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Arun Kumar
Department of Agricultural Meteorology, A.N.D. University of Agriculture & Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

SR Mishra
Department of Agricultural Meteorology, A.N.D. University of Agriculture & Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

Alok Kumar Pandey
Department of Agricultural Meteorology, A.N.D. University of Agriculture & Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

Rakesh Kumar Kushwaha
Department of Agricultural Meteorology, A.N.D. University of Agriculture & Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

Sandeep Kumar Singh
Department of Agricultural Meteorology, A.N.D. University of Agriculture & Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

AN Mishra
Department of Agricultural Meteorology, A.N.D. University of Agriculture & Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

AK Singh
Department of Agricultural Meteorology, A.N.D. University of Agriculture & Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

Corresponding Author:
Arun Kumar
Department of Agricultural Meteorology, A.N.D. University of Agriculture & Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

Effect of heat use efficiency on leaf area index, plant height and yield attributes on *Kharif maize* (*Zea mays* L.) cultivars

Arun Kumar, SR Mishra, Alok Kumar Pandey, Rakesh Kumar Kushwaha, Sandeep Kumar Singh, AN Mishra and AK Singh

Abstract
A field experiment was carried out at Agrometeorological Research Farm, Acharya Narendra Deva University of Agriculture & Technology, Narendra Nagar (Kumarganj), Ayodhya (U.P.) during kharif season of 2019 to study the effect of Effect of heat use efficiency on leaf area index, plant height and yield attributes on *kharif maize (Zea mays* L.) cultivars**.** The experiment comprised of nine treatment combinations and conducted in Randomized block design and replicated four times. Treatment consisted of three crop growing environment viz. 5th July, 15th July and 25th July with three cultivars Viz, Kanchan, Azad hybrid-1 and Azad hybrid-2. Results reveal that Crop growing Environment of 5th July (100000 plants ha-1) was found suitable for optimum growth and yield of Kharif maize. Among crop growing environments on 5th July recorded higher days taken from sowing to maturity. Crop growing Environment on 5th July and cultivar Kanchan recorded higher heat use efficiency from sowing to maturity of Kharif maize.

Keywords: Maize, heat use efficiency, leaf area index, plant height, yield attributes

Introduction
Maize (*Zea mays* L.) belongs to family poaceae is one of the most 3rd important cereal crops in the world after rice and wheat. Maize is called 'queen of cereal' as it grown throughout year due to its photo-thermo-insensitive character and highest genetic yield among the cereals. Being a C4 plant, it is very efficient in converting solar energy into dry matter. Over 85% of maize produced in the country is consumed as human food. The importance of maize lies in its wide industrial applications besides serving as human food and animal feed. Green cobs are roasted and consumed by people with great interest. Maize seed contains 10% protein, 4% oil and 2-3% crude fiber. Several food dishes including chapaties are prepared out of maize flours and grains. Green maize plants are used as succulent fodder. Popping the corn is a method of starch cookery. Maize is a raw material for a number of products viz., starch, glucose, dextrose, sorbitol, dextrine, high fructose syrup, malto dextrine, germ oil, germ meal, fiber rand gluten products which have application in industries such as alcohol, textile, paper, pharmaceuticals, organic chemicals, cosmetics and edible oil. Maize has got very high yield potentiality and wide adaptability under various agro climatic conditions than any other cereal crops Singh, 2013 [7]. In agriculture, heat units are often expressed as growing degree days (GDD). Sometimes growing degree days are called growing degree units (GDU), but the two terms are identical. Calculating GDD for a specific day uses a simple formula that involves subtracting a base or threshold temperature from the average temperature for the day. The base temperature is the threshold temperature for which plant growth begins. Plant species differ for base temperature. The base temperature for corn is 10 ºC Rao, 2008. It has got the highest genetic yield potential among the cereals and is cultivated on nearly 191.26 m ha in about 168 countries having wide diversity of soil, climate, biodiversity and management practices that contributes (1122.17 m t) in the global grain production. USA is the largest producer of maize contributing nearly 39 percent of the total production in the world, and maize has the highest productivity (5.87 t ha-1).whereas, area under maize production in India is about 9.47 m ha area and production about 28.72 m t with the average productivity of about 3.03 t ha-1. In Uttar Pradesh, maize occupies an area of 0.75 million hectares with a production of 1.48 million tonnes and productivity of 1.98 t ha-1. Anonymous, 2017-18. Maize yield is a function of climate, soil, variety and cultural practices. Correlating these functions to produce the highest possible yields with the greatest efficacy has been the aim of research workers ever since the maize production began.

Since there is a limited scope to increase the area under maize cultivation because of competition from other cereals and commercial crops, the only alternative is through enhancement of productivity by various management factors. Among the factors limiting yield of maize in many areas is inadequate irrigation and low plant population Reddy, 2017 [4]. Maize (*Zea mays* L.) being the highest yielding cereal crop in the world is of significant importance for countries like India, where rapidly increasing population already out stripped the available food supplies. Maize crop possesses great genetic diversity and can be grown across varied agro-ecological zones Ferdu *et al.,* 2002. The variation in crop growing environment modifies the microclimate to which the plants are exposed and it is responsible for biomass production and ultimately the yield. It is necessary to understand the knowledge of plant environment interaction for increasing the yield of crop. Phenological development of crop closely followed the changes in weather conditions occurring during crop growing period. So, a detailed study of crop phenological events in maize would provide a base for understanding different growth and developmental processes as related to weather parameters. The crop growing environment lead to changes in the crop microclimate which has a direct influence on the plant growth and development and resource utilization Hugar and Halikatti, 2015 [2].

Materials and Methods

The present investigation entitled "Effect of heat use efficiency on leaf area index, plant height and yield attributes on *kharif maize* (*Zea mays* L.) cultivars ." A field experiment was carried out at Agrometeorologiccal Research Farm, Acharya Narendra Deva University of Agriculture & Technology, Narendra Nagar (Kumarganj), Ayodhya (U.P.) during kharif season 2019.The experiment was conducted at Agro-meteorological Research Farm of A.N.D university of Agriculture & Technology, Kumarganj, Ayodhya (UP). Geographically experimental site falls under sub-tropical climate of Indo-gangetic plains having alluvial soil and is located at 26° 47' N latitude and 82° 12' E longitude and at an altitude of 113 meters above mean sea level. The average weekly weather data during crop period obtained from Agro meteorological observatory of A.N.D university of Agriculture & Technology, Kumarganj, Ayodhya (U.P).

Results

Data pertaining to heat use efficiency requirement of Kharif maize at different phenophases as affected by crop growing environment and moisture have been presented in Table 1. The maximum heat use efficiency requirement from sowing to maturity was recorded with (0.65) at crop growing environments 5th July while minimum heat use efficiency from sowing to maturity (0.60) was observed under crop growing environments of 25th July. This finding confirms that of Girijesh, *et al*., 2011. LAI of maize as affected by crop growing environment and cultivars are given in (Table-2). LAI successively increased till 75 DAS and there after it gradually declined till the harvest of crop due to leaf senescence. LAI was significantly higher under sowing done on 5th July followed by 15th July while its lowest value were obtained in delayed sowing on 25th July. Kanchan variety recorded significantly higher LAI as compared to rest varieties at all the successive stages of growth of maize. Increase in LAI was due to increased plant density which accommodates more number of plants per unit area there by increased the functional leaves and in turn enhanced the LAI. This finding confirms that of Kumar and Aravinth *et al.,* 2011. Leaf area index (LAI) of maize increased-progressively with the advance in the age of the crop up to 75 DAS, beyond which it was found declined upto harvest. Plant height of maize was affected significantly due to different crop growing environment and cultivars at all the stages of growth (Table-3). It increased till the harvest of the crop irrespective of treatments under present study. Sowing on 5th july recorded significantly taller plants at all the stages as compared to rest both of the sowing dates. Shortest plants were obtained in 25th July sowing (sowing delayed by 20 days over normal). Among the varieties Kanchan produced taller plants (191.84 cm) over rest both of the cultivars. It could be attributed to the fact that due to higher plant density, it would certainly reduce the amount of light availability to the individual plant, especially to lower leaves due to greater shading. As the mutual shading increases at high plant densities, the plant tends to grow taller. These findings were in close conformity with those of Thavaprakash and Velayudham, 2009 and Aravinth *et al.,* 2011. Data pertaining to yield attributes and yield of maize as affected by crop growing environment and cultivars are given in (Table-4) number of cobs per plant. Length of cob (cm), number of rows per cob, number of grains per row, number of grains per cob, weight of grains per cob, weight of cob, test weight and yields varied significantly due to crop growing environment. Cultivars also had significant influence on all the yield attributes and yield of maize. Sowing on 5th July recorded significantly higher values followed by 15th July and then 25th July growing environment. Among the varieties, Kanchan recorded superiority over rest both of the varieties with regard to yield attributes and yield of maize. No of cob, per plant of Kharif maize was significantly influenced by crop growing environment have been presented in Table -4. As regards the crop growing environment, significantly the higher no of cob per plant of maize was recorded with the crop growing environments 5th July which was at par with 15th July while significantly over 25th July cultivars. The number of cob per plant decreased as the plant population increased. Usually under high population stress, the late developing distal spikelets fail to set kernels and when the slow growing silks finally emerge, little or no pollen is available for fertilization. Also, high stand density reduces ear shoots growth, which results in fewer spikelets primordial transformed into functional florets by the time of flowering. The limited carbon and nitrogen supply to the ear finally stimulates young kernel abortion immediately after fertilization, Sangoi., 2001. Interaction effect of crop growing environment on no of cob per plant was significant.Interaction effect of crop growing environment on no of grain rows per cob was non significant. No of grains per row of Kharif maize was significantly influenced by crop growing environment have been presented in Table-4. As regards the crop growing environment, the higher No of grains per row of maize was recorded with the crop growing environments 5th July which was at par with 15th July while significant over 25th July cultivars. No of grains per row increases with decreasing plant density. Similar results were reported by Singh *et al.,* 1997. The no of grain number row increases with increase in frequency of irrigation, due to better root growth leads to better nutrient uptake. Similar results were reported by Majid *et al.,* 2017. Interaction effect of crop growing environment on No of grains per row was non significant. Number of grains per cob of Kharif maize as significantly influenced by crop growing environment have been presented in Table- 4.

As regards the crop growing environment, the highest No of grains per cob of maize was recorded with the crop growing environments 5th July which was significant over 15th July and 25th July cultivars. No of grains per cob decreases with increase in plant population due to competition between plants. Similar results were reported by Singh *et al.*, 1997 and Sharif *et al.*, 2009. Interaction effect of crop growing environment on no. of grains per cob was significant.

Table 1: Heat use efficiency of Kharif maize cultivars as affected by Crop growing environments

Treatments	Heat use efficiency (g/m2 /oc days)				
	Emergence	Knee high stage	Tasseling	Silking	Maturity
Crop growing environment					
5th July	0.15	0.19	0.30	0.57	0.65
15th July	0.14	0.18	0.28	0.52	0.61
25th July	0.14	0.17	0.26	0.50	0.60
Cultivars					
Kanchan	0.15	0.19	0.30	0.57	0.65
Azad Hybrid -1	0.14	0.18	0.29	0.54	0.63
Azad Hybrid -2	0.13	0.17	0.25	0.49	0.58

Table 2: Leaf area index of Kharif maize cultivars as affected by crop growing environments

Treatments	Leaf Area Index				
	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS
Crop growing environment					
5th July	0.65	1.30	2.10	3.36	3.19
15th July	0.64	1.28	2.00	3.20	3.04
25th July	0.62	1.24	1.70	2.72	2.58
Cultivars					
Kanchan	0.69	1.37	2.15	3.44	3.27
Azad Hybrid -1	0.65	1.29	1.90	3.04	2.89
Azad Hybrid -2	0.58	1.15	1.75	2.80	2.66
SEm±	0.012	0.024	0.031	0.053	0.046
CD at 5%	0.025	0.050	0.065	0.112	0.096

Table 3: Plant height (cm) of kharif maize cultivars as affected by crop growing environments

Treatments	Plant height (cm)					
	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	At harvest
Crop growing environment						
5th July	15.20	30.0	107.0	153.62	185.34	192.96
15th July	14.60	27.0	100.0	143.22	171.86	177.18
25th July	13.70	24.0	93.0	136.29	163.66	168.36
SEm±	0.32	0.597	2.448	3.019	4.013	4.554
CD at 5%	0.75	1.379	5.732	7.070	9.399	10.664
Cultivars						
Kanchan	14.90	30.62	106.00	150.15	180.51	191.84
Azad Hybrid -1	14.50	28.65	101.00	145.53	174.97	185.97
Azad Hybrid -2	14.10	21.73	93.00	137.45	165.27	175.68
SEm±	0.235	0.465	1.555	2.294	2.975	2.961
CD at 5%	0.493	0.976	3.264	4.817	6.247	6.217

Table 4: Yield attributes of kharif maize cultivars as affected by crop growing environments

Treatments	Number of cobs per plant	Length of cob (cm)	No of grain rows per cob	No of grains per row	No of grains per cob
Crop growing environment					
5th July	1.47	18.17	19.00	30.33	584.73
15th July	1.37	17.63	17.00	26.13	445.95
25th July	1.30	17.07	15.60	27.67	437.71
SEm±	0.029	0.430	0.371	0.658	13.057
CD at 5%	0.069	1.007	0.869	1.540	30.580
Cultivars					
Kanchan	1.53	18.60	19.00	30.33	578.91
Azad Hybrid -1	1.40	18.37	18.00	29.80	538.12
Azad Hybrid -2	1.20	15.90	14.60	24.00	351.36
SEm±	0.024	0.276	0.269	0.475	8.097
CD at 5%	0.050	0.580	0.564	0.997	17.001

Conclusion

Heat use efficiency requirement of Kharif maize at different phenophases as affected by crop growing environment and moisture. The maximum heat use efficiency requirement from sowing to maturity was recorded with (0.65) at crop growing environments 5th July while minimum heat use efficiency from sowing to maturity (0.60) was observed under crop growing environments of 25th July. LAI successively increased till 75 DAS and there after it gradually declined till the harvest of crop due to leaf senescence. LAI was significantly higher under sowing done on 5th July followed by 15th July while its lowest value were obtained in delayed sowing on 25th July. Kanchan variety recorded significantly higher LAI as compared to rest varieties at all the successive stages of growth of maize. Plant height of maize was affected significantly due to different crop growing environment and cultivars at all the stages of growth (Table-3). It increased till the harvest of the crop irrespective of treatments under present study. Sowing on 5th july recorded significantly taller plants at all the stages as compared to rest both of the sowing dates. Shortest plants were obtained in 25th July sowing (sowing delayed by 20 days over normal). Among the varieties Kanchan produced taller plants (191.84 cm) over rest both of the cultivars. It could be attributed to the fact that due to higher plant density, it would certainly reduce the amount of light availability to the individual plant, especially to lower leaves due to greater shading. As the mutual shading increases at high plant densities, the plant tends to grow taller. The yield attributes and yield of maize as affected by crop growing environment and cultivars, number of cobs per plant. Length of cob (cm), number of rows per cob, number of grains per row, number of grains per cob, weight of grains per cob, weight of cob, test weight and yields varied significantly due to crop growing environment. Cultivars also had significant influence on all the yield attributes and yield of maize. Sowing on 5th July recorded significantly higher values followed by 15th July and then 25th July growing environment. Among the varieties, Kanchan recorded superiority over rest both of the varieties with regard to yield attributes and yield of maize. No of cob, per plant of Kharif maize was significantly influenced by crop growing environment.

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