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Characterization and assessment of photoperiod sensitivity and yield with different sowing dates on local land race thalaivirichan sorghum in Vellore district of Tamilnadu

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Abstract

Thalaivirichan cholam is a sorghum landrace grown in north east and north western part of Tamilnadu state in India, it is locally adapted, often traditional variety developed over time, through well adaptation to its local regions. It is identified by its loose and long ear head with very tall and stout stem. It is Kharif season sorghum sowing taken from 1st June to end of July depending on the rainfall condition. To study the flowering behaviour this land race in different season *viz.*, summer, *kharif* and *rabi* the sowing was taken from 1st February to 1st October with one-month interval. The summer and Kharif sowing date from 1st February to 1st August attain flowering only in last week of October irrespective of time of sowing indicates highly photo sensitivity of the land race. The delayed sowing influenced the growth and development of the plant through gradual decrease in plant height, biomass, days to 50% flowering and grain yield. The Rabi sowing (1st September and 1st October) flowered during November with drastic reduction in plant height, biomass and flowering time when compared to Summer and Kharif sowing. To attain flowering, this land race demand short day with photo period of less than twelve hours than any other factor. First fortnight of June is best for sowing to attain high biomass with higher yield.

Keywords: Sorghum, photo sensitivity, land race, characterization

Introduction

Sorghum [*Sorghum bicolor* (L.) Moench] is a widely adaptable cereal crop cultivated around the world in semiarid, subtropical, tropical and temperate climates. It provides staple food for millions of people in Asia and Africa (Mundia *et al* , 2019) [9]. Globally cultivated sorghum occupies fifth place in cereal crop production after maize, rice, wheat and barley. In India sorghum is cultivated in both *kharif* and rabi season. kharif sorghum is called rainy season sorghum and having climate of long days and high temperature occupying period from June to October. Rabi season is called post rainy season with short day and low temperature from October to February. Sorghum grain production in India during *kharif* season is 43 per cent and in Rabi season is 57 per cent. The area of sorghum production in India is 4.1 million hectare with production of 4.2 million tonnes through productivity of 1000 kg per hectare (ipad.fas.usda.gov 2025). Tamil Nadu produced 10% of total sorghum production in India

Landraces are the ancient cultivars cultivated by the farmers and their successors through traditional method of selection over the decades. Common characteristics of landrace is a dynamic population(s) of a cultivated plant that has historical origin, distinct identity and lacks formal crop improvement, as well as often being genetically diverse, locally adapted and associated with traditional farming systems' (Villa *et a.*, 2005) [13]. Agricultural production is still influenced by land race, especially in marginal areas where cultivars become less competitive. Landraces are preferred by farmers in marginal areas because they adapt to local agro-environmental conditions and produce stable yields (Harlan, 1992; Frankel *et al* , 1998; Almekinders and Louwaars, 1999; Brown, 1999) [2, 3, 5,6]. Therefore, particularly in traditional and subsistence farming systems landraces persist to play a significant role in food security. Every land races are easily differentiated from one another and from cultivars by its special features. As a result, each landrace can be identified and typically has unique morphological traits and local names. Spatially, landraces are associated with one specific geographical location. Sorghum production continues to depend mainly on traditional cultivars characterized by hardiness, photoperiod sensitivity, long stalks and low harvest index (Akinseye *et al* , 2017). In Vellore district (12°55'N, 79°1'E, 238.67 m) of Tamilnadu state receives annual average rainfall of 971.1 mm from south west monsoon (June to September) 439.1 mm, north east monsoon (October to November) 385.6 mm, winter (January to February) 39.8 mm, summer (March to May) 106.6 mm and the sorghum cultivation is taken up in *kharif* season (June) as a rainfed crop with local land race called thalaivirichan sorghum (*Sorghum roxburghi*) also called siluppu cholam, Kollai mettu cholam. It is a native type of sorghum, traditionally grown in north east and north western regions especially Vellore, Thiruvannamali, Dharmapuri and Krishnagiri districts. Landrace of thalaivirichan sorghum "is recognized morphologically" by their free and long ear heads and long plant height of 4 to 4.5 meters with stout stalk and photoperiod sensitive. One of the notable traits of sorghum is their responsiveness to photoperiod, with sensitivity decreasing as latitude increases. The term 'photo' refers to light, while period signifies the duration time. The length of light within a day is termed photoperiod. The plant response to the varying lengths of day and night that triggers flowering is known as photoperiodism. Depending on the duration and amount of light required for flowering, plants are classified into the three categories. Short-day plants (SDP) in which the response is induced when the photoperiod is shorter than the critical day length (CDL); long-day plants (LDP) in which the response is induced when the photoperiod exceeds the CDL; and day-neutral plants (DNP) which do not respond to photoperiod. Sorghum is classified as a short-day photoperiod sensitive crop with its flowering development accelerated when day length falls below a critical threshold. Photoperiod can delay the natural progression to flowering by causing the plant to wait for a particular signal. The flowering dates of local land races occurring at the same time, despite significant differences in their sowing dates are called homeostasis. This homeostasis mechanism is likely influenced by photoperiod, as temperature variations between sowing dates are minimal. Analysis of segregation pattern of photoperiod sensitivity from crossing ten photo period insensitive lines with EBA-3 photoperiod insensitive line used as male showed nine of ten F_1 progeny were strongly photo period sensitive. Segregation analysis in eight of the F_2 populations fit a 9:7 Photo period sensitive and Photo period insensitive ratio, indicated complementary dominant epistasis (Rooney and Aydin 1999) [14]. Four maturity loci identified in sorghum each loci accounted for flowering from 40 -100 days with different maturity days depending on environment and in the events lateness is dominant to earliness Quinby and Karper (1945) [15]. and Quinby (1966) []. Photoperiod plays a crucial role in crop development, such as the breeding of varieties that flower at optimal times for specific environments. The aim of this study was to examine the characteristics of the local land race thalaivirichan sorghum and to assess its photoperiod sensitivity at the Agricultural Research Station in Virinjipuram, Vellore district, Tamil Nadu.

Materials and Methods

Seeds of local land race thalaivirichan sorghum sowing were taken in the field with spacing of 15 cm within plants and 60 cm between rows with four replications at the Agricultural Research Station, Virinjipuram. Sowing was planned during summer, *Kharif and rabi* from 1st February 2022 to 1st October of 2022 with one-month interval and standard agronomic practices were followed. The observations were taken on selected 5 plants for morphological and yield related traits *viz.*, days to 50 % flowering, days to maturity, plant height (cm), number of leaves, leaf length (cm), leaf width (cm), number of nodes, inter node length (cm), stem girth (cm), earhead length (cm), fodder yield per plant (g) grain yield per plant (g), leaf midrib colour, anther colour, dried anther colour, stigma colour, glume colour, glume coverage, panicle density/compactness, panicle shape, grain size, 100 seed weight, grain shape, grain colour, sheath colour, stem / stalk nature, node colour, disease reaction and photoperiod sensitivity. The photo sensitivity of the gentype was evaluated using photo period sensitivity index (Kp), which is calculated based on the reduction in the duration (in days) of the vegetative phase between two sowing dates.

$$Kp = \frac{DurH1 - DurH2}{DatS2 - DatS1}$$

DurH1 and DurH2 refers the duration in days from sowing to days to 50% flowering for the first and second sowing dates, respectively, and DatS1 and DatS2 the first and second sowing dates in Julian days (Kouressy *et al* 1998 [7], https://core2.gsfc.nasa.gov/time/julian.html).

The value of Kp is anticipated to range from 0 for photoperiod insensitivity cultivars, which do not alter the duration of their vegetative phase with changes in sowing date, to 1.0 for the most photoperiod sensitive cultivars that shorten their vegetative phase in direct proportion to the delay in sowing, thereby maintaining a consistent calendar date for flowering

Results and discussion

Being a short-day plant, sorghum requires less than 12 hours of sunlight (photo period) before reaching the reproductive stage. Ten to eleven hours is the ideal photoperiod for flower induction. Vegetative growth is promoted by photoperiods longer than 11 to 12 hours. Sorghum vegetative phase occur in between seedling emergences to panicle initiation In this study the duration of vegetative phase of thalaivirichan sorghum reveal extraordinarily huge variation from 92 days to 267 days related with sowing date (Table 1). These crops reached peak blooming in the final week of October, with all sowing dates being between 1st February and 1st August. The period between February to September are long days and the land race developed its vegetative growth. October has short days, and the northeast monsoon season begins at the end of the month. This short-day climatic condition favoured the induction of the reproductive phase. Whether thalaivirichan sorghum is sown in February or August, its peak flowering date is always the last week of October. This variation is due to photoperiod sensitivity of the local land race (Miller *et al* 1968) [8]. As the day length decreases to less than 12 hours, this landrace differentiates from vegetative phase to reproductive phase. The same finding was noted in *Sorghum roxburghii* var. hians, Stapf. (Jowar) when sowing times between February and June, the flowering occurs on October 24 or 25, when the daily light period is 11 hours and 28 minutes, and the flowering time and height at flowering gradually decrease with the lateness of sowing. (Sen Gupta JC and Saga J, 1950) [12]. It is observed that the days to 50% flowering, days to maturity, number of leaves, nodes, fodder yield per plant and grain yield were decreased from first sowing to last sowing (Table 2 & Fig. 2, 3 & 4). This is due to when day length decreases the vegetative growth also decrease. In short days, the sorghum vegetative period duration is minimum. One of the main causes for low fodder and grain yields in sorghum is late sowing that direct to fast growth and development with early termination of the vegetative period generally lead to smaller plants with short height and lean stem (Alagarswamy *et al* , 1997).

In terms of sowing date and yield, the highest yield was recorded on June 1st, followed by May 1st (Table 2). Although the fodder yield is higher from 1st February to 1st April the drying of the bottom leaves results in fewer actively photosynthesised leaves, which lowers grain yield. The ideal date for sowing is one of the most crucial elements that affect yield. In general, there is a good time to plant each product, and delaying planting can reduce yield. (Omid-Beigi, 2000) [11]. Different cultivars' sowing dates had no effect on the flowering window, but a reduction in day length but not low night temperatures had an impact on the flowering time. Late sowing generally reduces cultivars' potential yield (Naoura, *et al* 2023) [10]. Hence the optimum sowing date for land race thalaivirichan sorghum is first fortnight of June is best to attain higher yield. In general the optimum sowing time for Kharif sorghum is from last week of May to 2nd fortnight of July and Rabi is from Mid September to last week of October. The thalaivirichan sorghum gives more biomass and grain yield during Kharif season with 150 days maturity. Summer sowing of thalaivirichan sorghum cause long vegetative period due to long days and force the plant to wait for short days to induce flowering. Maintenance of long vegetative period is difficult due to lower leaves attain drying when extension of vegetative period. In *rabi* season from sowing to attainment of flowering is short day condition leads to early flowering and maturity with low biomass and low grain yield (Table 2). Photoperiod-insensitive varieties, which do not change the duration of their vegetative phase with the sowing date, should have a Kp of 0; the most strongly photoperiod-sensitive varieties, which shorten their vegetative phase to the same extent as the sowing delay while maintaining a constant flowering date, should have a Kp of 1.0 (Clerget *et al.* ,2007) [4]. Here the thalaivirichan sorghum maintain constant flowering date at end of the October irrespective of sowing date from February to end of July indicating strong photoperiod sensitivity and show Kp value 1(Table, 3). Delayed sowing reduces their plant height and vegetative growth and accelerated the flower induction. During rabi season the growth and development cease in short period that causes early flowering and maturity. This is due to short day during October and November facilitates early flower induction and early termination of vegetative phage. This causes low biomass through reduced plant height and stem girth. The reduction of total biomass ultimately leads to low grain yield. In long days, more of vegetative period with high photosynthetic rate causes accumulation of more biomass leads to high grain yield (Table 2). There is highly significant variation was observed in yield among the different sowing date (Table 4).

Conclusion

The regions specific local land race thalaivirichan sorghum is short day plant with highly photo sensitive one due to long vegetative phase from February to October. To attain high grain yield with biomass first fortnight of June sowing (Kharif) is highly suitable. It is not suitable for summer due to long vegetative period and as well as rabi owing to early termination of vegetative period leads to reduced plant height, stem thickness, leaf size and over all biomass. To convert the photo sensitive to photo insensitive induced mutagenesis can apply to make it suitable for summer, kharif, and *rabi* seasons.

Table 1: Characterization of local land race thalaivirivhan sorghum

S. No.	Characters	Description (Kharif Season)
1	Plant Height	300 -450 depending on sowing time
2	Days of 50% flowering	110 -140 depending on sowing time
3	Days to maturity	150 -180 depending on sowing time
4	Leaf length (cm)	74
5	Leaf breadth (cm)	7.9
6	Panicle length (cm)	34
7	Panicle grith (cm)	20
8	Number of leaves	22
9	Number of nodes	22
10	Stem girth (cm)	7.1
11	Leaf midrib colour	White
12	Stigma colour	Greenish white
13	Anther colour	Yellow
14	Dried anther Colour	Light brown
15	Glume colour	Pale white to light brown
16	Glume coverage	38%
17	Panicle density/Compactness	Loose and Free
18	Panicle shape	Broader from top to bottom- Lax panicle
19	Grain size	Small
20	100 Seed weight	2.5g
21	Grain shape	Ovate - Flattened dorso-ventrally
22	Grain colour	Pearly white with red spot
23	Sheath colour	Green
24	Stem / Stalk	Juicy
25	Node colour	Green
26	Photoperiod sensitivity	Highly sensitive
27	Disease reaction	Susceptible to Anthracnose

Fig1: Morphological charecteritics of thalaivirichan sorghum

Plant height

Anthracnose disease

Field view of thalaivirichan sorghum cultivation

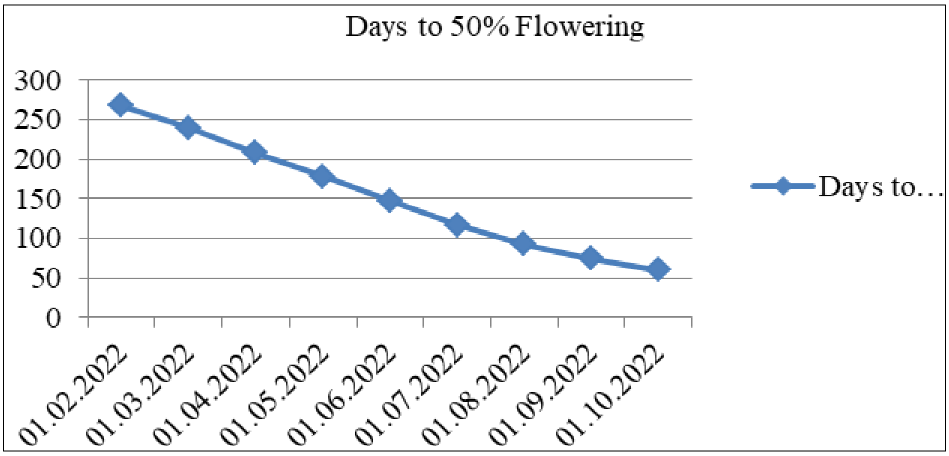

Fig 2: Effect of sowing date on flowering

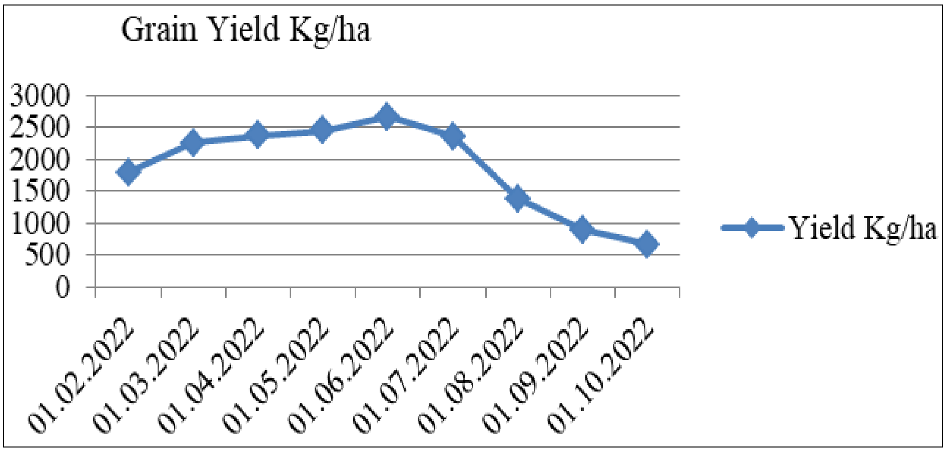

Fig 3: Effect of sowing date on grain yield

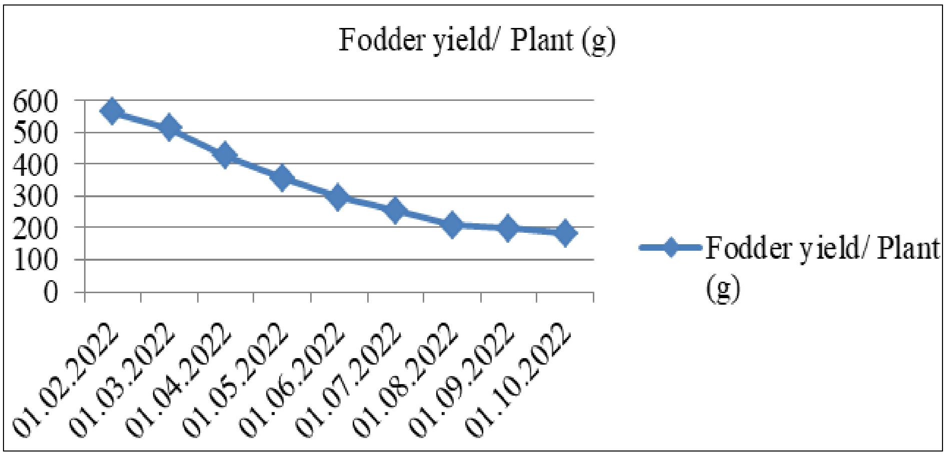

Fig 4: Effect of sowing date on fodder yield

Table 2: Characterization of local land race thalivirichan sorghum in different sowing date

Date of sowing	DFF	DM	PH (cm)	LL (cm)	LW (cm)	NNP	NLP	SG (cm)	PL (cm)	PG (cm)	FYP	GYP (g)	Plot Yield (Kg)	Yield Kg/ha
01.02.2022	267	307	486	78	8.1	26	26	6.8	32	17	564	38	3583	1792
01.03.2022	239	279	465	76	8.2	25	25	6.4	34	18	512	40	4506	2253
01.04.2022	208	245	450	77	8.1	24	24	7.1	35	19	426	42	4720	2360
01.05.2022	178	216	435	72	7.8	23	23	6.5	30	18	356	44	4876	2438
01.06.2022	147	184	428	74	7.9	22	22	7.1	34	20	296	45	5309	2655
01.07.2022	117	154	410	72	7.6	21	21	6.8	32	18	254	40	4706	2353
01.08.2022	92	127	324	72	7.4	17	17	5.2	27	16	208	31	2761	1379
01.09.2022	74	110	234	72	7.2	15	15	4.3	23	15	198	26	1788	894
01.10.2022	60	90	186	70	7.1	13	13	3.8	20	15	184	21	1317	658

DFF - Days to 50% flowering, DM- Days to maturity, PH-Plant Height, LL- Leaf length, LW- Leaf Width, NNP= Number of Nodes per Plant, NLP- Number of Leaves per Plant, SG-Stem Girth, PL - Panicle Length, PG- Panicle Girth, FLP –Fodder Yield per Plant, GYP- Grain Yield per Plant,

Table 3: Assessment of Photoperiod sensitivity and their effect on growth and development

Date of sowing	Julian date https://core2.gsfc.nasa.gov/ time/julian.html	Date of 50% flowering	Days to 50% flowering	Kp value	Date of maturity	Days to maturity	Height (cm)	Fodder yield/ Plant (g)	Yield kg /ha
01.02.2022	2459625	25.10.2022	267	1.0	05.12.2022	307	486	564	1792
01.03.2022	2459653	25.10.2022	239	1.0	05.12.2022	279	465	512	2253
01.04.2022	2459684	28.10.2022	208	1.0	05.12.2022	245	450	426	2360
01.05.2022	2459714	27.10.2022	178	1.0	05.12.2022	216	435	356	2438
01.06.2022	2459745	28.10.2022	147	1.0	05.12.2022	184	428	296	2655
01.07.2022	2459775	28.10.2022	117	0.8	05.12.2022	154	410	254	2353
01.08.2022	2459806	31.10.202	92	0.6	05.12.2022	127	324	208	1380
01.09.2022	2459867	13.11.2022	74	0.6	21.12.2022	110	234	198	894
01.10.2022	2459867	30.11.2022	60	-	31.12.2022	90	186	184	658

Table 4: Annova for grain yield

Source of Variance	df	SS	MSS	F cal	F table 5%	F table 1%
Treatment	8	67586983	8448373	16.880	2.305	3.256
Error	27	13513267	500491			
Total	35	81100249				
SEm	SEd	CD 5%	CD 1%	CV		
353.73	500.25	1015.55**	1362.57**	18.97		

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