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Growth parameters of tropical sugar beet as influenced by planting methods and dates of sowing in northern dry zone of Karnataka

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Abstract
Field experiment was conducted at University of Agricultural Sciences, Dharwad (Agricultural Research Station, Mudhol), Karnataka, during 2011-12 and 2012-13 in order to study the effect of planting methods and dates of sowing on growth and yield of tropical sugar beet under irrigated condition. The experiment was laid out in strip plot design with five replications. Two planting methods *viz.* Broad Bed and Furrows (BBF) and Ridges and furrows were assigned to horizontal plots and four dates of sowing *viz.* August 1st fortnight (FN), September 1st FN, October 1st FN and November 1st FN were assigned to vertical plots. Totally eight treatment combinations were evaluated for two seasons. Growth parameters are recorded at various intervals and final yield was recorded during harvesting. Experimental results showed that Planting on BBF found superior than ridges and furrows and sowing in October 1st FN found significantly superior to other treatments. Interaction effect did not differed significantly with respect to plant height, number leaves per plant, SPAD value and crop growth rate (CGR). October 1st FN sowing on BBF produced significantly higher dry-matter accumulation in dry-matter partitioning studies. The same treatment combination produced significantly higher root, top and sugar yield.

Keywords: BBF, ridges and furrows, tropical sugar beet, growth parameters, dry matter partitioning

Introduction

Tropical Sugar beet (*Beta vulgaris* L.) is considered as the second important sugar crop all over the world after sugarcane. Apart from sugar, sugar beet by-products like pulp and molasses are also valuable and are fed to animals (Singh *et al.* 2013) [15]. It is a biennial halophytic as well as Na- salts scavenger C_3 plant containing up to 20 % sugar on fresh weight basis. The storage organ of this plant is usually called as root, of which 90% is actually root derived and remaining 10% (the crown) is derived from the hypocotyls (Shrivastava *et al.* 2013) [14]. It contributes about 21.8 % of world's sugar production (Anon. 2017) [1]. Sugar beet is a versatile crop as it can withstand various climatic and soil conditions. Being tolerant to salinity and frost, it can help to bring several hundred hectares of uncultivable land under cultivation. The crop can also help to extend the factory season and consequently promotes employment. This tropical sugar beet is a short duration crop (5-6 months) with high sucrose content (14-20%) compared to sugarcane, which is a long duration crop (12-14 months) with low sucrose (10-12%) content.

The broad bed and furrow planting system is one of the new agronomic technology being adopted for most arable crops due to its water saving and better nutrient utilization, but adoption of this technology is being rarely seen in tropical sugar beet in India. This bed planting technology began to spread in 1980, when it was presented as an alternative for achieving better weed control, avoiding losses in yield and reducing the application of harmful agrochemicals. Sowing date of tropical sugar beet varies with the local climatic condition of the particular region. Therefore, sowing time is the most crucial factor affecting the yield of this crop to a great extent. Sugar beet sowing time also depends on the cultivation technology chosen (Romaneckas and Sarauskis, 2003) [12] and is also influenced by soil moisture. Generally, sowing time of sugar beet at any location is decided by the prevailing temperature of growing area.

Growth parameters such as plant height, number of leaves per plant, dry matter production and crop growth rate (CGR) are the prime factors which can ultimately influencing the final yield of the crop. The nitrogen is the supreme factor for vegetative growth and its uptake is precisely measured by analysis of plant sample, which is time consuming (Noh *et al.* 2006) [10]. Leaf chlorophyll measurement is a very good criterion for estimating crop nitrogen status (Shapiro, 1999) [13]. The SPAD value is the very good indicator for measurement of leaf nitrogen status under field condition.

Environmental factors cannot be controlled but may be adjusted to a positive direction for good crop performances in terms of yield and plant characters through sowing in optimum time. Sowing time for a crop is a non-monetary input but plays a significant role in increasing the yield of tropical sugar beet. Therefore, identification of proper planting method and appropriate date of sowing are essential for obtaining economic yield of the crop. Therefore, by considering the importance of growth parameters towards its contribution to yield, the experiment was conducted to study the effect of sowing dates and planting methods on growth and yield parameters of tropical sugar beet.

Material and Methods

Location of the Trial

Field experiment was conducted at the Agricultural Research Station, Mudhol, University of Agricultural Sciences, Dharwad to study the effect of planting methods and dates of sowing on growth and yield parameters of tropical sugar beet. The farm is located in the Northern Dry Zone (Zone 3) of Karnataka at 16^0 23' 56.4" North latitude, 75^0 6' 33" East longitude and at an altitude of 577.6 m above MSL. The experiment was conducted for two season *viz*. 2011-12 and 2012-13.

Weather conditions

The data pertaining to weather parameters prevailed during the period of experimentation are presented in Fig. 1. The total rainfall of the experimental site during the cropping period was 117.2 mm (11 rainy days) and 314.6 mm (19 rainy days) respectively during 2011-12 and 2012-13 as against the normal (372.63 mm) and deviated much in the first season. The rainfall distribution was un-erratic in the first season and was nearer to normal in the second season. The highest average maximum temperatures prevailed in the month of May (38.7^{0}C and 38.3^{0}C respectively in the first and second seasons) as against normal 37.4^{0}C. The higher minimum temperature was observed in the month of August, September, April and May wherein lowest minimum temperature range was observed in the month of November to March. There was huge variation in the distribution of relative humidity during the cropping period especially in the second season. The extreme morning and evening RH reached 98 per cent and 37 per cent deviation was observed from the normal. The August and September months were associated with lower bright sunshine hours and higher wind velocity.

Soil characteristics

The soil of experimental site was clayey with minimum drainage. The soil fertility status was low, medium and medium to high in available N, P_2O_5 and K_2O ha^{-1} respectively. The soil pH varied between 7 to 8 and low in organic carbon status.

Crop husbandry

The experimental field was ploughed once with double bottom tractor drawn mould board plough followed by tractor drawn cultivator. Poultry manure as source of organic manure was applied @ 3.5 t ha^{-1} fifteen days prior to planting by broadcasting and immediately incorporated into the soil. The ridges and furrows were opened with tractor drawn ridger by adjusting to the required row spacing of 75 cm (P_1). The broad beds and furrows were formed by using tractor drawn ridger by adjusting to row spacing of 150 cm (P_2). The variety PAC 60008 was obtained from Ses Vander Have, Pvt Ltd. and used for planting with the seed rate of 3.6 kg ha^{-1}. The pelleted sugar beet seeds were treated with *Trichoderma viridae*, a potent antagonistic fungus, *Azospirillum* and phosphate solubilizing bacteria. Two seeds were dibbled per hill in order to maintain 100% emergence and population. Later stands were thinned to required population. The recommended dose of fertilizer *i.e.* 140:60:120 kg N, P_2O_5 and K_2O ha^{-1} was used, entire phosphorus was applied as a basal dose, N and K_2O were applied in two splits. Immediately after sowing and fertilizer application, light or mild irrigation was given to the crop. Two hand weedings were done and need based irrigation was given to the crop during the period of experimentation. The pest and disease management measures were taken as per the guidance of Pest Control India, Pvt Ltd.

Layout of the experiment

The experiment was laid out in strip plot design with five replications, planting methods were assigned to horizontal plots *viz*. P_1: Ridges and furrows (75 cm apart) and P_2: Broad bed and furrows (60-90-60 cm paired rows). Dates of sowing were assigned to vertical plots *viz*. D_1: August 1st FN, $D_{2:}$ September1st FN, $D_{3:}$ October 1st FN and D_4: November 1st FN. Totally eight treatment combinations were tested in this trial. The crop sowing and harvesting schedules of vertical plot treatments are given below.

Sowing and harvesting dates as per the treatment schedule				
Treatment	2011-12		2012-13	
	Date of sowing	Date of harvesting	Date of sowing	Date of harvesting
August 1st FN	15-08-2011	11-02-2012	13-08-2012	09-02-2013
September 1st FN	15-09-2011	13-03-2012	14-09-2012	13-03-2013
October 1st FN	11-10-2011	08-04-2012	12-10-2012	10-04-2013
November 1st FN	14-11-2011	12-05-2012	13-11-2012	12-05-2013

Growth and yield parameters studied

Plant height and number of leaves plants^{-1} are the prime growth parameters, as they are providing greater and wider roof for photosynthesis to happen. Leaf chlorophyll content is the indicator for nitrogen uptake and is important for vegetative growth. Chlorophyll meter (SPAD 502, Soil Plant Analysis Division section, Minolta Camera Co., Osara, Japan) was used to obtain SPAD values of intact leaves as described by Peng *et al.* (1993) [11]. The above said parameters were recorded periodically at 45, 90,135 days after sowing (DAS) and at harvest. The Crop Growth Rate is the rate of increase in dry matter per unit land area per unit time. It was calculated by using the formula suggested by Watson (1958) [18] and was recorded between 45 to 90 DAS, 90 to 135 DAS and 135 DAS to harvest intervals. Dry matter partitioning *i.e* root and top dry matter production were also studied at different intervals from 45 DAS to harvest. During harvesting, the root and top weights were weighed separately from the individual plots (net plot area) after de-topping and converted to root and top yields per hectare and expressed in t ha^{-1}. Sugar yield (ton ha^{-1}) was calculated by using the formula as suggested by Hobbs *et al.* (2000) [4].

Statistical Analysis

Fischer's method of analysis of variance was carried out according to Gomez and Gomez (1984) [3]. The combined analysis was carried by using MSTATC computer software.

Results and Discussion

The data pertaining to plant height and number of leaves per plant are presented in Fig. 2. and Fig. 3 respectively. The plant height increased gradually upto 90 days irrespective of the treatments with advancement in crop growth and the values gradually attained the minimum at harvest. But, number of leaves per plant increased gradually from planting to harvesting in general. Planting sugar beet on broad bed and furrows recorded significantly taller plants with highest number of leaves than planting on ridges and furrows. Among the sowing dates, planting in 1st FN of October was recorded the highest means of plant height and number of leaves whereas, sowing in 1st FN of August produced shorter plants with lesser number of leaves per plant. Interaction effect of planting methods and sowing dates did not shown any marked difference in plant height and number of leaves.

Increased plant height with number of leaves per plant in BBF might be due to increased soil moisture availability as compared to ridges and furrows, this results in increased nutrient availability and there by faster nutrient uptake and cell division results in taller plants with more number of leaves per plant. These results are in line with the findings of Jnanesha *et al.* (2016) [5] in Maize. The maximum (27-38 ^{0}C) and minimum (20-21.8 ^{0}C) temperature that prevailed with earlier two dates of sowings (D_1 and D_2) are comparatively high with lower sunshine hours (2.5-4.6 hrs. day^{-1}). The maximum (28.3-37.3 ^{0}C) and minimum (18.6-20.7 ^{0}C) temperature that prevailed in the October and November sowings (D_3 and D_4) are comparatively low with more sunshine hours (6.8-8.7 hrs. day^{-1}) became more conducive for germination, lead to faster growth and development. Leach (1947) [9] reported that a linear increase in the emergence of the sugar beet seedlings with increase in temperature from 3 to 26^{0}C.

The data pertaining to dry matter partitioning *i.e.* root and top dry matter productions are presented in Table 1 and 2. The highest root and top dry matter production were recorded with October 1st FN sowing on broad bed and furrows during all the stages of plant growth as compared to other treatment combinations. Top dry matter increased gradually up to 90 days and declined towards harvest stage, which might be due to senescence as well as reduction in number of matured green leaves. Drying up of foliage after March was mainly due to high temperature (37.0 to 38.7 ^{0}C maximum and 21.1 to 22.9 ^{0}C minimum) and low relative humidity (50 to 56 %) prevailed during April and May. Suitable weather conditions prevailed during October 1st FN had increased water and nutrient use efficiency, supressed weed growth and good utilization of solar energy in BBF system. This led to encouragement of germination, establishment, promotion of vegetative growth and formation of good canopy, efficient photosynthesis and resulted in accumulation of more dry matter.

The growth and development of sugar beet plant depends upon the internal transport of sugar manufactured during the course of photosynthesis. The sugar first formed by the leaves is used to maintain basic metabolic processes. Secondly, it is utilized in the formation of new tissues. After fulfilling these requirements, the excess sugar is translocated for deposition in storage root. During initial stage of crop growth, sugar is mainly utilized in rapid development of tops and fibrous root. Consequently, deposition of sugar in storage root takes place in small quantity. But very soon the rate of development of root dry matter increases with age of the crop. Kandil *et al.* (2002) [6] also reported that suitable weather conditions results good foliage growth and formation of ample canopy able to make best photosynthesis, hence increased the dry matter accumulation. Lower dry matter production in August 1st FN sowing might be due lesser photosynthetic rate due increased pest and disease incidence. Higher humidity and poor availability of bright sunshine hours are found to be non-conducive and lead to lesser dry matter production.

The data related to SPAD value is presented in Fig. 4. Dates of sowing treatments differed in their leaf chlorophyll content (SPAD value) at all the stages of plant growth except at harvest. The highest leaf chlorophyll content was recorded in October 1st FN sowing compared to other treatments. This might be due to increased nitrogen uptake under favourable climatic conditions prevailed during the entire period. Planting methods and their interaction effects found non-significant.

The data related to CGR is presented in Table 3. Planting methods showed significant difference in CGR only between 45 DAS - 90 DAS and 135 DAS – harvest intervals. Broad bed and furrow planting recorded significantly higher CGR (29.68 and 14.31 g m^{-2} day^{-1} respectively) than the ridges and furrow planting (25.96 and 9.02 g m^{-2} day^{-1} respectively) during both the intervals. Dates of sowing showed significant difference only during 45-90 DAS. Significantly higher CGR was recorded with October 1st FN sowing (31.24 g m^{-2} day^{-1}) and was on par with November 1st FN sowing (29.86 g m^{-2} day^{-1}). The lowest CGR was noticed in August 1st FN sowing (23.17 g m^{-2} day^{-1}). The CGR was initially very high between 45-90 DAS and later it was declined. Such declining tendency of CGR was due to cessation of vegetative growth, senescence of leaves (Theurer, 1979) [16]. During early vegetative period the increase in CGR was high and it might be due to rapid growth due favourable conditions provided by BBF and weather parameters prevailed during the crop growth period. Similar findings are also reported by Ferdous Hossain *et al.* (2015) [2].

The data pertaining to yield is presented in Fig. 5. Sowing in October 1st FN on broad bed and furrows produced significantly higher root yield (55.15 t ha^{-1}) than all other treatment combinations followed by November 1st FN sowing. However, August 1st FN recorded the lowest (38.58 t ha^{-1}).

The highest top (10.03 t ha^{-1}) and sugar yield (9.06 t ha^{-1}) was registered under broad bed and furrow planting than planting on ridges and furrows (8.81 t ha^{-1} and 8.44 t ha^{-1} respectively). Among the dates of sowing, significantly higher top and sugar yield was recorded under October 1st FN (12.26 t ha^{-1} and 9.78 t ha^{-1} respectively). However, the lowest top (7.49 t ha^{-1}) and sugar yield (7.42 t ha^{-1}) was recorded by August 1st FN sowing. The interaction effect with respect to top and sugar yield was found to be non-significant.

October 1st FN sowing on broad bed and furrows has increased 42.94% root yield over August 1st FN sowing on ridges and furrows. The paired row on broad bed and furrows will cover the soil by early growth due to reduced row width, intensity of infestation of weeds is less and hence competition by weeds to moisture, nutrient and light are less. Bed system can grab maximum solar energy to convert it into chemical energy. In addition to that easy availability and encouraged nutrient uptake through bed system enhanced the growth and there by yield attributes and yield. These findings are also in line with the study done by Jnanesha *et al.* (2016) [5]. The higher yield in October 1st fortnight might be due to favourable minimum temperature for accumulation sugar and photosynthates from source to sink. October 1st Fortnight sowing reported significantly higher root, top and sugar yield with good quality of the produce. The findings of the study are in-line with the findings of Lamani and Halikatti (2019) [8]. August 1st FN sowing recorded lower yield might be due to lesser photosynthesis and dry matter accumulation. This high temperature may cause less translocation of assimilates to the developing roots due to more respiratory loss of assimilates. Tsialtas and Maslaris (2008) [17] also observed the higher respiratory loss in sugar beet at higher temperature. Similar findings are reported by Ferdous Hossain *et al.* (2015) [2]. Intensity of solar radiation intercepted by the canopy, temperatures at critical stages of crop growth and distribution of precipitation are the main limiting growth factors (Kenter *et al.*, 2006) [7] for obtaining higher yield.

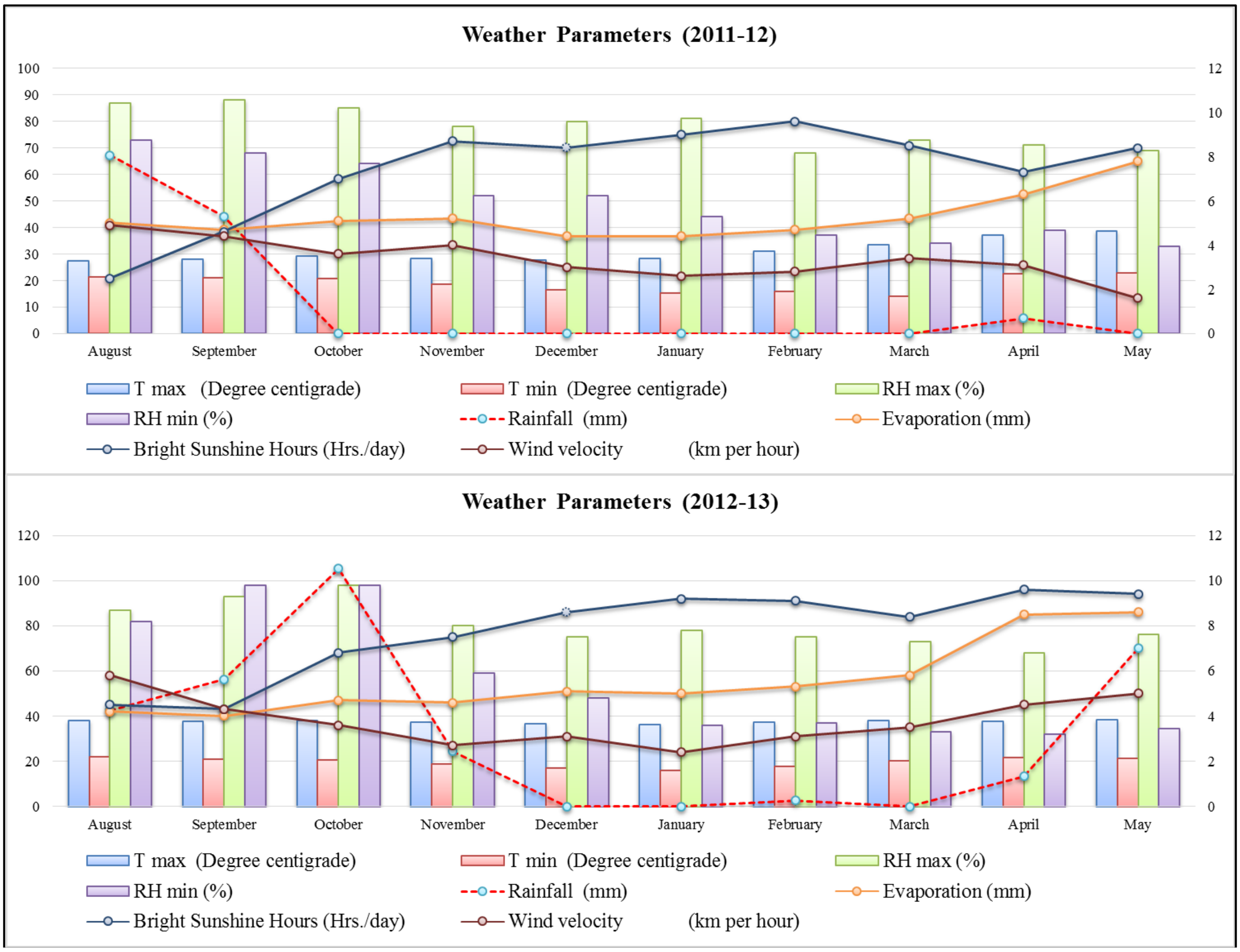


Fig 1: Weather parameters prevailed during the period of experimentation (2011-12 and 2012-13)

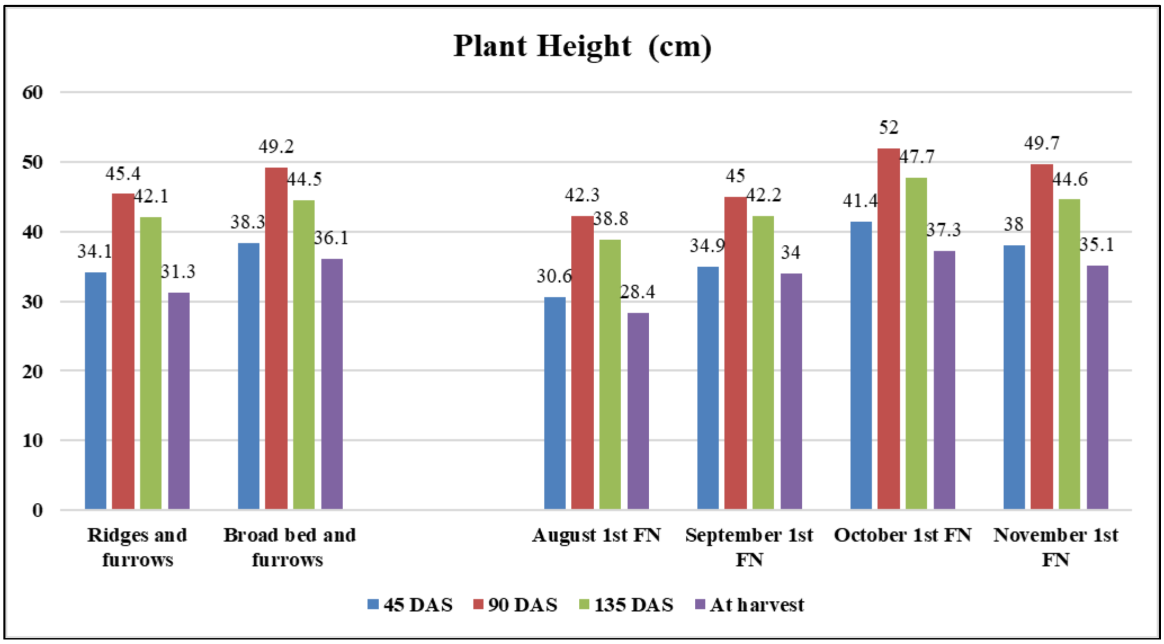


Fig 2: Plant height of tropical sugar beet at different growth stages as influenced by planting methods and dates of sowing (Pooled data of 2011 & 2012)

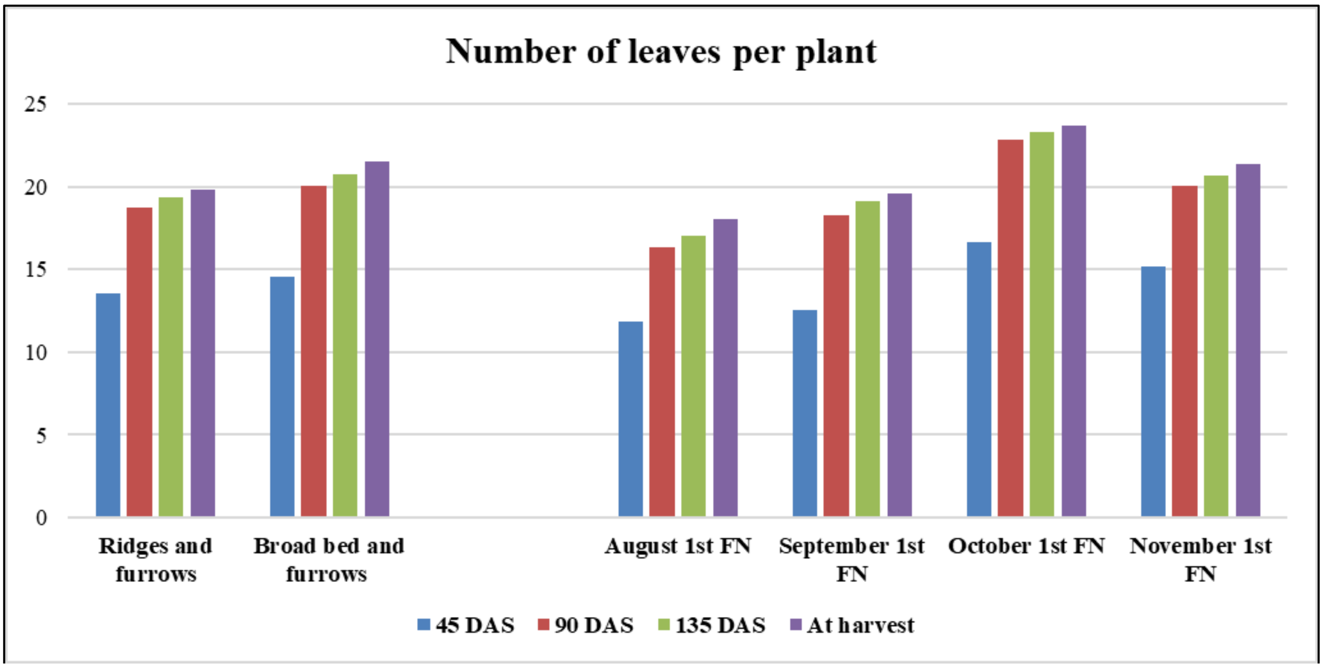


Fig 3: Number of leaves per plant of tropical sugar beet at different growth stages as influenced by planting methods and dates of sowing (Pooled data of 2011 & 2012)

Table 1: Root dry matter production of tropical sugar beet at different growth stages as influenced by planting methods and dates of sowing (Pooled data of 2011 & 2012)

Dates of sowing (D)	Root dry matter production (g plant^{-1})											
	45 DAS			90 DAS			135 DAS			At harvest		
	Planting method (P)											
	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean
D_1	12.48	13.25	12.86	38.65	41.76	40.20	108.28	120.15	114.21	148.80	174.80	161.80
D_2	14.01	17.56	15.79	43.75	59.74	51.74	120.39	127.20	123.80	160.08	187.19	173.64
D_3	17.87	29.95	23.91	61.17	80.05	70.61	135.08	153.14	144.11	180.78	222.23	201.51
D_4	17.14	23.13	20.13	58.54	69.23	63.89	126.75	136.68	131.71	172.07	206.52	189.29
Mean	15.38	20.97	18.17	50.53	62.69	56.61	122.62	134.29	128.46	165.43	197.68	181.56

	45 DAS S.Em±	45 DAS C.D. (P=0.05)	90 DAS S.Em±	90 DAS C.D. (P=0.05)	135 DAS S.Em±	135 DAS C.D. (P=0.05)	At harvest S.Em±	At harvest C.D. (P=0.05)
P	0.16	0.64	0.42	1.67	1.39	5.46	1.24	4.87
D	0.29	0.89	0.76	2.33	1.01	3.12	2.03	6.24
P x D	0.52	1.64	1.08	3.46	1.75	6.32	2.13	7.18

D_1 : August 1st FN **D_3** : October 1st FN **P_1** : Ridges and furrows (75 cm apart)
D_2 : September 1st FN **D_4** : November 1st FN **P_2** : Broad bed and furrows (60-90-60 cm paired rows)

Table 2: Top dry matter production of tropical sugar beet at different growth stages as influenced by planting methods and dates of sowing (Pooled data of 2011 & 2012)

Dates of sowing (D)	Top dry matter production (g plant^{-1})											
	45 DAS			90 DAS			135 DAS			At harvest		
	Planting method (P)											
	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean
D_1	17.87	20.56	19.21	66.54	79.73	73.13	37.62	39.90	38.76	24.47	26.85	25.66
D_2	19.45	23.19	21.32	77.40	83.94	80.67	43.12	51.71	47.42	32.79	38.36	35.57
D_3	28.18	34.56	31.37	86.13	99.56	92.85	53.11	64.67	58.89	38.75	47.50	43.13
D_4	24.12	31.57	27.85	82.54	93.50	88.02	48.36	58.86	53.61	36.75	42.12	39.44
Mean	22.40	27.47	24.94	78.15	89.18	83.67	45.55	53.79	49.67	33.19	38.71	35.95

	45 DAS S.Em±	45 DAS C.D. (P=0.05)	90 DAS S.Em±	90 DAS C.D. (P=0.05)	135 DAS S.Em±	135 DAS C.D. (P=0.05)	At harvest S.Em±	At harvest C.D. (P=0.05)
P	0.67	2.63	0.73	2.89	0.62	2.43	0.64	2.53
D	0.70	2.16	1.28	3.94	0.59	1.81	0.56	1.72
P x D	0.98	3.41	1.34	NS	0.89	3.11	0.93	3.24

D_1 : August 1st FN **D_3** : October 1st FN **P_1** : Ridges and furrows (75 cm apart) **NS**: Non Significant
D_2 : September 1st FN **D_4** : November 1st FN **P_2** : Broad bed and furrows (60-90-60 cm paired rows)

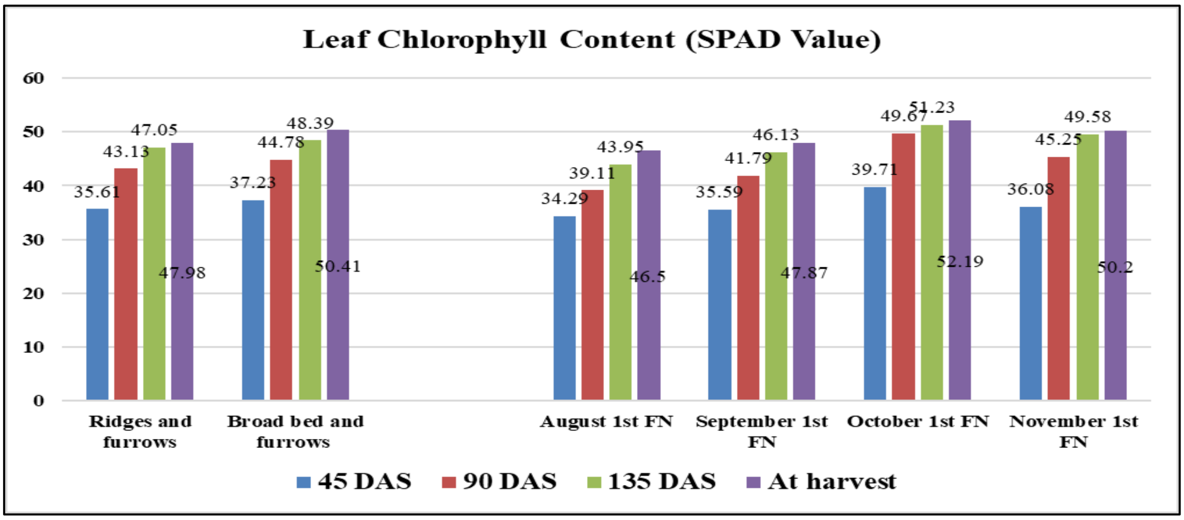
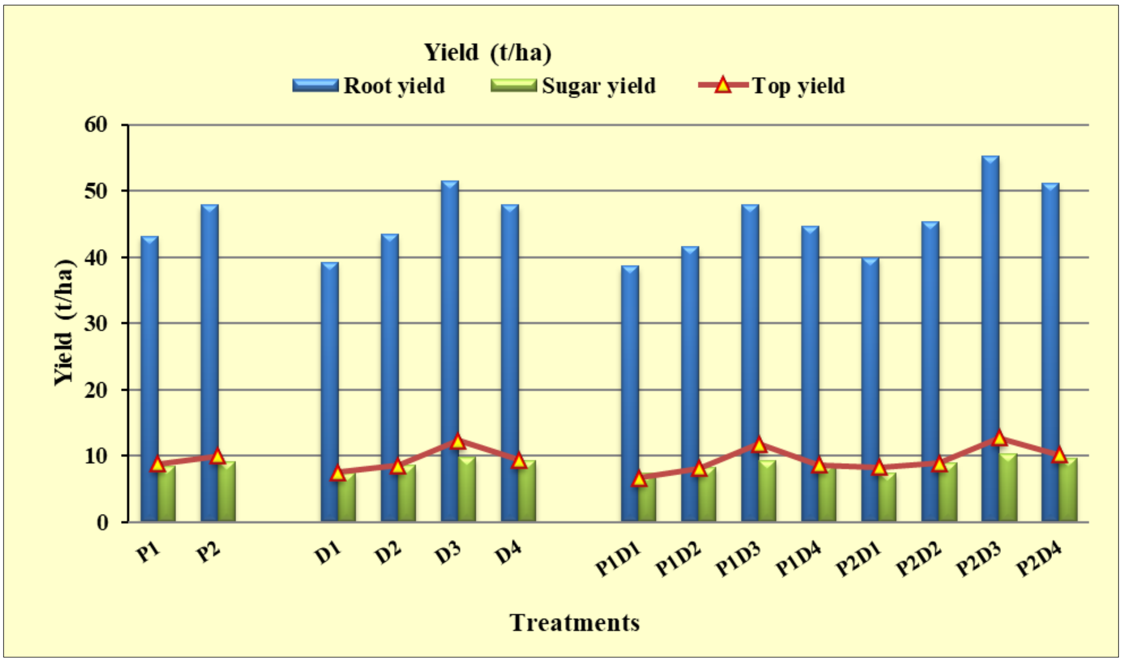


Fig 4: Leaf chlorophyll content (SPAD value) of tropical sugar beet at different growth stages as influenced by planting methods and dates of sowing (Pooled data of 2011 & 2012)

Table 3: Crop growth rate (CGR) of tropical sugar beet at different growth stages as influenced by planting methods and dates of sowing (Pooled data of 2011 & 2012)

Dates of sowing (D)	Crop growth rate (g m^{-2} day^{-1})								
	Between 45 DAS & 90 DAS			Between 90 DAS & 135 DAS			135 DAS & At harvest		
	Planting method (P)								
	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean
D_1	21.38	24.95	23.17	13.13	12.84	12.98	8.11	12.32	10.22
D_2	24.67	29.37	27.02	14.23	12.00	13.12	8.70	13.82	11.26
D_3	29.18	33.29	31.24	13.41	12.65	13.03	9.29	15.39	12.34
D_4	28.62	31.09	29.86	11.50	11.12	11.31	9.99	15.73	12.86
Mean	25.96	29.68	27.82	13.07	12.15	12.61	9.02	14.31	11.67
	S.Em±		C.D. (P=0.05)	S.Em±		C.D. (P=0.05)	S.Em±		C.D. (P=0.05)
P	0.34		1.34	0.67		NS	0.76		2.97
D	0.46		1.43	0.68		NS	0.77		NS
P x D	0.56		NS	0.95		NS	1.02		NS

D_1 : August 1st FN **D_3** : October 1st FN **P_1** : Ridges and furrows (75 cm apart) **NS**: Non Significant
D_2 : September 1st FN **D_4** : November 1st FN **P_2** : Broad bed and furrows (60-90-60 cm paired rows)



D_1 : August 1st FN D_3 : October 1st FN P_1 : Ridges and furrows (75 cm apart)
D_2 : September 1st FN D_4 : November 1st FN P_2 : Broad bed and furrows (60-90-60 cm paired rows)

Fig 5: Yield of tropical sugar beet as influenced by planting methods and dates of sowing (Pooled data of 2011 & 2012)

Conclusion

To obtain higher root, top and sugar yield in tropical sugar beet, Broad Bed Furrow (Paired row system) planting system is most ideal method of planting and October 1st fortnight is the ideal time of planting. Hence, it is recommended to adopt October 1st FN planting on BBF for tropical sugar beet cultivation.

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