

STUDIES ON HEAT UNIT AND HEAT USE EFFICIENCY UNDER DIFFERENT GROWING ENVIRONMENT^S 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. 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°C), D_2 (10th November)(23°C), and D_3 (20th November)(21°C) and three varieties V_1 (Bio-902), V_2 (NDR-8501) and V_3 (Varuna). Results showed that higher growth and yield ~~was were~~ observed when the crop was sown on 31st October than other sowing times. Among the varieties, Varuna gave the highest number of growth and 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 on 20th November from sowing to maturity of the crop. From the result, the best sowing date ~~of for~~ mustard is on 31st October in the early sowing. This study may help to understand and select suitable sowing time under the climatic condition of eastern Uttar Pradesh.

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

Introduction:

The prevalent climate of any location regulates agricultural production and productivity through 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, (M.K. Tripathi, 2019). 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 the family ~~brassicaceae~~ Brassicaceae. 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~~ 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 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). 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 (Sthanu R Nair). 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~~ weather changes 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 to~~ root and shoot growth as well as elongation, it may cause lesions of the whole system as well. 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 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 ~~m~~ meters 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 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-plowed~~ once with ~~tractor-tractor~~-drawn mouldboard ~~plough~~ 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. ~~Sulphur Sulfur~~ was applied as per treatment through elemental ~~sulphur~~ Sulfur. Half dose of nitrogen along with ~~a~~ full dose of ~~p~~Phosphorus, ~~p~~Potassium, and ~~sulphur~~ Sulfur were ~~was~~ applied as basal dressing and remaining dose of nitrogen was ~~top-top~~-dressed into two equal splits. 1st split was ~~top-top~~-dressed at 30 DAS and 2nd splits ~~doze~~ at 45 DAS (~~pre-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.

Growing degree days/ Heat unit (°days):

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

$$T_{\text{Max.Temp.}} + T_{\text{Min.Temp.}}$$

$$\text{Heat unit} = \frac{\quad}{2} - \text{Base temp}(T_b).$$

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 the heating unit obtained above as following follows Srivastava, *et al.* (2011).–

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

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).

Table 1: Growing Degree Days/Heat Unit at Different Phenophases (°C days) of Mustard as Affected by Growing Environment and Varieties

	Phenophase
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	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~~ were recorded at 0.88g/m²/°days for Varuna at 10th November sowing time. While lowest heat use efficiency from sowing to maturity 0.64g/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

	Heat use efficiency (g/m ² /°days)
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	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-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.

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