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Study of correlation between weather parameters and different growth stages of *Kharif* maize (*Zea mays* L.) with grain yield

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Abstract
In order to investigate the Study of correlation between weather parameter and different growth stages of *kharif* maize(*Zea mays* L.) with grain yield a one-year field experiment was conducted at PGI, an experimental farm of All India Co-ordinated Research Project on Safflower, VNMKV, Parbhani, during the *Kharif* season of 2015-16. A field experiment was conducted with the objective of worked out the correlation between maize hybrids and weather parameters. The experiment design was a split-plot design with three replications. Main plots consisted of three sowing dates and subplots were also allocated four different varieties *viz*. (900M Gold, Rajsri, NK-6240, and DKC-9133). The meteorological parameters (abiotic factor) play an essential role in deciding the success or failure of the crop because these factors strongly influence the physiological expression of the genetic potential of the crops, hence this study was undertaken. The correlation study was carried out between weather variables prevailed during P_1 to P_6 growth stages of different hybrids under different sowing dates. Correlation between weather parameter and phenophases of maize with grain yield showed that the weather parameters like rainfall and rainy day, temperature, relative humidity and bright sunshine hour have significant effects on critical growth stages. Correlation between weather parameters and growth stages of maize with grain yield was worked out. Rainfall and rainy days were found significantly positively correlated at P_5 (0.702*), (0.656*) and significantly negatively correlated at P_2 (-0.629*), (-0.635*), respectively. T_{max} and T_{min} were found significantly positively correlated at P_2 (0.600*) and (0.611*), respectively, while T_{max} was found significantly negatively correlated at P_5 (-0.655*) and P_6 (-0.612*) and T_{min} was found significantly positively correlated at P_5 (0.645*) and P_6 (0.603*). RH-I was found significantly negatively correlated at P_2 (-0.605*) and significantly positively correlated at P_5 (0.647*). RH-II was found significantly negatively correlated at P_2 (-0.590*) and significantly positively correlated at P_5 (0.579*) and P_6 (0.611*). Evaporation was found significantly positively correlated at P_2 (0.604*) and significantly negatively correlated at P_6 (-0.619*). Bright sunshine hours was found significantly positively correlated at P_1 (0.596*) and significantly negatively correlated at P_6 (-0.597*). Wind velocity was found significantly positively correlated at P_2 (0.614*) and P_5 (0.668*).

Keywords: weather parameter, *kharif* maize (*Zea mays* L.), meteorological parameters, phenophases of maize

Introduction

Maize is a versatile crop grown over a range of agro climatic zones. In fact the suitability of maize to diverse environments is unmatched by any other crop. It is grown from 58ºN to 40ºS, from below sea level to altitudes higher than 3000 m, and in areas with 250 mm to more than 5000 mm of rainfall per year (Shaw, 1988; Dowswell *et. al.*, 1996) [7, 15] and with a growing cycle ranging from 3 to 13 months (CIMMYT 2000) [5]. However the major maize production areas are located in temperate regions of the globe. The United States, China, Brazil and Mexico account for 70% of global production. India has 5% of corn acreage and contributes 2% of world production.

Maize is principally a rainy season crop and requires a minimum soil temperature of 13ºC for germination and root development (optimum range 21ºC- 27ºC). It response well to warm conditions (optimum of 21ºC- 30ºC) as growth increases with temperature up to 30ºC. In India, area and production of maize are about 9.23 million hectares and 23.73 million tonnes respectively, having average productivity about 2564 kg ha^{-1}. In Maharashtra, the area and production of maize is about 1.05 million hectares and 2.20 million tonnes production with the productivity of 2080 kg ha^{-1} (Anonymous, 2015b) [1].

The correlation between crop volumes and weather can result in successful yield or financial disaster. For more than decade weather risks management tools (including future contracts, reinsurance and weather derivatives) have been used to minimize the financial effects of such climatic fluctuations. Losses due to too much rain, too little rain and excessive heat or cold can be mitigated by using appropriate weather risk management tools for that need to fix weather indices for different crops.

Maize crop is primarily a warm weather crop and it is grown in a wide range of climatic conditions. Maize can successfully be grown in areas receiving an annual rainfall of 60 cm, which should be well distributed throughout its growing stage. It needs more than 50% of its total water requirements in about 30 to 35 days after tasseling and inadequate soil moisture at grain filling stage results in a poor yield and shriveled grains. It cannot withstand frost at any stage.

A prolonged cloudy period is harmful for the crop but an intermittent sunlight and cloud of rain is the most ideal for its growth. It needs bright sunny days for its accelerated photosynthetic activity and rapid growth of plants.

The seed yield of corn (*Zea mays* L.) consists of different proportional contributions of the effective factor in all growth stages from emergence to maturity. For a better

understanding of climatic and cultural effects on corn yield and grain quality, intensive research that evaluates different geographic locations, sowing dates and genotype selection are needed. In order to minimized negative effect of some abiotic and biotic stress on plant, sowing date can play a major role in determining the seed yield, quality, seed germination and understanding whole phenological stages in many regions. Some researchers pointed out that especially, the effect of sowing date and plant density on corn expressed that delay in sowing reduces the number of kernels in corn (Cantarero *et al*. (2000) [4]. Shumway *et al*. (1992) [16] explained that delay in sowing reduces quality performance and performance components of maize. Early and intermediate sowings tend to best utilize solar radiation for grain production (Otegui *et al*., 1995) [11].

Climate variability has a direct influence on the quantity and quality of maize production as water shortage combined with thermal stress adversely effect maize productivity. To deal with the impact of climate change, the potential adaption strategies are identifying stress resistant varieties, changing sowing dates; crop diversification, integrated farming system, etc. Optimum sowing date is important to mitigate climate change. Growing a suitable hybrid at an optimum sowing time may be better agronomic option under the water starved condition. There is a need to evaluate the different maturity hybrids of maize for their growth and yield under varying sowing dates (Pathak *et al*, 2011) [12].

Materials and methods

A field experiment was conducted to understand the crop weather relationships with different dates of sowing of maize hybrides during the *kharif* season of 2015-16 on the Experimental farm of All India Co-ordinated Research Project on Safflower, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. Agro climatically Parbhani is situated at latitude, longitude and altitude of 19^0 16' N, $76^0$47'E and 409 m above M.S.L (Mean Sea Level), respectively. The experiment was laid out in split plot design with 3 sowing dates as the main plot and 4 hybrids as subplot treatments and replicated thrice. The experiment comprised of 12 treatment combinations, consist of three sowing dates 29 June (26 MW), 6 July (27 MW), and 13 July (28 MW) and four different varieties *viz*. 900M Gold, Rajshri, NK6240 and DKC-9133. The line to line distance was kept as 60 cm with plant to plant of 20 cm with a seed rate of 20 kg ha^{-1}. The gross and net plot size were 6.0 x 5.0 m2 and 4.8 x 4.2 m^2 respectively.

Climatic conditions during the crop growth period (2015-16)

The meteorological data for the corresponding period of crop season recorded at Meteorological Observatory, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani is presented in Table 1.

Table 1: Weekly weather data recorded at agromet observatory, V.N.M.K.V., parbhani during *kharif* season of 2015.

MW	Period	Rainfall (mm)	RD	Temperature (^{0}C)		Humidity		EVP	BSS	WS
				T_{max}	T_{min}	RH-I	RH-II	(mm)	(hrs)	(km/hr)
25	18-24 June	37.5	2.0	31.6	23.5	86	64	4.5	2.5	5.8
26	25-01 July	0.0	0.0	35.1	24.3	75	43	7.3	7.5	6.6
27	02-08 July	5.0	1.0	35.8	23.8	76	38	8.1	9.4	9.4
28	09-15 July	0.0	0.0	36.2	25.8	69	37	6.0	9.4	9.4
29	16-22 July	0.6	0.0	35.8	24.8	76	45	5.5	8.9	8.9
30	23-29 July	8.0	1.0	34.0	24.0	75	47	4.9	8.5	8.5
31	30-05 Aug	19.8	1.0	33.0	23.1	80	59	6.0	8.4	8.4
32	06-12 Aug	28.8	4.0	29.9	23.0	87	68	2.4	5.5	5.5
33	13-19 Aug	23.4	2.0	31.3	23.0	85	57	4.1	5.7	5.7
34	20-26 Aug	11.2	1.0	32.9	23.0	81	49	9.5	6.0	6.0
35	27-02 Sept	0.0	0.0	32.2	23.3	79	50	7.0	6.3	6.3
36	03-09 Sep	88.1	4.0	32.9	22.2	87	60	7.0	4.8	4.8
37	10-16 Sep	38.4	4.0	31.8	22.7	90	63	6.2	3.6	3.9
38	17-23 Sep	57.4	1.0	31.4	22.0	81	59	4.1	5.9	4.7
39	24-30 Sep	0.0	0.0	33.5	20.9	74	44	6.7	7.5	3.6
40	01-07 Oct.	1.8	0.0	34.3	20.9	75	44	7.1	7.3	3.6
41	08-14 Oct.	0.0	0.0	35.1	19.4	73	32	7.8	9.0	2.2
42	15-21 Oct.	0.0	0.0	35.7	18.3	70	29	7.8	9.1	3.6
Total		320.0	21.0							
Mean				33.5	22.7	79	49	6.2	7.0	5.9

The perusal of data indicated that the average maximum and minimum temperatures during crop growing period were 33.5^0C and 22.9^0C, respectively. The average weekly minimum temperature was fluctuated during the season. The mean relative humidity (RH) of morning and evening hours were 79 and 49 per cent respectively. The mean sunshine hours per day was 7.0 hrs day^{-1}. The mean wind velocity was 5.9 km h^{-1}.

The total precipitation received during crop growth period was 320.0 mm with 21 rainy days. The highest evaporation (9.5 mm) and lowest evaporation (2.4 mm) recorded during the crop growing season was in MW-34 and MW-32 respectively. This climate favors for normal growth of crop and may increase its water requirement.

Plant protection measurements

The dose of the NPK for maize was worked out according to the present recommendation of Maize Hybrids on state level. The 100% NPK dose in kg ha^{-1} worked out was 150:75:75 for maize crop. For each treatment applied in form of urea, SSP and MOP. A basal dose of fertilizers (50% N and 100% P and K) were applied at the time of sowing and the remaining 50% of N was applied in two splits at 30 and 60 days after sowing. The pre-emergent

herbicide (Atrazine) was sprayed on the day of sowing to all the plots at the rate of 1.5 kg a.i.ha^{-1}. The plots were weeded manually twice at 30 and 50 days after sowing. To protect the crop from stem borer pest infestation one spraying of Chloropyriphos 25EC with a concentration of 0.01% was undertaken at 30 DAS. Irrigation was applied at critical growth stages.

Data collection and statistical analysis

Growth observations are recorded after 30 DAS at 15-day intervals and yield parameters like plant height, Number of nods, cob length, Number of functional leaves, grains per cob, grain yield per cob, Leaf area plant, No. of cobs plant[1] and test weight were recorded at harvest. The data on rainfall, rainy days, temperature, relative humidity, sunshine hours and evaporation were obtained from the agro-meteorological observatory located in the study area. The correlation coefficient was worked out between prevailed weather parameters at and different phenophases with grain yield of maize.

Results and discussions

Plant growth is a complex phenomenon, which involves both qualitative and quantitative characteristics, depending upon different weather conditions prevailed during different phenological growth stages. Considering this weather prevailed during crop growth period was recorded and tried to work out the correlation in between maize hybrids and weather parameters and also developed correlation equations.

Weather parameters during crop growth period as per date of sowing

The data on Phenophase wise weather parameters among the different treatments are presented in Table from 2 to 4.

The weather conditions prevailed during the crop growing season i.e. *kharif* 2015-2016 are presented graphically to different meteorological elements *viz*; rainfall and rainy days, air temperature, relative humidity, evaporation, bright sunshine hours and wind velocity, at Parbhani, during the crop growing season (June to October) and its impact on growth, development and yield of maize.

Rainfall (mm) and rainy days

The data on phenophase wise weather parameters among the different treatments are presented in Table 2.

The data of rainfall is given in Table 1 and it revealed that total rainfall during crop growth period (25 MW to 42 MW) received was 320.00 mm in 21 rainy days.

Among all the treatments of sowing dates total rainfall received during whole crop growth period for first date of sowing i.e. D_1 (26 MW) received highest rainfall i.e. 283.1 mm in 19 rainy days followed by second sowing D_2 (27 MW) i.e. 277.5 mm in 18 rainy days, and third sowing D_3 (28 MW) i.e. 277.5 mm in 18 rainy days.

In the month of June, rainfall received was 125.6 mm in 7 rainy days, which was useful to the initial crop growth stage. Highest rainfall received in the month of September i.e. 183.9 mm in 9 rainy days and lowest rainfall was received in the month of July i.e. 13.6 mm in 2 rainy days. Withdrawal of monsoon was experienced from 39 MW and thereafter, no single rainy day was recorded up to harvesting of crops.

The highest rainfall and rainy days recorded in D_1 (26 MW) i.e. 283.1 mm in 19 rainy days. The lowest rainfall and rainy days recorded in D_3 (28 MW) i.e. 277.5 mm in 18 rainy days.

The nature and distribution of rainfall during the cropping period seems to be much more important than the total quantity of rainfall with reference to the performance and yield of maize. The performance D_1 (26 MW) in yield was significantly superior to the rest of the treatments. It might be due to well nature and distribution of rainfall during the crop period.

During P_5 stage (silking to milk) rainfall and temperature (maximum and minimum) play an important role in milk stage initiation. In D_1 (26 MW) rainfall received 190.4 mm. was more as compared to D_2 (27 MW) (183.9 mm.) and D_3 (28 MW) (147.3 mm) whereas in D_2 (27 MW) low rainfall received during P_4 and D_3 (28 MW) in P_3 stage it affected silking stage in D_1 (26 MW).

There was a dry spell occurred during crop growth period at some of the crop growth stages and in all the sowing dates except there was no rainfall received (39 MW and 42 MW) at the physiological maturity of maize crop sown in D_2 and D_3.

Similar results were given by Soleymani *et al*. (2011) [17].

Air temperature

Weekly weather data given in Table 1 and revealed that the temperature prevailed during different phenological stages and it reported that, maximum and minimum temperature during crop growing period was ranged in between 29.9^{0}C to 36.2^{0}C and 18.3^{0}C to 25.8^{0}C respectively. While seasonal mean of maximum and minimum temperature was recorded 33.58^{0}C and 22.62^{0}C respectively.

The highest maximum temperature recorded in 28 MW was 36.2^{0}C. The maximum temperature ranged from 29.9^{0}C to 36.2^{0}C during crop growing season of D_1 and D_2 while, in D_3 it was ranged in between 29.9^{0}C to 35.8^{0}C and the average maximum temperature was recorded 33.4^{0}C, 33.4^{0}C and 33.8^{0}C in D_1, D_2, and D_3 respectively, which shows that there was not much variation in the range of maximum temperature.

The lowest minimum temperature was recorded at 42 MW (18.3^{0}C) and highest minimum temperature recorded at 28 MW (25.8^{0}C) during the crop growth period. There was not observed much variation in the range of minimum temperature observed in all the treatments and it was recorded 23.1^{0}C, 22.9^{0}C and 22.4^{0}C in D_1, D_2 and D_3 respectively.

Similar results were given by Bannayan *et al*. (2004) [3], Danaie (2007) [6] ans Soleymani *et al*. (2011) [17].

Relative humidity

Weekly weather data given in Table 1 and Its shows that mean relative humidity of morning (RH-I) and afternoon (RH-II) hours during the crop growing period (June to October) was 79 percent and 49 percent, respectively.

Highest morning relative humidity (RH-I) was recorded in 37 MW (90 percent) and lowest in 28 MW (69 percent).

Data from Table 2.0 to 4.0 revealed that the mean morning relative humidity (RH-I) in D_1, D_2 and D_3 was recorded 80, 78.2 and 78.4 percent respectively. It means that there is not much variation in the range of morning relative humidity during crop growing season in all the sowing dates.

Highest afternoon relative humidity (RH-II) was recorded at 32 MW (68 %) and lowest at 42 MW (29 %).

Data from Table 4.2 to 4.4 revealed that the mean afternoon relative humidity (RH-II) in D_1, D_2 and D_3 was recorded 49.0, 48.2 and 49.6 percent respectively. It means that there is not more variation in the range of afternoon relative humidity during crop growing season in all the sowing dates.

Evaporation

Data given in Table 1 and showed that the mean evaporation during crop growing season (from 25 MW to 42 MW) observed was 6.2 mm per day. It is observed lowest and highest EVP 2.4 mm (32 MW) and 9.5 mm (34 MW) respectively.

The highest values of evaporation were recorded due to maximum temperature and very less quantum of rainfall during this week while, evaporation was recorded lowest in 32 MW (2.4 mm) because of continuous rainfall and lowest temperature during this period.

Data from Table 2.0 to 4.0 revealed that the mean evaporation during whole crop growth stage in D_1, D_2 and D_3 was recorded 6.5 mm, 7.0 mm and 7.0 mm respectively. It means that there is not much variation in the range of evaporation during crop growing season in all the sowing dates.

Bright sunshine hours

Data given in Table 1 and revealed that the mean BSS during crop growing period (from 25 MW to 42 MW) were 7.0 hrs day^{-1}. It was observed that the highest value of bright sunshine hours 9.4 hrs day^{-1} were recorded in 27 MW and 28 MW while, lowest BSS 3.6 hrs day^{-1} in 37 MW.

From Table 2.0 to 4.0 data revealed that the mean BSS during the whole crop growth stage in D_1, D_2 and D_3 was recorded 6.7, 6.9 and 7.0 hours respectively. It shows that highest BSS was recorded in D_3 (7.0 hrs) and D_2 (6.9 hrs) and recorded lowest in D_1 (6.7 hrs) sowing.

Wind velocity

The data on weekly mean wind velocity during crop growing season of maize crop is presented in Table 1 and data revealed that, the mean wind velocity during crop growing period (from 25 MW to 42 MW) was recorded 5.9 kmhr^{-1}. It was observed that highest wind velocity 9.4 kmhr^{-1} was recorded in 27 MW and 28 MW, while lowest wind velocity 2.2 kmhr^{-1} was recorded in 41 MW. Lower wind velocity seems to be helpful for decrease in ET.

Data from Table 2.0 to 4.0 revealed that the mean wind speed during whole crop growth stage in D_1, D_2 and D_3 was recorded 6.1, 6.2 and 5.5 kmhr^{-1} respectively. It shows that highest wind speed was recorded in D_2 (6.2kmhr^{-1}) and D_1 (6.1 kmhr^{-1}) and lowest wind speed was recorded in D_3 (5.5 kmhr^{-1}) sowing date.

Table 2: Phenophase wise weather parameters in Maize D_1 (26 MW) sowing date

Weather parameters	Phenophases in D_1							
	P_1	**P_2**	**P_3**	**P_4**	**P_5**	**P_6**	**Total**	**Mean**
Rainfall (mm)	5.0	60.9	21.6	3.7	190.4	1.5	283.1	-
Rainy days	1	6.325	1.825	0.3	9.55	0.0	19.0	-
T_{MAX} (^{0}C)	35.5	33.5	33.0	32.5	32.1	33.6	-	33.4
T_{MIN} (^{0}C)	24.2	24.1	23.0	23.1	22.6	21.4	-	23.1
T_{MEAN} (^{0}C)	29.8	28.8	28.0	27.8	27.3	27.5	-	28.2
R.H I (%)	75	78	86	80	85	75.0	-	80
R.H II (%)	38	51	54	49	58	45.6	-	49
R.H Mean (%)	56.8	64.5	70.1	64.1	71.4	60.3	-	64.5
Evp. (mm)	8.2	7.9	5.2	5.9	5.3	6.6	-	6.5
B.S.S. (hrs day^{-1})	7.8	4.9	5.8	7.7	6.5	7.4	-	6.7
W.V. (kmh^{-1})	8.4	8.0	5.2	6.1	5.2	3.4	-	6.1

P_1: Sowing to seedling/sprouting **P_2:** Seedling/sprouting to grand growth **P_3:** Grand growth to tasseling
P_4: Tasseling to silking **P_5:** Silking to milk **P_6:** Milk to physiological maturity

Table 3: Phenophase wise weather parameters in Maize D_2 (27 MW) sowing date

Weather parameters	Phenophases in D_2							
	P_1	**P_2**	**P_3**	**P_4**	**P_5**	**P_6**	**Total**	**Mean**
Rainfall (mm)	0.0	82.5	9.3	0.0	183.9	1.8	277.5	-
Rainy days	0.0	8.2	0.8	0.0	9.0	0.0	18.0	-
T_{MAX} (^{0}C)	36.1	32.8	32.9	31.8	32.2	34.7	-	33.4
T_{MIN} (^{0}C)	25.2	23.6	22.7	23.3	22.3	20.3	-	22.9
T_{MEAN} (^{0}C)	30.7	28.2	27.8	27.6	27.3	27.5	-	28.2
R.H I (%)	70.6	80.4	79.7	80.4	83.1	74.7	-	78.2
R.H II (%)	36.9	54.5	53.3	48.5	57.3	38.9	-	48.2
R.H Mean (%)	53.8	67.5	66.5	64.5	70.2	56.8	-	63.2
Evp. (mm)	11.3	6.7	5.5	5.6	5.4	7.4	-	7.0
B.S.S. (hrs day^{-1})	7.0	4.9	8.9	5.8	6.4	8.2	-	6.9
W.V. (kmh^{-1})	9.8	7.2	6.2	6.5	4.5	3.3	-	6.2

P_1: Sowing to seedling/sprouting **P_2:** Seedling/sprouting to grand growth **P_3:** Grand growth to tasseling
P_4: Tasseling to silking **P_5:** Silking to milk **P_6:** Milk to physiological maturity

Table 4: Phenophase wise weather parameters in Maize D_3 (28 MW) sowing date.

Weather parameters	Phenophases in D_3							
	P_1	P_2	P_3	P_4	P_5	P_6	Total	Mean
Rainfall (mm)	0.6	91.2	9.3	28.8	147.3	0.3	277.5	-
Rainy days	0.0	9.0	1.0	1.6	6.3	0.0	17.9	-
T_{MAX} (^{0}C)	36.0	32.1	33.6	33.0	32.5	35.3	-	33.8
T_{MIN} (^{0}C)	25.3	23.2	23.1	22.0	21.9	18.9	-	22.4
T_{MEAN} (^{0}C)	30.7	27.6	28.4	27.5	27.2	27.1	-	28.1
R.H I (%)	73.4	81.6	77.5	84.4	81.5	71.8	-	78.4
R.H II (%)	43.2	55.7	47.0	66.1	54.3	31.2	-	49.6
R.H Mean (%)	58.3	68.6	62.3	75.3	67.9	51.5	-	64.0
Evp. (mm)	9.9	5.8	7.6	5.6	5.5	7.7	-	7.0
B.S.S. (hrs day^{-1})	5.9	5.3	9.0	6.5	6.4	9.1	-	7.0
W.V. (kmh^{-1})	8.3	6.7	6.9	3.9	4.0	3.0	-	5.5

P_1: Sowing to seedling/sprouting **P_2:** Seedling/sprouting to grand growth **P_3:** Grand growth to tasseling
P_4: Tasseling to silking **P_5:** Silking to milk **P_6:** Milk to physiological maturity

Correlation studies

Correlation between weather parameter and different growth stages of *kharif* maize with grain yield

The correlation studies were undertaken to assess the impact of different variables prevailed during the crop life for the various phenological stages which were important in utilizing the weather resources for the synthesis of yield are considered. The phases studied are sowing to seedling/sprouting (P_1), seedling/sprouting to knee height/grand growth (P_2), knee height/grand growth to tasseling/flower initiation (P_3), tasseling/flower initiation to silking (P_4), silking to milk/soft dough (P_5), and milk/soft dough to physiological maturity/hard dough (P_6). The correlation coefficient between grain yield and weather variables prevailed in different phenophases of mazie are presented in Table 5.

The correlation study was carried out between weather variables prevailed during P_1 to P_6 growth stages of different hybrids under different sowing dates. The correlation coefficient showing degree of association between grain yield and weather variables prevailed during various phenophases of maize are presented in Table 5.

The data on correlation between weather parameter and growth stages of maize with seed yield indicated that the rainfall was significantly positively correlated with P_1 (0.446), P_3 (0.455), P_5 (0.702), P_6 (0.418) stage. However it was significantly negatively correlated with P_2 (-0.629) and P_4 (-0.482) stage.

The correlation between rainy days and different phenophases of maize showed that rainy days are significantly positively correlated with P_1 (0.482), P_3 (0.390) and P_5 (0.656). However, it was negatively correlated at P_2 (0.635) and P_4 (-0.401) stage.

Maximum temperature (Tmax) showed significantly positive correlation at P_2 (0.600) stage. While, it was negatively significantly correlated at P_1 (-0.357), P_3 (-0.303), P_4 (-0.085), P_5 (-0.655) and P_6 (-0.612) stages.

Minimum temperature (Tmin) showed significantly positive correlation at P_2 (0.611), P_4 (0.473), P_5 (0.645) and P_6 (0.603) stage. While, it was negatively significantly correlated at P_1 (-0.500) and P_3 (-0.066) stage.

Morning relative humidity (RH-I) showed significantly positive correlation at P_1 (0.240), P_3 (0.543), P_5 (0.647) and P_6 (0.475) stage. While, it was significantly negatively correlated at P_2 (-0.605) and P_4 (-0.406) stage.

Afternoon relative humidity (RH-II) showed significantly positive correlation at P_3 (0.328), P_5 (0.579) and P_6 (0.611) stage. While, it was showed significantly negatively correlation at P_1 (-0.439), P_2 (-0.590) and P_4 (-0.397) stage.

Evaporation showed significantly positive correlation at P_2 (0.604) and P_4 (0.289) stage While, it was significantly negatively correlated at P_1 (-0.299), P_3 (-0.530), P_5 (-0.547) and P_6 (-0.619) stage.

Bright sunshine hours (BSS) showed highly significant positive correlation at P_1 (0.596), P_4 (0.245) and P_5 (0.414) stage. It was negatively significantly correlated at P_2 (-0.529), P_3 (-0.517) and P_6 (-0.597) stage.

Wind speed (W.S.) showed significantly positively correlation at P_1 (0.38), P_2 (0.614), P_4 (0.414), P_5 (0.668) and P_6 (0.548) stage. While, it was significantly negatively correlated at P_3 (-0.523) stage.

Table 5: Correlations between weather parameter and different growth stages of maize with grain yield

Weather Parameters	Phenophases of Maize					
	P_1	P_2	P_3	P_4	P_5	P_6
Rainfall (mm)	0.446	-0.629*	0.455	-0.482	0.702*	0.418
Rainy days	0.482	-0.635*	0.390	-0.401	0.656*	-
T_{MAX} (^{0}C)	-0.357	0.600*	-0.303	-0.085	-0.655*	-0.612*
T_{MIN} (^{0}C)	-0.500	0.611*	-0.066	0.473	0.645*	0.603*
T_{MEAN} (^{0}C)	-0.455	0.605*	-0.234	0.590*	0.583*	0.510
R. H. I (%)	0.240	-0.605*	0.543	-0.406	0.647*	0.475
R. H. II (%)	-0.439	-0.590*	0.328	-0.397	0.579*	0.611*
R. H. Mean (%)	-0.196	-0.598*	0.469	-0.413	0.615*	0.593*
Evp (mm)	-0.299	0.604*	-0.530	0.289	-0.547	-0.619*
B.S.S. (hrs day^{-1})	0.596*	-0.529	-0.517	0.245	0.414	-0.597*
W. V. (km h^{-1})	0.038	0.614*	-0.523	0.414	0.668*	0.548

(* Significant at 5%, ** Significant at 1%)

P_1: Sowing to seedling/sprouting **P_2:** Seedling/sprouting to grand growth **P_3:** Grand growth to tasseling
P_4: Tasseling to silking **P_5:** Silking to milk **P_6:** Milk to physiological maturity

Result

The data on mean seed yield indicated that the crop sown in first sowing date i.e. D_1 (26 MW) recorded significantly highest grain yield (4817.5 kg ha^{-1}) than third sowing date i.e. D_3 (28 MW) and was at par with D_2 (27 MW). Further, D_2 (27 MW) and D_3 (28 MW) produced significantly at par grain yield. An assessment of data indicates that the highest grain yield (4817.5 kg ha-1) was obtained under first sowing date D_1 (26 MW) which was significantly superior over third sowing date i.e. D_3 (28 MW). Grain yield was reduced due to delay in sowing beyond 26 MW. Reduction in the crop yield might be due to adverse effects of weather parameters particularly rainfall, temperature and relative humidity on the growth and development of the crop. Generally, environmental variable may over ride genetic influences and as such variations in meteorological parameters at different date of sowing exert their influence on the plant growth and ultimately yield. The early attainment of flowering under delayed sowing i.e. D_2 (27 MW) and D_3 (28 MW) brought about significant reduction in biomass production and shorter period for development of yield attributes. It was observed that maize planted earlier develops better and has a higher yield potential because the vegetative period of its development occurs in the cooler part of the season when moisture stress is less likely. Rainfall during grand growth and tasseling stages has a positive influence on the grain yield of kharif maize. Weather parameter i.e. rainfall and rainy days were found significantly positively correlated at silking to milk phenophases except seedling to grand growth the phenophases. Maximum temperature was found significantly positively correlated at seedling to grand growth phenophases and minimum temperature was found significantly positively correlated at seedling to grand growth, silking to milk and milk to physiological maturity phenophases. Whereas, morning relative humidity was found significantly positively correlated at silking to milk phenophases and afternoon relative humidity found significantly positively correlated at silking to milk and milk to physiological maturity phenophases. Evaporation was found significantly positively correlated at seedling to grand growth phenophases. Bright sunshine hour was found significantly positively correlated at sowing to seedling phenophases. These results were in conformity with the results of Prodhan (2001) [13], Rahman *et al*. (2001) [14], Awasthi *et al*. (2009) [2], Murthy (2012) [10] and Sulochana *et al*. (2015) [18]. The data revealed that significantly highest grain yield per ha^{-1} was observed in hybrid V_1 (900M Gold) 4849.5 kg ha^{-1} than V_4 (DKC-9133) and V_2 (Rajshri) and was at par with V_3 (NK-6240). The hybrid V_2 (Rajshri) produced significantly lowest grain yield than all other hybrids. The hybrids V_3 (NK-6240) and V_4 (DKC-9133) were also at par with each other in respect of grain yield. It seems that a major portion of the photosynthetic of different hybrids was diverted toward economic yield i.e. grain. The results are in close accordance with finding of Rahman *et al*. (2001) [14], Khan *et al*. (2009) [9], Jadhav *et al*. (2015) [8] and Sulochana *et al*. (2015) [18].

Conclusion

On the basis of observations tabulation and analysis of data it was observed that sowing of maize in 26 MW and 27 MW recorded significantly highest grain and biological yield. Among the four hybrids, V_1 (900 M Gold) and V_3 (NK-6240) produced significantly highest grain yield as compare to other hybrids. It was observed that duration of each phenophases from sowing to maturity was shown as follows, sowing to seedling (P_1), seedling to grand growth (P_2), grand growth to tasseling (P_3), tasseling to silking (P_4), silking to milk (P_5), and milk to physiological maturity (P_6). First date of sowing had more duration (99 days) as compared to delayed sowing. In cultivars, V_1 (900M Gold) had more duration (98 days) as compared to all other cultivars. This shortening of duration was due to thermal stress at later sowing dates.

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