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Effect of Varying Thermal Regimes on Yield and Yield Attributes of Mustard Varieties (*Brassica juncea* L.)

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ABSTRACT

A field experiment was conducted at Agro-meteorological Research Farm, Acharya Narendra Deva University of Agriculture and 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 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 observed when crop was sown on 31st October than other sowing times. Different thermal regimes were found to have a substantial impact on the yield attributes. Among the varieties Varuna gave highest growth and maximum yield as compared to other varieties due to fulfillment of congenial thermal Regime. Maximum utilization of heat from sowing to maturity was obtained when crop was sown on 31st October while minimum utilization of heat 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, Thermal regime, Growth, Yield, Yield attributes.

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 change in growing environment, (Tripathi 2019). Mustard (*Brassica juncea* L.) is a

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Latin name 'must'/'mustum' that mean "grape juice" and "ardens," which means "hot and scorching" (Ahlawat 2008). It is a member of the brassicaceae family and is also referred to as toria, rai, and laha in India. Additionally, mustard is grown as a supply of condiment for the spice industry. After soybean (*Glycine max*) and palm oil (*Elaeis guineensis* Jacq), mustard is the third most important oilseed crop in the world. 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 and Statistics, DAC and 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

The development and productivity of the crops may be directly impacted by environmental conditions in a system. Mustard is a major winter oilseed crop that is grown all over the world. The conditions for optimal growth and development must be cool and dry. Because weather changes have an effect on how it grows, climate change may therefore have a significant impact on its output. In current practice, the vegetative phase finishes while the temperature is relatively high, but the temperature is low during flowering and gradually rises as the crop matures. The germination rate of seeds and plant root development are directly influenced by soil temperature. Extremely high temperatures can damage the entire system as well as affect root and shoot growth and elongation. Nutrient absorption is hampered by extremely low temperatures. Plants' ability to absorb moisture from the soil may also stop at very low temperatures. The majority of mustard is grown in temperate climates. It is additionally grown as a cold-weather crop in a few tropical and subtropical regions. According to reports, Indian mustard can withstand annual precipitation between 500 and 420 mm, annual temperatures between 6 and 27°C, and annual pH values between 4.3 and 8.3. Regarding carbon absorption, the rapeseed-mustard plant pathway is a C_3 plant mechanism. As a result, at temperatures between 15-20°C, it displays an excellent photosynthetic response. At this temperature, the plant exchanges CO_2 to its fullest potential. The black mustard (rai) is mostly grown as a rain-fed crop, is relatively tolerant of soil acidity, and can resist drought in climates with hot days and cool nights. Its ideal pH value ranges from 5.5 to 6.8. Mustard performs well with rain-fed cropping systems since it thrives on sandy loam soil with good drainage and needs little water (240–400 mm). Over 20% of the land used for these crops is covered by rain-fed crops (Shekhawat 2012).

MATERIALS AND METHODS

An experiment was conducted during *rabi* season 2019-2020 at the Agromet Research Farm of Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (UP) 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 (D_1) (23.5°C), crop sown on November 10th (D_2) (23°C) and crop sown on November 20th (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 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. Sulfur was applied as per treatment through elemental sulfur. Half dose of nitrogen along with full dose of phosphorus, potassium and sulfur 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.

Observations recorded

Yield attributes

Number of siliquae per plant

At harvest total number of siliquae of sample plants of each plot were counted and average were calculated. Number of siliquae was counted separately on primary, secondary and tertiary branches. Total number of siliquae per plant was worked out by summing up the siliquae number on different type of branches.

Length of siliquae (cm)

Ten siliquae were randomly selected from each plot of the experimental field. The length measured from the base to the beak and average was drawn.

Number of seeds per siliqua

Seed per siliqua were recorded at harvest by counting the number of seeds of ten randomly selected siliqua from 3 sample plants of each plot.

1000 Seed weight (g)

Counting of 1000 seeds was done on seed counter from sample of each net plot produce and weight of counted seeds was done on electronic balance. It was recorded for all plots separately and average was drawn.

Yield

Grain yield (q/ha)

From the individual plot, the net plot area was harvested and produce was sun dried. After drying the crop was threshed and cleaned separately on the net plot basis. The final weight was recorded in kg per net plot and finally converted into q/ha.

Stover yield (q/ha)

Stover yield was computed by subtracting the seed yield from total produce on the net plot basis. Stover yield was recorded in kg per net plot area and converted into q/ha.

Biological yield (q/ha)

Above the ground parts of plant was harvested per plot after maturity then weighted to represent the biological yield and expressed in q/ha.

Harvest index (%)

The harvest index is the ratio of grain yield and biological yield, it was calculated by following formula:

$$\text{Harvest indest (\%)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

RESULTS AND DISCUSSION

Yield attributing characters

Number of siliquae/plant

Table 1 and Fig. 1 show data on the quantity of siliquae/plant as a function of thermal regimes and variety. A review of the data revealed that the number of siliquae per plant was considerably impacted by the thermal regime. When the crop was sown on the 31st of October, a higher number of siliquae/plant (281.6) was reported, which was much better than the growing conditions on the 10th and 20th of November. When seeding took place on November 20th, the lowest number of siliquae/plant was reported. The results are in conformity with the Singh *et al* (2014).

Number of siliquae/plant was significantly affected by different varieties. Maximum numbers of siliquae/plant (293.6) were recorded with Varuna variety followed by NDR-8501 (268.03) and then Bio-902 (232.9). These findings are in agreement with Singh *et al.* (2008).

Length of siliqua (cm)

Table 1 contains information on the length of siliqua (cm) as a function of environmental conditions and variety. The observed data revealed that the length of

Table 1. Yield attributes of mustard as affected by thermal regimes and varieties.

Treatments	No. of siliquae/plant	Length of siliqua (cm)	No. of seeds/siliqua	Test weight (g)
Thermal regimes (3)				
31st Oct (D_1)/(23.5°C)	281.5	8.0	16.8	4.5
10th Nov (D_2)/(23°C)	270.5	7.7	14.9	4.3
20th Nov (D_3)/(21°C)	242.4	6.9	13.8	4.2
SEm±	4.49	0.13	0.28	0.07
CD at 5%	13.10	0.38	0.82	NS
Varieties (3)				
Bio-902 (V_1)	232.9	6.8	14.1	3.7
NDR-8501 (V_2)	268.0	7.7	15.4	4.4
Varuna (V_3)	293.6	8.0	16.0	4.8
SEm±	4.49	0.13	0.28	0.07
CD at 5%	13.10	0.38	0.82	0.22

the siliquae/plant was considerably impacted by the thermal regimes. The maximum length of siliqua (8.0) was reported when the crop was sowed on October 31st, which was much better than the growing conditions on November 10th and November 20th. The least length of siliqua was recorded when crop was sown at thermal regime of November 20th. The results are conformity with Singh *et al* (2014).

Different varieties had a significant impact on the length of siliqua. Varuna variety has the longest siliqua length (8.07), followed by NDR-8501 (7.7), and Bio-902 (6.9) Singh *et al.* (2008).

Number of seeds/siliqua

Table 1 shows data on the number of seeds/siliqua produced as a function of thermal regimes and varieties. The data revealed that the quantity of seeds/siliqua was considerably influenced by the thermal regimes. When the crop was sowed on the 31st of October, the highest number of seeds/siliqua (16.9) was reported, which was much higher than the growing conditions on the 10th and 20th of November. When sowing was completed on November 20th, the lowest number of seeds siliqua^{-1}(13.8) was reported. These findings are in agreement with Singh *et al* (2014).

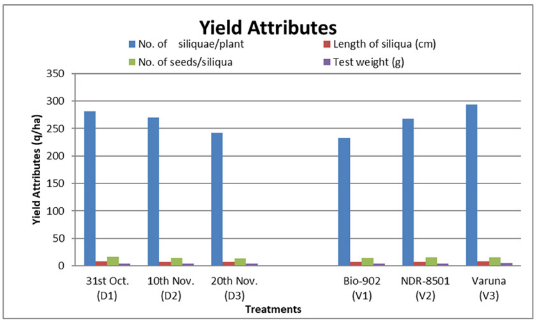

Fig. 1. Yield a ttributes of mustard as affected by thermal regimes and Varieties.

Different varieties had a substantial impact on the number of siliqua^{-1} seeds produced. Varuna variety has the highest number of seeds/siliqua (16), followed by NDR-8501 (15.4), and Bio-902 (14.1). Similar results are reported by Singh *et al*. (2008).

Test weight (g)

In Table 1, data on test weight (g) as a function of thermal regimes and variety is shown. The observed data revealed that the test weight was strongly influenced by the thermal regimes. When the crop was sown on the 31st of October, the maximum test weight (4.5) was obtained, which was much higher than the growing conditions on the 10th and 20th of November. When sowing was completed on November 20th, the minimum test weight (4.2) was recorded. The results are conformity with here in Singh *et al* (2014).

Different varieties had a substantial impact on test weight. Varuna had the highest test weight (4.8),

Table 2. Yield of mustard as affected by thermal regimes and varieties.

Treatments	Grain yield (q/ha)	Stover yield (q/ha)	Biological yield (q/ha)	Harvest index (%)
Thermal regimes (3)				
31st Oct (D1)/(23.5°C)	20.7	72.2	93.0	22.3
10th Nov (D2)/(23°C)	19.3	67.6	86.9	22.1
20th Nov (D3)/(21°C)	16.2	58.7	74.9	21.6
SEm±	0.35	1.18	1.47	0.37
CD at 5%	0.97	3.46	4.31	1.1
Varieties (3)				
Bio-902 (V1)	16.1	57.3	73.5	22.3
NDR-8501 (V2)	19.5	68.9	88.5	22.0
Varuna (V3)	20.6	72.3	92.9	21.2
SEm±	0.36	1.18	1.47	0.4
CD at 5%	0.98	3.46	4.31	1.10

followed by NDR-8501 (4.4), and Bio-902 (3.7). Similar results are reported by Singh *et al.* (2008).

Yield

Grain yield (q/ha)

Table 2 and Fig. 2 show the data on grain yield (q/ha) as a function of thermal regimes and varieties. A review of the data revealed that the grain yield was greatly affected by the Thermal regimes. When the crop was sowed on the 31st of October, the maximum grain yield (20.7 q/ha) was reported, which was much higher than the growth conditions on the 10th and 20th of November. When sowing at the 20th November Thermal regime, the minimal grain yield (16.2 q/ha) was obtained. Panda *et al.* (2004), Lallu *et al*. (2010) and Kumari *et al*. (2012).

Different varieties had a considerable impact on grain yield (q/ha). Varuna produced the highest grain yield (20.6 q/ha), followed by NDR-8501 (19.5 q/ha), and Bio-902 (16.1 q/ha). When seeding was done too early or too late, all of the growth and yield variables that affected the grain yield of mustard crop were negatively influenced, which may have resulted in poor growth and photosynthetic translocation from source to sink, resulting in a reduced yield. Similar results are reported by Singh *et al* (2008).

Stover yield (q/ha)

Table 2 and Fig. 2 show the data on stover yield (q/ha) as a function of thermal regimes and varieties. The data revealed that the thermal regimes had a considerable impact on the Stover yield. The highest stover yield (72.2 q/ha) was reported when the crop was sowed on the 31st of October, which was much higher than the growth conditions on the 10th and 20th of November. When sowing was completed on November 20th, the lowest stover yield (58.7 q/ha) was reported. When seeding was done too early or too late, all of the growth and yield variables that controlled the stover yield of mustard crop were negatively influenced, which may have resulted in poor growth and translocation of photosynthates from source to

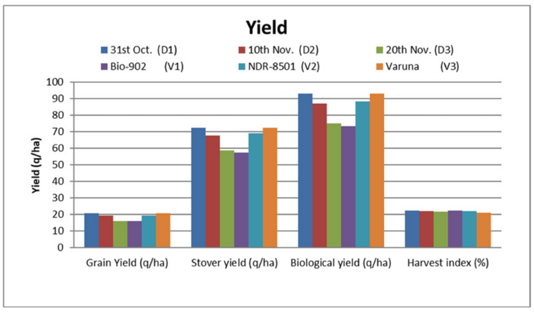

Fig. 2. Yield of mustard as affected by thermal regimes and varieties.

sink, resulting in a reduced yield. The results are in agreement with Kumar and Singh (2003).

Different varieties had a substantial impact on stover yield (q/ha). Varuna produced the highest stover yield (72.3 q/ha), followed by NDR-8501 (68.9 q/ha), and Bio-902 (57.3 q/ha). Similar results are reported by Singh *et al.* (2008).

Biological yield (q/ha)

Table 2 contains information on biological yield (q/ha) as a function of thermal regimes and variety. The data revealed that the thermal regime had a considerable impact on the biological yield. The highest biological yield (93.02 q/ha) was achieved when the crop was planted on the 31st of October, which was much higher than the crop growing conditions on the 10th and 20th of November. When sowing was completed on November 20th, the lowest biological yield (74.9 q/ha) was reported.

Different varieties had a considerable impact on biological yield (q/ha). Varuna produced the highest biological yield (92.9 q/ha), followed by NDR-8501 (88.5 q/ha), and Bio-902 (73.0 q/ha). The results obtained were found in close accordance with Saha and Khan (2008) and Nihalani *et al.* (2008) significant effect of all treatments on the biological yield of mustard was also observed.

Harvest index (%)

Table 2 and Fig. 2 show data on harvest index (%) as a function of thermal regimes and variety. The data revealed that the thermal regimes had a considerable impact on the biological yield. When the crop was sowed on the 31st of October, the maximum harvest index (22.3%) was recorded, which was much better than the growth conditions on the 10th and 20th of November. When sowing was done at the 20th November, the minimal harvest index (21.6%) was reported.

Different varieties had a substantial impact on the Harvest index (%). Varuna variety has the highest Harvest index (22.1%), followed by NDR-8501 (22.05%), and Bio-902 (22.02%) (21.9%). Similar results are reported by Singh *et al.* (2008).

CONCLUSION

Greater yield was observed when crop was sown on 31st October than that of 10th November and 20th November, which abstain the crop from abiotic stresses for more time might have favored higher number branches, dry matter production, yield attributing characters and yield at maturity. Different sowing dates were found to have a substantial impact on yield attributes. In case of varietal performance Varuna had higher yield when it was sown on 31st October followed by 10th November and 20th November.

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