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Studies on crop growing environment of mustard (*Brassica juncea* L.) varieties of eastern plain zone

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Abstract
A field experiment was conducted during rabi season of 2018-19 entitled "Studies on crop growing environment of mustard (*Brassica juncea* L.) varieties of Eastern Plain Zone" at Agromet Research Farm of Narendra Deva University of Agriculture & Technology, Narendra Nagar (Kumarganj), Ayodhya (U.P.). The experiment was conducted in spilt plot design which consisted of nine treatment combinations comprised of three crop growing environments viz. Oct. 20th, Oct. 30th and Nov. 9th and three varieties viz. Varuna, NDR-8501 and Kranti. Results reveal that higher dry matter accumulation was recorded in crop growing environment Oct. 20th which was at par with crop growing environment Oct. 30th while significant over crop growing environment Nov. 9th. Among the varieties, higher dry matter accumulation was recorded in Varuna variety which was at par with NDR-8501 while significant over Kranti variety recorded lowest dry matter accumulation at all the growth stages.
Maximum thermal sensitivity Index from sowing to maturity was recorded in Varuna variety while minimum thermal sensitivity index was obtained in Kranti variety from sowing to maturity of Indian mustard. Higher GDD was recorded in crop growing environment Oct. 20th followed by crop growing environment Oct. 30th and crop growing environment Nov. 9th. Among the varieties, higher GDD was recorded under Varuna followed by NDR-8501 at all the stages of Indian mustard.

Keywords: Dry matter accumulation, thermal sensitivity index, GDD, Growing environment, mustard

Introduction
Indian mustard belongs to cruciferae family. Rapeseed is locally called sarson, toria, yellow toria, whereas, mustard is called rai or laha. Among the oilseeds *Brassica*, is the most important member of groups because more than 80 per cent of the area under rapeseed-mustard is followed by *toria, yellow sarson, gobhisarson, brown sarson and taramira*. Oilseeds, the second largest agricultural commodity after cereals in India, plays a significant role in India's agrarian economy, as more than 85 per cent of country's vegetable oil supply depend upon seven edible oilseeds (groundnut, rapeseed-mustard, soybean, sesame, sunflower, Niger and safflower) and two non-edible oilseeds (linseed and castor). Among the seven edible oilseed cultivation in India, rapeseed-mustard (*Brassica* spp.) contributes 28.6% in the production of oilseeds. Rapeseed-mustard is the major *rabi* oilseed crop of the country. India occupies the third position in rapeseed and mustard production in world after Canada and China. In India during year 2017-18, the area of Rapeseed-mustard was 6.4 million ha. with the production of 6.4 million tonnes and productivity of 987 kg/ha. In India, it is mainly cultivated in Rajasthan, Gujrat, Maharashtra, Haryana, Uttar Pradesh, Madhya Pradesh, Bihar, Assam, and West Bengal in varied situation. (Anonymous, 2017-18). Neoget *et al.,* (2005) revealed that as growing degree days (GDD) increased from 1270 to 1684 ºC day in Pusa Jaikisan and Varuna, the seed yield -also increased and with the further increase in GDD accumulation, there was a decline in the seed yield of mustard. Change in sowing dates led to change in thermal environments of the cultivars with respect to different growth and development stages leading to variation in completion of life cycle (Roy *et al.,* 2005) [4]

Materials and Methods
The experiment was conducted at Agromet Research Farm of Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya- (U.P.) during Rabi season 2018-19, respectively. The farm is located 40 km away from Ayodhya city on Ayodhya- Raibareily road

at 26˚47′ N latitude and 82˚12′ E longitude and at an attitude of about 113 meter above the mean sea level. The experiment was conducted in spilt plot design which consist of nine treatment combinations comprised of three crop growing environments viz., Oct. 20th, Oct. 30th and Nov. 9th and three varieties viz. Varuna, NDR-8501 and Kranti**.** The crop was fertilized with a uniform dose of nitrogen, phosphorus and potassium @ 80kg, 60kg and 40 kg ha^{-1}, respectively Urea, DAP and muriate of potash were used as the source of nitrogen, phosphorus and potassium. The specific quantity of fertilizer was calculated on the basis of gross plot size. 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. First split was top dressed at 30 DAS and second splits at pre flowering stage of the crop.

Thermal Sensitivity Index was measured for each varieties sown at different dates were calculated as per following formula**;**

$$\text{TSI} = \frac{\text{Range of duration}}{\text{Average duration}} \text{x } 100$$

Growing degree days (GDD) at different phenological stages were calculated by using following formula; $\text{GDD} = \sum_{i=1}^{n} \text{G. D. D.}$

Where,

i= 1, 2, 3…….. n is the number of day.

$$\text{GDD} = \frac{\text{T max} + \text{Tmin}}{2} - \text{Base temp.}$$

Base temperature for rabi season is 5 °C.

Results and Discussion

Dry matter accumulation (g/m²)

It is quite obvious from the data that dry matter accumulation varied significantly crop growing environment at all the stages except 30 DAS of mustard. It was recorded higher under the treatment when mustard was sown on 20th October while significantly superior over rest both of the crop growing environment. Late sown mustard recorded lowest dry matter at all the stages. Dry matter accumulation was affected significantly at all the stages due to varieties except 30 DAS. Higher dry matter accumulation was recorded in Varuna variety which was at par with NDR-8501 while significant over Kranti variety recorded lowest dry matter accumulation at all the growth stages. Similar results were reported by (Singh and Singh, 2002, Lallu *et al*., 2010 and Kumar *et al.*, 2008) [5, 3, 2].

Thermal sensitivity index (%)

The thermal sensitivity index ranged from 8.2 % to 12.30 % irrespective of different varieties. Highest thermal sensitivity index from sowing to maturity was obtained in Varuna 12.30% cultivar while minimum Thermal sensitivity index was obtained in Kranti 8.2%from sowing to maturity of Indian mustard.

Accumulation heat unit/ Thermal unit (GDD)

Maximum heat Unit requirement from sowing to maturity were recorded 1674 ºC days at growing environment of 20th October while minimum accumulated growing degree days from sowing to maturity 1449 ºC days was observed under growing environment 09th November. Late sown mustard crop recorded minimum GDD requirement at all the stages. Accumulated GDD ranged from 1611 ºC days to 1839 ºC days irrespective of different varieties. Maximum Thermal unit/Accumulated heat unit requirement from sowing to maturity was recorded by 1839 ºC days was obtained in Varuna, while minimum thermal unit was obtained in Kranti by 1611 ºC days from sowing to maturity of Indian mustard. Similar results were reported by (Singh *et al.,* 2014, Hundal *et al.,* 2003 and Srivastava *et al.,* 2011) [6, 1, 7].

Table 1: Dry matter accumulation (g/m²) of Indian mustard as affected by crop growing environment date and varieties

Treatments	Dry matter accumulation			
	30 DAS	60 DAS	90DAS	At Harvest
Crop growing environments				
20th Oct.	54.5	162.1	560.8	620.0
30th Oct.	51.5	153.1	530.3	587.4
09th Nov.	41.3	122.0	425.0	474.8
SEm±	1.40	3.84	15.15	18.46
CD at 5%	NS	12.11	47.76	58.17
Varieties				
Varuna	54.2	161.4	558.6	617.7
NDR-8501	50.1	148.9	516.5	572.3
Kranti	43.0	126.9	441.0	492.2
SEm±	2.80	2.86	10.48	11.98
CD at 5%	NS	8.36	30.60	34.97

Table 2: Growing degree days/ Thermal unit at different phenophases (˚C days) of Indian mustard as affected by crop growing environment and varieties.

Treatments	Phenophases					
	Emergence	Four Leaf Stage	Flower Initiation	Siliquae Initiation	Pod Develop -ment	Maturity
Crop growing environment						
20th Oct.	163	272	765	945	1089	1674
30th Oct.	144	242	737	842	1042	1550
09th Nov.	120	252	627	769	965	1449
Varieties						
Varuna	96	348	587	822	1152	1839
NDR-8501	95	324	550	779	1106	1719
Kranti	93	297	493	707	1099	1611

Table 3: Thermal sensitivity index (%) of varieties

Varieties	TSI (%)
Varieties	
Varuna	12.30
NDR-8501	9.6
Kranti	8.2

Table 4: Category of TSI

TSI Category	Thermal sensitivity	Varieties
< 5	Insensitive	Nil
5-10	Moderately Insensitive	NDR-8501, Kranti
>10	Moderately Sensitive	Varuna

Conclusions

Conclusively, higher dry matter accumulation was recorded in crop growing environment Oct. 20th followed by crop growing environment Oct. 30th. Among the varieties, higher dry matter accumulation was recorded in Varuna which was at par with NDR-8501 while significant over Kranti. Kranti variety recorded lowest dry matter accumulation at all the growth stages. Higher GDD was recorded in crop growing environment Oct. 20th followed by crop growing environment Oct. 30th and crop growing environment Nov. 9th. Among the varieties Higher GDD was recorded under Varuna followed by NDR-8501 at all the stages of Indian mustard. Maximum thermal sensitivity Index from sowing to maturity was obtained in Varuna variety while minimum thermal sensitivity index was obtained in Kranti variety from sowing to maturity of Indian mustard.

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