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Effect of Sowing Time on Growth and Seed Yield of Finger Millet [*Eleusine coracana* (L.) Gaertn.] Varieties under Climate Change Regime

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A B S T R A C T

Afield experiment was conducted at National Seed Project, University of Agricultural Sciences, GKVK, Bengaluru (Karnataka) during 2017-18 to study the effect of sowing time under changing climatic condition and standardization of date of sowing in finger millet. Seven popular varieties of finger millet (short duration GPU-48; medium duration-GPU-28 -GPU-67, INDAF-7 and ML-365; long duration MR-1 and MR-6) were planted in RCBD at every month. The observations were recorded at monthly intervals and results were analyzed using suitable statistical tool. The study revealed that, Effect of sowing time on seed yield of finger millet varieties, GPU-28 recorded maximum seed yield in month of August-18 (40.67 q/ ha), GPU-48 in July-18 (38.10 q/ ha), GPU-67 in April-18 (37.78 q/ ha), Indaf-7 in Dec-17 (42.38), ML-365 inJuly-18 (45.52), MR-1 in June-18 (51.75 q/ ha) and MR-6 in Dec-17 (51.75 q/ ha). The present investigation we found that there is no shifting in sowing time in GPU-48, ML-365 and MR-1. Whereas, GPU-48 from Late Kharif (August) to Kharif (June July), GPU-67 from kharif (June) to early kharif (April) followed by Kharif (June-July), Indaf-7 from Rabi (Oct) to Late Rabi (December) followed by Kharif (July) and MR-6 from Kharif (June) to Rabi (December) sowing show alternative sowing time and gives better seed yield. In terms of growth and seed yield MR-6 shows best performance compare to other varieties of finger millet. Hence, increasing yield in finger millet choice of variety and sowing time played a key role.

Introduction

Nutri-cereals have gained attention due to their inherent quality of early maturity, capacity to yield even under poor soil, drought and low management conditions. They have a very high resilience to soil moisture and weather variations therefore have become vital in Indian agriculture. Small millets are less attracted by biotic stress to be it disease or pest. Consumption of these grains have demonstrated positive health benefits among the diabetics. Hence, they are immensely sought after food among urbanities and eventually drawing the attention of food processing industries. The crops under this umbrella are finger millet (Ragi), kodo millet (Kodo), foxtail millet (Kangni), little millet (Kutki), proso millet (Cheena), and barnyard millet (Sawan); grown in many states of India.

Finger millet [*Eleusine coracana* (L.) Garten.] is a tetraploid crop (2n=4x=36; genome constitution AABB) belonging to the grass family *Poaceae*, subfamily *Chloridoideae* commonly called as ragi in India. The name ragi is derived from its Sanskrit name "rajika". It ranks third in importance among millets in the country.

Finger millet has dual importance as a source of food grain as well as straw and is grown in an area of 1.01 million hectare with annual production of 1.8 million tones and with productivity of 1.37 tonnes per hectare (Anon., 2018). While over 50 per cent of the crop area in India is in Karnataka (0.60 m ha) with of productivity of 1.44 t/ ha, which is higher than Indian average. Karnataka state shares 60.8 per cent of the area and two third of production (68.6 %) and 34 % of global production (Anon., 2018).

Finger millet is the staple food for millions of people in India and Africa. It is the main dietary component in southern Karnataka particularly in districts of Bangalore, Kolar, Tumkur, Mysore, Hassan, Mandya and Chitradurga. The major finger millet growing states are Karnataka, Tamil Nadu, Andhra Pradesh, Orissa, Jharkhand, Maharashtra and Uttaranchal. Finger millet is the staple food for millions of people in India and Africa. It is the main dietary component in southern Karnataka and in this region farmers are facing problem of ear head development, seed setting and uneven maturity of crop. In this contest, to know the precise sowing time of finger millet varieties to optimize the growth and yield parameter under changing climatic situation, the experiment was selected. Seven popular varieties of finger millet (GPU-28, GPU-48, GPU-67, INDAF-7, ML-365, MR-1 and MR-6) (Table 1) were taken for study of "Effect of sowing time on growth parameters of finger millet [*Eleusine coracana* (L.) Gaertn.] under climate change regime."

As climate change resulting from human activities has emerged as a global concern in the past 20 years. One particular worry is the potentially disastrous consequence for agriculture and food security in many parts of the world, particularly developing countries. Crop farming is extremely vulnerable to climate change and it has been predicted that climate change will impact negatively on agricultural yield in the 21st century through higher temperatures, more variable rainfall and extreme climate events such as floods, cyclones, droughts and rising sea levels. Climatic condition is considered to be one of the main edaphic factors that strongly limit the growth and yield of plants worldwide (FAOSTAT, 2017)

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. Transplanting increases the yield and also compensates the yield in case of delayed sowing (Bhaskar, 1986). Similarly, age of seedling splays vital role in establishment and tolerance to withstand root injury shocks during the process of transplanting.

Today, more attention is being paid due to increasing evidence of less seasonal rainfall, terminal heat, frequent occurrence of extreme weather events resulting in abnormal growth, delay the date of flowering is largely due to reduced or lengthened vegetative phase, uneven maturity, improper ear head development, seed setting, incidence of pest and disease which depends on photoperiod and growth season. Transplanting is another option in basket of choice available to minimize the risk of crop failure or patchy stands, so achieving better yields during years when scenario of fluctuating climate condition. Thus, flowering behavior, seed setting and maturity problems could be

manipulated by the use of optimum time of sowing.

Materials and Methods

The field experiment was conducted at National Seed Project, UAS, GKVK, Bengaluru, Karnataka from November-2017 to Octomber-2018. The sowing was done in every month in randomized complete block design (RCBD) with package of practice. Observations were recorded at monthly intervals and also noted the meteorological date from beginning of experiment to end (Table 2).

Plant height (cm)

The plant height was measured from the base of the plant at ground level to the growing tip (base of the head) at 30, 60 and 90 days after sowing. After emergence of ear head, the height was taken up to the tip of ear head on the main shoot. The average plant height was worked out and expressed in centimeters.

The seed crop was harvested when it attained physiological maturity. At this stage, seed moisture is expected around 24 per cent. The harvested heads were dried under sun for three days on threshing floor. Threshing was done by beating with the sticks manually. The seed was cleaned and net plot seed yield was recorded after thorough drying and expressed in kilograms.

Seed yield (q/ha)

The ears heads from each net plot were threshed, dried under sun and seed weight was recorded. From each treatment of the replication was averaged and later converted to quintals per hectare.

The data obtained from various parameters were subjected to statistical analysis. The analysis of variance and interpretation of data was done as per the procedure given by Gomez and Gomez (1984). The level of significance used in 'F' and 'T' tests was P=0.05. Critical difference value was calculated whenever 'F' test was significant.

Results and Discussion

The performance of figure millet varieties under climate change regime with different sowing time shows significant difference in growth and yield parameters (Table 2).

Plant height (cm)

Finger millet varieties sown in each month (time) of a year differed significantly for plant height. MR-1 recorded significantly higher plant height when sowing was taken in the month of Jan-18 (77.93 cm), May (73.47), June-18 (74.87 cm), July (72.80) and Sept-18 (71.40) followed by MR-6. Whereas, MR-6 shows significantly higher plant height in Jan-18 (68.20 cm), May (74.40 cm), June (68.40), July (73.80 cm) and Sept-18 (87.13 cm) month of sowing in followed by MR-1.

GPU-67 documented significantly superior plant height in Feb-18 (38.33 cm) and April-18 (45.53 cm) month of sowing compare to other medium duration varieties. Indaf-7 recorded higher plant height in the month of Dec-17 (54.53 cm), March-18 (41.80 cm), Jul-18 (68.73 cm), Sept (82.87 cm) and Oct-18 (41.73 cm). However, ML-365 in Nov-18 (33.40 cm), Jan-18 (64.87cm), May-18 (74.00 cm), June-18 (68.60 cm) and August-18 (52.00 cm).GPU-28 was noticed in July-18 (68.60 cm), August-18 (49.93 cm) and Sept-18 (64.87 cm) month of sowing.

However, short duration variety of GPU-48 recorded significantly superior plant height in Nov-17 (39.40), Dec-17 (40.80), Jan-18 (74.60), Feb (41.53), March (42.40), April

(40.80), May (65.13) and June-18 (69.53) month of sowing.

The highest plant height of all finger millet varieties were crop was sown in the month of Jan, May, June and July-18. The variation in plant height were observed in different varieties of finger millets it might be due to availability of growing condition like temp (29.76^{o} C), relative humidity (78.34 %), sunshine hours (7.15 hrs) and average rain fall (85.40mm) from January to December-18.the number of rainy days at pre-flowering and total amount of rainfall received during the vegetative period of crop growth had inversely affected seed production. The optimum temperature during day (32° C) and night (25° C) time seems to be more favorable for the growth and development and sunlight is also very essential. The yield of finger millet is influenced by the solar radiation particularly during the last 35 to 45 days of ripening period. Bright sunshine with low temperature during ripening period of the crop helps in the development of seeds. Similar finding also reported by Sudhishree and Dass (2006) in finger millets (Fig. 1).

Seed yield (q/ ha)

Significant difference in seed yield was noticed in different months of sowing of finger millet varieties (Table 3).

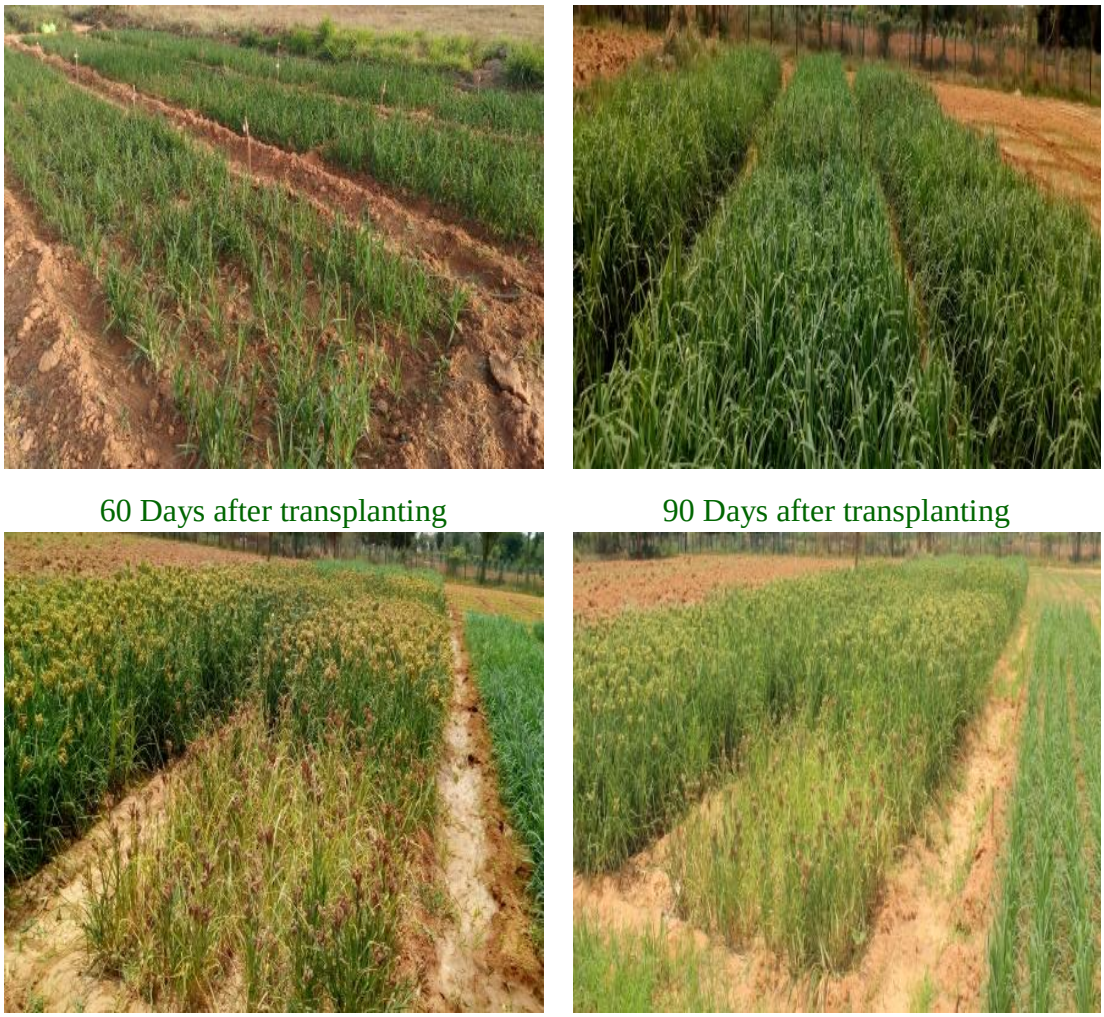
Significantly superior seed yield (q/ha) was obtained in MR-1 when sown in month of Nov-17 (38.10q/ha), Feb-18 (30.72), March (43.56), April (41.14), June (44.76) and Sept-18 (42.11). However, MR-6 recorded significantly better seed yield inDec-17 (51.56), Jan-18 (47.30), May (44.83), July (47.30), August (49.62) and Oct-18 (28.83q/ha) month of sowing (Fig. 2).

As per this study there was no alternative sowing time in MR-1. June-18 month of sowing recorded maximum seed yield (51.75 q/ha), if any change in the planting or sowing time there was reduction in seed yield in MR-1. However, MR-6 shows 6.92 % deviation from recommended date of sowing (June) to alternative sowing time, Maximum seed yield was recorded in the month of Dec-17 (51.56 q/ha), this is on far with June-18 (48.22 q/ha) and average seed yield was recorded in all month of sowing except, Sept-18 month of sowing recorded lowest seed yield (28.83 q/ha) due to low rain fall (0.69, 0.09 and 0.00 mm) and high RH (71.63, 70.45 and 71.50 %) in Nov-17, Dec-17 and Jan-18 months. Among the varieties MR-6 was showing best performance in Sept-18 month of sowing.

GPU-67 recorded significantly superior seed yield (q/ha) when crop was sown in the month of Jan-18 (35.08) and April-18 (37.78). Whereas, Indaf-7 in Dec-17 (42.38), Sept-18 (39.62) and Oct-18 (24.44). ML-365 in Nov-17 (35.05), Feb-18 (27.82), March-18 (36.57), May-18 (36.95), June-18 (44.76), July-18 (45.52) and August-18 (43.11). Remaining sowing month shows significantly lower seed yield.

In GPU-67, Slight deviation (6.66%) in sowing time from kharif to early kharif (April) in achieving better seed yield (37.78 q/ha) followed by July (35.43 q/ha) and 7.69% deviation from April to Jan sowing (34.08 q/ha). It might be due to influence of moderate temp (27.40, 33.20 and 27.74 in Jan-18, April and July-18 respectively). Good rain was received in the month of June (85.02 mm) helps in achieving maximum yield in April-18 month and utilization of soil moisture in July month of sowing.

As per the recommended date sowing time of Indaf-7 is best suitable for Rabi, supporting to this statement this study also notice there is no change in the sowing time when crop was sown in the month December (42.38 q/ha).



60 Days after transplanting | 90 Days after transplanting

At Physiological maturity | 120 Days after transplanting

Fig.1 General view of experimental plot

Table.1 Finger millet varieties description

Sl. No.	Duration of varieties (Days)	Varieties	Recommended date of sowing
1	Short duration (95-100)	GPU-48	April-May; Aug; Jan-Feb
2	Medium duration (115-120)	GPU-28	July-Aug
		GPU-67	June to Aug
		INDAF-7	Sept-Oct
		ML-365	June to Aug;Jan-Feb
3	Long duration (120-125)	MR-1	June-July
		MR-6	

Package of practice by UAS, Bengaluru

Table.2 Meteorological data for the crop growth period from 2017 to 19 at GKVK, UAS, Bangalore

Month	(Rainfall mm)	Maximum Temperature (^{0}C)	Minimum Temperature (^{0}C)	Relative humidity (%)	Sunshine hours (hrs)
Nov-17	0.00	26.87	16.53	90.8	7.20
Dec-17	0.28	26.31	14.95	73.62	6.67
Jan-18	0.00	27.40	14.14	69.60	8.72
Feb-18	0.11	29.20	17.99	66.97	6.93
Mar-18	2.01	32.00	17.70	2.01	8.55
April-18	0.90	33.20	20.80	61.09	8.50
May-18	7.40	31.66	20.13	64.52	7.43
June-18	85.02	30.40	18.00	25.82	7.98
July-18	2.02	27.74	19.49	75.00	4.04
Aug-18	3.15	27.03	18.82	76.77	3.46
Sept-18	5.12	29.19	19.19	71.17	6.49
Oct-18	0.94	28.89	17.77	72.13	7.53
Nov-18	0.69	28.37	16.94	71.63	7.19
Dec-18	0.09	27.80	16.26	70.45	6.25
Jan-19	0.00	27.90	13.10	71.50	8.50
Feb-19	24.0	30.60	17.20	67.00	9.40
Mar-19	0.00	33.70	20.10	59.00	9.10
Total	**131.73**	-	-	-	-

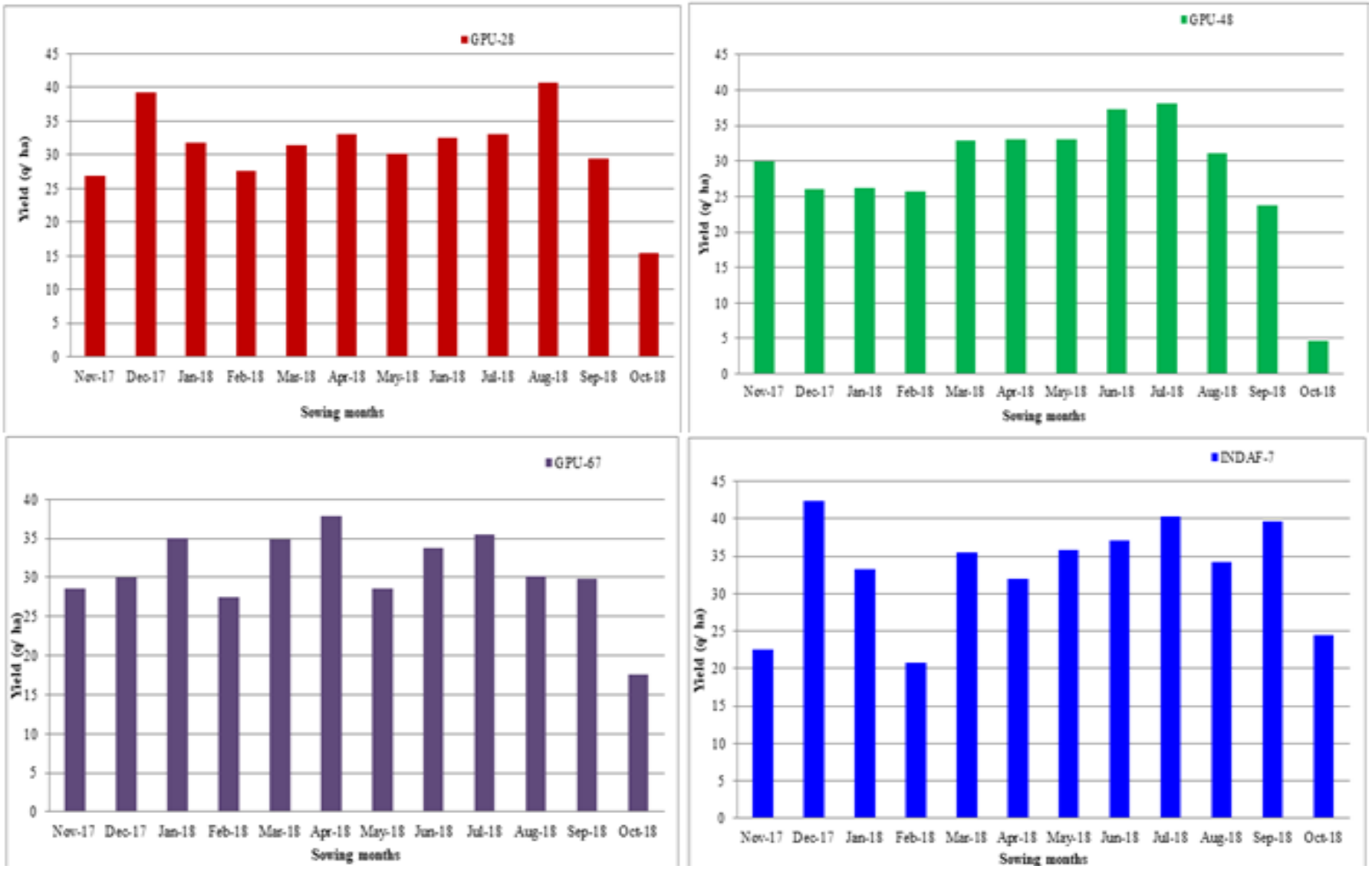
Table.3 Effect of sowing time on plant height of finger millet varieties under climate change regime during 2017-18

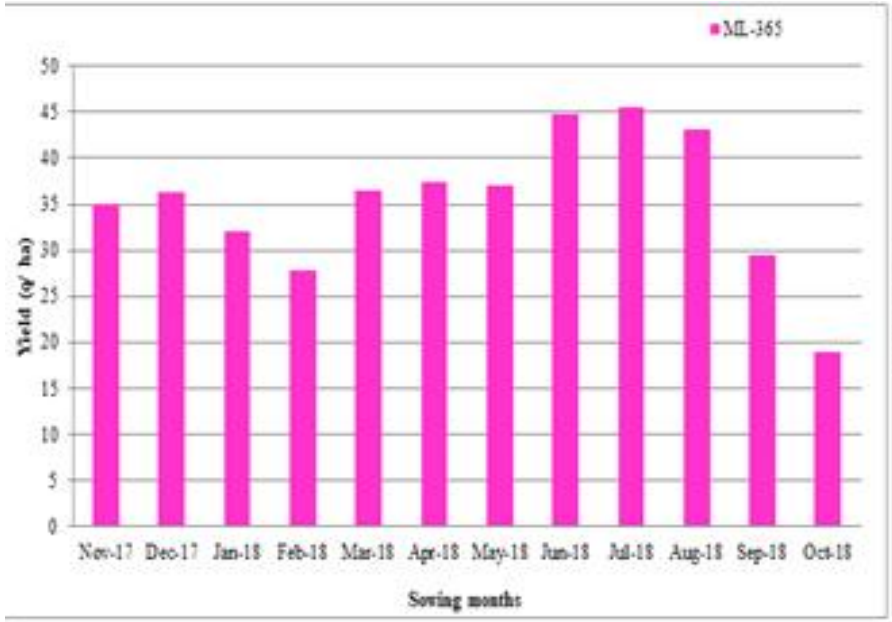
Varieties	Plant height (cm)											
	Nov-17	Dec-17	Jan-18	Feb-18	March-18	April-18	May-18	June-18	July-18	Aug-18	Sept-18	Oct-18
GPU-28	35.80	40.13	68.47	40.47	37.47	33.73	63.33	63.53	68.60	49.93	64.87	38.93
GPU-48	39.40	40.80	74.60	41.53	42.40	40.80	65.13	69.53	60.80	49.13	37.73	39.27
GPU-67	24.40	39.10	58.80	38.33	41.50	45.53	66.27	63.13	58.80	50.27	55.20	27.47
INDAF-7	25.87	54.53	67.20	38.00	41.80	35.40	71.20	63.47	68.73	43.73	82.87	41.73
ML-365	33.40	42.27	64.87	34.67	38.07	39.67	74.00	68.60	67.60	52.00	63.13	40.40
MR-1	36.00	62.80	77.93	40.53	51.73	45.93	73.47	74.87	72.80	38.73	71.40	55.00
MR-6	24.40	55.27	68.20	38.00	48.07	54.40	74.40	68.40	73.80	40.67	87.13	53.47
Mean	**31.32**	**47.84**	**69.30**	**38.79**	**43.00**	**42.21**	**69.69**	**67.36**	**67.30**	**46.35**	**66.05**	**42.32**
SEm±	**2.35**	**2.22**	**4.03**	**1.98**	**3.47**	**2.29**	**2.21**	**3.84**	**2.39**	**3.29**	**1.35**	**1.07**
CV (%)	**13.00**	**8.04**	**10.08**	**8.86**	**13.99**	**9.40**	**5.50**	**9.88**	**6.15**	**12.29**	**3.54**	**4.36**
CD 5%	**7.24**	**6.85**	**12.42**	**6.11**	**10.71**	**7.06**	**6.82**	**11.84**	**7.36**	**10.14**	**4.16**	**3.28**

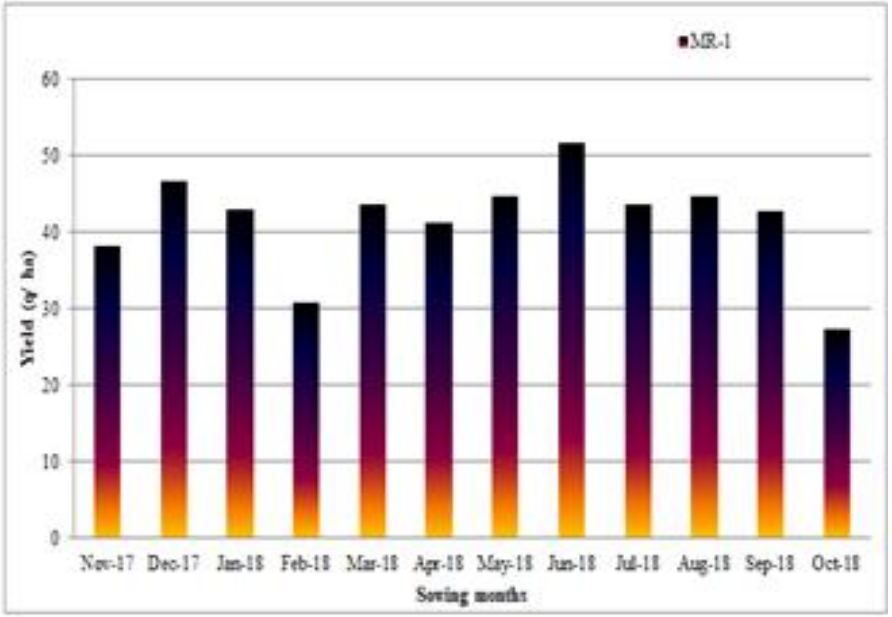
Table.4 Effect of sowing time on seed yield of finger millet varieties under climate change regime during 2017-18

Varieties	Seed yield (q/ha)											
	Nov-17	Dec-17	Jan-18	Feb-18	March-18	April-18	May-18	June-18	July-18	Aug-18	Sept-18	Oct-18
GPU-28	26.92	39.27	31.87	27.53	31.49	33.14	30.16	32.43	33.02	40.67	29.40	15.37
GPU-48	29.97	26.00	26.13	25.71	32.89	33.08	33.02	37.37	38.10	31.17	23.68	4.58
GPU-67	28.62	30.00	35.08	27.52	34.79	37.78	28.62	33.82	35.43	30.19	29.90	17.52
INDAF-7	22.54	42.38	33.33	20.70	35.49	31.94	35.75	37.05	40.32	34.19	39.62	24.44
ML-365	35.05	36.21	32.06	27.82	36.57	37.33	36.95	44.76	45.52	43.11	29.45	18.92
MR-1	38.10	46.67	43.08	30.72	43.56	41.14	44.76	51.75	43.75	44.76	42.79	27.24
MR-6	37.21	51.56	47.30	30.19	41.90	39.81	44.83	48.22	47.30	49.62	30.73	28.83
Mean	**31.20**	**38.87**	**35.55**	**27.17**	**36.67**	**36.32**	**36.30**	**40.77**	**40.49**	**39.10**	**32.23**	**19.56**
SEm±	**2.72**	**3.71**	**3.63**	**2.26**	**2.72**	**2.73**	**3.81**	**4.42**	**3.30**	**4.06**	**3.33**	**2.17**
CV (%)	**15.13**	**16.52**	**17.68**	**14.40**	**12.85**	**13.03**	**18.20**	**18.76**	**14.11**	**17.98**	**17.88**	**19.19**
CD 5%	**8.40**	**11.42**	**11.18**	**6.96**	**8.38**	**8.42**	**11.75**	**13.61**	**10.16**	**12.51**	**10.25**	**6.68**

Fig.2 Effect of sowing time on seed yield of finger millet varieties under climate change regime during 2017-18




ML-365
Yield (q/ ha)
0
5
10
15
20
25
30
35
40
45
50
Nov-17 Dec-17 Jan-18 Feb-18 Mar-18 Apr-18 May-18 Jun-18 Jul-18 Aug-18 Sep-18 Oct-18
Sowing months


MR-1
Yield (q/ ha)
0
10
20
30
40
50
60
Nov-17 Dec-17 Jan-18 Feb-18 Mar-18 Apr-18 May-18 Jun-18 Jul-18 Aug-18 Sep-18 Oct-18
Sowing months


MR-6
Yield (q/ ha)
0
10
20
30
40
50
60
Nov-17 Dec-17 Jan-18 Feb-18 Mar-18 Apr-18 May-18 Jun-18 Jul-18 Aug-18 Sep-18 Oct-18
Sowing months

But this is on far with July (40.32q/ ha) month of sowing followed by all month of sowing except Nov-17 (22.54 q/ha), Feb (20.70 q/ha) and September (24.44 q/ha) months recorded low seed yield. It might be due to sowing time coupled with rain fall (0.00, 0.11 and 0.94 mm), temperature (26.87, 29.20 and 28.89^{o}C) and RH (90.8, 66.97 and 72.13%) in the month of November, February and October respectively.

There is no shift in the sowing month of ML-365, highest seed yield was recorded in the July-18 (45.52 q/ha) followed by June (44.76 q/ha) and August-18 (43.11 q/ha) it might be due to good amount of rain fall received in the month of June-18 (85.02 mm) coupled with moderate temperature (30.40, 27.74 and 27.03^{o}C) and RH (25.82, 75.00 and 76.77 %) in the month of June, July and August-18 respectively. Whereas, lowest seed yield was recorded in the month of Sept -18 (18.92q/ha) due to vegetative and reproductive stage coincide with low rain fall (0.69, 0.09 and 0.00 mm) and high RH (71.63, 70.45 and 71.50 %) in the month of November-17, December-17 and January-18 respectively. GPU-28 record significantly higher seed yield when sowing is taken in the month of Dec-17 (39.27), Jan-18 (31.87), Feb (27.53), April (33.14), August (40.67), Sept (29.40) and Oct-18 (15.37) (Table 4).

Short duration variety (GPU-48) show significantly better seed yield (q/ha), when crop is sown in Nov-17 (29.97), March-18 (32.89), May (33.02), June (37.37) and Jul-18 (38.10).

As per the package of practice, GPU-28 variety show best performance in the late kharif (August) to obtained maximum seed yield. From this study, sowing was taken in the month ofAug-18 gives maximum seed yield (40.67 q/ ha) this is on far with Dec-17 month of sowing (39.27 q/ha). Lowest seed yield was recorded in Sept-18 h (15.37 q/ha) which was lower than the recommended (package of practice) sowing time, it might be due to adverse weather condition *via.*, temperature (29.19- 19.19^{o}C), relative humidity (71.17%), sun shine hours (6.49 hrs) and low rain fall (5.12 mm) during growth stages. Low sun shine hours reduce the photosynthetic activity their by reduce the seed yield.

Whereas, GPU-48 shifting in sowing time means as per the recommended date of sowing late kharif (August) is best for achieving maximum seed yield but in this study shows June-July-18 (37.37-38.10 q/ha) recorded maximum seed yield, followed by March, April and May-18 (32.89, 33.08 and 33.02 q/ ha respectively) and lowest was recorded in Sept-18 (4.58 q/ha). The variation in the seed yield attributes might be due to changing weather condition, in June good amount of rain fall (85.02 mm) to achieve better seed yield in June-July, moderate temp (30.40, 27.74^{o}C respectively), RH (25.82 and 75%) and bright sun shine (7.98 and 4.04hrs respectively).

The difference in seed yield was noticed in finger millet varieties, it might be due to cumulative temperature, rain fall, relative humidity and bright sun shine hours play vital role in growth and development. Flowering period recorded significant association among themselves, while the effect of temperature and the number of rainy days at pre-flowering stages constituted significant negative association with seed yield, days to maturity and precipitation received at post-flowering period. An increased or decrease in total rainfall and number of rainy days at pre-flowering period, brought down the air-temperature, which in turn fluctuate the vegetative phage, there by decreased physiological production capacity for effective growth and days to maturity of crop.

The similar finding also reported by Sudhishree and Dass (2006) in finger millets. Pandiselvi *et al.,* (2010) conducted the experiment on evaluation of optimum time of sowing of finger millet (*Eleusine coracana* G.) varieties in Karaikal region with three varieties.

They conclude that shifting in sowing time has given maximum seed yield that the regular sowing time.

The present investigation we found that GPU-28, ML-365and MR-1 there is no shift in the sowing time and also we found alternative planting or sowing time in GPU-48 from Late Kharif (August) to Kharif (June July), GPU-67 from kharif (June) to early kharif (April) followed by Kharif (June-July), Indaf-7 from Rabi (Oct) to Late Rabi (December) followed by Kharif (July) and MR-6 from Kharif (June) to Rabi (December) sowing gives better growth and seed yield. In terms of growth and seed yield MR-6 shows best performance compare to other varieties of finger millet. Hence, increasing yield in finger millet choice of variety and sowing time played a key role.

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