Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.4016

ISSN: 2320 – 7051

Int. J. Pure App. Biosci. **5 (4):** 980-993 (2017)

Research Article

International Journal of Pure & Applied Bioscience

OPEN ACCESS

Simulating Date of Sowing in Maize (*Zea mays* L.) Under Irrigated Conditions Using CERES-Maize Model

Gurdeep Singh, B. A. Lone*, Zahoor Ahmad Dar, Purshotam Singh, Asma Fayaz, Sandeep Kumar, Sameera Qayoom and K. N. Singh

Division of Agronomy, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir (SKUAST), Kashmir, India

*Corresponding Author E-mail: alonebilal127@gmail.com

Received: 11.06.2017 | Revised: 20.06.2017 | Accepted: 22.06.2017

ABSTRACT

Field experiments was conducted at Shalimar Campus of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir during 2012 and 2013 under irrigated conditions with the objective to study the growth and yield of maize at different planting dates and planting density and to simulate trends of maize production. Experiment was laid in split-plot design assigning four planting dates 15th April (D_1), 30th April (D_2), 15th May (D_3) and 30th May (D_4) to main plots and three planting density 50cm×20cm (S_1), 60cm×20cm (S_2) and 70cm×20cm (S_3) to sub-plots. Genetic coefficients of maize variety C_6 were verified/generated for calibration and validation of model CERES-Maize (DSSAT v 4.5). The planting date 15th April (D_1) produced highest yield of 50.60 and 53.81 q ha^{-1} under irrigated conditions during 2012 and 2013, respectively. Growth characters like LAI, dry matter and yield attributes like cob length, grains per cob, harvest index and nutrient uptake was recorded highest with planting date 15th April (D_1) which had longer vegetative phase than late planting dates. Among planting density 60cm×20cm (S_2) recorded highest grain yield of 42.32 and 44.72 q ha^{-1} under irrigated conditions during 2012 and 2013, respectively. Growth and yield attributing characters also recorded highest value with planting density 60cm×20cm (S_2). The simulation studies on growth and yield due to varied growth parameters under irrigated conditions were carried out by using soil and experimental data. The CERES-Maize simulation model was calibrated using field data and validated with anthesis, maturity, grain, biological yield and LAI.

Simulated studies indicated that early sowing i.e 15th April (D_1) predicted highest grain yield during all the years from 1986-2013. Under irrigated conditions increasing levels of N predicted increased grain and stover yield from N levels up to 90 kg N ha^{-1}. Under irrigated and mulched conditions increased level of N predicted increase in maize grain and stover yield upto 120 kg N ha^{-1}. Maize yield was also simulated at different sowing dates and in combination with variable spacings and it was predicted that under irrigated condition closer spacing 40cm×20cm at 15th April sowing recorded highest grain and stover yield of maize. Soil water balance under simulation studies indicated that potential ET was recorded comparatively higher with early sowing date than late sowing date under irrigated conditions. Similar trend was recorded with respect to transpiration under conditions. Simulated soil evaporation was more in wider spacing than closer spacing. Similar trend was recorded with regard to simulated run-off. Predicted nitrate content (final) of irrigated soil decreased. It is concluded that DSSAT v 4.5CERES-Maize model is very robust in predicting the growth and yield of maize as influenced by agrotechniques and could be used in wider perspective.

Key words: *Standard meteorological week, days after sowing, planting dates, planting density, simulation, yield attributes, yield.*

Cite this article: Singh, G., Lone, B.A., Dar, Z.A., Singh, P., Fayaz, A., Kumar, S., Qayoom, S. and Singh, K.N., Simulating Date of Sowing in Maize (*Zea mays* L.) Under Irrigated Conditions Using CERES-Maize Model, *Int. J. Pure App. Biosci.* **5(4):** 980-993 (2017). doi: http://dx.doi.org/10.18782/2320-7051.4016

INTRODUCTION

Maize (*Zea mays* L.) is emerging as an important cereal crop in the world after wheat and rice. It is now an important ingredient in food, feed, fodder and large number of industrial products. It has acquired dominant role in the farming sector and macro-economy of the Asian region. It has the highest potential of per day carbohydrate productivity. Thus, it is not without any basis that father of green revolution, the renowned Noble Laureate, Dr. Norman E. Borlaug, believes that "After the last two decades saw the revolution in rice and wheat, the next few decades will be known as maize era"

Maize is widely cultivated throughout the world, and produced each year greater than any other grain. The United States produces 40% of the world's harvest; other top producing countries include China, Brazil, Mexico, Indonesia, India, France and Argentina. The maize is cultivated on an area of 161.82 million ha in world with production of 844.36 million tonnes[2] (FAO, 2010). Maize known as the "Queen of Cereals" is the third most important cereal crop in India after rice and wheat and is cultivated on 8.17 million ha with the production of 19.73 million tonnes and productivity of 4.21 tonnes ha^{-1}[1]. Among the major crops of Jammu and Kashmir in terms of acreage maize is grown in area of 315.81 thousand hectares with the production of 0.63 million tonnes and productivity of 2.0 tonnes ha^{-1}.

The DSSAT v 4.5 CERES-Maize Crop Simulation Model which was tested over a wide range of environments[4,15] has been used in present investigation. Keeping in view to develop agro-techniques for maize the present investigation entitled "Optimization of Agro-techniques to maximize productivity of Maize *(Zea mays* L.) under irrigated conditions using CERES-Maize Model''.

MATERIALS AND METHODS

A field experiment entitled "Optimization of Agro-techniques to maximize productivity of Maize (*Zea mays* L) under irrigated and un-irrigated conditions using CERES-Maize Model" was conducted at the experimental farm of the Division of Agronomy, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir that lies between 34.08 ^{o} N latitude and 74.83 ^{o} E longitude at an altitude of 1587 meters above the mean sea level.

The climate is temperate type characterized by hot summers and severe winters. The average annual precipitation over past twenty-five years is 786 mm (Division of Agronomy, SKUAST-Kashmir) and more than 80 % of precipitation is received from western disturbances during winter/spring months. During crop growth period (15th April - 4th October) the maximum temperature ranged between 18^{0}C to 32^{0}C, while minimum temperature ranged between 4.30 ^{0}C to 17.78 ^{0}C with relative humidity 49-89% (maximum) and minimum being between 23% to 86%. (Fig 1). The soil was silty clay loam, neutral in reaction and medium in available nitrogen, phosphorus and potassium. The experiment included four dates of sowing with three levels of spacing was laid out in a Split Plot Design with three replications. Certified seed of maize variety "C_6" was used in the experiment. Urea, Diammonium phosphate (DAP), Muriate of potash (MOP) and zinc sulphate were used as source of nitrogen, phosphorus, potassium, and zinc respectively. A fertilizer dose of 10 ton FYM ha^{-1}, 120 kg N ha^{-1}, 60 kg P_2O_5 ha^{-1}, 30 kg K_2O ha^{-1}, 20 kg $ZnSO_4$ ha^{-1} was applied.

Furrow method of irrigations was followed. Irrigation was applied at IW/CPE ratio 0.75 in Experiment-I. In IW: CPE approach, cumulative pan evaporation values from standard USWB class 'A' pan evaporimeter were used for scheduling of irrigation. A common depth of irrigation was maintained at 6 cm uniformly[5,14].

To know the role of simulation model in agronomic research, the Decision Support System for Agro-technology Transfer (DSSAT) v 4.5 CERES-Maize model was used. All its functions are fully supported in Windows 95, Windows 98, Windows NT and OS/2 operating systems[15]. This model was used to simulate the growth, development and yield of maize as influenced by planting dates and plant density for the experiments conducted during the cropping seasons of 2012 and 2013.

For simulation of CERES-Maize model, minimum data sets (MDS) on crop management, macro and micro-environmental parameters associated with weather, soil and crop are required as input. Input data files of CERES-Maize model are as per IBSNAT standard input/output formats and file structure described in DSSAT v 3[4]. Daily weather data required are total solar radiation (MJ m^{-2} day^{-1}) minimum and maximum air temperature (^{0}C) and rainfall (mm). These daily weather data including site specific information, other optional weather variables were collected and used for creating weather file (WTH) and running CERES- Maize model. The soil file already developed at Shalimar for DSSAT was used for running model.

Observed weather data of Shalimar main campus of University for growing seasons 2012 and 2013 was used for calibrating the coefficients of maize cultivar. The coefficients for cultivar were estimated from field experiment by adjusting coefficients until close match were achieved between simulated and observed phenology and yield (Table 1). Model was run repeatedly till simulated yield was close with observed yield. The available data included planting date, germination date, emergence date, anthesis date, maturity date, maximum LAI, grain yield and stover yield.

Table 1: Genetic coefficients of maize cultivar

Cultivar	**Parameters**					
	P-1	**P-2**	**P-5**	**G-2**	**G-3**	**PHINT**
C6	230	0.0	450	600	9.9	6.6

P-1: Thermal time from seedling emergence to the end of the juvenile phase (expressed in growing degree days above a base temperature of 8 ^{0}C) during which plant is not responsive to changes in photoperiod.

P-2: Extent to which development (expressed as days) is delayed for each hour increase in photoperiod at which development proceeds at a maximum rate (which is considered to be 12.5 hours).

P-5: Thermal time from silking to physiological maturity (expressed in degree days above a base temperature of 8 ^{0}C).

G-2: Maximum possible number of kernels $plant^{-1}$.

G-3: Kernel filling rate during the linear grain filling stage under optimum condition (mg day^{-1}).

PHINT: Phylochron interval; the interval in thermal time (degree days) between successive leaf tip appearances.

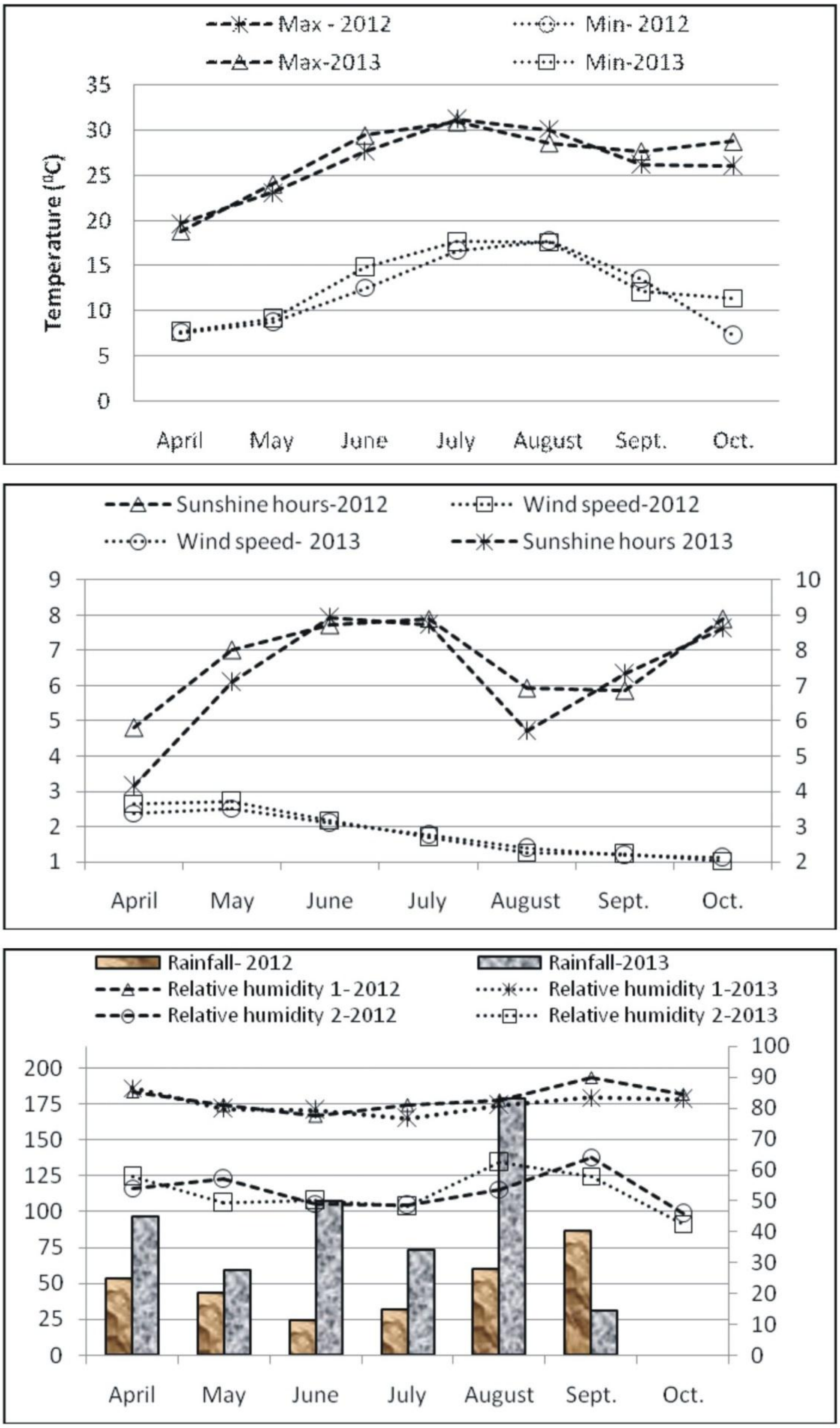
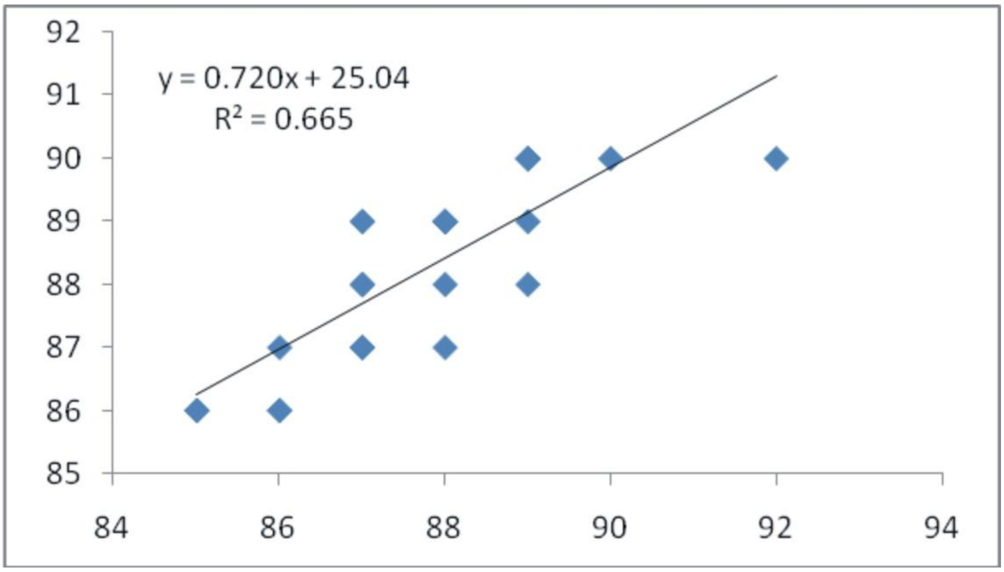


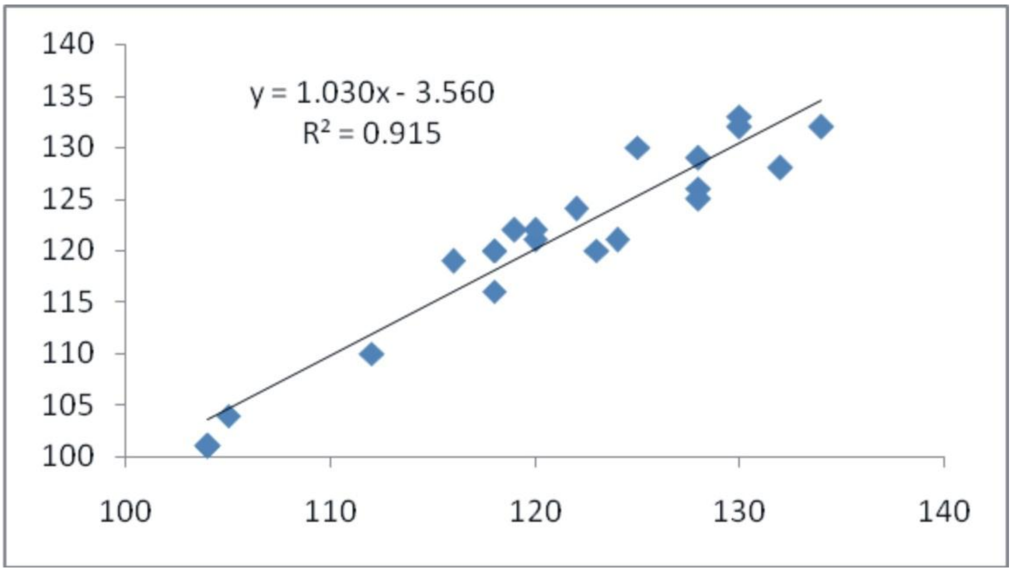
Fig. 1: Temporal change in weather parameters during field experimentation

To assess the accuracy of the model simulation compared with the observations, data generated from four planting dates 15th April (D_1), 30th April (D_2), 15th May (D_3) and 30th May (D_4) and planting density 50cm×20cm (S_1), 60cm×20cm (S_2) and 70cm×20cm (S_3) over two years (2012 and 2013) was used for validating the performance of CERES-Maize model. Prediction capabilities of the model were tested by judging the performance of the crop in terms of maximum LAI, phenology, days taken to a thesis and maturity, grain yield and biological yield.

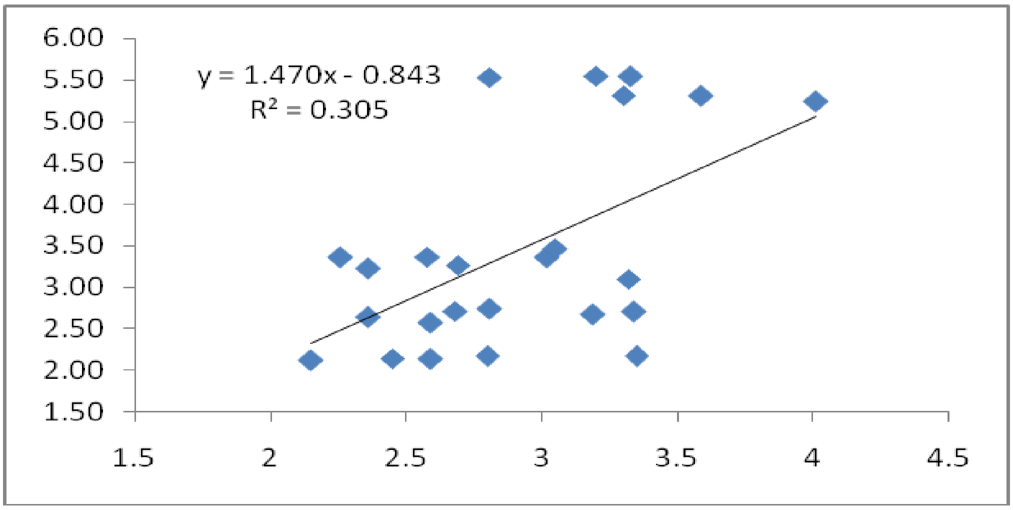
After calibration of model using 1st year data of four dates of sowing and verification of genetic coefficients the model CERES – Maize was validated for four planting dates; 15th April (D_1), 30th April (D_2), 15th May (D_3) and 30th May (D_4) and three planting density; 50cm×20cm (S_1), 60cm×20cm (S_2) and 70cm×20cm (S_3) during 2012 and 2013. Validation results were in terms of phenology (days to anthesis and maturity), maximum LAI, grain yield and biological yield.



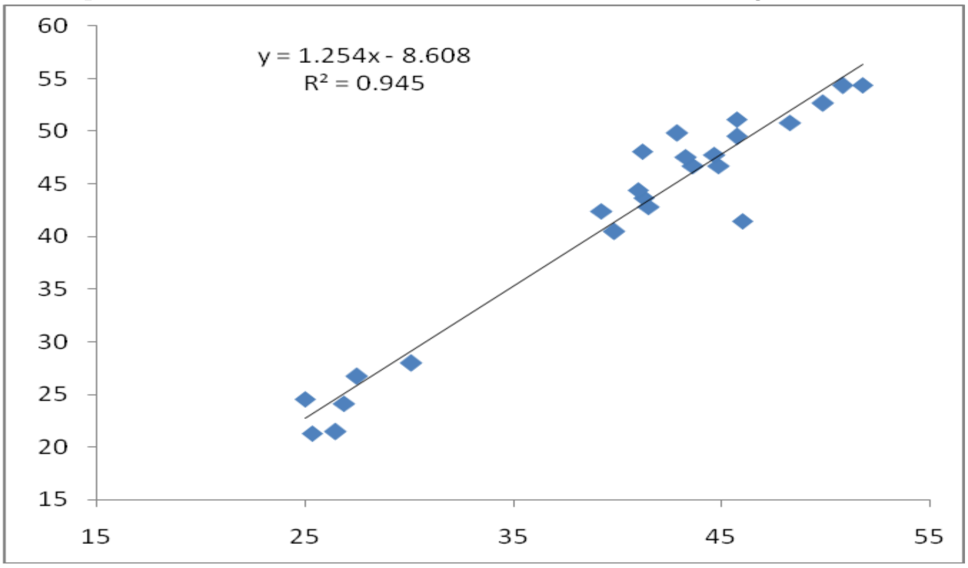
Comparison of simulated and observed days to anthesis of maize under irrigated conditions



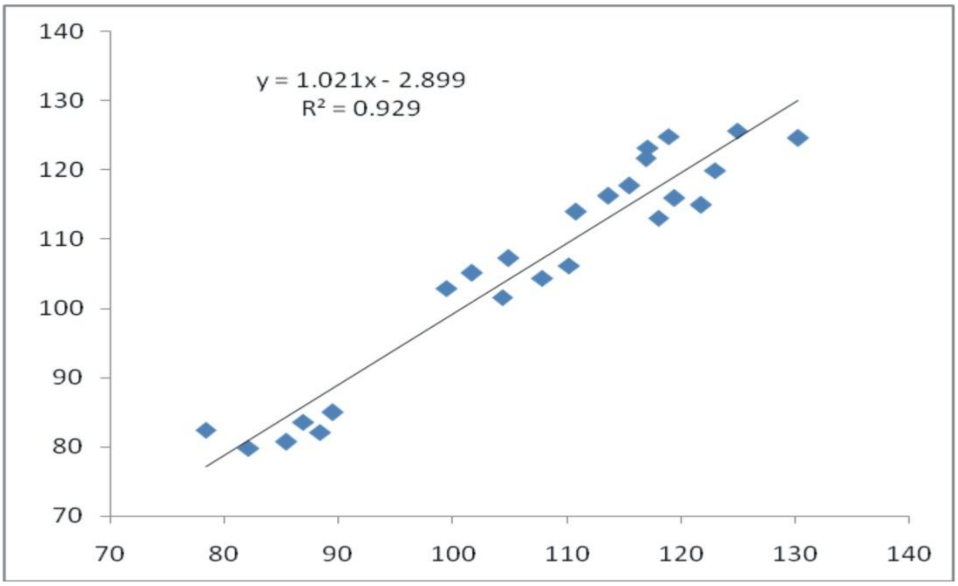
Comparison of simulated and observed days to maturity of maize under



Comparison of simulated and observed LAI of maize under irrigated conditions



Comparison of Simulated And Observed Grain Yield Of Maize Under Irrigated Conditions (Q Ha^{-1})



Comparison of simulated and observed observed biological yield of maize under irrigated conditions (q ha^{-1})

Table 2: Validation results of maize for grain yield and biological yield under different planting dates and planting density under irrigated conditions

Treatments	Grain yield(q ha^{-1})								Biological yield (q ha^{-1})							
	2012				2013				2012				2013			
	Sim	Obs	Deviation	% deviation	Sim	Obs	Deviation	% deviation	Sim	Obs	Deviation	% deviation	Sim	Obs	Deviation	% deviation
D1S1	45.73	51.15	-5.42	10.59	49.89	52.69	-2.80	5.31	123.0	119.9	3.02	2.51	130.3	124.6	5.63	4.53
D1S2	48.28	50.83	-2.55	5.00	50.08	54.35	-3.55	6.52	117.10	123.2	-6.14	-4.98	124.9	125.7	-0.80	-0.63
D1S3	42.88	49.84	-6.96	13.96	51.77	54.39	-2.62	4.82	116.79	121.7	-4.84	-3.97	118.9	124.8	-5.92	-4.74
D2S1	43.62	46.72	-3.10	6.64	44.66	47.80	-3.14	6.57	118.03	113.1	4.89	4.32	119.4	115.9	3.55	-3.05
D2S2	41.18	48.09	-6.91	14.36	45.73	49.51	-3.78	7.62	121.80	115.0	6.78	5.89	115.5	117.8	-2.31	-1.96
D2S3	44.87	46.74	-1.87	4.01	43.28	47.59	-4.31	9.05	110.80	114.0	-3.23	-2.82	113.6	116.2	-2.58	-2.22
D3S1	46.00	41.47	4.53	-10.93	41.48	42.84	-1.36	3.16	104.37	101.6	2.71	2.66	101.7	105.1	-3.49	-3.31
D3S2	41.25	43.69	-2.44	5.58	40.99	44.42	-3.43	7.71	107.86	104.4	3.42	3.27	104.9	107.2	-2.36	-2.20
D3S3	39.85	40.48	-0.63	1.56	39.24	42.43	-3.19	7.51	99.45	102.9	-3.52	-3.41	110.2	106.1	4.01	3.77
D4S1	26.47	21.47	5.00	-23.29	24.98	24.57	0.41	-1.65	82.11	79.88	2.23	2.79	78.36	82.44	-4.08	-4.94
D4S2	27.48	26.70	0.78	-2.93	30.09	27.96	2.13	-7.62	88.42	82.12	6.30	7.67	89.47	85.01	4.46	5.24
D4S3	25.34	21.30	4.04	-18.98	26.86	24.14	2.71	-11.26	85.40	80.78	4.62	5.72	86.90	83.60	3.30	3.94

Grain yield: Mean = 13.3, RMSE = 3.7, RE = 8.87

Biological yield: Mean = 17.6, RMSE = 4.2, RE = 3.95

Sim: Simulated Obs: Observed RMSE : Root mean square error RE : Relative error

D_1: 15th April -16th Standard Meteorological week (SMW)
D_2: 30th April -18th Standard Meteorological week (SMW)
D_3: 15th May – 20th Standard Meteorological week (SMW)
D_4: 30th May - 22nd Standard Meteorological week (SMW)

S_1: 50cm×20cm
S_2: 60cm×20cm
S_3: 70cm×20cm

Table 3: Validation results of maize for grain yield and biological yield under different planting dates and planting density under un-irrigated mulched conditions

Treatments	Grain yield (q ha^{-1})								Biological yield (q ha^{-1})							
	2012				2013				2012				2013			
	Sim	Obs	Deviation	% deviation	Sim	Obs	Deviation	% deviation	Sim	Obs	Deviation	% deviation	Sim	Obs	Deviation	% deviation
D_1S_1	38.56	41.76	-3.20	7.65	40.03	43.82	-3.79	8.64	99.4	104.9	-5.47	-5.21	114.3	108.5	5.90	5.43
D_1S_2	43.26	45.50	-2.24	4.91	43.65	46.39	-2.74	5.90	107.4	107.6	-0.24	-0.22	115	111.2	3.81	3.42
D_1S_3	44.12	43.53	0.59	-1.35	42.88	45.64	-2.76	6.04	103.5	106.0	-2.42	-2.28	109.7	109.6	0.07	0.06
D_2S_1	36.89	38.53	-1.64	4.26	36.38	40.58	-4.20	10.35	94.3	98.8	-4.49	-4.54	103.8	102.1	1.74	1.70
D_2S_2	41.87	42.01	-0.14	0.32	41.66	43.71	-2.05	4.69	99.3	100.4	-1.08	-1.07	106.5	104.0	2.52	2.42
D_2S_3	36.78	39.59	-2.81	7.09	38.42	40.57	-2.15	5.28	98.1	99.4	-1.29	-1.30	105.3	102.4	2.91	2.83
D_3S_1	34.38	35.23	-0.85	-2.40	41.08	37.17	4.63	-12.46	98.7	90.1	8.64	9.59	100.2	94.9	5.35	5.63
D_3S_2	35.07	37.89	-2.82	7.45	37.78	39.31	-1.53	3.88	97.66	94.0	3.68	3.91	101.2	96.9	4.31	4.45
D_3S_3	35.19	37.03	-1.84	4.98	39.07	38.54	0.53	-1.37	96.37	93.3	3.07	3.29	92.78	96.1	-3.30	-3.43
D_4S_1	21.67	18.50	3.17	-17.13	23.88	19.20	-4.60	-24.34	71.08	66.8	4.30	6.43	72.23	68.9	3.38	4.90
D_4S_2	24.54	21.12	3.42	-16.18	28.09	24.71	3.38	-13.65	74.38	69.6	4.80	6.89	77.26	71.5	5.79	8.10
D_4S_3	20.41	18.90	1.51	-7.96	20.37	16.93	3.44	-20.28	70.53	68.2	2.33	3.41	75.02	69.9	5.14	7.35

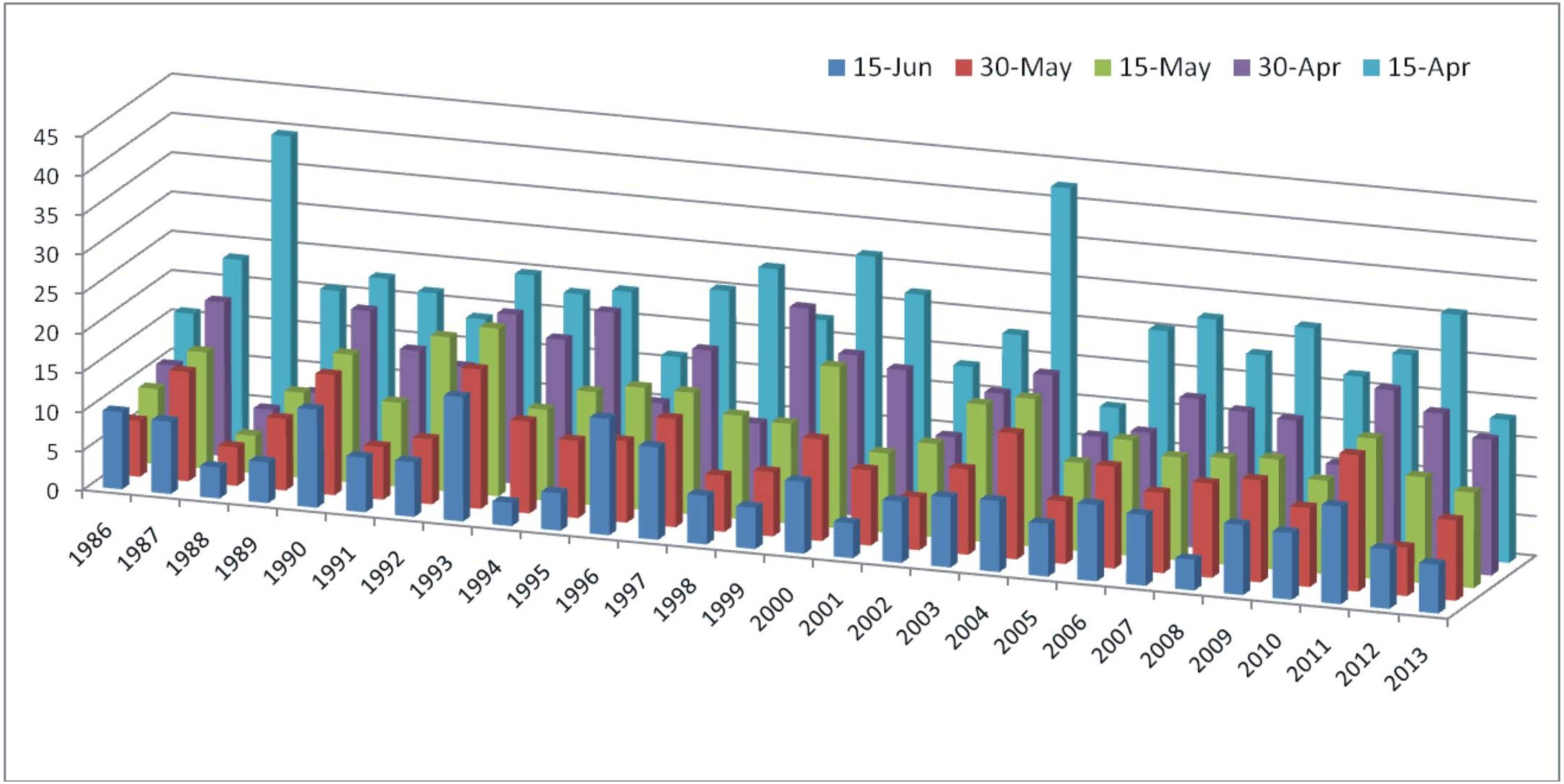
Grain yield: Mean = 13.3, RMSE = 3.7, RE = 8.87

Biological yield: Mean = 17.6, RMSE = 4.2, RE = 3.95

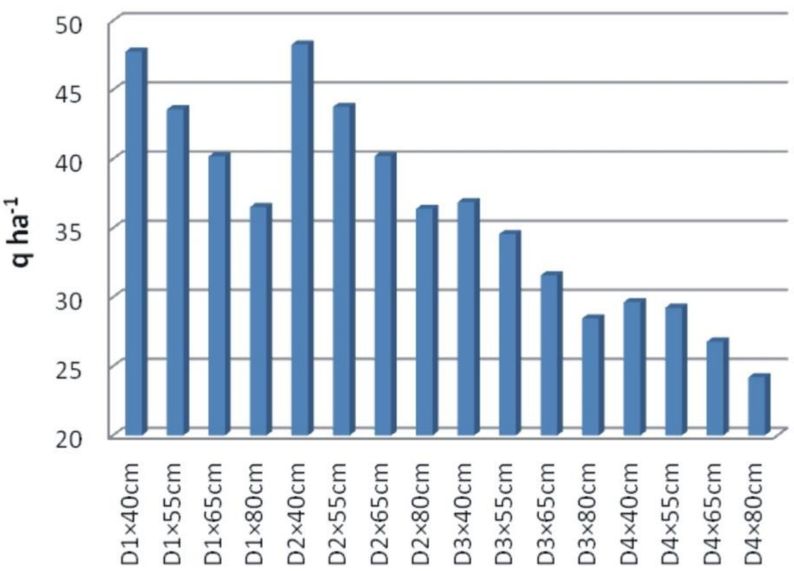
Sim: Simulated Obs: Observed RMSE : Root mean square error RE : Relative error

D_1: 15th April -16th Standard Meteorological week (SMW)
D_2: 30th April -18th Standard Meteorological week (SMW)
D_3: 15th May - 20th Standard Meteorological week (SMW)
D_4: 30th May - 22nd Standard Meteorological week (SMW)

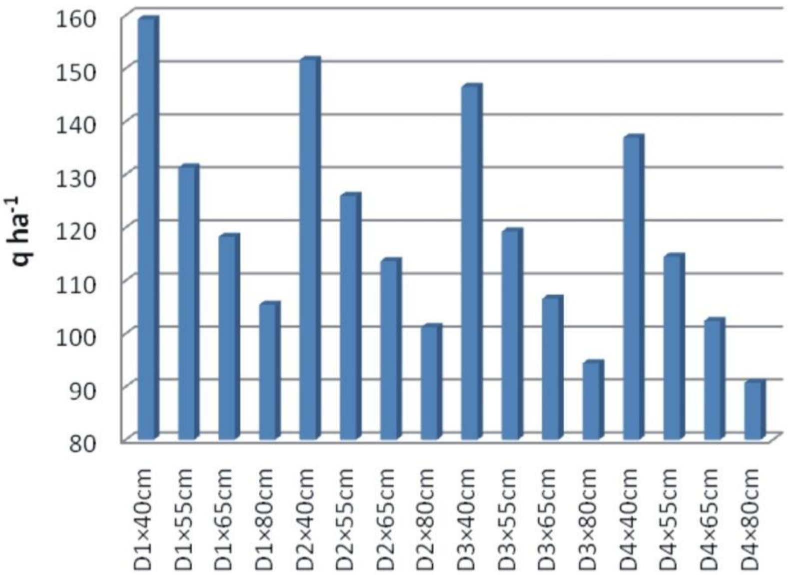
S_1: 50cm×20cm
S_2: 60cm×20cm
S_3: 70cm×20cm



Simulated yield of maize sown on variable dates (1986 to 2013)



Simulated grain yield of maize as influenced by planting dates with different planting density under irrigated conditions



Simulated stover yield of maize as influenced by planting dates with different planting density under irrigated conditions

Simulated stover yield of maize as influenced by planting dates with different planting density under irrigated conditions

Planting dates:	**Spacings:**
15th April : D_1	**45cm × 20cm**
30th April : D_2	**55cm × 20cm**
15th May : D_3	**65cm × 20cm**
30th May : D_4	**80cm × 20cm**

RESULTS

Salient features of weather conditions during the course of investigation which explains that the precipitation received during the crop growth period was 326.8 mm and 546.6 mm during 2012 and 2013, respectively. Wettest months during crop growth period were September (86.4 mm) and August (178.4 mm) during 2012 and 2013, respectively. The mean maximum and minimum temperature for entire crop growth period of maize crop for 2012 was 26.33 and 12.01 ^{o}C, respectively and corresponding values for 2013 were 26.89 and 12.97 ^{o}C. For different planting dates 15th April (D_1), 30th April (D_2), 15th May (D_3) and 30th May (D_4) the mean maximum and minimum temperature was 26.98 and 13.48 ^{o}C, 27.69 and 14.09 ^{o}C, 28.24 and 14.49 ^{o}C, 28.85 and 14.90 ^{o}C respectively during 2012 and corresponding values for 2013 were 27.25 and 14.05 ^{o}C, 28.07 and 14.45 ^{o}C, 28.79 and 15.14 ^{o}C, 19.12 and 15.42 ^{o}C , respectively (Fig 1). Sunshine hour values were higher during 2013 than 2012 whereas values of wind speed and relative humidity were higher in case of 2012. Comparatively variable temperature and solar radiation at different growth stages may be reason for overall higher grain yield irrespective of planting dates and planting density in 2012 and 2013.

Days taken to various phenophases decreased as sowing were delayed. Crop sown on 15th April (D_1) took more days to reach anthesis and maturity compared to sown date 30th April (D_2) which in turn took more days than 15th May (D_3) and 30th May (D_4). This may be due to higher temperature during initial growth period of late sown crop which resulted in quicker coverage of these phases under later planting dates. Similar findings were also recorded by Khan *et al*[7]. It was also noted that the time between sowing to anthesis, anthesis to maturity decreased as sowing was delayed and it clearly showed that sowing date primarily influenced the length of vegetative phase.

Early planting 15th April (D_1) recorded significantly taller plants followed by 30th April (D_2). This may be attributed to longer growth period and better weather conditions under earlier sowing date which favoured profuse vegetative growth[12]. Similar findings were also recorded by Moosavi *et al*[11]., and reported that there is a significant decrease in plant height with the delay in the planting time of maize. As late planting dates maize was subjected to high temperature compared to early planting dates, development phases become quicker leading to initial faster increase in plant height. The growth and yield of maize significantly influenced by plant density due to differential availability of resources like light, moisture and nutrients. Under irrigated conditions, planting density 60cm×20cm (S_2) was found comparatively higher in plant height as compared to other planting dates during both the years.

At early growth stage 15 days after sowing, 30th May (D_4) registered more number of leaves plant^{-1} due to ideal growth conditions. But on later stages planting date 15th April (D_1) recorded maximum number of leaves up to 90 days after sowing and then gradually decreased up to harvest during both the years. Similar trend was followed by planting date 30th April (D_2). Delay in sowing results in the reduction of photoperiod which ultimately results in the decrease in the number of leaves. Planting density at 60cm×20cm (S_2) recorded more number of leaves as compared to other dates during both the years.

The highest leaf area index recorded in planting date 15th April (D_1) up to 90 days after sowing followed by 30th April (D_2) during both the years and gradually declined till maturity. It is attributed to more functional leaves at anthesis. At early growth stage i.e. at 15, 30 and 45 days after sowing, 30th May (D_4) recorded higher LAI. But on later stages 30th May (D_4) recorded lowest leaf area index. It was due to delay in sowing that leads to reduction in leaf area index of maize because of the shortening of growing cycle. The results are in conformity with the findings of Ma *et al*[9].

With respect to planting density, spacing 60cm×20cm (S_2) was found comparatively higher than other spacings during both the years. Earlier planting date 15th April (D_1) recorded higher value of dry matter yield at 15 and 30 days after sowing and at 45 days after sowing 30th May (D_4) registered higher dry matter accumulation. However, from 75 days after sowing and onwards planting date 15th April (D_1) significantly recorded maximum dry matter accumulation as compared to other planting dates during both the years. This finding can be attributed to higher LAI, functional leaves per plant and optimum crop growth period associated with early sowing dates. This can be substantiated by the finding of Girijesh *et al*[3]. (2011). Planting density 60cm×20cm (S_2) recorded higher dry matter at all growth during both the years[8] (Loomis and Williams 1993). This can be attributed that 60cm×20cm (S_1) spacing recorded better growth in terms of plant height, LAI and functional leaves.

Different yield attributing characters were significantly influenced by planting dates during both the years. During 2013, significantly higher cob length, number of grains row^{-1}, number of rows cob^{-1}, grains cob^{-1} and cob diameter were recorded in 15th April (D_1) followed by 30th April (D_2). This may due to more production of biomass and better partitioning of dry matter to cob and more number of days taken to anthesis and maturity. However minimum yield attributing characters were recorded in 30th May (D_4). This is due to delay in sowing reduces the growth duration, LAI and dry matter production[16].

Among planting density 60cm×20cm (S_2) significantly recorded higher yield attributing characters like cob length, number of grains row^{-1}, number of rows cob^{-1}, and cob diameter during both the years. Spacing 70cm×20cm (S_3) significantly exhibited more number of grains cob^{-1} while other yield attributing characters were least. However minimum yield attributing characters were recorded in spacing 50cm×20cm (S_1) during both the years. The results are in the corroboration with the findings of Marchao *et al*[10]. Since spacing 60cm×20cm (S_2) recorded comparatively longer growth phases, better dry matter production and partitioning resulting better yield attributing characters.

The difference in yield index components such as grain yield, stover yield, biological yield, harvest index and seed index due to planting date was significant. Highest grain yield was recorded in planting date 15th April (D_1) 50.60 and 53.81 q ha^{-1} during 2012 and 2013, respectively over 30th April (D_2) 47.18 and 48.30, 15th May (D_3) 41.88 and 43.22. Grain yield decreased by delayed sowing. Lowest grain yield was recorded in 30th May (D_4) 23.15 and 25.55 during both the years. Stover yield, biological yield and harvest index recorded were also higher in 15th April (D_1) followed by 30th April (D_2) during both the years. Higher stover yield and biological yield at 15th April (D_1) and 30th April (D_2) can be attributed to higher growth attributes like dry matter accumulation, LAI and longer growth duration. Similar results were recorded by several workers Zhang *et al*[17]., Khan *et al*[6]. This leads to enhancement in the time of vegetative phase due to low temperature in 2013, which contributed higher dry matter accumulation at anthesis. However, at later stage temperature was relatively higher in 2013 resulting congenial conditions for higher yield.

Model was validated under irrigated conditions using two-year data in terms of days to anthesis, days to maturity, LAI, grain yield and biological yield. (Fig. 2). Days to anthesis, days to maturity, grain yield and biological yield data obtained in the field experimentation matched well with the simulated data. However, LAI was under estimated and did not matched well with the predicted values. The RE was 38.3 %. Where under un-irrigated conditions RE was 41.09 % indicating that variation between simulated and observed values was very high. With regard to other parameters value of RE for days to anthesis, days to maturity, LAI, grain yield and biological yield under irrigated condition was 1.13, 2.15, 8.87, 3.95, respectively indicating that the RE value below 10%. This variation between observation and simulated data was in close agreement.

Grain yield of maize under irrigated conditions was simulated using weather data from 1986-2013 (27 years) with variable sowing dates: 15th April, 30th April, 15th May, 30th May and 15th June. Data indicating that early sowing date 15th April (D_1) as expected predicted highest grain yield from 1986-2013. Lowest yield was recorded at 15th June for all the years. Whereas at each successive sowing date beyond 15th April recorded decreasing grain yield. The delayed sowing recorded a decline in the grain and stover yield because of shorter time available for the late sown crop to utilize available growth resources like nutrients, moisture, responsive for lower LAI and poor plant growth which results poor dry matter accumulation for the production and partitioning of assimilates to various sink for better vegetative growth. Similar findings were reported by Khan *et al*[7]., and Namakka *et al*[13].

CONCLUSION

Under agro-climatic conditions of Kashmir valley crop growth period during summer months is restricted due to low temperature during spring and autumn months. Therefore, early sowing (15th April) of maize is recommended for highest yield, though initial growth period is subjected to low temperature under both irrigated as well as un-irrigated mulched conditions. Since most of the maize area in Kashmir valley is rainfed. Simulation studies indicated that under irrigated conditions with mulch, nitrogen response increased as compare to irrigated condition without mulching. Under irrigated condition for higher grain yield planting density can be decreased i.e 40cm×20cm.

REFERENCES

1. Agriculture Research Data Book. IASRI Library Avenue Pusa New Delhi. pp 15-158 (2013).
2. FAO, FAO STAT Production Statistics, Food and Agriculture Organization, Rome http//:ww.faostat.fao.org/p.pageI=567/ancor. (2010).
3. Girijesh, G.K., Kumara swamy, A.S., Sridhara, S. Dinesh Kumar, M., Vageesh, T.S. and Nataraju, S.P., Heat use efficiency and helio-thermal units for maize genotypes as influenced by dates of sowing under southern transitional zone of Karnataka state. *International Journal of Science and Nature*, **2(3):** 529-533 (2011).
4. Hoogenboom, G., Wilkens, P.W. and Tsuji, G.Y., *DSSAT v 3 Volume 4*. University of Hawaii, Honolulu, Hawii, (1999).
5. Jenson, M.C., Middleton, J.E. and Pruuit, W.D., Scheduling of irrigation from pan evaporation. *Washington Agriculture Experimental Station Bulletin* 459, p.28 (1961).
6. Khan, H.Z., Iqbal, S., Iqbal, A., Akbar, N. and Jone, D.L., Response of maize varieties to different levels of nitrogen. *Crop and Environment.* **2(2):** 15-19 (2011).
7. Khan, N., Qasim, M., Ahmad, F., Naz, F., Khan, R., Khanzada, S.A. and Khan, B.A., Effect of sowing dates on yield of maize under agroclimatic condition of Kaghan Valley. *Asian Journal of Plant Sciences,* **1(2):** 146-147 (2002).
8. Loomis, R.S., and Williams, W.A., Maximum crop productivity: an estimate. *Crop Science*, **3:** 67-72 (1993).
9. Ma, G.S., Xue, J.Q., Lu, H.D., Zhang, R.H., Tai, S.J. and Ren, J.H., Effects of planting date and density on population physiological indices of summer corn (*Zea mays L*.) in central Shaanxi irrigation area. *Ying Yong Sheng Tai Xue Bao*. **18(6):** 1247-1253 (2007).
10. Marchao, R.L. Brasil, E.M. Duarte, J.B. Guimaraes, C.M. and Gomes, J.A., Plant density and agronomic traits of maize hybrids in narrow row spacing. *Pesquisa Agropecuaria Tropical*., **35(2):** 93-101 17 ref. [Journal article] (2005).
11. Moosavi, S.G., Seghatoleslami, M.J. and Moazeni, A., Effect of planting date and plant density on morphological traits, LAI and forage corn yield. *International Research Journal of Applied and Basic Sciences*, **3(1):** 57-63 (2012).

12. Morin, C.D. and Dormency, H., Limits of a simple model to predict yield losses in maize. *Weed Research*, **33:** 248-261 (1993).
13. Namakka, A., Abubakar, I.U., Sadik, I.A., Sharifia, A.I. and Hassan, A.H., Effect of sowing date and nitrogen level on the yield and yield components of two extra early maize varieties in Sudan Savanna of Nigeria. *Asian Research Publishing Network Journal of Agricultural and Biological Science*, **3(2):** 1-5 (2008).
14. Pruitt, W.D., Relation to consumptive use of water to climate. *Transaction of ASAE*, **3:** 9-13 (1960).
15. Tsuji, G.Y., Uehara, G. and Balas, S., *DSSAT v 3*. University of Hawaii, Honalulu, Hawaii (1994).
16. Valencia, J.A. and Steven, A.B., Sasakawa Africa Association, Mexico City: 14 (1999).
17. Zhang, D.M., Zhang, W., Liu, E.K., Jiang, C.X., Chen, Q.H., Yan, L., Huang, X.F., Liu H.T., Zhao, C. and Chi. B.L., Response of dryland maize yield to fertilization rate and planting density at different sowing dates in early-maturity areas. [Chinese]. Zhongguo Shengtai Nongye Xuebao / *Chinese Journal of Eco-Agriculture*, **21(12):** 1449-1458 (2013).