Impact of weather parameters on mustard yield in two diverse locations of India

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ABSTRACT

Different weather parameters and its variation effect the growth and development of oilseeds, cereals and other agriculture crops. Weather also plays a significant role by influencing growth and pod formation of mustard at various growth stages. As India accounts for holding 11% of overall mustard production in the world, study on impact of weather on mustard yield and its correlation is of great importance in the field of agriculture meteorology. Present study highlights the relationship between eight different weather parameters and mustard yield at Hisar and Kanpur district of India from standard meteorological week (SMW 40 to SMW 13) using SPSS statistical software. The result showed that Minimum temperature has significant positive correlation during flowering and pod formation stage in Hisar but has negative correlation during SMW 52 (pod formation stage) at Kanpur. Windspeed and sunshine hours has negative significant correlation in Hisar but does not show any significant correlation at Kanpur district of Uttar Pradesh.

Introduction

In India, majority of seasonal crops like mustard, wheat, rice largely depends on weather. Different weather and climate parameters effect the yield of crops from sowing till harvesting stage. The influence of weather parameters on yield of different crops can highly differ based on regional weather conditions (like irregular rainfall distribution, excessive high or low temperature) resulting in variation in crop production. Optimum weather condition can act as a catalyst to enhance overall production and yield of crops whereas unfavourable or adverse weather condition or growing season climate can decline growth and development of various crops (Iizumi and Ramankutty, 2015). As mustard crop is grown during *rabi* season in India, very high temperature during its pod formation stage can decline its productivity. Mustard is one of the important oilseed crop cultivated all across globe as it is the rich source of high edible nutrient and oil content. At global level, leading mustard growing countries are: India, France, Poland, Pakistan, China, Bangladesh and Sweden. Around 16% of world mustard production is from India. Also India covers 35% area of overall mustard cultivation throughout the world. Uttar Pradesh, Rajasthan, Madhya Pradesh, Haryana, West Bengal and Gujarat are the leading mustard growing states of India. In India, Rajasthan state alone contributes nearly 49% of country's total production of mustard followed by Uttar Pradesh, Haryana and Madhya Pradesh by 11% each

(Darekar and Reddy, 2018). Mustard crop can be cultivated both in tropical as well as sub-tropical region of India (Shekhawat *et al.,* 2012). With such massive production and demand of mustard crop in India and around the world, current study deals with analysing the effect and correlation of different weather variables like maximum and minimum temperature (°C), rainfall (mm), morning and evening relative humidity (%), windspeed (kmph), sunshine hour (hrs) and evaporation (mm) on mustard yield in two study area (Hisar and Kanpur) at various growth stages of mustard from sowing to maturity. First fortnight of October to September month for sowing and harvesting at the time of February and March is considered best for mustard crop in India in sandy loam soil (Singh *et al.,* 2017). On commercial point of view, some of the important varieties of *Brassica juncea* are: NPJ-112, Pusa Agrani (SE J-2), Sita Pusa Mahak (JD-6), Kranti, Pusa Vijay (NPJ-93), Pusa Karishma (LES-39) and Pusa Mustard 22 (LET-17). Growth stages of crop should have the sync with the real time environmental condition for better growth and production.

Materials and Methods

Study Area: This study comprises of two study areas which are Hisar located in Haryana state with coordinates 29.14°N and 75.72°E and Kanpur in Uttar Pradesh state with coordinates 26.44°N and 80.33°E. Weather data like maximum temperature (Tmax), minimum temperature (Tmin), rainfall (Rf), sunshine hours (SSH), evaporation (EVP), windspeed (ws), morning (RH1) and evening relative humidity (RH2) from year 1999 to 2018 was collected from ICAR-Central Research Institute for Dry Land Agriculture (AICRPAM unit). Mustard yield data was taken from Directorate of Economics and Statistics, Government of India.
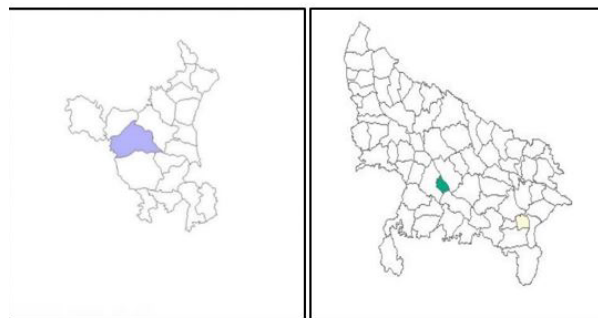

Fig. 1. Map of study area (Hisar and Kanpur)

For assessing the impact of all eight weather parameters on mustard yield in the study area, the correlation between weather variables and mustard yield using SPSS regression method were analysed. Weekly weather data from standard meteorological week 40 to standard meteorological week 13 (SMW 40 to SMW 13) and actual mustard yield data from year 1999 to 2018 were imported in spss model, where mustard yield was taken as dependent variable and weather variables like Tmax, Tmin, windspeed, rainfall, RH1, RH2, evaporation and sunshine hours was taken as independent variables. At 95% confidence interval and 5% significant level, correlation regression analysis was carried out using spss statistical software at different growth stages of mustard like germination/emergence, flowering, pod formation and fruiting, ripening and maturity stages. The impact of correlation coefficients of weather on weekly basis at developmental stages of mustard growth can give clear picture regarding the impact of each weather parameter on mustard productivity which varies from one study area to another. The duration of single growth stages of mustard was categorised according to standard meteorological week as mentioned below in Table 1.

Results and Discussion

This study deals with analysing the correlation between different weather variables based on Standard Meteorological Week(SMW) and mustard yield at different growth stages in two study area: Hisar and Kanpur by using SPSS statistical model. Table 2 shows that for Hisar region, maximum temperature (Tmax) shows positive significant relationship at SMW 42 (germination and emergence stage), SMW 49 (flowering stage) and SMW 50 (pod formation/fruiting stage). Minimum temperature also showed positive significant correlation at SMW 49 (flowering) and SMW 50 (pod formation/fruiting growth stage) at 5% significant level. Morning relative humidity (RH1) has given positive significant correlation during SMW 2 and 5 at pod formation and ripening stage respectively, whereas evening relative humidity (RH2) showed positive significant correlation during SMW 46. Other meteorological parameter like windspeed showed negative significant correlation during SMW 1 at pod formation stage and SMW 10 at full maturity stage. At SMW, 45 and 46 (flowering stage of mustard) and SMW 12 (full maturity), Sunshine hours has given negative

Table 1. SMW duration at different growth stages of mustard

Stages of mustard crop	Standard Meteorological Week (SMW) Duration
Germination	SMW 40 to 43 weeks
Flowering	SMW 44 to 49 weeks
Pod formation and fruiting	SMW 50 to 3 weeks
Ripening	SMW 4 to 6 weeks
Full Maturity	SMW 7 to 13 weeks

Table 2. Correlation between weather and mustard yield at different growth stages (Hisar)

Growth stages of mustard	Correlation Coefficient Matrix, Hisar (1999-2018)								
	SMW	Tmax	Tmin	RH1	RH2	WS	RF	SS	EVP
Germination and	40	-0.10	0.00	0.16	-0.11	0.16	-0.19	-0.10	-0.30
Emergence	41	0.32	0.32	0.15	-0.02	-0.09	0.28	-0.32	-0.28
	42	**0.52***	0.17	-0.13	-0.32	0.10	-0.34	0.32	0.07
	43	0.39	0.28	0.14	0.08	-0.09	0.00	-0.07	-0.25
Flowering	44	0.16	0.32	-0.02	0.23	0.19	0.22	-0.27	-0.19
	45	0.16	0.34	0.38	0.14	-0.32	-0.31	**-0.55***	**-0.46***
	46	-0.03	0.46	0.26	**0.54***	0.26	-0.04	**-0.69***	**-0.44***
	47	-0.17	0.31	0.22	0.46	0.09	0.40	-0.34	0.20
	48	0.17	0.10	0.41	0.09	-0.35	0.00	0.00	0.27
	49	**0.54***	**0.56***	0.01	0.22	-0.32	0.34	-0.17	0.30
Pod formation	50	**0.50***	**0.58***	-0.07	0.17	0.22	0.08	-0.04	0.36
and fruiting	51	0.21	0.38	0.16	0.02	0.04	0.18	0.03	0.31
	52	0.34	0.10	0.09	-0.12	-0.18	-0.02	0.36	0.36
	1	0.27	0.06	0.37	-0.01	**-0.56***	-0.10	0.08	0.31
	2	0.04	0.26	**0.71***	0.26	-0.34	0.38	-0.34	-0.38
	3	0.00	-0.06	0.43	-0.01	-0.16	0.18	0.17	-0.34
Ripening stage	4	-0.05	0.10	0.34	0.26	-0.29	0.08	-0.16	-0.38
	5	-0.13	0.32	**0.52***	0.33	-0.01	0.13	-0.39	**-0.42***
	6	0.35	0.13	0.21	0.00	-0.33	-0.22	0.13	-0.16
Full Maturity	7	-0.20	-0.22	0.01	0.13	-0.04	0.03	-0.09	**-0.40**
	8	-0.08	-0.11	-0.01	-0.05	-0.30	-0.01	-0.07	-0.39
	9	0.17	0.20	0.13	-0.03	-0.30	-0.12	-0.14	**-0.54***
	10	-0.09	0.24	0.00	0.24	**-0.46***	-0.04	-0.25	**-0.47**
	11	0.09	-0.18	-0.09	-0.16	-0.32	-0.28	0.25	-0.23
	12	0.03	0.18	0.00	0.02	-0.38	0.00	**-0.47***	**-0.52***
	13	0.12	0.23	-0.01	0.06	-0.29	0.01	-0.35	-0.37

*Significant at 5% level and 95% confidence interval

significant correlation. Evaporation also showed negative significant correlation during SMW 45 and 46 at flowering stage and at SMW 5 (ripening stage) and SMW 7, 9, 10 and 12 (full maturity stage) at 5 % significance level for Hisar. Singh *et al.* 2002 also conducted study regarding significant correlation between different weather parameters and mustard yield, LAI and biomass accumulation at various growth stages of mustard where increase in day time temperature results in increase in biomass accumulation.

Table 3 shows correlation coefficient matrix be-

tween weather variables and mustard yield at different growth stages for Kanpur region. Maximum temperature has positive significant correlation during SMW 42 and 43 at germination stage. Minimum temperature shows negative significant correlation during pod formation stage at SMW 52 and SMW 9 and SMW 12 at full maturity stage. Morning relative humidity (RH1) shows positive significant correlation during SMW 41 at germination and emergence stage, during fruiting stage at SMW 2. Morning and evening relative humidity showed significant positive correlation at full maturity stage of mustard

Table 3. Correlation between weather and mustard yield at different growth stages (Kanpur)

Growth stages of mustard	Correlation Coefficient Matrix, Kanpur (1999-2018)								
	SMW	Tmax	Tmin	RH1	RH2	WS	RF	SS	EVP
Germination and Emergence	40	-.01	-.20	.32	.06	.35	.32	.12	.07
	41	-.15	.05	**.44***	.23	-.18	.08	.07	-.07
	42	**.42***	.07	-.19	-.09	-.27	-.33	.05	.14
	43	**.40***	.18	.05	.03	.11	-.22	.08	.38
Flowering	44	.18	-.33	-.01	-.12	.11	.12	.12	.36
	45	.14	-.30	.15	-.08	-.20	-.23	.15	**.41***
	46	.27	-.14	-.21	-.08	.16	-.02	-.06	.39
	47	-.02	-.14	-.02	.10	-.21	.26	.08	.34
	48	.03	.08	.01	-.03	.23	.26	.06	.38
	49	-.35	-.25	.12	.20	-.24	.15	.01	.37
Pod formation and fruiting	50	-.15	-.18	.04	.01	.23	-.16	.18	.25
	51	.36	-.26	-.23	-.32	-.04	-.33	.12	.21
	52	.35	**-.41***	-.26	-.20	-.20	-.30	-.01	.24
	1	.00	.00	.35	.04	-.04	.13	-.18	.00
	2	-.27	-.34	**.41***	.16	-.12	-.15	-.35	-.21
	3	.22	-.34	.08	-.20	-.05	.04	-.04	.00
Ripening stage	4	.24	-.35	.25	-.16	-.11	-.02	.12	-.03
	5	.25	-.28	.19	-.22	.17	.08	.29	.04
	6	.15	-.16	.15	-.18	-.10	.33	-.03	-.12
Full Maturity	7	-.01	-.34	.06	-.20	-.05	-.01	.13	.08
	8	-.36	-.27	.32	-.03	-.18	.13	-.09	-.09
	9	-.29	**-.55***	.25	.12	-.22	.24	-.01	-.09
	10	-.14	-.38	.08	-.13	-.30	-.34	.09	-.11
	11	-.15	-.32	-.10	-.09	.10	-.22	.07	.10
	12	-.14	**-.53***	.14	.23	-.09	-.33	.04	.11
	13	-.15	-.25	**.45***	**.51***	.09	.14	-.04	.18

*Significant at 5% level and 95% confidence interval

crop at Kanpur. Evaporation also has positive significant correlation during flowering stage at standard meteorological week (SMW 45). Rao *et al.* 2011, also conducted study on correlation of weekly weather variables and mustard yield where maximum temperature shows positive significant correlation with mustard yield from 1st to 7th week after sowing (WAS) and minimum temperature showed significant negative correlation from 16, 18 to 20 week after sowing.

Conclusion

Present study aimed at finding out the correlation between different weather variables and mustard yield at various growth stages in Hisar district of Haryana and Kanpur district at Uttar Pradesh state. Minimum temperature showed significant positive correlation during flowering and pod formation stage in Hisar but has negative correlation during SMW 52 (pod formation stage) at Kanpur. Maxi-

mum temperature showed positive significant correlation during germination and emergence stage in both the study area. Other weather parameters like windspeed showed negative significant correlation during SMW 1 (pod formation) and SMW 10 (full maturity) stage and sunshine hours also showed negative significant correlation during SMW (45-46) at flowering growth stage in Hisar, whereas Windspeed and Sunshine hours does not show any significant correlation with mustard yield at Kanpur. During flowering stage, evaporation showed negative significance with respect to yield at Hisar but showed positive correlation at Kanpur at 5% significance level and 95% confidence interval.

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