Journal of Agrometeorology

ISSN : 0972-1665 (print), 2583-2980 (online)
Vol. No. 26 (2) : 257 - 260 (June - 2024)
https://doi.org/10.54386/jam.v26i2.2293
https://journal.agrimetassociation.org/index.php/jam

Short Communication

Crop-weather relationship of finger millet varieties under varying environments at Keonjhar, Odisha

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Finger millet, scientifically known as *Eleusine Coracana*, Poaceae family and is often referred to as mandua or ragi in India. The cultivation of finger millet in India spans an area of around 1.19 million hectares, resulting in an output of 1.98 million metric tons and a productivity rate of 1661 kg per hectare (Padmaja *et al*., 2021). In Odisha, the annual production of finger millet is 30,910 metric tons over 55,000 ha areas, with a productivity rate of 5.62 quintals per hectare (Sial *et al*., 2022). The adaptability, durability, and greater yields of Odisha's agricultural practices make it popular among tribal people and farmers, particularly on marginal soils without irrigation. The optimal conditions for the crop occur in regions with an annual precipitation range of 700-1200 mm. The crop is not tolerant of excessive rainfall during the grain ripening stages. It thrives in dry conditions and is well-suited for elevations ranging from 1000 to 2000 meters, with an average temperature of 27^{0}C. Finger-millet exhibits resilience to three types of stressors: warming stress, water stress, and nutrition stress. This remarkable ability qualifies it as a Climate Change Compliant Crop (CCCC). Agrometeorological information like the maximum and minimum temperature, rainfall, humidity, daylight hours, wind speed, and other environmental conditions regulate most plant biological functions like photosynthesis, respiration, and transpiration. Sowing timing is a major non-monetary crop yield factor. The best period to cultivate crops provides a suitable environment during all phenophases. Timely crop sowing produces healthy, strong plants that maximize yield (Bashir *et al*., 2015). Heat units above the basic temperature accumulate during crop growth from sowing to maturity. Quantified heat units are needed to reach a phenophase (Pradhan *et al*., 2018).

A field experiment was conducted at Experimental Block, Regional Research and Technology Transfer Station, Keonjhar, Odisha, India during the Kharif season for two consecutive years i.e. 2020 and 2021 to find the Crop and weather relationship of Finger millet varieties under various dates of sowing in North Central Plateau Zone of Odisha. The field experiment was laid out in split plot design with three replications and two factors, the first one being the dates of sowing (Factor A) and the second one is varieties (Factor B). There were 4 dates of sowing in Factor A (D_1-20 June, D_2-30 June, D_3- 10 July , D_4- 20 July) and 3 varieties in factor B (V_1-Bhairabi , V_2-Arjuna and V_3- Kalua. Altogether there were 12 treatment combinations. All the recommended packages and practices were followed. The crop was harvested after reaching maturity in accordance with the varieties time frame, when more than 50% of the plants' ear heads and straw had become brownish in colour. From the net plot of each treatment, the straw and ear heads were separately harvested. Ears were harvested manually. The grain was separated from ears by winnowing then weights were separately recorded.

The crop duration of ragi was divided into six phenophases; P_1- Sowing to germination, P_2- Germination to vegetative stage, P_3- Vegetative stage to flowering stage, P_4-Flowering stage to heading stage, P_5- Heading stage to grain filling stage, P_6- Grain filling stage

Article info - DOI: *https://doi.org/10.54386/jam.v26i2.2293*
Received:29 July 2023; Accepted: 05 April 2024; Published online : 1 June 2024

Table 1: Influence of date of sowing and varieties on yield and yield attributes of Finger millet (Pooled data of 2020-2021)

Treatments	Grains per panicle	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
Date of sowing			
D_1(20th June)	1195	1031.6	1229.8
D_2(30th June)	1138	970.9	1181.5
D_3(10th July)	1029	878.4	1100.2
D_4(20th July)	965	820.1	1024.5
S.Em. (±)	41.3	32.39	43.27
CD at 5 %	126.0	99.74	128.33
Varieties			
V_1(Bhairabi)	1268	1031.5	1279.8
V_2(Arjuna)	1011	862.8	1071.6
V_3(Kalua)	988	831.7	1065.5
S.Em. (±)	37.3	31.77	40.21
CD at 5 %	148.2	107.52	154.89
Interaction			
S.Em. (±)	67.4	60.16	79.74
CD at 5 %	NS	NS	NS

Table 2: Correlation coefficient between seed yield and weather parameters variables of cultivars of finger millet

	Correlation coefficient					
Parameters	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**
V_1(Bhairabi)						
Rainfall	-0.648**	0.878**	0.707**	-0.789**	0.986**	….
Rainy Days	-0.671**	0.934**	0.726**	-0.968**	0.968**	….
Max Temp	0.984**	-0.906**	-0.548*	-0.985**	-0.942**	0.973**
Min Temp	0.843**	0.717**	0.997**	-0.084	0.976**	0.984**
RH-I	-0.896**	0.944**	-0.392	0.691**	0.997**	0.965**
RH-II	-0.843**	0.932**	0.943**	0.877**	0.997**	-0.754**
Evp	0.942**	-0.883**	-0.991**	-0.777**	-0.975**	0.961**
BSS	0.713**	-0.865**	-0.997**	-0.101	-0.931**	-0.966**
Wind Speed	-0.299	-0.725**	0.855**	0.983**	0.678**	-0.066
V_2(Arjuna)						
Rainfall	-0787**	0.536*	0.791**	-0.542*	0.901**	….
Rainy Days	-0.463*	0.702**	0.877**	-0.844**	0.842**	….
Max Temp	0.716**	-0.454*	-0.878**	-0.992**	-0.831**	0.964**
Min Temp	0.784**	0.721**	0.714**	0.786**	0.646**	0.660**
RH-I	-0.522*	0.817	-0.206	0.929**	0.963**	0.957**
RH-II	-0.691**	0.622**	0.984**	0.935**	0.957**	-0.294
Evp	0.826**	-0.661**	-0.908**	-0.950**	-0.876**	0.968**
BSS	0.298	-0.383	-0.984**	-0.615**	-0.832**	-0.727**
Wind Speed	-0.827	-0.927**	0.942**	-0.622**	0.801**	0.085
V_3(Kalua)						
Rainfall	-0.762**	0.560**	0.835**	-0.532*	0.879**	….
Rainy Days	-0.417	0.795**	0.937**	-0.791**	0.795**	….
Max Temp	0.844**	-0.473*	-0.881	-0.983**	-0.927**	0.895**
Min Temp	0.691**	0.802**	0.947**	-0.092	0.889**	0.903**
RH-I	-0.661**	0.771**	-0.104	0.726**	0.947**	0.992**
RH-II	-0.696**	0.614**	0.994**	0.932**	0.959**	0.064
Evp	0.832**	-0.642**	-0.899**	-0.984**	-0.887**	0.846**
BSS	0.537*	0.214	0.032	-0.888**	-0.862**	-0.828**
Wind Speed	-0.802**	-0.927**	0.915**	0.211	0.916**	-0.351

*-5% Significant; **-1% Significant; P_1- Sowing to germination, P_2- Germination to vegetative stage, P_3-Vegetative stage to flowering stage, P_4-Flowering stage to heading stage, P_5- Heading stage to grain filling stage, P_6- Grain filling stage to Maturity stage

Table 3: Effect of date of sowing and varieties on Growing Degree Days (GDD) in ^{0}C, Photothermal unit (PTU) in ^{0}C day h and Helio thermal unit (HTU) in ^{0}C day h at different phenophases of Finger millet crop (Pooled data of 2020-2021)

Treatments	P1			P2			P3		
	GDD	PTU	HTU	GDD	PTU	HTU	GDD	PTU	HTU
D_1 (20th June)	123	1545	406	391	5041	1005	1080	13849	3341
D_2 (30th June)	111	1522	576	412	5333	425	1068	13649	4028
D_3 (10th July)	136	1767	430	523	6748	1693	1033	13244	4842
D_4 (20th July)	148	1863	350	532	6821	1854	1016	13040	5270
V_1 (Bhairabi)	153	1981	432	465	5988	1243	1038	13317	4385
V_2 (Arjuna)	108	1399	286	478	6075	1265	1058	13510	4342
V_3 (Kalua)	127	1651	314	461	5896	1220	1053	13518	4374
Treatments	P4			P5			P6		
	GDD	PTU	HTU	GDD	PTU	HTU	GDD	PTU	HTU
D_1(20th June)	399	5255	2836	446	5927	2923	570	7546	5054
D_2(30th June)	415	5495	3030	428	5639	3327	494	6593	4368
D_3(10th July)	420	5570	2674	452	5950	4026	406	5373	3706
D_4(20th July)	458	5965	3681	408	5379	3529	351	4652	3220
V_1(Bhairabi)	421	5549	3103	445	5894	3558	478	6327	4293
V_2(Arjuna)	435	5803	3175	412	5449	3274	445	5834	3959
V_3(Kalua)	405	5356	2892	448	5818	3520	447	5934	4015

GDD : Growing Degree Day, PTU: Photothermal unit, HTU: Helio thermal unit, AGDD: Aggregate Growing Degree Day, APTU: Aggregate Photothermal unit, AHTU: Aggregate Helio thermal unit

to maturity stage. The total amount of rainfall (mean of two years) received during 20th June, 30th June, 10th July and 20th July sowing was 505.2 mm, 475.5 mm, 430 mm, and 398.8 mm respectively. The agrometeorological indices were calculated as follows:

Growing degree days (GDD): The sum of effective temperature (heat) accumulated during the growth of a crop is called the growing degree days. GDD is calculated using Nuttonson (1955) method given as follows:

GDD(days) = ∑[(Max temperature (^{0}C) + Min temperature (^{0}C)) ÷ 2] – Base temperature. Base temperature is 10.0 ^{0}C (Pradhan *et al*., 2018)

Photo thermal units (PTU): Photo thermal units =Growing degree days × day length (Day length was estimated by calculating the sun rise and sun set.

Helio thermal units (HTU): Helio thermal units = Growing degree days × actual sunshine hours.

Yield and yield attributes

Maximum grains per panicle (1195), grain yield (1031.6 kg ha^{-1}) and straw yield (1229.8 kg ha^{-1}) was recorded in the crop sown on 20th June(D_1) (Table 1). 20th June sowing had received the maximum rainfall during its growth period, specifically phenophase P_3 *i.e.* vegetative to flowering had received the highest level of rainfall which might be the probable reason of higher yield and yield attributing characters. The grain yield and straw yield of 20th June (D_1) sowing was at par with 30th June sowing (D_2) (970.9 kg ha^{-1} and 1181.5 kg ha^{-1}) respectively. D_4(20th July) sowing recorded the lowest grains per panicle (965), grain yield (820.1 kg ha^{-1}) and straw yield (1024.5 kg ha^{-1}). Among the different varieties Variety V1 (Bhairabi) recorded the maximum grains per panicle (1268), grain yield (1031.5 kg ha^{-1}) and straw yield (1279.8 kg ha^{-1}) which was statistically superior to the rest of the varieties.

Correlation analysis

Seed yield of all the three varieties Bhairabi, Arjuna and Kalua was negatively correlated with rainfall at phenophases P_1 and P_4 however, it was positively correlated at phenophases P_2,P_3 and P_5.Seed yield was positively correlated with maximum temperature at phenophases P_1 and P_6, with minimum temperature at phenophases P_1, P_2, P_3, , P_5 and P_6, withRH-1 at phenophases P_2, P_4, P_5 and P_6,with RH-2 phenophases P_2, P_3, P_4 and P_5, with evaporation at phenophases P_1 and P_6, with BSS only at phenophase P_1 and with wind speed at phenophases P_3, P_4 and P_5 stage (Table 2).

Growing degree days (GDD)

During the life cycle of the finger millet crop i.e. from phenophase P_1 to P_6 the mean growing degree days of the four sowing dates and 3 cultivars (mean of two years) was 493 ^{0}C day. Taking into account the first date of sowing (20th June), the mean heat unit requirement was 501 ^{0}C day which was followed by D_2 (30th June), D_3 (10th July) and D_4 (20th July) i.e. 488 ^{0}C day, 495 ^{0}C and 485 ^{0}C day respectively. This indicates that there is decrease in the mean heat load with delay in sowing dates of finger millet.

Aggregate growing degree days were maximum in D_1 (20th June) (3011.3 ^{0}C day) in comparison to the rest of the treatments as the mean maximum temperature of the air was more during the growth period of the finger millet crop sown on 20th June. The heat units declined with the advancement in sowing dates. The lowest Growing degree days (2914 ^{0}C day) was observed in 20th July sowing which might be due to the decrease in the temperature during the life cycle of the crops with subsequent sowings. From this it is evident that Growing degree days of Finger millet is affected by the prevailing air temperature during its life cycle. In 20th June sowing phenophase P_3 *i.e.* vegetative to flowering stage recorded the maximum heat units i.e. 1080 ^{0}C day. Among the cultivars the mean heat unit requirement of V_1 (Bhairabi) was the maximum (500 ^{0}Cday) during the life cycle of the crop, followed by V_2 (Arjuna) and V3 (Kalua) i.e., (489 ^{0}C day) and (490 ^{0}Cday) respectively. The difference in the GDD of the different cultivars may be due to the inherent character of the varieties or due to the difference in the maturity dates of the varieties.

Photo thermal unit (PTU)

PTU differed with dates of sowing and crop, daily average temperature and lengths of the day. The average photo thermal unit was 6407 ^{0} C day h which was accumulated during the various dates of sowing, however, the maximum photo thermal unit was observed in 20 June sowing (6527 ^{0}C day h) at all the phenophases which was followed by sowing of finger millet crop on 10th of July (6442 ^{0}C day h). Among the genotypes, the total Photo thermal unit accumulated during the crop growth period was 6509 ^{0}C in Bhairabi, 6345 ^{0}C in Arjuna and 6362 ^{0}C in Kalua (Table 3). Differences in the maturity dates of the different varieties might be the reason for variation in Photo thermal unit accumulated values.

Helio thermal unit (HTU)

Among the four dates of sowing, the number of helio-thermal units accumulated at various phenophases and growth period of finger millet varied with the variation in mean daily air temperature and bright sunshine hours. It is observed that the mean helio-thermal unit was the highest in 20th July sowing (2984^{0}C day h) which was followed by 10th July sowing (2895 ^{0}C day h) and 30th June sowing (2626^{0}C day h) (Table 3). This might be due to the lower air temperature and less bright sunshine hours for a greater number of days prevailing under late sown conditions (Prasad *et. al*., 2017). The lowest Helio thermal unit was recorded with 20th June sowing (2594 ^{0}C day h).

Hence, it can be concluded that the finger millet variety Bhairabi sown early i.e. on 20th June recorded the Maximum grains per panicle, grain yield and straw yield. Also, the crop variety Bhairabi sown on this date performed better in terms of accumulation and utilization of heat units at North Central Plateau Zone of Odisha.

ACKNOWLEDGEMENT

This study was supported by Regional Research and Technology Transfer Station, OUAT, Keonjhar, Odisha

Funding: No Funding

Conflict of Interests The authors declare that there is no conflict of interest related to this article.

Data availability: The data that support the findings of this study are available on request from the corresponding author

Authors Contribution: **M. Ray:** Conceptualization, resources, writing—original draft preparation; **P.K. Roul:** Conceptualization, resources; **A. Baliarsingh:** Formal analysis **S. Ray:** Methodology, data curation, Writing-original draft preparation; **R. K. Tiwari:** Investigation; **P. Kapoor:** Software; **S.Yadav:** Formal analysis; **P. Mishra:** Formal analysis, Writing—Review and editing; All authors have read and agreed to the published version of the manuscript.

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REFERENCES

Bashir, M.M.H., Yagoub, S.O. and Ahmed Mohammed, S. A. (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 J. Pl. Soil Sci*., 5(4):191-200.

Nuttonson, M.Y. (1955). Wheat climate relationship and use phenology in ascertaining the thermal and photothermal requirement of wheat. American Institute of Crop ecology, Washington DC, 388 pp.

Padmaja, Jagati, Indurekha, Mahapatra and Debasmita, Dash (2021). Finger millet (Ragi) as an essential dietary supplement with key health benefits: A review. *Int. J. Home Sci.,* 7(2): 94-100

Pradhan, Adikant, Nag, S.K. and Mukherjee, S.C. (2018). Thermal requirement of small millets in Chhattisgarh plateau under rainfed cropping situation. *J. Agrometeorol*., 20(3): 244-245, https://doi.org/10.54386/jam.v20i3.554

Prasad, S., Agrawal, R. and Prakash, V. (2017). Heat unit requirement of wheat cultivation under varying thermal regimes at Jabalpur. *J. Agrometeorol.,* 19(3):283-285. https://doi.org/10.54386/jam.v19i3.674

Sial, S.K., Swain, S.K., Behera, D., Mohapatra, P.M., Mohapatra, A.K., Dash, A.K., Das, D.M. and Jena, P.P. (2022). Performance evaluation of different methods of Ragi threshing in Odisha (India). *J. Pharm. Innov.* P-11(11): 1582-1585