree days/ Heat unit (°days):

Accumulated GDD ranged from (1614.5°C days) to (1395°C days). The variety Varuna had the highest heat unit (GDD) demand from sowing to maturity (125 DAS) (1614.5°C days) in the growing environment (31st October), while the variety Bio-902 had the lowest (135DAS) (1395°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.* (2014) and Srivastava, *et al.* (2011).

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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						
31 st Oct. (23.5°C)	92.2	180.2	642.25	792.7	975.7	1568.5
10 th Nov. (23°C)	117	182.7	569.75	676.2	887.7	1497.7
20 th Nov. (21°C)	73.5	148.7	443.25	560	792.7	1395
NDR-8501						
31 st Oct. (23.5°C)	92.2	198.3	653.75	794.7	983.2	1597.4
10 th Nov. (23°C)	101	182.7	569.75	676.2	887.7	1497.7
20 th Nov. (21°C)	88.2	148.7	443.25	560	792.7	1409.7
Varuna						
31 st Oct. (23.5°C)	111	198.2	642.25	794.5	975.7	1614.5
10 th Nov. (23°C)	117	197	569.75	686.7	898.2	1497.7
20 th Nov. (21°C)	88.2	163.2	449.5	566.7	792.7	1409.7

Heat use efficiency (g/m²/°days):

The highest heat use efficiency and requirement from sowing to maturity was recorded 0.88 g/m²/°days for Varuna at 10th November sowing time. While lowest heat use efficiency from sowing to maturity 0.64 g/m²/°days was observed for Bio-902 at 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 (2000), Singh, *et al.* (2014) Khushu, *et al.* (2005), Hundal, *et al.* (2003) 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 2: Heat Use Efficiency (g/m²/°days) of Mustard as Affected by Growing Environment and Varieties

Treatments	Heat use efficiency (g/m ² /°days)			
	30DAS	60DAS	90DAS	At Harvest
Bio-902				
31 st Oct. (23.5°C)	0.11	0.23	0.70	0.50
10 th Nov. (23°C)	0.11	0.24	0.69	0.50
20 th Nov. (21°C)	0.12	0.23	0.64	0.46
NDR-8501				
31 st Oct. (23.5°C)	0.12	0.28	0.84	0.60
10 th Nov. (23°C)	0.12	0.29	0.84	0.60
20 th Nov. (21°C)	0.12	0.28	0.77	0.56
Varuna				
31 st Oct. (23.5°C)	0.13	0.28	0.88	0.63
10 th Nov. (23°C)	0.12	0.3	0.88	0.63
20 th Nov. (21°C)	0.13	0.29	0.80	0.58

Conclusions:

Higher growth and yield was observed when crop was sown on 31st October than that of 10th November and 20th November sowing times, 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 fulfilment 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.

References:

- Ahlawat, I. P. S. 2008. Rapeseed and Mustard (Book) Division of Agronomy Indian Agricultural Research Institute New Delhi- 110012.10.
- Tripathi, M.K. 2019. Study of Crop Weather Relationship in Indian Mustard under Different Growing Environments. *J. Multidisciplinary Advance Research*. **8**(2): 36–45.
- Shekhawat, K. Rathod, S.S. Premi, O.P. Kandpal, B.K. and Chauhan, J.S. 2012. Advances in agronomic management of Indian mustard (*Brassica juncea* L.) an overview. *Inter. J. Agron. Volume 2012* pages 2012. doi:10.1155/2012/408284 2012.
- Srivastava, A.K. Adak, T. Chakravarty, N.V.K. 2011. Quantification of growth and yield of oilseed Brassica using thermal indices under semi-arid environment. *J. Agrometeorology*. **13**(2):135-140 2011.
- Singh, M. P. Lallu and Singh, N. B. 2014. Thermal requirement of Indian mustard (*Brassica juncea*) at different phenological stages under late sown condition. *Indian J. Plant Physiol.* **19** (3):238-243.
- Singh, R.P. Kumar, R. and Yeshpal. 2008. Yield and quality of Brassica species as influenced by different dates of sowing and varieties. *Pantnagar J. Research*. **6**(1): 6-11.
- Bhuiyan, M.S. Mondol, M.R.I. Rahaman, M.A. Alam, M.S. and Faisal, A.H.M.A. 2008. Yield and yield attributes of rapeseed as influenced by date of planting. *Int. J. Sust. Crop Prod.* **3** (3): 25-29.
- Panda, B.B. Bandyopadhyay, S.K. and Shivay, Y.S. 2004. 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*. **74**(6): 331-342.
- Kumari, A. Singh, R. P. and Yeshpal. 2012. Productivity, nutrient uptake and economics of mustard hybrid (*Brassica juncea*) under different planting time and row spacing. *Indian J. Agron.* **57** (1): 61-67.

- Lallu, R. S. Baghel, V.S. and Srivastava, S. B. L. 2010. Assessment of mustard genotypes for thermo tolerance at seed development stage. *Indian J. Plant. Physiol.* **15** (10): 36-43.
- Hundal, S.S. Kaur, P. and Malikpuri, S.D.S. 2004. Radiation use efficiency of mustard cultivars under different sowing dates. *J. Agromet.* **6**(1): 70-75.
- Kar, G. and Chakravarty, N.V.K. 2000. Phenological stages and growth dynamics of *Brassica* as influenced by weather. *J. Agrometeorology.* **2**(1): 39-46.
- Khushu, M. K. and Singh, M. 2005. Thermal response of mustard under rain-fed condition of Jammu. *Environment and Ecology.* **23** (3): 683-686.

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