Forage Res., **50**(2) : pp. 183-188 (2024) **http://forageresearch.in**

STUDY IMPACT OF WEATHER ENTITIES ON PEARL MILLET GROWTH UNDER SEMI-ARID CONDITION

ANIL KUMAR*, C. S. DAGAR, AMBIKA AND M. L. KHICHAR

Department of Agricultural Meteorology,
CCS Haryana Agricultural University, Hisar-125 004 (Haryana), India
**(e-mail : anilmeteo@gmail.com)*

(Received: 26 June 2024; Accepted: 24 September 2024)

SUMMARY

An experiment was conducted under rainfed condition at Hisar, Haryana to study the influence of various agro-meteorological parameters (Agromet) *i.e.* temperature (Maximum & minimum), rainfall (mm), soil temperature (°C), radiation ($MJm^{-1}day^{-1}$), photosynthetically active radiation (PAR) in pearl millet. The research covers critical growing environments months of June, July and followed by 1 week of August (only in D3: 7 August 2021, late sown) in a semi-arid region, providing insights into how these factors interact and affect pearl millet development. The prevailing micrometeorological conditions within the canopy, wind speed (km/hr) and cloudiness on the growth and yield of pearl millet were impacted as the diurnal based. Results indicate that optimal growth is associated with specific ranges of rainfall, air temperature, soil temperature & moisture, and radiation components levels. On a rainy-day rainfall in the crop field reached a soil depth of 4.5 to 6 cm when a single day received ±2.5 millimetres of rainfall. The pearl millet crop was influenced as an average 12 rainy day and 9 crop rainy day required to complete the life cycle. An average ~49% deviation of rainfall over the normal was good and successfully harvested the pearl millet, in the positive %deviation of rainfall was negative or altered influenced to the third growing environment in this region. The grain and straw yield showed negative significant correlation with morning relative humidity.

Key words: Pearl millet, weather entities, semi-arid region, temperature, rainfall, crop yield

Pearl millet (*Pennisetum glaucum*) is a staple crop in semi-arid regions due to its resilience to harsh weather conditions. It is mainly grown in *kharif* season to meet the grain, green fodder as well as dry fodder requirement of the livestock in areas characterized by low rainfall, high temperature, drought and low soil fertility (Sheoran *et al*., 2016). Understanding the relationship between agro-meteorological parameters (Sharma *et al.,* 2019) and the growth of pearl millet is crucial for optimizing agricultural practices and improving yields (Siddig *et al*., 2013). Study focuses on the semi-arid region of Hisar, Haryana, examining how temperature, rainfall, soil temperature, radiation, photosynthetically active radiation (PAR), micrometeorological conditions within the canopy (Jarwal *et al*., 1990), wind direction and speed, and cloudiness impact pearl millet during its critical growing period in June and July (Ong, 1983). The study aims to enhance understanding and guide future agricultural practices in similar climatic conditions in semi-arid condition especially on rainfed situation (Burroughs, 2003; Maurya *et al*. (2016). It is generally grown as a rainfed crops in arid and semi-arid regions of the world. It ranks as a sixth most important cereal crop grown in world followed by rice, wheat, maize, barley and sorghum (Satpal *et al*., 2018). Singh *et al*. (2017) studied that the precipitation had a positive effect on most crops, while temperature had a negative effect.

Influence the weather parameters of pearl millet

Different agro-meteorological parameters affect pearl millet growth in semi-arid regions. By understanding these relationships, farmers and agricultural practitioners can better manage their practices to enhance crop yields (Siddig *et al*., 2013). Agro-meteorological parameters plays crucial role in the growth and yield of pearl millet in semi-arid regions (Kingra *et. al.*, 2004). The findings align with previous research but also highlight specific conditions unique to Hisar for instance, the interaction between high temperatures and soil moisture was found to be critical for optimal growth (Joshi *et al*., 1997). Pearl millet is highly adaptable to diverse climatic conditions, but its growth and yield are significantly influenced by specific meteorological factors and growing environments (Bashir *et al.,* 2015; Maurya *et al*., (2016). Studies

have shown that temperature fluctuations, soil moisture levels (Niwas *et. al*., 2006), and solar radiation play pivotal roles in determining the productivity of pearl millet (Mahalakshmi *et. al*., 1988). However, comprehensive research focusing on the interaction of these parameters in semi-arid regions like Hisar remains limited. This literature review synthesizes existing knowledge and identifies gaps that this study aims to address.

MATERIALS AND METHODS

Study Area: The field experiment was conducted at Research farm of Department of Agricultural Meteorology, CCS HAU, Hisar, Haryana, India in kharif seasons (of 2019-2023), located at latitude 29º 10' N, longitude 75º 46' E with an altitude of 215.2 m over the mean sea level. The location lies under the eastern agroclimatic zone of Haryana under which comprises the ten district of Haryana state. In the summer (May-June month) observed the heat wave condition or severe heat wave and this region is fall under the semi-arid climate type with hot summers and temperature exceed to >45°C in the month of May and June.

Data Collection, design and data analysis: Agro-Meteorological data for June, July and September were collected from adjacent Agromet Observatory, CCS HAU, Hisar, including temperature (°C), rainfall (mm), soil temperature(°C), radiation ($MJm^{-2}day^{-1}$), PAR ($MJm^{-2}day^{-1}$), wind direction(degree) and speed (km/hr). Experimental Design and Data Analysis of pearlmillet under semi-arid condition of Hisar, Haryana. Pearl millet was cultivated under controlled conditions to monitor the effects of the collected meteorological parameters.

Online line data analysis of the experiment: Statistical design and tools opstat.pythonanywhere.com (under development the new platform) was analysed online at (http://192.168.2.174/opstat/twofactor.html?flavor). Further other yield and yield parameters was analysed to countrification of the relationship between meteorological parameters and pearl millet growth, yield and yield attribute under the different growing environments.

RESULTS AND DISCUSSION

The pearlmillet experiments was conducted under the rainfed condition and only depends upon rainfall received during the month of July to September. An average day was taking to completed the physiological maturity D1: 70, D2: 68 and D3:65 day, respectively. The three varieties were used to conducted the experiment V1: GHB 558 (national check), HHB 67 Imp & HHB 272 of our university release varieties, depicted in the Table 1.

Climatic conditions of experimental location

The Hisar climate is mainly characterized by its continental location and situated in the sub-tropical and semi-arid climatic zone of India. It lies on the margins of the monsoon region and an average onset of South West Monsoon 27 June to 1st July and withdrawal 25 to 30th September. Bajra cultivated under the S.W. Monsson rainfall. The rainfall is low and erratic in this region, south-westerly wind prevailing during monsoon season brings rain from 1st week of July to mid-September (Fig 1a to 1e). During crop season, the maximum temperature of above 44 °C (Fig. 1b) and other hand minimum temperature was varied 22 to 30°C and not observe <21.5 °C (Fig 1a to 1e). Moreover, fluctuations of the extreme temperature may occur mostly within a very short-time interval during the crop season. An average rainfall was received from 2019: 2446, 2020:275, 2021:662.1, 2022:548 & 2023 138.1 mm (Fig. 1a to 1e), which is mostly received during vegetative phases of crops from south-west monsoon season.

Weather conditions during the pearl millet growing seasons

Kharif 2019 to 2023, variable weather was observed during life cycle of pearl millet crop. In the 2019, there was two spells of rainfall 83 mm & 77.0 mm amount, the results shown in the Fig. 1a & 2020 (123 mm), rainfall (Fig. 1b) received, both (2019 & 2020), the years were not received the extreme rain. The September 2022 month received 428.2 mm rainfall which kept the field in saturated condition during the month. During 23-25 Sep, 2022 which proved detrimental to the pearl millet crop particularly the late sowing (D3, sown on 7th Aug). The heavy rain spell leads to the stagnation of water and create submerged condition. At that time, first sowing (D1, 15th July) was at its physiological maturity stage (HHB 67 improved and HHB 272) and dough stage (GHB 558), second sowing date (D2, 23rd July) was at milking stage (GHB 558) and dough stage (HHB 67 improved & HHB 272). The third sowing date (D3) completely damaged when it was at flag leaf (GHB 558) and

TABLE 1
Number of year experiment and data used under this study (2019-2023)

S. No.	Year of experiment	Growing environments/ Actual date of sown	Physiological maturity (days)	Verities (National/ university)	Remarks
1.	2019	3 (three)			
		D1: 5 July 2019	D1: 63.8	V1: GHB 558	Cultivated the pearl millet on Rainfall condition only, no irrigation applied during the life cycle of crop, in respective years of experiments (in semi-arid region)
		D2: 18 July 2019	D2: 65.4	V2: HHB 67 Imp	
		D3: 31 July 2019	D3:64.7	V3: HHB 272	
2.	2020	3 (three)			
		D1: 30 June 2020	D1: 67.3	V1: GHB 558	
		D2: 10 July 2020	D2: 64.0	V2: HHB 67 Imp	
		D3:30 July 2020	D3:62.5	V3: HHB 272	
3.	2021	3 (three)			
		D1: 15 July 2021	D1: 70	V1: GHB 558	
		D2: 23 July 2021	D2: 67	V2: HHB 67 Imp	
		D3: 07 August 2021	D3: --	V3: HHB 272	
4.	2022	3 (three)			
		D1: 24 June 2022	D1: 75.2	V1: GHB 558	
		D2: 18 July 2022	D2: 70.2	V2: HHB 67 Imp	
		D3: 02 August 2022	D3: --	V3: HHB 272	
5	2023	3 (three)			
		D1: 30 June 2023	D1: 72	V1: GHB 558	
		D2: 13 July 2023	D2: 71	V2: HHB 67 Imp	
		D3: 27 July 2023	D3:67	V3: HHB 272	

booting stage (HHB 67 improved & HHB 272 and data could not be recorded thereafter. Fig 1c shows the weather conditions prevailed during crop growing season. During *kharif* 2022, The September 2022 month received 192.0 mm rainfall which kept the field in saturated condition during the month. Fig. 1d shows the weather conditions prevailed during crop growing season (*kharif* 2022). D2 (18th July) and D3 (10th Aug) crops received heavy rainfall during the last phase of crop and recorded 190.8 mm of rainfall during 21-25 Sept., 2022 which proved detrimental particularly to D3 sown crop. 8th August (D3) sown crop was completely damaged when it was at 50% flowering stage due to heavy rainfall. During *kharif* 2023, the monsoon onset was early and took place on 24th June. The July month received good amount of rainfall (107.3 mm) whereas, the August month received only 16.6 mm rainfall. The crop experienced monsoon breaks of 25 days from 23rd Aug 2023 to 17th Sep 2023 which adversely affected the D3 crop particularly as the crop face moisture stress from flag leaf to milking stage depicted in the Fig. 1e.

Total rainfall during July to Sept (mm) crop season under respective growing environments was received (Table 2). The long period average compared with the actual amount of rainfall received during the respective growing environments of pearl millet crop (Table 2). During the pearl millet cultivation, the mean rainfall (2019-2023) crop season was 374, standard deviation (221) and percentage coefficient of variation 59, respective experimental year. On a rainy day (RD), the rainfall in the crop field reached a soil depth of 4.5 to 6 cm when a single day received ±2.5 millimetres of rainfall.

The average number of rainy days was 14 (Table 2). Crop rainy day (CRD): In the crop field, the rainfall amount of water reached a soil depth of approximately 9-10 cm when a single day received ±5.0 millimetres of rainfall. The average total number of rainy days was 11 during the respective year of the experiment (Table 2). An average ~49% deviation of rainfall over the normal was analysed and it noticed the successfully cultivation of pearlmillet, but positive %deviation of rainfall over the normal was impacted to the third growing environment in this region (Table 2). The pearl millet crop was influenced as an average 12 rainy day and 9 crop rainy day required to complete the life cycle.

In Table 3, the results show that the pearl millet crop was received varying amounts of rainfall to complete its life cycle in different years. The amount of rainfall varied among the years, with the month of September (especially 2021 & 2022) received excess amount of rainfall, which was not needed to the

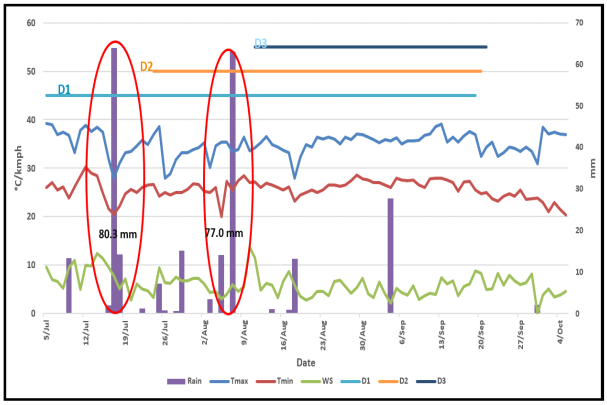

Fig. 1a: Weather conditions during the pearl millet growing season 2019.

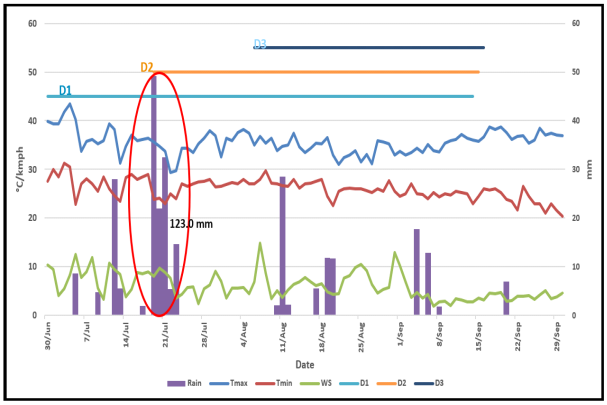

Fig. 1b: Weather conditions during the pearl millet growing season 2020.

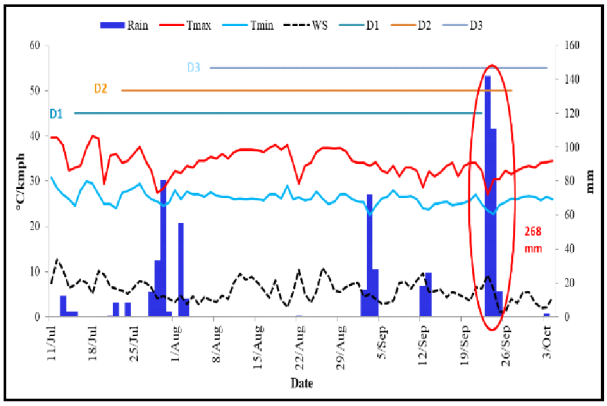

Fig. 1c: Weather conditions during the pearl millet growing season 2021.

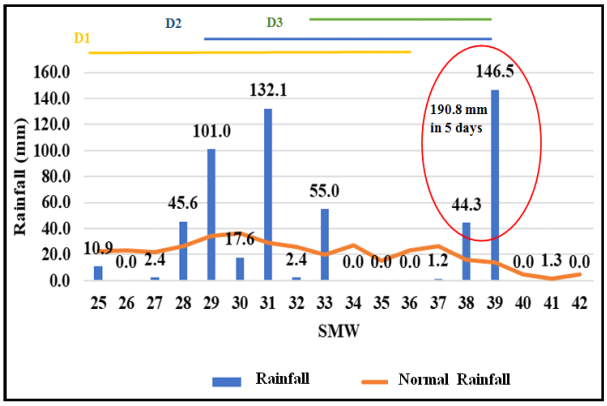

Fig. 1d: Weather conditions during the pearl millet growing season 2022.

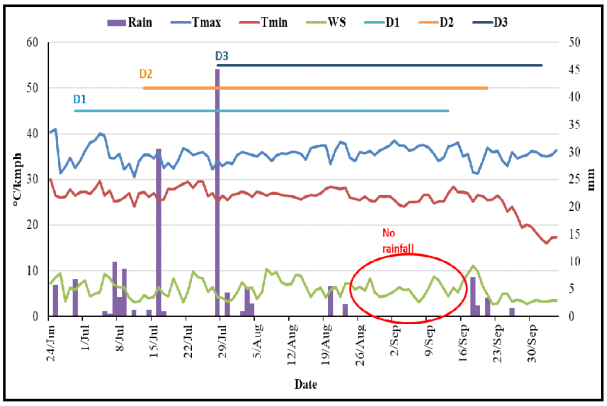

Fig. 1e: Weather conditions during the pearl millet growing season 2023.

Fig. 1 (a to d): Prevailing weather condition (2019-2023) under different growing environment of Pearl millet.

pearlmillet crop. This excessive rainfall in September impacted the crop in the 2nd and 3rd third growing environment (2021 & 2022). The below the normal and well distributed rainfall was favoured to the growth and development of pearl millet and positive % deviation over the normal were reported the negative effect to the pearl millet crop (Table 3).

Relationship of yield with weather parameters

The correlation studies between yield of pearl millet with weather parameters (Table 4). The sunshine hours showed significant positive correlation with grain yield (0.96) whereas, RHe showed negative correlation with grain yield (0.84). The correlation of pearl millet

TABLE 2
Different growing environments received rainfall (mm) to complete the life cycle

Years	Different growing environment			July to September (three month) rainy season at Hisar				
	D1: 1st	D2: 2nd	D3: 3rd	RD	CRD	RF_c	N_1L	N_2R
2019	244.6 (-25.5)	165.2 (-49.7)	126 (-61.6)	10	4	244.6	317.7 (-23.0)	328.3 (-25.5)
2020	274.4 (-16.4)	260.9 (-20.5)	101.5 (-69.1)	16	16	275.0	317.7 (-13.0)	328.3 (-16.2)
2021	646.6 (97.0)	364.6 (11.1)	428.7 (30.6)	19	17	662.1	317.7 (108.4)	328.3 (101.7)
2022	548.1 (67.0)	479.6 (46.1)	258.8 (21.2)	14	13	548	317.7 (72.5)	328.3 (66.9)
2023	138.1 (-57.9)	113.1 (-65.5)	80.4 (-75.5)	10	7	138.1	317.7 (-56.5)	328.3 (-57.9)
Mean	370	277	199	14	11	374	-	-
Std.	216	149	146	4	6	221	-	-
CV%	58	54	73	28	50	59	-	-

Whereas: Number of rainy day/RD (nos.) Number of crop rainy day/CRD (nos.), Total rain received/ crop season rainfall/RFc (mm), N1L: Normal rainfall (mm) (1972-2022), N2R: Normal rainfall (mm) (1993-2022)
Parenthesis given the percentage of deviation over the normal (30 year of normal rainfall) during crop season (July to September month @ Hisar; Rainy day: if ±2.5 mm of rainfall received in a day; Remarks: 1993-2022 LPA was considered for the computation of rainfall received under different growing environment of season.

TABLE 3
Amount of rainfall (mm) distribution under different growing environments of pearlmillet in crop season (July, August, September)

Year	Rainfall (mm) distribution (three month) under the different growing environments (D1, D2, D3) of pearlmillet crop								
	D1: 1st growing environment			D2: 2nd growing environment			D3: 3rd growing environment		
	July	August	Sept	July	August	Sept	July	August	Sept
2019	120.4	96.1	29.9	39.2	126	29.9	0.0	96.1	29.9
2020	172.9	62	39.5	172.9	62	39.5	0.0	62	39.5
2021	167.2	66.7	428.2	151.7	66.7	428.2	-	0.5	428.2
2022	225.6	130.5	192	225.6	130.5	192	-	66.8	192
2023	107.3	107.3	107.3	82.3	16.6	14.2	50.6	16.6	14.2
Mean	158.7	92.5	159.4	134.3	80.4	140.8	16.9	48.4	140.8
Std.	47.1	28.6	163.7	74.0	47.9	175.9	29.2	39.1	175.9
CV%	29.7	30.9	102.7	55.0	59.6	125.0	173.2	80.7	125.0

TABLE 4
Correlation coefficients of yield with weather parameters (2019-2022)

Yield	Weather parameters						
	Tmax	Tmin	RHm	RHe	WS	SSH	RF
Grain yield	0.76	0.64	0.75	-0.84*	0.50	0.96**	0.76
Stover Yield	0.77	0.66	0.76	-0.84*	0.53	0.89*	0.78
Biological yield	0.77	0.66	0.76	-0.85*	0.53	0.92**	0.78

Tmax- maximum temperature (°C), Tmin-minimum temperature (°C), RHm & RHe-morning and evening relative humidity (%), WS-wind speed (km/hr), BSH- bright sunshine hours (hr.), RF- rainfall (mm)
*Significant at 0.05 p level, ** Significant at 0.01p level.

TABLE 5
Correlation of pooled of weather parameters and yield of Pearl millet (2016-2022)

Weather parameters	Grain yield	Straw yield
Tmax	0.15	0.45
Tmin	0.43	0.28
RHm	-0.68*	-0.89*
Rhe	0.04	-0.50
WS	0.32	0.11
BSH	-0.50	0.08
Rain	0.17	0.19

Tmax- maximum temperature (°C), Tmin-minimum temperature (°C), RHm & RHe-morning and evening relative humidity (%), WS- wind speed (km/hr), BSH- bright sunshine hours (hr.), RF-rainfall (mm); *Values are significant at 0.05 probability level (n=24)

stover yield and biological yield with weather parameters has shown the correlation trend similar to grain yield.

Correlation studies between weather parameters and yield of pearl millet (2016 to 2022): Correlation studies between pooled of weather parameters and yield of pearl millet (Table 5). The grain and straw yield showed negative significant correlation with morning relative humidity.

CONCLUSION

The analysis revealed that pearl millet growth was significantly influenced by adequate rainfall in last week of June and July led to better soil moisture and higher yields but month of September (rainfall amount excess over the normal), got the negative effect on pearl millet. Ideal soil temperatures ranged from 28.8 °C to 36.6 °C July and August month up to 5 cm of soil depth, which favouring the growth of crop at Hisar condition. The <3.5 km/hr wind was not influenced, toward the logging of pearl millet at flowering to dough stage. Moderate (2.8 to 3.2 km/h) wind speeds facilitated better air circulation (momentum), zero plan displacement and reduced disease-pest incidence. Sunshine hours showed significant positive correlation with grain yield. An excess rainfall in September (%deviation over the normal) impacted the crop in the 2nd and 3rd third growing environments (2021 & 2022). Normal and well distributed rainfall was favoured to the growth and development of pearl millet and positive % deviation over the normal were reported the negative effect and an average ~49% deviation of rainfall over the normal was successfully cultivated the pearl millet in this region. The impact of cloudiness on reducing radiation and affecting photosynthesis was also more pronounced in semi-arid, than in other regions.

REFERENCES

Bashir, M.M.H., S.O. Yagoub, and Ahmed S.A. Mohammed, 2015 : Effect of different sowing dates on growth and yield of three pearl millet (*Pennisetum glaucum* (L.) R. Br.) cultivars in west Darfur Sudan. *International Journal of plant and soil science*, **5**(4): 191-200.

Burroughs, W. and W.S. Burroughs, eds., 2003. Climate: Into the 21st century. Cambridge University Press.

Jarwal, S.D. and P. Singh and S.M. Virmani, 1990 : Influence of planting geometry on PAR interception and dry matter production relationships in pearl millet. *Biomass*, **21**(4): 273-284.

Joshi, A.K., J.N. Pandya, R.K. Madhukia, K.V. Pethani, and H.R. Dave, 1997 : Seed germination in pearl millet hybrids and parents under extreme temperature condition. *GAU Research Journal*. **23**(1): 77-83.

Kingra, P. K., P. Kaur, M. K. Khera and S. S. Hundal, 2007 : Thermal requirement and heat use efficiency of sunflower (*Helianthus annus* L.) in Punjab. *J. Agrometeorol.,* **9**(2): 223-230.

Mahalakshmi, V., F.R. Bidinger and G.D.P. Rao., 1988 : Timing and intensity of water deficits during flowering and grain filling in pearl millet. *Agronomy Journal*, **80**:130-135.

Maurya, S.K., Nath, S., Patra, S.S. and Rout, S., 2016. Effect of different sowing date on growth and yield of pearl millet *Pennisetum glaucum* varieties on the Allahabad condition. *International Journal of Science and nature,* **7**(1): 62-69.

Niwas, R., S. Singh, D. Singh, M.L. Khichar and R. Singh, 2006 : A text book on agricultural meteorology. Department of Agricultural Meteorology, College of Agriculture, CCS HAU, Hisar. pp. 141.

Ong, C.K., 1983 : Response to temperature in a stand of pearl millet (*Pennisetum typhodies* S. & H.) 1. Vegetative development. *Journal of experimental botany*, **34**: 322-336.

Satpal, J. Tokas, K. K. Bhardwaj, A. Kumar and S. Ravi Kumar, 2018 : Potential productivity and radiation use efficiency of multi-cut forage Sorghum [*Sorghum bicolor* (L.) Moench] genotypes. *J. Agrometeorol.,* **20**(1SI): 307-310.

Sharma, S., A.K. Yadav, Satyavan, A. Kumar, D.V. Yadav, and R. Pathania, 2019 : Performance of pearl millet (*Pennisetum glaucum* L.) hybrids and their parents (B and R - lines) under rainfed & irrigated situations. *J. Agrometeorol.,* **21**(1SI): 42-55.

Sheoran, R.S., Satpal, U.N. Joshi, B.S. Duhan and S. Arya, 2016 : Response of forage pearl millet (*Pennisetum glaucum* L.) genotypes to different nitrogen levels. *Forage Res.,* **42**(2): 115-118.

Singh, R., G. Devi, D.J. Parmar and S. Mishra, 2017 : Impact of rainfall and temperature on yield of major crop in Gujarat state of India: A Panel data analysis (1980-2011). *Current journal of Applied Science and Technology*, **24**(5): 1-9.