Environment & Ecology 35 (2C) : 1274—1280, April—June 2017
Website: environmentandecology.com ISSN 0970-0420

Influence of Weather Parameter on Yield and Yield Attributes of Mustard (*Brassica juncea*) at Hisar Condition

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Received 18 July 2016 ; Accepted 23 August 2016 ; Published online 9 September 2016

Abstract Field experiment was conducted during *rabi* season of 2014-15 to study relationship between weather parameters and yield, and yield attributes of mustard crop as influenced by growing environment. The main plot treatments consisted of three date of sowing (26th October, 5th November and 15th November) and sub plot treatments consisted of three varieties (Kranti, RH 406 and RH 0749). The yield and yield attributes were found more in RH 0749 as compared to RH 406 and Kranti. The delay in sowing of mustard crop reduced the number of siliquae per plant, seed yield per plant, biological yield and seed yield as compared to early sowing of crop. The number of seeds per siliqua, biological yield, seed yield, test weight and harvest index in 26th October sown crop were significantly higher. Among the varieties, RH 0749 performed better in all three growing environments. T_{max} and T_{min}, sunshine hours, evaporation during vegetative stage showed significant positive correlated with number of siliquae per plant, seed and biological yield whereas, these parameters showed significant negative correlated during reproductive stage. RH_m and RH_e at vegetative stage was significantly negative correlation with number of siliquae per plant, seed yield and biological yield at during reproductive stage was observed positively correlated.

Keywords Indian mustard, Growing environment, Correlation, Meteorological indices, Yield and yield attributes.

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Introduction

Indian mustard (*Brassica juncea*) is the second most important oil seed crop in India after soybean. It accounts for nearly 20–22% of the total oilseeds produced in the country. The crop occupies an area of approximately 6.90 million hectare with a production of 8.18 million tones [1]. In India, the Haryana state contributes 10.2% to the total rapeseed-mustard production in the country. Likewise, area under mustard in Haryana has increased from 1.98 lakh ha in 1966-67 to 5.70 lakh ha in 2013-14. A considerable improvement in mustard productivity has also happened during the period with its increase from 405 kg/ha in 1966-67 to 1,350 kg/ha in 2013-14 [2].

Indian - mustard is much sensitive to climatic variables ; hence, climate change could have significant effect on its production. One month delay in sowing from mid of October resulted in 40.6% loss

in seed yield [3] ; there was significant interaction between growing environment and cultivars with respect to seed yield of mustard. It was concluded that normal or early sowing of Pusa Jai Kisan or Pusa Bold cultivar may be practiced for achieving higher seed yield, radiation and water use efficiency in semi arid environment of north and north-western part of India [4]. It was observed that longer vegetative and shorter reproductive stage in mustard with delay in sowing. The vegetative stage of late sown crop was exposed to low temperature and lower amount of solar radiation and hence required more number of days for accumulation of given amount of growing degree days. The total crop duration also decreased with delay in sowing [5]. Higher temperature during the vegetative period reduced LAI and physiological activities causing lower seed yield in the earliest sown crop [6] ; change in growing environmental 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 [7]. Reduction in seed yields to the relatively higher temperature prevailing during the pod filling stage especially if the crop is sown beyond the sowing window on October 1st to 22nd [5].

LAI was significantly positive correlated with maximum and minimum temperature and bright sunshine hours during vegetative and flowering phenophases but negatively correlated with different weather parameters during seed development phase. With the delay in planting date, the higher mean temperature was experienced during flowering which led to accelerate the decrease of LAI and reduction of the flowering period [8, 9].

Materials and Methods

Climate and weather conditions of experiment location in brief

The climate of Hisar is mainly characterized by its continental location on the outer margins of the monsoon region. It is situated in the tract of semi-arid and sub-tropical monsoonal climate. In winter only 2-3 rainy showers are received due to western disturbances followed by low temperature. The occurrence of frost on certain days is also not an unusual feature here.

Experimental details

The data were taken at Hisar station from experiment which was conducted during *rabi* season of 2014-15 using split plot design comprising three dates of sowing (25th Oct, 5th Nov and 15th Nov) in main plots and cultivars (Kranti, RH 406 and RH 0749) in sub plots. The thirty six treatment combinations were tested in four replications. The package and practices for Indian mustard cultivation was followed as per the recommendation of CCS Haryana Agricultural University. Various agro-physiological observations like yield and yield attributes such as number of primary and secondary branches at harvest, siliqua length (cm), number of siliquae per plant, number of seeds per siliqua, seed yield per plant (g), test weight (g), seed yield (kg ha^{-1}), biological yield (kg ha^{-1}) and harvest index (HI, %) were recorded from field experiment conducted at Research Farm, Department of Agricultural Meteorology, CCS HAU, Hisar.

Computation of agrometeorological indices

Phototemperature (*Tp*)

The effective light temperature can be best defined by

$$T_p = T_{max} - 1/4\ (T_{max} - T_{min})$$

Where, T_{max} and T_{min} are the daily maximum and the minimum temperatures in °C respectively. This index is computed cumulatively for 30-day intervals for each growing environment and reflects the importance of the mean temperature during daytime, when solar radiation levels are satisfactory.

Nyctotemperature (T_n)

Nyctotemperature corresponds to a mean temperature during night, when light levels are limited. This index is expressed by

$$T_n = T_{min} - 1/4\ (T_{max} - T_{min})$$

Table 1. Weekly weather parameters during the crop season 2014-15.

Weekly weather data–2014-15 CCSHAU, Hisar											
SMW	Max Temp (°C)	Min Temp (°C)	G_{min} Temp (°C)	AVP (mm of Hg) M	AVP (mm of Hg) E	RH (%) M	RH (%) E	AVG WS (km/h)	BSS (Hrs)	PAN Evap (mm)	Rain-fall (mm)
43	32.4	19.0	–	16.6	16.4	85	47	3.5	7.0	2.9	0.0
44	30.7	14.6	–	12.7	11.1	88	35	3.1	6.4	2.7	1.0
45	29.9	14.3	–	12.4	11.2	87	36	2.9	6.7	2.8	0.0
46	27.1	7.7	–	7.8	7.5	79	28	1.9	7.1	2.4	0.0
47	26.6	6.9	–	7.9	7.4	88	29	1.5	7.8	2.9	0.0
48	28.1	9.9	0.9	9.1	9.2	81	32	2.5	7.7	3.0	0.0
49	26.9	7.9	2.6	8.6	8.9	91	35	2.2	7.8	1.9	0.0
50	20.5	6.8	2.9	8.3	8.7	94	56	3.6	5.2	1.5	9.0
51	13.8	5.0	1.9	7.3	9.0	100	88	2.4	1.6	0.3	0.0
52	15.0	3.9	0.4	6.9	8.6	100	71	2.7	4.0	0.5	0.0
1	16.9	2.4	– 1.9	6.1	8.1	95	59	2.7	4.4	1.0	0.0
2	18.5	3.3	– 0.8	6.4	8.1	96	52	2.3	5.5	1.2	0.0
3	16.4	6.5	3.7	8.3	10.8	99	84	3.4	2.3	0.5	0.0
4	18.3	8.8	5.3	9.4	12.1	98	78	5.0	2.8	1.4	2.0
5	21.0	8.6	6.0	9.2	12.4	98	72	3.4	4.2	0.8	0.0
6	20.6	7.9	3.7	9.3	10.9	97	65	4.7	6.0	1.9	4.1
7	19.5	5.5	1.0	7.5	10.5	95	63	3.6	6.5	1.6	1.5
8	21.9	8.5	4.0	9.0	12.5	92	66	4.5	6.4	1.9	3.1
9	21.9	8.7	5.1	10.0	13.5	99	70	3.7	6.1	1.7	3.8
10	22.5	9.0	–	10.4	13.4	96	64	3.1	5.7	2.3	11.3
11	24.9	11.0	–	10.9	14.5	92	66	6.2	7.9	2.6	13.3
12	28.3	12.3	–	12.0	12.2	89	42	3.6	8.8	3.2	1.1
13	28.0	15.7	–	13.5	14.5	86	54	5.2	5.5	3.7	21.3
14	31.2	14.3	–	13.9	12.7	88.1	38.1	5.0	9.1	4.4	8.5
15	33.3	16.4	–	13.4	12.1	72.0	31.1	5.7	9.5	6.2	0.0

Statistical analysis

Mean weather parameter viz. T_{max} : Maximum temperature, T_{min} : Minimum temperature, RH_m : Morning relative humidity, RH_e : Evening relative humidity, BSS : Bright sunshine hours, EP : Evaporation during the crop growing period of mustard was recorded from meteorological observatory. Correlation was carried out between weather parameter with yield attributes. The data were statistically analyzed using analysis of variance (ANOVA) as applicable to split plot design. The significance of the treatment effects was determined using *F*–test at 1% and 5% significance level.

Results and Discussion

Weather

The weekly weather parameters during the crop season 2014-15 (43^{th} to 15^{th} standard meteorological weeks –SMW) are presented in the Table 1.

Agrometeorological indices

Agrometeorological indices are presented in Table 2.

Photo temperature

It showed that 25^{th} October sown crop were effective light temperature influence or favorable temperature as compared to delayed. The highest production of yield in earlier sown crop could be attributed to efficient utilization of radiation and maximum production of photosynthates. The decrease in yield with delay in sowing can be also attributed to higher air temperature experienced during pod filling phase of the crop that ultimately resulted in forced maturity [4].

Table 2. Agrometeorological indices. *DAS–Days after sowing.

Treatments	Photo temperature (T_p) 25th Oct	5th Nov	15th Nov	Nycto temperature (T_n) 25th Oct	5th Nov	15th Nov
30 DAS*	13	11	10.9	6.4	4.6	4.3
60 DAS	11.4	11.6	11.8	5.2	5.8	6.1
90 DAS	12.2	12.6	12.1	6.4	6.8	6
120 DAS	12.6	12.7	13.8	6.5	7.2	7.5
Maturity	13.7	13.1	14.3	7.3	6.9	5.8

Nycto temperature

Higher night temperature leads to higher respiration rates, lower biomass production and therefore lower crop yields. If night temperature are higher, then more chances of frost attack.

Yield and its attributes

Yield and yield attributes are presented in Table 3.

Number of primary and secondary branches at harvest

The number of branches significantly reduced with the delay in sowing at different sowing environment. Among varieties, higher numbers of primary and secondary branches were recorded in RH 0749 followed by RH 406 and Kranti at harvesting time. Among growing environment, higher numbers of primary and secondary branches were recorded at 25th October followed by 5th November and 15th November at harvesting time.

Siliquae length

The first sown crop was highest siliqua length as compared to second and third sown crop. Among varieties, RH 0749 was attained the highest value as compared to other varieties [9].

Number of siliquae per plant

The table reveals that the number of siliquae per plant was significantly higher in 25th October and it drastically reduced with delay in sowing. RH 0749 was significantly highest value among varieties but Kranti was lowest value [9].

Number of seeds per siliqua

It reveals that 25th October and 5th November crops were statistically at par and found significantly higher number of seeds per siliqua as compared to 15th November crops. Among the varieties, RH 0749 had

Table 3. Yield and yield attributes.

Treatments	Primary branch	Secondary branch	Siliqua length (cm)	No of siliquae/ plant	No of seeds/ siliqua	Test wt (g)	Seed yield/ plant (g)	Seed yield (kg/ ha)	Biological yield (kg/ ha)	HI (%)
25th Oct	7.72	12.53	5.38	356.83	14.36	7.00	36.65	1870.31	12238.88	14.59
5th Nov	6.36	10.77	4.82	324.41	13.60	6.48	29.58	1525.51	10880.88	13.59
15th Nov	5.58	8.65	4.64	282.52	12.83	5.56	21.09	1099.89	6241.67	12.44
Kranti	4.85	8.86	4.37	305.50	12.34	5.13	19.31	1318.57	8667.46	12.28
RH 406	6.68	10.20	4.93	317.81	13.30	6.20	26.24	1479.21	9326.04	13.29
RH 0749	8.14	12.89	5.54	340.45	15.16	7.70	41.76	1697.93	11367.92	15.05
CD at 5% (D)	0.29	0.63	0.18	12.36	0.47	0.36	0.72	38.83	518.75	0.37
CD at 5% (V)	0.28	0.22	0.16	7.22	0.52	0.26	0.94	45.57	365.48	0.52
D*V	0.52	0.44	0.30	13.66	NS	0.48	1.68	81.85	680.47	NS

Table 4. Correlation between weather and yield attributes at different phenophases. * Significant at 5% level of significance. ** Significant at 1% level of significance.

Weather parameters	Stage	Siliqua length (cm)	Number of siliquae/ plant	Number of seeds/ siliqua	Test weight (g)	Seed yield/ plant (g)	Seed yield (kg/ha)	Biological yield (kg/ha)
T_{max}	Vegetative	0.42	0.82**	0.37	0.38	0.46	0.84**	0.81**
	Reproductive	–0.21	– 0.67*	– 0.18	– 0.21	–0.28	–0.68*	– 0.71*
T_{min}	Vegetative	0.51	0.83**	0.43	0.43	0.51	0.86**	0.79**
	Reproductive	–0.20	– 0.67*	– 0.23	– 0.27	–0.32	–0.67*	– 0.77*
RH_m	Vegetative	– 0.36	– 0.80**	– 0.34	– 0.36	–0.42	–0.82**	– 0.82**
	Reproductive	0.36	0.78*	0.40	0.45	0.48	0.79**	0.87**
RH_e	Vegetative	– 0.41	– 0.82**	– 0.37	– 0.39	–0.46	–0.84**	– 0.83**
	Reproductive	0.27	0.72*	0.31	0.36	0.40	0.72*	0.82**
SS	Vegetative	0.41	0.81**	0.36	0.38	0.46	0.83**	0.82**
	Reproductive	–0.36	– 0.70*	– 0.48	– 0.55	–0.53	–0.69*	– 0.85**
EP	Vegetative	0.42	0.80**	0.36	0.37	0.44	0.83**	0.79**
	Reproductive	–0.24	– 0.69*	– 0.27	– 0.33	–0.36	–0.70*	– 0.80**

maximum value followed by RH 406 and Kranti.

Test weight

It showed that 25th October crop was highest test weight as compared to 5th November and 15th November crops. RH 0749 was found significantly higher test weight as compared to RH 406 and Kranti. The results regarding decrease in test weight with delayed sowing.

Seed yield per plant

It showed that 25th October crop was highest seed yield per plant as compared to 5th November and 15th November crops. RH 0749 variety was found significantly higher seed yield per plant as compared to RH 406 and Kranti.

Seed yield

Maximum seed yield was recorded in 25th October as compared to 5th November and 15th November. RH 0749 recorded highest seed yield among varieties from the others. Increasing temperature lowered the days to flowering and days to maturity thus shortening the seed formation period. A higher temperature leads to higher respiration rates, lower biomass production, smaller and lighter grain and therefore lower crop yields. The highest seed yield in 25th October sown crop was also due to significantly improved yield attributes as compared to crop sown on other dates [4, 5, 8, 10—12].

Biological yield

The crop sown on first date produced highest biological yield as compared to crops sown on second and third date. Among varieties, RH 0749 had significantly higher biological yield as compared to RH 406 and Kranti. Various workers are also reported that less amount of above ground biomass yield were recorded from sowing to maturity in *Brassica* as planting was delayed [5, 13].

Harvest index

The crop sown on 25th October was higher harvest index as compared to 5th November and 15th November under delayed sowing. Among varieties, RH 0749 was significantly higher harvest index as compared to RH 406 and Kranti.

Relationship between agrometeorological parameter and crop parameter

The correlation was carried out to quantify the rela-

tionship of crop parameters with weather parameters. The correlation coefficients of weather parameters with crop parameters during various phenophases were pooled for different cultivars and growing environments are presented in Table 4.

T_{max} and T_{min} during vegetative stage were significant positive correlation with number of siliquae per plant, seed and biological yield with correlation coefficients whereas this parameter during reproductive stage shows that significant negative correlation with the above crop parameter. Sunshine hours during vegetative stage was significant positive correlation with number of siliquae per plant, seed and biological yield with correlation coefficient respectively it shows significant negative correlation with the crop parameters. Sunshine hours during reproductive stage showed significant negative correlation with reproductive stage in number of siliqua per plant, seed yield and biological yield. Such results are also observed a negative correlation between air temperature and sunshine hours during seed development phase with leaf area index [9].

Negative correlation between temperature during two later phenophases and seed yield were due to higher temperature during reproductive phase [12, 14]. Relative humidity at morning and evening hours at vegetative stage was significantly negative correlation with number of siliquae per plant, seed yield and biological yield, whereas during reproductive stage. It shows significantly positive correlation with the above parameter. Evaporation shows that positive correlation with seed yield, number of siliquae per plant and biological yield whereas reproductive stage had negative correlated with these parameters [15].

Conclusion

From the above study it was concluded that the crop sown on 26th October performed significantly better in respect of yield and yield attributes as followed to 5th and 15th November mustard sown. Early or normal growing environment, varieties like RH 0749, RH 406 and Kranti that owing the performance in actual weather variables and further these cultivars practiced for achieving good yield in the semi arid environment of north western part of India.

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