INFLUENCE OF WEATHER PARAMETERS ON PEARL MILLET (*PENNISETUM GLAUCUM* L.) VARIETIES AT ALLAHABAD

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Abstract: A field experiment was conducted during the kharif season 2014 at the research farm of School of Forestry & Environment, Sam Higginbottom Institute of Agriculture Technology and Sciences, Allahabad, to find out influence of weather parameters on pearl millet (*Pennisetum glaucum* L.) varieties under Allahabad condition in Randomized block design (factorial) with nine treatments replicated thrice. The results revealed that on 23rd July maximum growing degree day (1874.4 ^{0}C), hygrothermal unit-I (159679.6%), hygrothermal unit-II (100522.0%), photo temperature (2968.4 ^{0}C), nycto temperature (2968.4 ^{0}C). Whereas, maximum photo thermal unit (18885.2 ^{0}C), heliothermal unit (12147.9^{0}C) and inter-diurnal temperature (846.8 ^{0}C) was recorded at 06 August sowing date.

Keywords: Pearl millet, Varieties, Agrometeorological indices

INTRODUCTION

In last few decades, there has been an increasing of the importance of millets in India, major cereals which are grown on soils supplied with large quantity of fertilizers, irrigation and pesticide inputs have attained yield plateau. Millets have potentiality of contributing to increased food production, both in developing and developed countries. Millets are one of the cereals asides the major wheat, rice, and maize. Millets are major food sources for millions of people, especially those who live in hot, dry areas of the world. Millets are classified with maize, sorghum, and Coix (Job'stears) in the grass sub-family Panicoideae. In contrast, millet is the major source of energy and protein for millions of people in Africa. It has been reported that millet has many nutritious and medical functions (Yang *et al*. 2001). They are grown mostly in marginal areas under agricultural conditions in which major cereals fail to give substantial yields. Pearl millet [(*Pennisetum glaucum* L.) Br. Emend stuntz.] popularly known as *Bajra,* cattle millet, bulrush millet belongs to the grass family or gramineae. In the world, it's rank sixth followed by rice, wheat, corn, barley and sorghum (Anonymous, 2010). However, in India, it is fourth most important cereal crop after rice, wheat and sorghum. It has the greatest potential among all the millets. In India, annual planting area under pearl millet is 9.4 million hectares producing nearly 10.1million tonns of grains. The Pearl millet growing countries are India, China, Nigeria, Pakistan, Sudan, Egypt, Arabia, and Russia. India is the largest producer of Pearl millet in the world. In India major producing state are Rajasthan (46%), Maharashtra (19%), Gujarat (11%), Uttar Pradesh (8%) and Haryana (6%). Sowing time is the most important non-monetary input influencing crop yield. Sowing at optimum time improves the productivity by providing suitable environment at all the growth stages. Upadhyay *et al*. (2001) have reported higher grain yield of summer pearl millet when sown on 15 march and found reduction in grain yield with delay in sowing. Identifying suitable time of sowing for pearl millet during summer is important to have proper growth and development of plants, save the crop from early monsoon showers and timely vacate the field for succeeding kharif crop. Keeping in view of the importance the study was aimed to investigate influence of weather parameters on pearl millet (*Pennisetum glaucum* L.) varieties under Allahabad condition

MATERIAL AND METHOD

The study was conducted at research farm of School of Forestry & Environment, Sam Higginbottom Institute of Agriculture, Technology and Sciences (Deemed-to-be-University), Allahabad during in one year 2014-2015 in the *Kharif* season. The area is situated on the south of Allahabad on the right hand of rivers Yamuna at Rewa Road at a distance of about 06 km of Allahabad city. It is positioned at 25^{o}57' N latitude 81^{o}50'E longitude and at the altitude of 98 meters above the sea level. Allahabad has a sub-tropical climate prevailing in the south east part of U.P. With both the extremes in temperature the summer. In summer the temperature rises up to 46-48^{0}C during the month of May and June. The average rainfall is around 1013.4 mm achieve is mostly received during the middle of July to end of August. Both the mechanical and chemical analysis of soil were done before the start of the experiment to ascertain the initial fertility gradient of the soil fence, the soil of the experimental field was analyzed mechanically and found, sand was 60%, clay 26%,

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slit 14% and its fall under textural class of sandy loam.

Chemical Analysis

The chemical analysis was done for pH, Organic carbon, Electrical Conductivity (EC), available nitrogen, phosphorus and potassium. pH was determined by Digital pH meter. The organic carbon was estimated by Walkley and Black method (1934). The Electrical Conductivity (EC) was estimated by electrical conductivity meter. The available nitrogen was estimated by Kjeldahl method, the available phosphorus was determined by Olsen's Spectrophotometer method and available potassium was determined by Flame photometer analysis are presented in the following table 1.

Table 1. Chemical properties of soil before sowing

Analysis	Quantity	Method
Bulk density(g/cm^3)	1.64	Core method (Black, 1965)
Particle density (g/cm^3)	2.70	Volumetric flask method (Black, 1965)
Pore space (%)	34.3	Volumetric flask method (Black, 1965)
Water holding capacity (%)	11.37	Volumetric flask method (Muthuaval *et al.* (1992)
pH (1:2)	7.6	Digital pH meter (Jackson, 1973)
EC (dSm^{-1})	0.38	Digital EC meter
Organic carbon %	0.36	Rapid titrations method (Wilcox, 1955)
Available nitrogen (kg ha^{-1})	260	Alkaline permanganate Subbiah, and Asija, (1956)**.**
Available Phosphorus (kg ha^{-1})	26	Colorimetric method (Olsen,1954)
Available Potassium (kg ha^{-1})	252	Flame Photometric method (Toth and price, 1949)

The field experiment were laidout in a randomized block design 3X3 factorial with 9 treatment combination, each treatment replicated three times. The factors were located randomly and 3 sowing dated and 3 pearl millet varieties. This design allowed irrigation and other cultural practices to be performed on each sowing time independently. Treatment combinations as follows viz.,

Treatment details

Treatment No.	Treatment Combination	Varieties	Dates
T_1	D_1V_1	Ganga kaveri-22	23rd July
T_2	D_1V_2	DHANYA-1	
T_3	D_1V_3	Pusa-322	
T_4	D_2V_1	Ganga kaveri-22	30 July
T_5	D_2V_2	DHANYA-1	
T_6	D_2V_3	Pusa-322	
T_7	D_3V_1	Ganga kaveri-22	6th August
T_8	D_3V_2	DHANYA-1	
T_9	D_3V_3	Pusa-322	

Seed treatment were performed with Chloropyriphos @ 4 ml kg^{-1} seed to control termite and squirrel all such. Recommended dose of fertilizer was applied through chemical fertilizers at the time of sowing. The nutrients were applied in the form of urea [$CO(NH_2)_2$] and di-ammonium phosphate [$(NH_4)_2HPO_4$]. Nitrogen was applied in three split doses with 50 percent as basal application, 25 percent at 25 days after sowing and remaining 25 % at sowing after 45 DAS. Subsequently irrigation was applied to the crop as per requirement. Other plant protections measures were taken as and when required. The seeds were sown as per the treatment combination. The observations were recorded on five randomly selected competitive plants in each replication. Agro meteorological indices developed by utilizing various meteorological elements are found in literature to study the crop weather relationships. The indices such as (i) Growing degree days (GDD), (ii) Photo thermal units (PTU), (iii) Heliothermal units (HTU), (iv) Phenothermal index were employed in the present study. The methods of computation of the indices are as under. Growing degree days (GDD) in this investigation (remainder index) were calculated by simple accumulation of daily mean air temperature above a given threshold or base temperature.

It can be mathematically expressed as

$$GDD = \sum_{ds}^{dp}[(Tmax. + Tmin.)/2 - Tb]$$

Photothermal unit (PTU)
The photothermal unit which takes into account the maximum possible duration of day light (day length factor or maximum possible sunshine hours) were worked out for each day by multiplying the growing degree days for a day with the corresponding day length factor (Rajput, 1980). The response of crop was examined in relation to both photo thermal units and growing degree days. The degree days for each date of sowing and varieties for different phenological stages were calculated in terms of PTU from the formula given by Wang (1963).

$$PTU = GDD \times N$$

Where, N- Maximum possible sunshine hours which varies with latitude and month at a location

Heliothermal units (HTU)
The value of heliothermal unit represents the product of GDD and actual duration of bright sunshine hours (BSS) for a particular day as recorded by the sunshine recorder .This may be termed as actual photothermal unit. The heliothermal units for each planting i.e. date of sowing and varieties for different phenological stages were calculated by following expression.

$$HTU = GDD \times n$$

Where, n = Actual duration of bright sunshine hours as recorded by sunshine recorder for a particular location

Phenothermal index
The phenothermal index is expressed as degree day per growth day It can be expressed as under

$$\text{Phenothermal Index} = \frac{\text{Accumulated thermal units during phenophase}}{\text{Duration of the phenophase}}$$

Hygrothermal unit-I&II
The value of hygrothermal unit represents the product of GDD and relative humidity (Morning & afternoon) for a particular day as recorded by the observatory.

$$HgTU = GDD \times RH$$

The data observed were subjected to statistical analysis as for the methods detailed by Gomez and Gomez (1984).

RESULT AND DISCUSSION

The result obtained during the present course of investigation was carried out to visualize a significant influence of different date sowing

Temperatures
In case of the average per day maximum temperature remained more or less same for 23rd July and 06 August sowing conditions. However, maximum temperatures were higher for D_1 (23rd July) and D_2 sown conditions. Per day Maximum temperature increased constantly during flowering, milking and Dough stage in different sowing conditions (Table. 3). On the other hand, per day minimum temperature was higher in D_3 (06 August) sown conditions and irrespective of duration of maturity period (Table.4). The average per day mean temperature decreased constantly during flowering, milking and Dough Stage development in D_1 and D_3 sowing conditions except second dates of sowing.

Relative humidity-I and Relative humidity-II
The average per day RH during morning hours decreased gradually from sowing to grain development stage in all dates of sowing. Among dates of sowing, the per day morning relative humidity was found to be higher in D_3 (85.98 %) and followed by D_2 (85.24%) sowing conditions. The per day evening relative humidity was observed highest in D_2 sowing conditions (53.87%) however it was observed minimum in D_3 (52.95) (Table.5).

Bright sunshine hours
The average bright sunshine hours for the whole crop season under different sowing conditions remained slightly higher in D_3 (6.33 hours/day) than other dates of sowing. Among dates of sowing, the bright sunshine hours increased consistently from sowing to maturity stage in D_1 and D_2.

Active evaporation (hr/day)
The average active evaporation (hr/day) for the whole crop season under different sowing conditions remained slightly higher in D_1 (3.87 hours/day) than other dates of sowing. Among dates of sowing, the active evaporation hours increased consistently from sowing to maturity stage in D_2 and D_3 (Table 7).

Growing degree days
The data pertaining to accumulated heat units in different date of sowing are presented in table. 8 Different dates of sowing significant influenced GDD. The GDD accumulation was significantly highest in D_1 (1874.4 day °C) than other dates of sowing. The minimum GDD was accumulated in D_3 sowing (1814.9 day °C).The GDD accumulation was highest in D_1 due to longer duration of crop growing period and lowest in D_3 sowing due to forced maturity caused by increase in temperature. The decrease in GDD may be due to decrease in the maturity period of the pearl millet.

Photothermal unit
The photothermal unit (PTU) under various dates of sowing is presented in the table 8 Different dates of sowing were found to be significant for accumulation of PTU.
However, crop dates of sowing were significantly differed for accumulation of photothermal unit (PTU). The highest PTU was obtained by D_3

(18885.2°day hrs) followed by D_2 (18854.8°day hrs). However, non significantly lowest PTU was recorded by D_1 (11575.5°day hrs).

Heliothermal units

The accumulated heliothermal unit (HTU) under various dates of sowing is presented in the table 8. Different dates of sowing significantly influenced heliothermal unit (HTU). The D_3 accumulated maximum heliothermal units (12147.9°day hrs) to reach maturity stage. The lowest HTU was accumulated in D_1 sowing date that is (11629.4°day hrs).This may be due to cloudiness prevailed during the grain development stage of D_1 sown crop.

Hygrothermal Unit-I

The accumulated morning hygrothermal unit-I required by the crop for various phenophases under different dates of sowing are presented in table 8. The hygrothermal unit-I significantly influenced by dates of sowing. The hygrothermal unit-I was highest (159679.6°day%) in the D_1 followed by D_2 (158131.6°day%). The accumulation of HgTU-I was the lowest in D_3 (155445.9°day%) due to short crop growth period.

Hygrothermal Unit-II

The accumulated afternoon hygrothermal unit –II accumulated the crop during various phenophase under different dates of sowing are presented in the table 8.

The hygrothermal unit-II (HgTU-II) significantly influenced by different dates of sowing. The D_1 sown condition accumulated the highest hygrothermal unit (100522.0°day%), while lowest hygrothermal unit-II was accumulated by D_3 sowing condition (94968.7°day%).

Photo temperature (T_{photo})

The photo temperature (T_{photo}) significantly influenced by different dates of sowing (Table 8.). The photo temperature was the highest in the D_1 (2968.4^{0}C) followed by D_2 sowing condition (2951.9^{0}C). The lowest photo temperature was taken by D_3 sowing condition (2928.7^{0}C).

Nycto temperature (T_{nycto})

The nycto temperature (T_{nycto}) significantly influenced by different dates of sowing.The nycto temperature was the highest in D_1 sowing conditions (2580.5^{0}C) followed by D_2 sowing condition (2541.2^{0}C). The lowest photo temperature was taken by D_3 sowing condition (2500.9^{0}C).

Inter diurnal temperature (T_{IDR})

The inter diurnal temperature (T_{IDR}) was significantly influenced by different dates of sowing. The inter diurnal temperature was highest in the D_3 sowing (846.8^{0}C) followed by D_2 sowing (815.5^{0}C). The lowest inter diurnal temperature was taken by D_3 (774.9^{0}C) (Table.8).

CONCLUSION

From the above study it is concluded that Agrometeorological parameters i.e. maximum GDD (1874.4 ^{0}C), HGTU- I (159679.6), HGTU- I I (100522), PHT (2968.4), NCT (2580.4) observed by 23rd July and PTU (18885), HTU (12147.9), DNR (846.8) observed by 06 August, while minimum GDD (1814.9), HGTU- I (155445.9), HGTU- I I (94968.7), PHT (2928.7), NCT (2500.9) observed by 06 August and PTU (11575.5), HTU (11629.4), DNR (774.9) observed by 23rd July dates of sowing respectively.

Table 2. Weekly mean weather data during *kharif* crop season 2014 at Allahabad.

Months Week	Dates	Rainfall (mm)	Temperature (^{0}C)		Relative humidity (%)		Eo (hr/day)	SS (hr/day)
			Max.	Min.	Max.	Min.		
July-04	23-29	1.31	33.5	27.14	81	59	3.82	6.57
Aug-01	30-05	18.71	35.05	27.28	85.71	61.71	3.6	3.12
02	06-12	4.54	33.65	27.62	90.42	61.28	3.62	1.85
03	13-19	1.83	34.45	28.05	84.71	57.85	4.05	4.95
04	20-26	0.18	37.94	28.91	81.28	49.57	4.4	7.58
05	27-02	1.16	37.6	29.09	83.28	52	4.4	8.25
Sep-01	03-09	1.15	35.2	26.69	86	53.57	3.88	6.51
02	10-16	2.42	34.82	25.71	86.57	49.71	3.74	6.08
03	17-23	1.77	35.25	26.74	88	47.42	3.52	6.61
04	24-30	NIL	36.88	26.22	84.85	46.57	4.44	7.34
Oct-01	01-07	NIL	35.22	25.02	87	47.42	4.25	7.4
02	08-14	15.65	34.65	24.51	85.28	60.85	3.74	6.51
03	15-21	0.14	32.42	20.78	85.71	53.14	3.57	7.54
04	22-28	NIL	32.45	20.22	86.57	54.28	3.28	8.34
Nov-01	29-04	NIL	33.22	20.28	86.14	47.71	3.02	8.31

Source: Agro-Meteorological Observatory Unit, School of Forestry and Environment, SHIATS, Allahabad.

Table 3. Average temperatures during *kharif* crop season 2014-2015 (A) Maximum temperature (^{0}C/day)

Sowing date	PHENOPHASE									Average
	P1	P2	P3	P4	P5	P6	P7	P8	P9	
D1	34.33	34.76	34.08	37.61	35.20	35.40	35.34	35.90	33.70	35.14
D2	35.30	33.62	36.10	36.55	34.83	35.47	35.93	35.60	32.40	35.08
D3	33.60	34.70	37.80	35.10	35.30	36.80	35.80	32.60	33.00	34.97

[P1 = 3rd leaf stage, P2 = 5th leaf stage, P3 = panicle initiation, P4 = flag leaf visible, P5 = boost stage, P6 = 50% stigma emergence, P7 = milking stage, P8 = dough stage, P9= physical maturity]

Table 4. Temperature (b) Minimum temperature (^{0}C/day)

Sowing date	PHENOPHASE									Average
	P1	P2	P3	P4	P5	P6	P7	P8	P9	
D1	27.17	27.11	27.98	28.93	26.69	24.2	26.80	25.20	23.20	26.40
D2	27.50	27.47	28.33	28.09	25.71	26.93	25.97	25.60	20.60	26.20
D3	27.50	28.10	29.20	26.30	26.70	26.90	25.50	22.00	20.22	25.80

(c) Mean temperature (^{0}C/day)

Sowing date	PHENOPHASE									Average
	P1	P2	P3	P4	P5	P6	P7	P8	P9	
D1	30.20	30.90	31.03	33.27	30.94	29.8	31.07	30.60	28.50	30.70
D2	31.40	30.50	32.22	32.32	30.27	31.20	30.95	36.60	26.50	31.33
D3	30.51	31.40	33.45	30.73	31.00	31.83	30.67	27.30	26.60	30.39

Table 5. Relative humidity-I and Relative humidity-II (a)Maximum relative humidity (%/day)

Sowing Date	PHENOPHASE									Average
	P1	P2	P3	P4	P5	P6	P7	P8	P9	
D1	80.83	86.11	87.33	82.47	86.00	86.00	86.60	86.30	85.50	85.24
D2	85.33	89.78	83.00	84.27	86.57	86.67	86.57	84.40	87.10	85.97
D3	90.20	85.40	81.90	86.20	88.00	84.00	85.40	86.30	86.40	85.98

(b) Minimum relative humidity (%/day)

Sowing Date	PHENOPHASE									Average
	P1	P2	P3	P4	P5	P6	P7	P8	P9	
D1	60.50	60.89	59.42	51.7	53.57	48.00	48.71	45.90	56.10	53.87
D2	60.83	62.00	53.50	52.4	49.71	46.67	46.93	49.60	58.30	53.33
D3	61.66	58.00	50.00	51.73	47.42	48.66	47.28	59.90	51.90	52.95

(c) Mean relative humidity (%/day)

Sowing date	PHENOPHASE									Average
	P1	P2	P3	P4	P5	P6	P7	P8	P9	
D1	70.66	73.50	73.37	67.08	69.78	67.35	67.65	66.10	70.80	69.58
D2	73.08	75.89	68.25	68.33	68.14	66.67	66.75	67.00	72.70	69.65
D3	75.93	71.70	65.95	68.96	67.71	66.33	66.34	73.10	69.15	69.46

Table 6. Mean Received rainfall (mm/day)

Sowing date	PHENOPHASE									Average
	P1	P2	P3	P4	P5	P6	P7	P8	P9	
D1	0.63	15.4	3.26	0.68	1.22	2.51	1.55	NIL	NIL	2.8
D2	18.6	5.68	1.07	1.23	3.65	2.06	NIL	NIL	NIL	3.58
D3	4.96	1.64	0.1	1.4	3.1	NIL	NIL	NIL	18.26	3.27

Table 7. Mean Active evaporation (hr/day)

Sowing date	PHENOPHASE									Average
	P1	P2	P3	P4	P5	P6	P7	P8	P9	
D1	3.83	3.57	3.89	4.37	3.85	3.8	3.63	3.62	4.3	3.87
D2	3.63	2.46	4.24	4.12	3.7	3.61	4.08	4.32	4.13	3.81
D3	1.8	4.08	4.4	3.8	3.57	4.08	4.32	3.97	3.46	3.72

Table 8. Effect of dates of sowing on various Agrometeorological indices to reach maturity stage in pearl millet crop during crop *kharif* season 2014.

Date	THERMAL AND PHOTOTHERMAL							
	GDD	PTU	HTU	HGTU-1	HGTU-2	PHT	NCT	DNR
D1	1874.4	11575.5	11629.4	159679.6	100522.0	2968.4	2580.5	774.9
D2	1846.5	18854.8	11657.3	158131.6	98417.7	2951.9	2541.2	815.5
D3	1814.9	18885.2	12147.9	155445.9	94968.7	2928.7	2500.9	846.8
MEAN	1845.2	16438.5	11811.5	157752.3	97969.4	2949.6	2540.8	812.4
F -test	s	s	s	s	s	s	s	s
S.D.	29.76	4211.50	70.14	2142.17	2803.65	19.940	39.80	36.05

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