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Nandini KM
Department of Agronomy, University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Sridhara S
Department of Agronomy, University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Correspondence
Nandini KM
Department of Agronomy, University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

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

Nandini KM and Sridhara S

Abstract

A field experiment was conducted during *kharif* seasons of 2016 and 2017 at College of Agriculture, UAHS, Shivamogga, India to study the phenology, and various agrometeorological indices *viz.*, accumulated growing degree days (GDD), helio thermal use efficiency (HTUE), photo thermal units (PTUE) and heat use efficiency (HUE) of foxtail millet genotypes grown under different dates of sowing. Treatments consist of three dates of sowing (June 30th, July 30th and August 30th) with four genotypes (Local, HMT-1 and SIA 2644). The experiment conducted in RCBD with factorial concept with three replications. The accumulated heat unit required to attain different phenological stages decreased in all the genotypes with every delay in sowing date. The crop sown on June 30th took significantly maximum GDD, to attain different phenological stages *viz*., germination, tillering, 50 per cent panicle initiation, 50 % flowering, grain formation and physiological maturity, which reduced significantly with subsequent delay in sowing date. Also, HUE, PTUE and HTUE were found to be significantly highest in crop sown on June 30th followed by July30th and August 30th. Among genotypes, SIA 2644 consumed significantly higher GDD to attain different phenological stages till physiological maturity, also resulted significantly higher HUE, PTUE and HTUE as compared to other genotypes.

Keywords: Foxtail millet, sowing dates, genotypes, agrometeorological indices, and phenological stages

Introduction

Foxtail millet is an important ancient crop of dry-land agriculture and the climate-resilient crop for food and nutritional security. This crop is highly nutritious with diverse usage and it is well adapted to marginal lands, and mostly grown by resource-poor farmers. In Karnataka, small millets are cultivated on an area of 26 thousand hectares producing 12.3 thousand tonnes with a productivity of 510 kg per ha Anand Kumar *et al.* (2017) [2]. The optimum sowing time and selection of improved cultivars play a remarkable role in exploiting the yield potential of the crop under particular agro climatic condition. It governs the crop phenological development and the efficient conversion of biomass into economic yield. Crop phenology is an essential component of crop growth and yield and it can be used to estimate the most appropriate date and time of specific development process. The duration of each phenophase determines the dry matter accumulation and its partitioning into different organs. Anand Kumar *et al.* (2017) [2] reported that the duration of growth stage of any particular species was directly related to temperature and it could be predicted using the sum of daily air temperature. Temperature is an important environmental factor that influences the growth and development, phenology and yield of crops (Bishnoi *et al.*, 1995) [3]. Hence, it becomes imperative to have the knowledge of exact duration of various phenological stages of crop in a particular growing environment and their impact on its yield. Delay in sowing caused early maturity resulting drastic reduction in yield as compared to normal sowing which has a longer growth duration which consequently provides an opportunity to accumulate more biomass. Growing of suitable varieties at an appropriate time is an essential for ensuring optimum crop productivity. Plants have a definite temperature requirement to attain phenological stages. Hence, it becomes imperative to have knowledge of the exact duration of phenological stages in a particular crop-growing environment and their impact on yield of crop. Therefore, an experiment was conducted to determine the phenology and heat unit requirement of promising foxtail millet varieties under different crop growing environment.

Materials and Methods

The field experiment was conducted at ZAHRS, Shivamogga, India during consecutive *Kharif* season of consecutive years of 2016 and 2017. It is situated at 13° 58' to 14° 1' North latitude and 75° 34' to 75° 42' East longitude with an altitude of 650 m above the mean sea level. The station lies in the Southern Transition Agroclimatic Zone of Karnataka. The total rainfall received during the cropping period of 2016 and 2017 was 467.2 and 683.6 mm as against normal rainfall with the highest mean maximum temperatures 32.3 ºC (2016) and 31.8 ºC (2017) and While the lowest mean minimum temperatures of 16.1 ºC and 18.1 ºC were observed during 2016 and 2017, respectively. The soil of experimental site was clay loam in texture, slight acidic in reaction (pH 6.4), low in available nitrogen (198.83 kg ha^{-1}) and high in available phosphorus (64.00 kg ha^{-1}) and potassium (239.00 kg ha^{-1}). The experiment comprised of 9 treatment combinations, consist of three sowing dates (June 30, July 30 and August 30) and three genotypes (Local, HMT-1 and SIA 2644). The experiment was laid out in a factorial randomized complete block design with three replications taking dates of sowing as first factor and genotypes as second factor and replicated three times. The line-to-line distance was kept as 30 cm with plant to plant distance of 10 cm with a seed rate of 30 kg ha^{-1}. Normally 40 kg ha^{-1} nitrogen and 40 kg ha^{-1} phosphorus were applied through urea and SSP. All data are presented as mean values of three replicates. Data were analysed statistically for analysis of variance (ANOVA). (Please give materials applicable to an Agrometeorology Journal). Nothing of that sort is seen here.

Phenological observations
The crop was inspected at frequent intervals (2 or 3 days) to observe the phenological events closely. The phenological events recorded were germination, tillering, 50 per cent panicle initiation, 50 per cent flowering, grain formation and physiological maturity.

Growing degree days (GDD)
Cumulative growing degree days were determined by summing the daily mean temperature above base temperature, expressed in degree day. For millets, T base is considered as 10 °C (Lucas *et al.* 2016). This was determined by using the following formula as per (Nuttonson, 1995):

$$GDD(^{\circ}C) = \frac{(T_{max} + T_{min})}{2} - T_{base}$$

Where
Tmax = Daily maximum temperature (°C)
Tmin = Daily minimum temperature (°C)
Tbase = Minimum threshold/base temperature (°C)

Heat use efficiency (HUE)
Heat use efficiency is also represented by thermal time use efficiency (TTUE), which indicates the amount of dry matter produced per unit of growing degree days or thermal time. This was computed by using the following formula:

$$HUE = \frac{\text{Total dry matter (g hill}^{-1})}{\Sigma GDD}$$

Helio thermal units (HTU)
The product of the growing degree day and the corresponding actual bright sunshine hours had been termed as Helio thermal units (HTU) and expressed as g ºC $days^{-1}$ hrs^{-1} (Chakravarthy and Sastry, 1985) [4].

Helio thermal units (HTU) = GDD × actual bright sunshine hours

Helio thermal use efficiency (HTUE)
Helio thermal use efficiency was calculated by dividing the total dry matter recorded at respective days by the accumulated helio thermal units and expressed as g ºC $days^{-1}$ hrs^{-1}.

Helio thermal use efficiency was calculated as

$$HTUE = \frac{\text{Total dry matter (g hill}^{-1})}{\Sigma HTU}$$

Where
Σ HTU = cumulative helio thermal units

Photo thermal units (PTU)
The product of the growing degree-days and the length of the day in hours accumulated over a given period is the photo thermal units (PTU) and expressed as ºC $days^{-1}$ hrs^{-1} (Chakravarthy and Sastry, 1985) [4].
Photo thermal units (PTU) = GDD × day length

Photo thermal use efficiency (PTUE)
Photo thermal use efficiency was calculated by dividing the total dry matter recorded at respective days by the accumulated photo thermal units and expressed as g ºC $days^{-1}$ hrs^{-1}. Photo thermal use efficiency was calculated as:

$$PTUE = \frac{\text{Total dry matter (g hill}^{-1})}{\Sigma PTU}$$

Where
Σ PTU = cumulative photo thermal units

Statistical analysis
The data collected from the experiment at different growth stages were subjected to statistical analysis by adopting Fisher's method of analysis of variance as outlined by Gomez and Gomez (1984) [5]. The mean values of interaction effects were separately subjected to Duncan's Multiple Range Test (DMRT) using the corresponding error mean sum of squares and degrees of freedom values under D–SAAT program.

Results and Discussion
Effect of Different Dates of Sowing, Genotypes and Their Interactions on Phenophases
Growing degree days accumulated at different phenophases were calculated during crop seasons of *Kharif* 2016 and 2017. The pooled data shows highest number of growing degree days were accumulated by June 30th sown crop to attain different phenological stages such as germination (81.61 ºC), tillering (289.86 ºC), 50 per cent panicle initiation (707.07 ºC), 50 per cent flowering (849.62 ºC) and grain formation (1034.18 ºC), physiological maturity (1207.03 ºC) followed by July30th and August 30th sown crop at all the phenophases. Among three genotypes SIA 2644 consume significantly higher heat units to complete different phenological stages such as germination (86.45 ⁰C), tillering (278.11ºC), 50 per cent panicle initiation (691.96 ºC), 50 per cent flowering (850.47 ºC) and grain formation (1020.86 ºC), physiological maturity (1181.21 ºC) of crop growth as compared to HMT-1 and Local (Table 1 and 1a). This might be due to genetic

potentiality of crop which can response well to the prevailed weather conditions during crop growth and efficient utilization of available growing degree days to complete each phenological stages.Among the interaction effects, SIA 2644 sown on June 30^{th} consume significantly more heat units to complete different phenological stages such as germination (80.10 ºC), tillering (297.10 ºC), 50 per cent panicle initiation (717.22 ºC), 50 per cent flowering (859.90 ºC), grain formation (1039.57 ºC) and physiological maturity (1243.03 ºC). However it was found to be on par with crop sown on SIA 2644 sown on June 30^{th}, local sown on June 30^{th}as compared to August 30^{th} (Table 1 & 1a). This might be due to as the early sown crop availed more degree days to attain maturity compared to others. In late sown crop, moisture stress and increased temperature at time of flowering accelerated the plant senescence and shortened the duration of grain filling. This is in accordance with the result of Towhida *et al.* (2015) [15] Sidiqque *et al.* (2002) [12].

Table 1: Heat unit (^{0}C) required to complete different phenological stages of foxtail millet as influenced by dates of sowing and genotypes

Treatments	Germination			Tillering			50 per cent panicle initiation		
	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
Date of sowing									
D_1:June 30^{th}	77.72	85.50	81.61	282.09	297.63	289.86	683.60	730.53	707.07
D_2:July 30^{th}	82.13	92.91	87.52	260.92	290.79	275.86	645.72	709.58	677.65
D_3:August 30^{th}	89.27	106.12	97.69	217.51	267.16	242.33	614.49	691.06	652.77
F test	*	*	*	*	*	*	*	*	*
S.Em±	1.39	1.29	0.98	3.37	5.01	4.19	3.38	7.53	4.85
CD(p=0.05)	4.17	3.87	2.93	10.12	15.02	12.56	10.13	22.58	14.54
Genotype									
G_1:Local	87.23	97.11	92.17	244.72	275.13	259.93	632.67	694.01	663.34
G_2:HMT-1	80.94	95.47	88.21	254.20	285.83	270.02	651.34	713.03	682.19
G_3:SIA 2644	80.94	91.96	86.45	261.60	294.61	278.11	659.80	724.12	691.96
F test	*	NS	*	*	*	*	*	*	*
S.Em±	1.39	1.29	0.98	3.37	5.01	4.19	3.38	7.53	4.85
CD(p=0.05)	4.17	3.87	2.93	10.12	15.02	12.56	10.13	22.58	14.54
D×G									
D_1G_1	83.77^{b}	85.50^{d}	84.63^{cd}	275.40^{a-c}	295.93^{ab}	282.65^{ab}	668.30^{b}	727.20^{ab}	694.30^{ab}
D_1G_2	74.70^{c}	85.50^{d}	80.10^{d}	280.37^{ab}	299.30^{a}	289.83^{ab}	688.77^{a}	730.60^{ab}	709.68^{a}
D_1G_3	74.70^{c}	85.50^{d}	80.10^{d}	290.50^{a}	303.70^{a}	297.10^{a}	693.73^{a}	740.70^{a}	717.22^{a}
D_2G_1	82.13^{bc}	96.20^{bc}	89.17^{bc}	258.20^{c}	285.63^{ab}	271.92^{bc}	630.57^{de}	704.47^{a-c}	664.53^{c}
D_2G_2	82.13^{bc}	91.27^{cd}	86.70^{c}	261.33^{c}	289.90^{ab}	276.07^{a-c}	645.53^{cd}	709.80^{a-c}	677.67^{bc}
D_2G_3	82.13^{bc}	91.27^{cd}	86.70^{c}	263.23^{bc}	290.80^{ab}	279.58^{a-c}	661.07^{bc}	720.30^{ab}	694.13^{ab}
D_3G_1	95.80^{a}	109.63^{a}	102.72^{a}	200.57^{e}	249.87^{c}	225.22^{e}	599.13^{f}	670.00^{c}	634.57^{d}
D_3G_2	86.00^{b}	109.63^{a}	97.82^{a}	220.90^{d}	267.40^{bc}	244.15^{de}	619.73^{e}	691.73^{bc}	659.22^{cd}
D_3G_3	86.00^{b}	99.10^{b}	92.55^{b}	231.07^{d}	284.20^{ab}	257.63^{cd}	624.60^{e}	698.70^{a-c}	661.15^{cd}
S.Em±	2.41	2.23	1.69	5.85	8.68	7.25	5.85	13.05	8.40

Table 1a: Heat unit (^{0}C) required to complete different phenological stages of foxtail millet as influenced by dates of sowing and genotypes

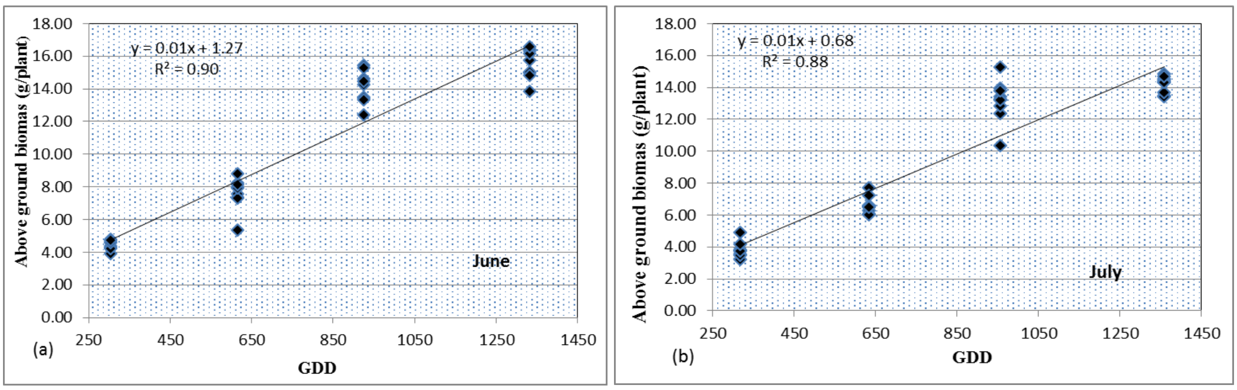
	50 per cent flowering			Grain formation			Physiological maturity		
Treatments	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
Date of sowing									
D_1:June 30^{th}	829.70	869.54	849.62	1008.23	1060.13	1034.18	1174.70	1239.37	1207.03
D_2:July 30^{th}	810.44	875.24	842.84	974.69	1046.76	1010.72	1126.20	1197.81	1162.01
D_3:August 30^{th}	790.39	860.26	825.32	951.43	1023.96	987.69	1085.70	1138.68	1112.19
F test	*	*	*	*	*	*	*	*	*
S.Em±	6.18	3.33	4.34	5.03	4.40	3.02	8.33	7.82	7.94
CD(p=0.05)	18.53	9.99	13.02	15.08	13.20	9.05	24.99	23.44	23.81
Genotype									
G_1:Local	795.31	853.79	824.55	967.12	1031.31	999.22	1114.02	1174.66	1144.34
G_2:HMT-1	813.67	871.87	842.77	979.36	1045.69	1012.52	1124.11	1187.26	1155.68
G_3:SIA 2644	821.54	879.39	850.47	987.88	1053.84	1020.86	1148.47	1213.94	1181.21
F test	*	*	*	*	*	*	*	*	*
S.Em±	6.18	3.33	4.34	5.03	4.40	3.02	8.33	7.82	7.94
CD(p=0.05)	18.53	9.99	13.02	15.08	13.20	9.05	24.99	23.44	23.81
D×G									
D_1G_1	813.93^{ab}	877.70^{ab}	846.28^{ab}	1003.47^{ab}	1060.17^{a}	1028.82^{ab}	1152.70^{bc}	1214.70^{b}	1183.70^{bc}
D_1G_2	834.90^{a}	879.53^{a}	852.32^{ab}	1008.17^{ab}	1060.97^{a}	1034.17^{ab}	1162.80^{b}	1225.93^{b}	1194.37^{b}
D_1G_3	840.27^{a}	880.93^{a}	859.90^{a}	1013.07^{a}	1066.07^{a}	1039.57^{a}	1208.60^{a}	1277.47^{a}	1243.03^{a}
D_2G_1	810.45^{ab}	870.17^{ab}	840.23^{ab}	963.80^{c-e}	1034.50^{bc}	999.15^{c}	1113.57^{c-e}	1182.90^{bc}	1148.23^{c-e}
D_2G_2	811.63^{ab}	872.33^{ab}	843.08^{ab}	981.87^{b-d}	1054.17^{ab}	1018.87^{b}	1129.73^{b-d}	1200.17^{b}	1164.95^{b-d}
D_2G_3	812.73^{ab}	875.70^{ab}	845.22^{ab}	986.77^{a-c}	1055.87^{ab}	1023.87^{ab}	1135.30^{b-d}	1210.37^{b}	1172.83^{bc}
D_3G_1	763.87^{c}	829.67^{c}	796.77^{c}	942.47^{e}	1016.33^{c}	979.40^{d}	1075.80^{e}	1126.37^{d}	1101.08^{f}
D_3G_2	795.67^{bc}	859.37^{b}	832.92^{b}	948.03^{e}	1021.03^{c}	984.53^{cd}	1079.80^{e}	1135.67^{d}	1107.73^{ef}
D_3G_3	808.13^{ab}	869.73^{ab}	836.65^{ab}	955.43^{de}	1023.43^{c}	989.43^{cd}	1101.50^{de}	1154.00^{cd}	1127.75^{d-f}
S.Em±	10.70	5.77	7.52	8.71	7.63	5.23	14.44	13.54	13.76

Effect of different dates of sowing, genotypes and their interactions on thermal time efficiencies

Crop sown on June 30thwas found more efficient in utilizing thermal time use efficiency, the crop sown on June 30th recorded significantly higher heat use efficiency (14.68 × 10^{-3} g ºC day^{-1}) followed by July 30th(13.38 × 10^{-3} g ºC day^{-1}) and less heat use efficiency was observed when crop sown on August 30th(11.19× 10^{-3} g ºC day^{-1}),Photo thermal use efficiency also shows similar trend (11.80 × 10^{-4} g ºC hrs^{-1}) (Table 2).Significantly higher helio thermal use efficiency was observed on June 30th (4.04× 10^{-3} g ºC hrs^{-1}) followed by July 30th (2.93 × 10^{-3} g ºC hrs^{-1}) and August 30th(2.08× 10^{-3} g ºC hrs^{-1}) (Table 2). This higher use efficiency shows the efficient dry matter portioning to various plant parts. The results also are evidenced in the studies of Sandhu, *et al.* (2013) in pearl millet and Gouri *et al.* (2005), Lucas *et al.* (2016). Among genotypes, SIA 2644 resulted significantly higher heat use efficiency, helio thermal use efficiency and photo thermal use efficiency (13.71 × 10^{-3} g ºC day^{-1}, 3.38, × 10^{-3} g ºC hrs^{-1} and 11.27 × 10^{-4} g ºC hrs^{-1}, respectively) followed by HMT-1 (13.21 × 10^{-3} g ºC day^{-1}, 3.23 × 10^{-3} g ºC hrs^{-1} and 10.86 × 10^{-4} g ºC hrs^{-1}, respectively) and local (12.32 × 10^{-3} g ºC day^{-1}, 2.99 × 10^{-3} g ºC hrs^{-1} and 10.12 × 10^{-4} g ºC hrs^{-1}, respectively) (Table 2).The use efficiencies recorded at 60 DAS was also significantly higher with respect to interaction effects. When SIA 2644 sown on June 30th recorded significantly higher heat use efficiency, helio thermal use efficiency and photo thermal use efficiency (15.49 × 10^{-3} g ºC day^{-1}, 5.81 × 10^{-3} g ºC hrs^{-1} and 12.46 × 10^{-4} g ^{0}C hrs^{-1} respectively). However it was found to be on par with HMT-1 sown on June 30th (14.86 × 10^{-3} g ºC day^{-1}, 4.09 × 10^{-3} g ºC hrs^{-1}and 11.95 × 10^{-4} g ºC hrs^{-1}, respectively) and SIA 2644 sown on July 30th and fewer observations were noticed with local sown on August 30th(Table 2 & Fig. 1,2,3). This higher use efficiency shows the efficient dry matter portioning to various plant parts. The results also are evidenced in the studies of Revathi and Rekha (2017) in finger millet. Heat use efficiency (HUE), is the conversion of heat energy into dry matter and depends on crop type, genetic factors and sowing time (Abhilash *et al.* 2017 and Sulochana *et al.* 2015). Total heat energy available to any crop is never completely converted to dry matter even under most favourable agro climatic conditions.

Table 2: Heat use efficiency, Helio thermal use efficiency and Photo thermal use efficiency of foxtail millet at 60 DAS as influenced by dates of sowing and genotypes at different days after sowing

Treatments	HUE (g ºC day^{-1}× 10^{-3})			HTUE (g ºC hrs^{-1} × 10^{-3})			PTUE (g ºC hrs^{-1} × 10^{-4})		
	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
Date of sowing									
D$_1$:June 30th	14.11	15.24	14.68	3.83	4.25	4.04	11.35	12.25	11.80
D$_2$:July 30th	12.98	13.77	13.38	3.07	2.79	2.93	10.59	11.24	10.92
D$_3$:August 30th	10.79	11.58	11.19	2.01	2.15	2.08	9.27	9.79	9.53
F test	*	*	*	*	*	*	*	*	*
S.Em±	0.33	0.03	0.17	0.012	0.014	0.013	0.22	0.16	0.16
CD(p=0.05)	0.99	0.08	0.50	0.035	0.041	0.038	0.66	0.47	0.49
Genotype									
G$_1$:Local	11.93	12.70	12.32	2.81	2.87	2.84	9.82	10.41	10.12
G$_2$:HMT-1	12.79	13.63	13.21	3.00	3.08	3.04	10.54	11.18	10.86
G$_3$:SIA 2644	13.17	14.26	13.71	3.09	3.23	3.16	10.85	11.70	11.27
F test	*	*	*	*	*	*	*	*	*
S.Em±	0.33	0.03	0.17	0.012	0.014	0.013	0.22	0.16	0.16
CD(p=0.05)	0.99	0.08	0.50	0.035	0.041	0.038	0.66	0.47	0.49
D×G									
D$_1$G$_1$	13.21^{a-c}	14.15^{c}	13.67^{b}	3.58^{b}	3.94^{b}	3.76^{b}	10.63^{bc}	11.55^{c}	11.15^{cd}
D$_1$G$_2$	14.37^{ab}	15.36^{b}	14.86^{a}	3.90^{a}	4.28^{a}	4.09^{a}	11.55^{ab}	12.35^{ab}	11.95^{ab}
D$_1$G$_3$	14.76^{a}	16.22^{a}	15.49^{a}	4.00^{a}	4.52^{a}	4.26^{a}	11.87^{a}	13.04^{a}	12.46^{a}
D$_2$G$_1$	12.84^{b-d}	13.54^{d}	13.19^{b}	3.03^{c}	2.74^{c}	2.89^{c}	10.48^{bc}	11.06^{cd}	10.77^{cd}
D$_2$G$_2$	12.92^{a-d}	13.62^{d}	13.27^{b}	3.05^{c}	2.76^{c}	2.90^{c}	10.54^{bc}	11.12^{cd}	10.83^{cd}
D$_2$G$_3$	13.18^{a-c}	14.13^{c}	13.66^{b}	3.11^{c}	2.86^{c}	2.99^{c}	10.75^{a-c}	11.36^{bc}	11.00^{bc}
D$_3$G$_1$	9.65^{e}	10.35^{g}	10.00^{d}	1.80^{e}	1.93^{e}	1.86^{e}	8.29^{d}	8.76^{f}	8.52^{f}
D$_3$G$_2$	11.16^{de}	11.98^{f}	11.57^{c}	2.08^{de}	2.23^{de}	2.16^{de}	9.58^{cd}	10.13^{e}	9.86^{e}
D$_3$G$_3$	11.56^{c-e}	12.40^{e}	11.98^{c}	2.16^{d}	2.31^{d}	2.23^{d}	9.93^{c}	10.49^{de}	10.21^{de}
S.Em±	0.57	0.04	0.29	0.020	0.024	0.022	0.38	0.27	0.28



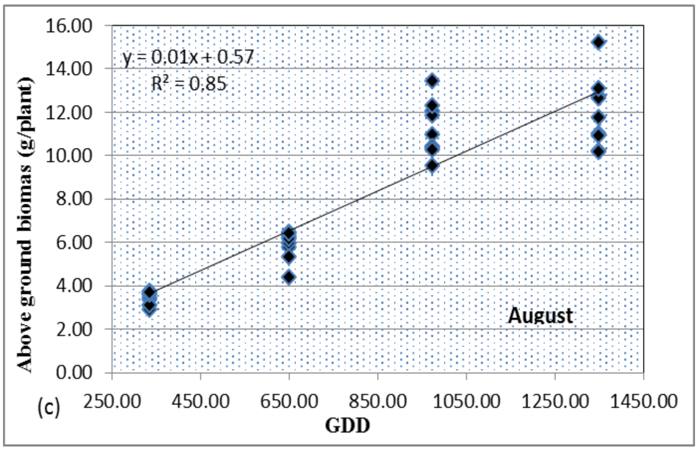
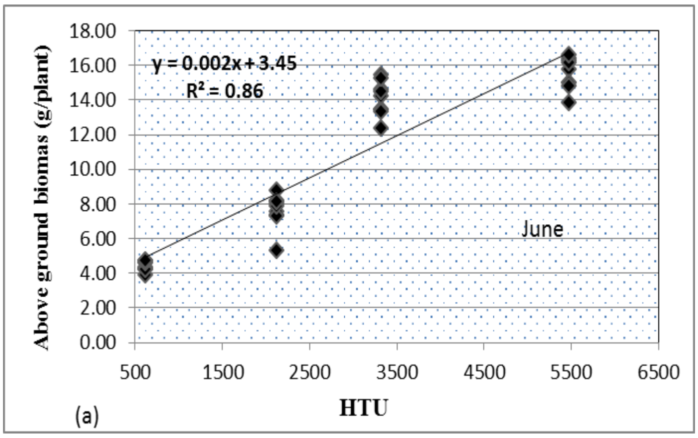
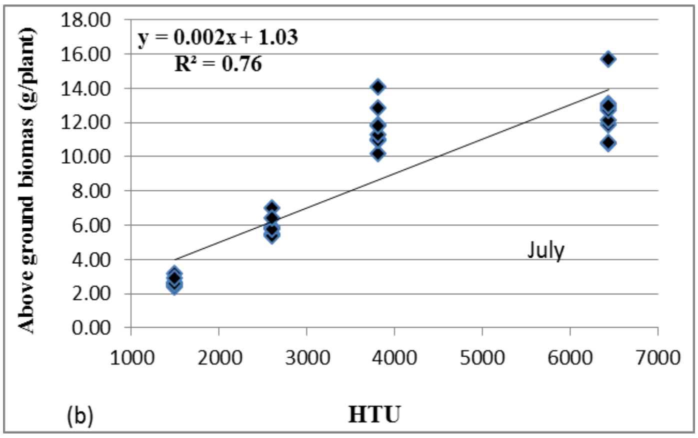


Fig 1: Heat use efficiency of foxtail millet as influenced by date of sowing





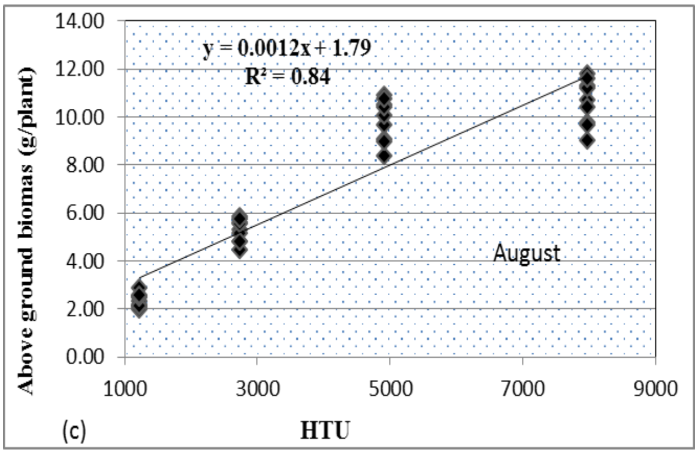
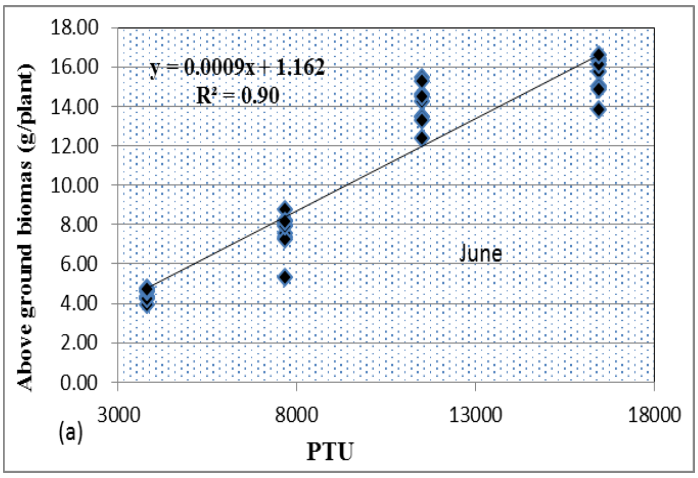
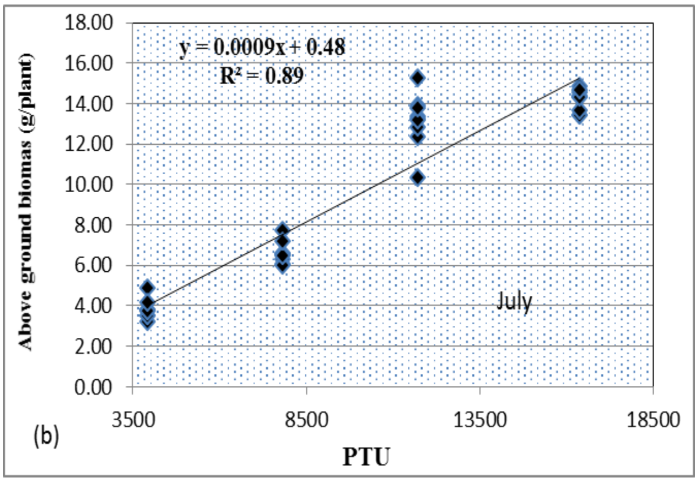


Fig 2: Helio thermal use efficiency of foxtail millet as influenced by date of sowing





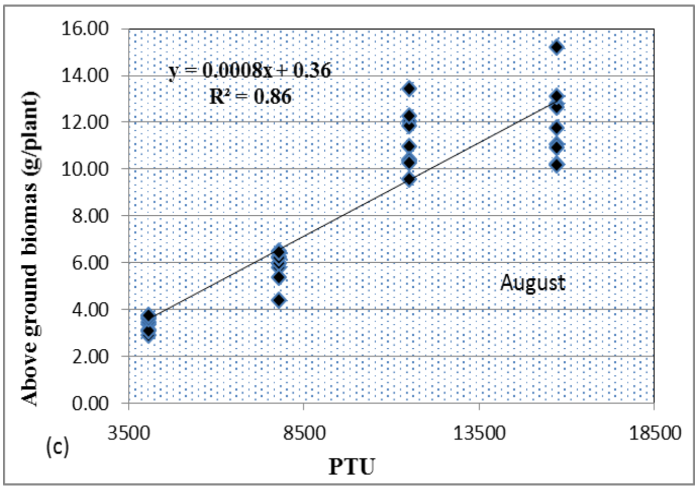


Fig 3: Photo thermal use efficiency of foxtail millet as influenced by date of sowing

Table 3: Grain yield (kg ha^{-1}), straw yield (kg ha^{-1}) and harvest index of foxtail millet as influenced by dates of sowing and genotypes

Treatments	Grain yield (kg ha^{-1})			Straw yield (kg ha^{-1})		
	2016	2017	Pooled	2016	2017	Pooled
Date of sowing						
D_1:June 30th	1986	2113	2049	4153	4370	4262
D_2:July 30th	1739	1850	1794	3807	3989	3898
D_3:August 30th	1411	1501	1456	3210	3369	3290
F test	*	*	*	*	*	*
S.Em±	56.29	56.27	48.95	79.76	94.45	70.20
C.D.(p=0.05)	168.75	168.69	146.74	239.13	283.16	210.45
Genotype						
G_1:Local	1592	1694	1643	3519	3691	3605
G_2:HMT-1	1730	1841	1786	3767	3960	3863
G_3:SIA 2644	1813	1929	1871	3885	4077	3981
F test	*	*	*	*	*	*
S.Em±	56.29	56.27	48.95	79.76	94.45	70.20
C.D.(p=0.05)	168.75	168.69	146.74	239.13	283.16	210.45
D×G						
D_1G_1	1831^{a-c}	1948^{a-c}	1890^{bc}	3901^{bc}	4092^{a-c}	3996^{bc}
D_1G_2	2010^{ab}	2138^{ab}	2074^{ab}	4221^{ab}	4447^{ab}	4334^{ab}
D_1G_3	2116^{a}	2251^{a}	2184^{a}	4338^{a}	4570^{a}	4454^{a}
D_2G_1	1704^{b-d}	1812^{cd}	1758^{c-e}	3762^{c}	3947^{b-d}	3854^{cd}
D_2G_2	1725^{b-d}	1836^{b-d}	1781^{cd}	3799^{bc}	3969^{b-d}	3884^{cd}
D_2G_3	1787^{bc}	1902^{bc}	1844^{b-d}	3861^{bc}	4050^{a-c}	3956^{bc}
D_3G_1	1242^{e}	1322^{e}	1282^{f}	2857^{e}	3013^{e}	2935^{f}
D_3G_2	1456de	1549de	1502^{ef}	3319de	3485de	3402^{e}
D_3G_3	1535^{c-e}	1634^{c-e}	1584de	3455^{cd}	3610^{cd}	3532de
S.Em±	97.49	97.46	84.78	138.15	163.59	121.59

Effect of different dates of sowing, genotypes and their interactions on Grain yield and Straw yield

The result of pooled data revealed that grain yield was significantly influenced by sowing dates. Among three dates of sowing evaluated for their performance, crop sown on June 30th recorded the significantly higher grain and straw yield (2049 and 4262 kg ha^{-1}, respectively). This was followed by July 30th grain and straw yield (1794 and 3898 kg ha^{-1}, respectively) as compared to August 30th (1456 and 3290 kg ha^{-1}, respectively). The delay in sowing dates for foxtail millet decreased the grain yield by 28.93 per cent as compared to June 30th of sowing. The possible reason for decline in grain yield for late planting date was due to decrease in duration of grain filling. During this phase, increased mean maximum temperature *i.e.*, 32.3 °C and 31.4 °C during 2016 & 2017, respectively caused water stress which resulted in decline in grain number and grain weight. The maximum temperature reported during the late planting date *i.e.*, August was more than 30°C which might have favoured the phenomenon explained above. Comparable results were reported by Rao, *et al*. (1999) who observed that the grain filling rate was slower with the number of days delay in sowing and also with the delay in harvesting time. Singh and Pal (2013), reported that water stress occurs during late planting dates, which reduces the grain growth. In the present study, it has been observed that the genotype SIA 2644 gave significantly higher grain yield (1871 kg ha^{-1}) and straw yield (3981 kg ha^{-1}) than HMT-1 (1786 kg ha^{-1} and 3863 kg ha^{-1}, respectively) and Local (1643 kg ha^{-1} and 3605 kg ha^{-1}, respectively) (Table 3). Among the interactions, genotype SIA 2644 sown on 30th June recorded significantly higher grain and straw yield, harvest index (2183.76kg ha^{-1} and 4454.20 kg ha^{-1} and 0.33, respectively) and it was found on par with sowing HMT-1 on 30th of June (2074.05 kg ha^{-1}, and 4334.13 kg ha^{-1}, respectively) and SIA 2644 sown on 30th of July (1844.46 kg ha^{-1}, and 3955.50 kg ha^{-1}, respectively) compared to late sowing of genotype local on 30th August (1281.95kg $ha^{-1}$and 2935. 27 kg ha^{-1} respectively) (Table 3).

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