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Influence of varieties and nitrogen levels on weather health indices of foxtail millet [*Setaria italica* (L.)]

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Abstract
Based on the hypothecation that there are differences in weather health indices among the foxtail millet varieties in response to nitrogen fertilizer, a field experiment was conducted on sandy clay soil of Agricultural College Farm, Bapatla, during *kharif*, 2018 with four foxtail millet varieties (Prasad, Narasimharaya, SiA 3156 and CO-2) and four nitrogen levels (0, 20, 40 and 60 kg N ha^{-1}). Results indicated that the variety CO-2 accumulated the highest GDD, HTU and PTU, while variety Prasad accumulated the highest HUE, HtUE and PtUE for both grain and stover yields. The highest GDD, HTU, PTU and HUE, HtUE and PtUE for both grain and stover yields were recorded with 60 kg N ha^{-1} application.

Keywords: Foxtail millet, varieties, nitrogen levels, GDD, HTU, PTU, HUE, HtUE and PtUE, grain yield, stover yield

Introduction
Foxtail millet, highly nutritious with diverse usage, locally known as *korra* and also known as Italian millet, is one of the traditional crops of dryland farming and well equipped with climate resilient characters which is grown for both food and feed. It aids and confronts the people of arid and semi-arid regions in making sound and stable management under increasing evidence of low seasonal rainfall, increase in temperature and frequent occurrence of extreme weather conditions. They are the poor man's food particularly in the dry regions of the world.
The optimum nitrogen level and selection of high yielding cultivars play an exceptional role in realizing the genetic yield potential of foxtail millet under particular geographical conditions. Nitrogen level not only determines the crop phenological development but also the effective biomass conversion. The pertinent date and time of a particular crop development process can be estimated with crop phenology and is considered as an essential component of crop growth and yield (Nandini and Sridhara, 2019) [7].
Duration of each crop growth stage could be directly influenced with temperature and could be determined with sum of daily air temperature (Anand Kumar *et al.*, 2017) [1]. Bishoni *et al.* (1995) [3] reported that the temperature is an important weather factor that could directly influence the crop growth, development, phenology and yield. So, it becomes indispensable to have sound knowledge on exact duration of different crop phenological stages growing in a particular environment and its impact on crop yields.
Cultivation of suitable foxtail millet varieties under optimum nitrogen level is necessary for realizing its optimum genetic yield potential. No nitrogen application results in early crop maturity but shows negative impact on yield when compared to optimum nitrogen application which not only enhances crop growth duration but also brings an opportunity to accumulate more biomass. Hence, a field experiment was carried to determine the phenology, heat units and heat efficiencies required for different foxtail millet varieties under different nitrogen levels.

Material and methods
An experiment was conducted with four foxtail millet varieties *viz.*, Prasad (V_1), Narasimharaya (V_2), SiA 3156 (V_3) and CO-2 (V_4) and four nitrogen levels *viz.*, 0 kg N ha^{-1} (N_1), 20 kg ha^{-1} (N_2), 40 kg ha^{-1} (N_3) and 60 kg ha^{-1} (N_4) which was replicated thrice. It was carried out on sandy clay soils of Agricultural College Farm, Bapatla during *kharif*, 2018

and the soil was neutral in soil reaction, very low in available nitrogen and medium in organic carbon and available phosphorus, very high in available potassium. The experiment was laid out in randomized block design with factorial concept. The crop was sown at 30 cm and 10 cm inter and intra row distance, respectively and adopted all the standard package of practices. The entire dose of phosphorus@ 20 kg ha^{-1} was applied uniformly to all plots as basal. The scheduled nitrogen was applied in two equal splits as per the treatments *viz.*, half as basal and remaining half as top dressing at 30 DAS. A total of 187.2 mm rainfall was received in 14 rainy days during the crop growth period. The weather data on growing degree days (GDD), helio thermal units (HTU), photo thermal units (PTU), heat use efficiency (HUE), helio thermal use efficiency (HtUE) and photo thermal use efficiency (PtUE) were recorded as per standard statistical procedures. The data was analyzed by following the analysis of variance (ANOVA) for randomized block design with factorial concept as suggested by Panse and Sukhatme (1985) [10].

Weather health indices

These indices, which give a better meaning and full conclusion on the growth, development and yield of the crop, were computed from the direct weather parameters. The following derived weather parameters were computed for total crop duration by adding the values of vegetative, reproductive and maturity stages.

1. Growing degree days (GDD)

The temperature below which no growth takes place is base temperature and varies with crop. This is generally high for tropical crops and low for temperate crops. Growing degree days had been computed with the accumulation of daily mean temperature above the base temperature by considering 10°C as base temperature for foxtail millet (Anderson, 1994) [2]. Growing degree days were computed from sowing to harvesting by using the following formula (Iwata, 1984) [5] and expressed as ^{0}C day.

$$\text{Growing Degree Days (GDD)} = \sum \frac{T_{max} + T_{min}}{2} - T_b$$

Where,
T_{max} = Maximum Temperature,
T_{min} = Minimum Temperature,
T_b = Base temperature

2. Helio Thermal Units (HTU)

Helio Thermal Units (HTU) were computed by multiplying GDD with bright sunshine hours which were measured daily with the help of Campbell – Stokes Sunshine Recorder and were expressed as ^{0}C day hour. HTU were computed with the following formula which was given by Rajput (1980) [14].

$$\text{Helio Thermal Units (HTU)} = \sum (\text{GDD} \times \text{Bright Sunshine Hours})$$

Where,
GDD = Growing Degree Days

3. Photo Thermal Units (PTU)

Nuttonson (1956) [9] used Photo Thermal Units (PTU) concept in climatic analogue studies for improving GDD concept by applying day length factor. PTU was computed with the following formula and was expressed as ^{0}C day hour.

$$\text{Photo Thermal Units (PTU)} = \sum (\text{GDD} \times \text{Day length})$$

Where,
GDD = Growing Degree Days

4. Heat Use Efficiency (HUE) (kg ha^{-1} $^0C^{-1}$ day^{-1})

Heat use efficiency is the yield per day ^{0}C on growing day concept or yield per unit of day ^{0}C hours on helio thermal units which indicate the efficiency of the available heat utilized for grain yields. HUE was computed with the following formula which was given by Haider *et al.* (2003) [4] and was expressed as kg ha^{-1} $^0C^{-1}$ day^{-1}.

$$\text{Heat Use Efficiency (HUE)} = \frac{\text{Total dry matter or seed yield (kg ha}^{-1})}{\text{Accumuated heat units (°C day)}}$$

5. Helio Thermal Use Efficiency (HtUE) (kg ha^{-1} $^0C^{-1}$ day^{-1} hour)

Helio Thermal Use Efficiency is the total drymatter yield per hours ^{0}C on growing day concept or per unit of ^{0}C day hours on helio thermal units which indicate the efficiency of available sunshine hours utilized for drymatter yields. It was computed with the following formula which was given by Rajput (1980) [14] and was expressed as kg ha^{-1} $^0C^{-1}$ day^{-1} hour.

$$\text{HtUE} = \frac{\text{Total drymatter or seed yield (kg ha}^{-1})}{\text{Helio thermal units (HTU)}}$$

6. Photo Thermal Use Efficiency (PtUE) (kg ha^{-1} $^0C^{-1}$ day^{-1} hour)

Photo Thermal Use Efficiency is the total drymatter yield per hour ^{0}C on growing day concept or per unit of ^{0}C day hours on photo thermal units which indicate the efficiency of available day length utilized for drymatter yields. It was computed with the following formula which was given by Rajput (1980) [14] and was expressed as kg ha^{-1} $^0C^{-1}$ day^{-1} hour.

$$\text{PtUE} = \frac{\text{Total dry matter or Seed yield (kg ha}^{-1})}{\text{Photo Thermal Units (PTU)}}$$

Where,
PtUE = Photo Thermal Use Efficiency

Results and discussion

Growing degree days

For completion of total crop duration of different varieties, total GDD of CO-2 (1648°C) was found to be significantly superior over the remaining varieties *i.e.,* SiA 3156, Narasimharaya and Prasad. The least degree days (1543°C) (Table 1.) were accumulated in Narasimharaya. However, total GDD of Narasimharaya and Prasad were on par with each other.

Irrespective of the variety and phenophase, increase in accumulated GDD with increase in nitrogen levels and the highest GDD accumulation (1688°C) under the highest nitrogen application@ 60 kg ha^{-1} (Table 1.).

Helio thermal units

Total HTU of CO-2 (9136 ^{0}C day hours) (Table 1.) was found to be significantly superior over the remaining varieties *i.e.,* SiA 3156, Narasimharaya and Prasad for completion of total crop duration. The least HTU values (8418 ^{0}C day hours) were accumulated in Narasimharaya.

Total HTU, with respect to nitrogen levels, was maximum@ 60 kg N ha^{-1} which was found to be significantly superior

(9165°C day hours) over all the other N levels *i.e.*, 40 kg, 20 kg and 0 kg ha^{-1} (Table 1.). The least total HTU (8294°C day hours) were accumulated under no nitrogen application.

Photo thermal units

For completion of total crop duration, total photo thermal units of CO-2 was found to be significantly superior (19391 ^{0}C day hours) over the remaining varieties *i.e.*, SiA 3156, Narasimharaya and Prasad. The least PTU values (18144°C day hours) were accumulated in Narasimharaya followed by Prasad (Table 1.).

With respect to nitrogen levels, total PTU@ 60 kg N ha^{-1} were found to be significantly superior (19835°C day hours) over remaining nitrogen levels *i.e.*, 40 kg, 20 kg and 0 kg ha^{-1} (Table 1.). The least PTU (17637 ^{0}C day hours) were accumulated with no nitrogen application among the nitrogen levels tried.

The highest and the lowest GDD, HTU and PTU of CO-2 and Narasimharaya might be due to variation in days, bright sunshine hours and day length, respectively, required for completing total crop duration of respective varieties which in turn was dependant on the genetic makeup and potential and prevailed weather conditions. The above results are in agreement with documented results of Nandini and Sreedhara (2019) [7], Pradhan *et al.* (2018) [11] and Navya Jyothi (2016) [8].

Increase in accumulated GDD, HTU and PTU with increase in nitrogen levels and highest GDD, HTU and PTU accumulation under the highest nitrogen application@ 60 kg ha^{-1} might be attributed to the fact that higher nitrogen supply had increased the number of calendar days and thermal time of the crop which in turn increased the GDD. HTU and PTU. The above results are in conformity with the research findings of Priyadarshi *et al.* (2018) [13], Sukhpreet Kaur Sidhu and Tilak Raj (2018) [19].

Heat use efficiency

Heat Use Efficiency (HUE) is the conversion of heat energy into drymatter and depends on crop type, genetic factors and sowing time. The total heat energy available to any crop is never completely converted to drymatter even under most favourable agro climatic conditions as reported by Rao *et al.* (1999) [16].

a. HUE for total drymatter

Among the four varieties, the highest heat use efficiency for total drymatter (2.58 kg ha^{-1} $^{0}C^{-1}$ day^{-1}) was recorded with Prasad which was significantly superior over SiA 3156 and CO-2, which recorded the lowest HUE (1.71 kg ha^{-1} $^{0}C^{-1}$ day^{-1}). However, HUE of Prasad was on par with Narasimharaya (Table 2.).

The highest HUE (2.44 kg ha^{-1} $^{0}C^{-1}$ day^{-1}) was recorded with the highest nitrogen application of 60 kg ha^{-1} which was significantly superior over no nitrogen application (N_1) (Table 2.). However, the HUE of N_4 treatment was on par with N_3 and N_2. The lowest HUE (1.58 kg ha^{-1} $^{0}C^{-1}$ day^{-1}) was recorded with no nitrogen application.

b. HUE for grain yield

The highest heat use efficiency for grain yield (1.03 kg ha^{-1} $^{0}C^{-1}$ day^{-1}) was recorded by Prasad which was significantly superior over SiA 3156 (0.84 kg ha^{-1} $^{0}C^{-1}$ day^{-1}) and CO-2 (0.52 kg ha^{-1} $^{0}C^{-1}$ day^{-1}) (Table 2.). However, HUE of Prasad for grain yield was on par with Narasimharaya.

The highest HUE for grain yield (0.98 kg ha^{-1} $^{0}C^{-1}$ day^{-1}) was recorded with highest nitrogen application @ 60 kg ha^{-1} which was significantly superior over no nitrogen application. However, the HUE of N_4 treatment was on par with N_3 and N_2. The lowest HUE (0.49 kg ha^{-1} $^{0}C^{-1}$ day^{-1}) was recorded with no nitrogen application (Table 2.).

Helio thermal use efficiency

a. HtUE for total drymatter

The highest helio thermal use efficiency (0.47 kg ha^{-1} $^{0}C^{-1}$ d^{-1} hour) was recorded by Prasad which was significantly superior over SiA 3156 and CO-2, which recorded the lowest HtUE (0.31 kg ha^{-1} $^{0}C^{-1}$ d^{-1} hour) (Table 3.). However, HtUE of Prasad was on par with Narasimharaya.

The highest HtUE was (0.45 kg ha^{-1} $^{0}C^{-1}$ d^{-1} hour) recorded with the highest nitrogen application@ 60 kg ha^{-1} which was significantly superior over no nitrogen application. However, the HtUE of N_4 treatment was on par with N_3 and N_2. The lowest HtUE (0.29 kg ha^{-1} $^{0}C^{-1}$ d^{-1} hour) was recorded with no nitrogen application (Table 3.).

b. HtUE for grain yield

Among the four varieties, the highest helio thermal use efficiency for grain yield (0.19 kg ha^{-1} $^{0}C^{-1}$ d^{-1} hour) was recorded by Prasad which was significantly superior over SiA 3156 and CO-2, which recorded the lowest HtUE (0.09 kg ha^{-1} $^{0}C^{-1}$ d^{-1} hour) (Table 3.). However, HtUE of Prasad was on par with Narasimharaya.

The highest HtUE for grain yield (0.18 kg ha^{-1} $^{0}C^{-1}$ d^{-1} hour) was recorded with the highest nitrogen application@ 60 kg ha^{-1} which was significantly superior over 20 kg N ha^{-1} and no nitrogen application. However, the HtUE of N_4 treatment was on par with N_3 (Table 3.). The lowest HtUE (0.09 kg ha^{-1} $^{0}C^{-1}$ d^{-1} hour) was recorded with no nitrogen application.

Photo thermal use efficiency

a. PtUE for total drymatter

Prasad variety was found to be recorded with the highest photo thermal use efficiency (0.22 kg ha^{-1} $^{0}C^{-1}$ d^{-1} hour) which was significantly superior over SiA 3156 and CO-2, which recorded the lowest PtUE (0.15 kg ha^{-1} $^{0}C^{-1}$ d^{-1} hour) (Table 4.). However, PtUE of Prasad was on par with Narasimharaya.

The highest PtUE for total drymatter (0.21 kg ha^{-1} $^{0}C^{-1}$ d^{-1} hour) was recorded with the highest nitrogen application@ 60 kg ha^{-1} which was significantly superior over no nitrogen application (Table 4.). However, the PtUE of N_4 treatment was on par with N_3 and N_2. The lowest PtUE (0.13 kg ha^{-1} $^{0}C^{-1}$ d^{-1} hour) was recorded with no nitrogen application.

PtUE for grain yield

Among the four varieties, the highest photo thermal use efficiency for grain yield (0.09 kg ha^{-1} $^{0}C^{-1}$ d^{-1} hour) was recorded by Prasad which was significantly superior over SiA 3156 and CO-2, which recorded the lowest PtUE (0.04 kg ha^{-1} $^{0}C^{-1}$ d^{-1} hour). However, PtUE of Prasad was on par with Narasimharaya (Table 4.).

The highest PtUE for grain yield (0.08 kg ha^{-1} $^{0}C^{-1}$ d^{-1} hour) was recorded with the highest nitrogen application@ 60 kg ha^{-1} which was significantly superior over no nitrogen application. However, the PtUE of N_4 treatment was on par with N_3 and N_2 (Table 4.). The lowest PtUE (0.04 kg ha^{-1} $^{0}C^{-1}$ d^{-1} hour) was recorded with no nitrogen application.

The highest HUE, HtUE and PtUE for both total drymatter and grain yield of Prasad can be attributed to the highest drymatter accumulation and grain yield coupled with lesser number of accumulated heat units, helio thermal units and photo thermal units and also due to its genetic make-up and potential. The lowest value of HUE, HtUe and PtUE for both total drymatter and grain yield of CO-2 might be due to its lowest genetic potential coupled with the highest heat units, helio thermal units and photo thermal units and also might be due to the failure of CO-2 in conversion of the highest accumulated photo thermal units into economic yield). These results are in consonance with Nandini and Sridhara (2019) [7], Revathi and Sree Rekha (2017) [17] and Prakash *et al.* (2017) [12].

Irrespective of the variety, increase of HUE, HtUe and PtUE for both total drymatter and grain yield with increase in nitrogen levels from 0 to 60 kg N ha^{-1} was observed. The highest HUE, HtUE and PtUE at 60 kg N ha^{-1} might be due to the highest drymatter accumulation and grain production at that nitrogen level and also due to proportionate increase of total drymatter accumulation and grain yield per each photo thermal unit absorbed.

Yield (kg ha^{-1})

Among the varieties, Prasad variety (V_1) gave significantly higher grain yield (1609 kg ha^{-1}) and shown its statistical supremacy over the remaining three varieties. The lowest grain yield was recorded by CO-2 (860 kg ha^{-1}). Nitrogen@ 60 kg ha^{-1} resulted in maximum grain yield (1645 kg ha^{-1}) and was significantly superior over 20 kg N ha^{-1} and no nitrogen levels (741 kg ha^{-1}). However, it was on par with grain yield@ 40 kg N ha^{-1}.

With respect to stover yield, Prasad variety (2405 kg ha^{-1}) produced maximum and was significantly superior over SiA 3156 and CO-2 varieties, which recorded the lower stover yield (1959 kg ha^{-1}). However, stover yield of Prasad was on par with Narasimharaya. Among the nitrogen levels, the maximum stover yield was produced with 60 kg N ha^{-1} application (2467 kg ha^{-1}) which was significantly superior over 20 kg N and 0 kg N ha^{-1}, which resulted in significantly lower stover yield (1612 kg ha^{-1}). However, stover yield obtained with N_4 treatment was statistically on par with N_3 treatment.

Significant superiority of Prasad variety for both grain and stover yields might be due to its genetic constitution of yield attributing morpho-physiological parameters and maximum drymatter content. Similar results were also expressed by Ramyasri *et al.* (2018) [18], Shanthi *et al.* (2017) [18] and Jyothi *et al.* (2016) [6].

The interaction effect between varieties and nitrogen levels was not found significant for all parameters studied.

Table 1: Total growing degree days (^{0}C), helio thermal units (^{0}C day hours) and photo thermal units (^{0}C day hours) of foxtail millet varieties as influenced by varieties and nitrogen levels

Treatments	GDD	HTU	PTU
Varieties			
V_1 – Prasad	1559	8489	18321
V_2 – Narasimharaya	1543	8418	18144
V_3 - SiA 3156	1618	8988	19066
V_4 - CO – 2	1648	9136	19391
SEm±	5.9	23.0	67.5
CD (P=0.05)	17	66	195
Nitrogen levels (kg ha^{-1})			
N_1 - 0	1499	8294	17637
N_2 - 20	1559	8649	18357
N_3 – 40	1621	8941	19092
N_4 – 60	1688	9165	19835
SEm±	5.9	23.0	67.5
CD (P=0.05)	17	66	195
Interaction (V × N)			
SEm±	11.8	46.0	135.1
CD (P=0.05)	NS	NS	NS
CV%	1.2	0.9	1.2

Table 2: Heat use efficiency (kg ha^{-1} ^{0}C^{-1} day^{-1}) of foxtail millet varieties as influenced by nitrogen levels

Treatments	Total GDD (^{0}C)	Total drymatter (kg ha^{-1})	HUE on total drymatter basis	Grain yield (kg ha^{-1})	HUE on total grain yield basis
Varieties					
V_1 – Prasad	1559	4024	2.58	1609	1.03
V_2 – Narasimharaya	1543	3613	2.34	1402	0.90
V_3 - SiA 3156	1618	3451	2.13	1366	0.84
V_4 - CO – 2	1648	2829	1.71	860	0.52
S.Em±	5.9	138.8	0.095	69.4	0.046
CD (P=0.05)	17	401	0.27	200	0.13
Nitrogen levels (kg ha^{-1})					
N_1 - 0	1499	2364	1.58	741	0.49
N_2 - 20	1559	3480	2.23	1336	0.86
N_3 – 40	1621	3950	2.43	1514	0.93
N_4 – 60	1688	4122	2.44	1645	0.98
S.Em±	5.9	138.8	0.095	69.4	0.046
CD (P=0.05)	17	401	0.27	200	0.13

Interaction (V × N)					
S.Em±	11.8	277.7	0.189	138.9	0.093
CD (P=0.05)	NS	NS	NS	NS	NS
CV%	1.2	13.8	15.0	18.3	19.6

Table 3: Helio thermal use efficiency (kg ha^{-1} ^{0}C^{-1} day^{-1} hour) of foxtail millet varieties as influenced by nitrogen levels

Treatments	Total HTU (°C day hours)	Total Drymatter (kg ha^{-1})	HtUE on total drymatter basis	Grain yield (kg ha^{-1})	HtUE on total grain yield basis
Varieties					
V_1 – Prasad	8489	4024	0.47	1609	0.19
V_2 – Narasimharaya	8418	3613	0.43	1402	0.17
V_3 - SiA 3156	8988	3451	0.38	1366	0.15
V_4 - CO – 2	9136	2829	0.31	860	0.09
SEm±	23.0	138.8	0.017	69.4	0.008
CD (P=0.05)	66	401	0.05	200	0.02
Nitrogen levels (kg ha^{-1})					
N_1 - 0	8294	2364	0.29	741	0.09
N_2 - 20	8649	3480	0.40	1336	0.15
N_3 – 40	8941	3950	0.44	1514	0.17
N_4 – 60	9165	4122	0.45	1645	0.18
SEm±	23.0	138.8	0.017	69.4	0.008
CD (P=0.05)	66	401	0.05	200	0.02
Interaction (V × N)					
SEm±	46.0	277.7	0.034	138.9	0.017
CD (P=0.05)	NS	NS	NS	NS	NS
CV%	0.9	13.8	14.6	18.3	19.3

Table 4: Photo thermal use efficiency (kg ha^{-1} ^{0}C^{-1} day^{-1} hour) of foxtail millet varieties as influenced by nitrogen levels

Treatments	Total PTU (°C day hours)	Total Drymatter (kg ha^{-1})	PtUE on total drymatter basis	Grain yield (kg ha^{-1})	PtUE on total grain yield basis
Varieties					
V_1 – Prasad	18321	4024	0.22	1609	0.09
V_2 - Narasimharaya	18144	3613	0.20	1402	0.08
V_3 - SiA 3156	19066	3451	0.18	1366	0.07
V_4 - CO – 2	19391	2829	0.15	860	0.04
SEm±	67.5	138.8	0.008	69.4	0.004
CD (P=0.05)	195	401	0.02	200	0.01
Nitrogen levels (kg ha^{-1})					
N_1 - 0	17637	2364	0.13	741	0.04
N_2 - 20	18357	3480	0.19	1336	0.07
N_3 – 40	19092	3950	0.20	1514	0.08
N_4 – 60	19835	4122	0.21	1645	0.08
SEm±	67.5	138.8	0.008	69.4	0.004
CD (P=0.05)	195	401	0.02	200	0.01
Interaction (V × N)					
SEm±	135.1	277.7	0.016	138.9	0.008
CD (P=0.05)	NS	NS	NS	NS	NS
CV%	1.2	13.8	14.8	18.3	19.4

Conclusion
It can be concluded that Prasad variety of foxtail millet performed well with respect to yields with higher HUE, HtUE and PtUE even though GDD, HTU and PTU were lesser. Among the nitrogen levels, 60 kg N ha^{-1} resulted in higher yields. However, it was on par with 40 kg N ha^{-1}.

References

1. Anand Kumar, Manoj Kumar Tripathi, Virender Pal. Effect of Sowing Time on Growth, Phenology and Yield Attribute of Summer Groundnut (*Arachis hypogaea* L.) in Allahabad. 2017; 6(4):2357-2365.
2. Anderson RL. Planting date effect on no-till Proso millet. Journal of Productive Agriculture. 1994; 7:454-458.
3. Bishnoi OP, Singh S, Niwas R. Effect of temperature on phenological 9development of wheat (*Triticum aestivum* L.) crop in different row orientations. Indian journal of Agricultural Sciences. 1995; 65:211-214.
4. Haider SA, Alam MZ, Alam MF, Paul NK. Influence of different sowing dates on the phenology and accumulated heat units in wheat. Journal of Biological Sciences. 2003; 3:932-939.
5. Iwata F. Heat unit concept of crop maturity. Physiological aspects of dryland farming, (Gupta, U.S. ed). Oxford and IBH, 1984, 351-370.
6. Jyothi KN, Sumathi V, Sunitha N. Productivity, nutrient balance and profitability of foxtail millet varieties as influenced by levels of nitrogen. IOSR Journal of Agriculture and Veterinary Science. 2016; 9(4):18-22.
7. Nandini KM, Sridhara S. Heat use efficiency, helio thermal use efficiency and photo thermal use efficiency of foxtail millet (*Setaria italica* L.) genotypes as

influenced by sowing dates under southern transition zone of Karnataka. Journal of Pharmacognosy and Phytochemistry. SP 2, 2019, 284-290.
8. Navya Jyothi K. Productivity of Foxtail Millet (*Setaria italica* L.) Varieties as Influenced by Levels of Nitrogen", M.Sc. (Ag.) Thesis, Acharya NG Ranga Agricultural University, Guntur, 2016.
9. Nuttonson MY. A comparative study of lower and upper limits of temperature in measuring variability of day-degree summation of wheat, barley and rye. American Institute of Crop Ecology, Washington D.C, 1956.
10. Panse VG, Sukhatme PV. Statistical Methods for Agricultural Workers. ICAR, New Delhi, 1985, 100-174.
11. Pradhan A, Nag SK, Mukherjee SC. Thermal requirement of small millets in Chhattisgarh plateau under rainfed cropping situation. Journal of Agrometeorology. 2018; 20(3):244-245.
12. Prakash V, Mishra JS, Rakesh Kumar, Ravikanth Kumar, Kumar S, Dwivedi SK *et al*. Thermal evaluation and heat use efficiency of sorghum cultivars in middle Indo-Gangetic Palins. Journal of Agrometeorology. 2017; 19(1):29-33.
13. Priyadarshi DS, Mohapatra AKB, Pasupalak S, Baliarsingh A, Rath BS, Nanda A *et al*. Agro-meteorological indices and phenology of rice (*Oryza sativa* L.) under different dates of planting and nitrogen levels. International Journal of Chemical Studies. 2018; 6(5):3298-3302.
14. Rajput RP. Response of soybean crop to climatic and soil environments. Ph.D. (Ag.) Thesis, Indian Agricultural Research Institute, New Delhi, India, 1980.
15. Ramyasri K, Ramana AV, Upendra Rao A, Guru Murthy P. Nutrient uptake *vis a vis* grain yield of foxtail millet varieties as influenced by nitrogen levels in rice fallows. International Journal of Current Microbiology and Applied Sciences. 2018; 7(9):2626-2629.
16. Rao VUM, Singh D, Singh R. Heat use efficiency of winter crops in Haryana. Journal of Agrometeorology. 1999; 1(2):143-148.
17. Revathi T, Sree Rekha M. "Phenology of Fingermillet (*Eleusine coracana* L.) In Relation to Agro Climatic Indices under Different Sowing Dates. International Journal of Emerging Trends in Science and Technology. 2017; 4(2):5029-5032.
18. Shanthi P, Radha Kumari C, Niveditha M, Reddy PKY, Reddy S. Genetic variability studies in Italian millet (*Setaria italica* (L.) Beauv) varieties under rainfed conditions in scarce rainfall zone of Andhra Pradesh. The Andhra Agricultural Journal. 2017; 64(2):330-334.
19. Sukhpreet Kaur Sidhu, Tilak Raj. Growing degree day's accumulation of wheat (*Triticum aestivum* L.) cultivars as influenced by different nitrogen level. International Journal of Current Microbiology and Applied Sciences. 2018; 7(9):3041-3048.