International Journal of Agronomy and Agricultural Research (IJAAR)
ISSN: 2223-7054 (Print) 2225-3610 (Online)
http://www.innspub.net
Vol. 7, No. 1, p. 53-60, 2015

INNSPUB

RESEARCH PAPER

OPEN ACCESS

Effect of sowing dates on growth and yield of tropical sugar beet

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Article published on July09, 2015

Key words: Sugar Beet, Sowing date, Growth, Yield

Abstract

A field experiment was conducted at the research farm of the Department of Agronomy, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, from November 2011 to May 2012 to find out the growth pattern and optimum sowing date of tropical sugar beet in Bangladesh. The tropical sugar beet genotypes were Cauvery, Shubhra and EB0616, and sowing dates were 01 November, 15 November, 01 December and 15 December. The interaction effect of sowing dates and sugar beet genotypes was statistically significant in growth parameters like leave number, leaf area index (LAI), crop growth rate (CGR), root weight per plant, root yield. The highest root yield was obtained from genotypes EB0616 when sown on 01 November (103.5 t/ha) and 15 November (100 t/ha). The genotypes Cauvery and Shubhra gave identical root yield i.e., 90.27 t/ha and 92.86 t/ha, respectively on 01 November sowing. Root yield significantly decreased in all the three genotypes with the advancement of sowing dates from 01 November onwards. For high root yield the optimum sowing date for tropical sugar beet in Bangladesh seems to be in early November.

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Introduction

Sugar beet (*Beta vulgaris* L.), belonging to the Chenopodiaceae family, is a plant whose root contains high concentration of sucrose. Although sugar beet is a temperate crop, the international company "Syngenta" successfully developed some sugar beet genotypes that can be grown under tropical climatic conditions, and hence, the beet is known as "tropical sugar beet". 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 (Syngenta, 2004). In Bangladesh due to acute shortage of sugarcane as raw materials most of the sugar mills remain inoperative for a particular period of time. In this regard sugar beet might be an excellent alternative to sugarcane in Bangladesh by enhancing processing facilities in the sugar mills.

Sowing date of tropical sugar beet varies with the climate of the region and the genotypes used. 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 (Romaneckaset *et al.,* 2003) and is influenced by soil moisture. Generally the time of sowing of sugar beet at any location is decided by the prevailing temperature of growing area.

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 genotypes /variety and specific sowing date are essential for obtaining economic yield of the crop. So it is crucial to find out a genotype specific optimum sowing date with a view to obtain maximum root yield from tropical sugar beet in Bangladesh. By considering the above facts, the research work was undertaken to find out the optimum sowing time and growth pattern of tropical sugar beet in Bangladesh.

Materials and methods

Site, design and crop husbandry

The trial was conducted during 2011 to 2012 in the experimental field of the Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur Bangladesh. The experiment was laid out in Randomized Complete Block Design (RCBD) having two factors with three replications. Since the pH of the experimental field was 5.7, therefore, dolomite was applied @ 1500kg/ha (Rahman *et al.,* 2007) to raise the soil pH. Therefore, the final pH of the soil was 7.2. Seeds of three tropical sugar beet genotypes were sown on four different dates at 15 days interval starting from 1st November 2011 maintaining 50× 20 cm spacing in 3×2 m^2 unit plot. During final land preparation cow dung @ 15 t ha^{-1} was incorporated into the soil. A fertilizer dose of 120 kg N, 105 kg P_2O_5, 150 kg K_2O, 18 kg S, 3.5 kg Zn and 1.2 kg B ha^{-1} was applied in the form of urea, TSP, MoP, $ZnSO_4$ and boric acid, respectively. One third of the total urea and all other fertilizers were applied during final land preparation. The remaining amount of urea was applied as top dressing in two equal installments at 60 and 100 days after sowing (DAS). The field was kept weed free by hand weeding at 20, 40 and 60 DAS. Plant was thinned out keeping one plant per hill during the second weeding. Irrigation frequency was enough to prevent significant plant water stress. Plants were infected by damping off disease at seedling stage, and sclerotium root rot at seedling and later stages of growth. These were controlled by applying Dithane M 45 @ 2.2 kg ha^{-1} at seedling stage, and at later stage by applying Score 250 EC 0.5 ml/L of water.

Data collection

Out of the 6 m^2 of unit plot 2 m^2 was kept in each plot for final harvest to estimate the root yield and from the remaining 4 m^2 of land three plants were randomly selected from each plot at 30, 60, 90, 120, 150 and 165 days after emergence (DAE) according to sowing dates for recording number of leaves, leaf area index, dry matter and crop growth rate. Total number of fully developed green leaves was counted in three plants at each sampling and averaged to per plant.

The leaf area was measured with an automatic leaf area meter (Model: Li- 3100C).

The crop growth rate (CGR) was calculated by the following formula as described by Grander *et al.* (1985).

$$CGR = \frac{1}{GA} \times \frac{W_2 - W_1}{T_2 - T_1} gm^{-2} day^{-1}$$

Where,

W_1 = dry weight at time T_1 (g), W_2 = dry weight at time T_2 (g) and GA = ground area (m^2)

Based on sowing dates, plants were harvested at 165 DAE from 2 m^2 of land from each plot and their root yield was calculated to kg m^{-2} and t ha^{-1}. The data were subjected to the combined analysis of variance and LSD test was used for means separation by using the MSTAT-C statistical software.

Air temperature during experimental period was recorded which is shown on table. 1.

Number of leaves per plant

Number of leaves per plant was significantly influenced by different sowing dates. Leaf number increased rapidly up to 120 DAE, irrespective of sowing dates, in all genotypes and thereafter it increased at a slower rate up to 150 DAE. The number of leaves per plant started to decline due to drying of older leaves after 150 DAE onwards as shown in Fig. 1. Plants of all sowing dates produced statistically similar number of leaves up to 120 DAE, though that was significantly different at 150 and 165 DAE. Throughout the growing period all the 3 genotypes sown on 01 November produced the highest number of leaves per plant and the leaf number reduced with delay in sowing. Irrespective of sowing dates, the highest number of leaves per plant was obtained at 150 DAE in all genotypes. The reduction in leaf number per plant in late sowing may be due to lower temperature during early growth stage than that of early sowing. During later stages of late sowing plants, high temperature and rainfall may cause death of older leaves.

Results and discussion

Table 1. Maximum, minimum, average air temperature at different growth stages of tropical sugar beet during experimental periods.

Sowing dates	Crop growth stage (DAE)	Air temperature (° C)		
		Maximum	Minimum	Avg.
01 Nov.	Seedling stage up to 60 DAE	25.45	17.61	21.53
	Rapid root development stage (61 to 150 DAE)	27.01	15.36	21.22
	Late root development stage (151 to 165 DAE)	33.52	21.95	27.73
15 Nov.	Seedling stage up to 60 DAE	23.68	14.60	19.14
	Rapid root development stage (61 to 150 DAE)	29.30	16.98	23.14
	Late root development stage (151 to 165 DAE)	35.20	24.48	29.84
01 Dec.	Seedling stage up to 60 DAE	22.64	12.48	17.57
	Rapid root development stage (61 to 150 DAE)	31.75	19.96	25.86
	Late root development stage (151 to 165 DAE)	34.71	26.53	30.62
15 Dec.	Seedling stage up to 60 DAE	22.75	19.90	17.33
	Rapid root development stage (61 to 150 DAE)	33.07	22.11	27.59
	Late root development stage (151 to 165 DAE)	34.97	27.08	31.02

Leaf area index

Irrespective of sowing dates and genotypes, the Leaf area index increased (LAI) sharply after emergence up to 90 DAE then gradually attained a peak at 120 DAE and thereafter decreased gradually as shown in Fig. 2. This increase was due to the production of higher number of functioning leaves, which increased total photosynthetic area.

Similar trend was also reported by Theurer (1979) in sugar beet. Different sowing dates strongly influenced the LAI at 90, 120, 150 and 165 DAE in all the genotypes. The highest LAI (3.68) was obtained at 120 DAE on 01 November sowing in EB0616. This LAI was statistically similar to the LAI of other two genotypes viz. Shubhra (3.67) and Cauvery (3.61) sown on 01 November, and of all the 3 genotypes, sown on 15 November. Plants of genotype EB0616, sown on 15 December gave the lowest LAI (2.74) which was identical to that of plants sown on 01 December.

The reduction in LAI at later part of growth might be due to the death of older leaves which could not be entirely replaced by that of the newly formed leaves. The highest LAI at early sowing throughout the growing season might be due to the presence of favorable environmental condition for vegetative growth than that of late sowing. Theurer (1979) reported that early sowing of sugar beet provides better leaf growth throughout the growing season in the USA. Plants sown on 01 December and 15 December got lower temperature at early growing period which might be a cause of lower leaf area index of late sowing plant. Milford and Thorne (1973) also found that cold temperature during early growing period resulted in slightly smaller leaf areas.

Table 2. Effect of sowing dates on individual root weight and yield in three tropical sugar beet genotypes.

Sowing date	Individual root weight (g)			Root yield (t/ha)		
	Cauvery	Shubhra	EB0616	Cauvery	Shubhra	EB0616
01 Nov.	1149	1174	1252	90.27	92.86	103.5
15 Nov.	1107	1119	1214	85.29	88.45	100.0
01 Dec.	920.4	933.6	1013	72.21	74.44	80.89
15 Dec.	790.3	797.8	750.3	59.42	61.55	58.72
LSD(.05)	6.511			6.511		
CV%	5.74			3.74%		

Total dry matter

Different sowing dates showed a marked influence on the total dry matter production in tropical sugar beet. The pattern of dry matter production in all 3 genotypes was almost similar as shown in Fig. 3. Regardless of the different sowing dates, the total dry matter production in all genotypes increased progressively over time. The rate of increase, however, varied depending on the growth stages. In the beginning of the growth period, the variation in total dry matter within and between genotypes due to different sowing dates was less conspicuous but over time the difference widened. A rapid growth rate was observed after 60 DAE that persisted till 150 DAE in all genotypes. The highest rate of TDM production was observed from 90 to 120 DAE irrespective of sowing dates and genotypes.

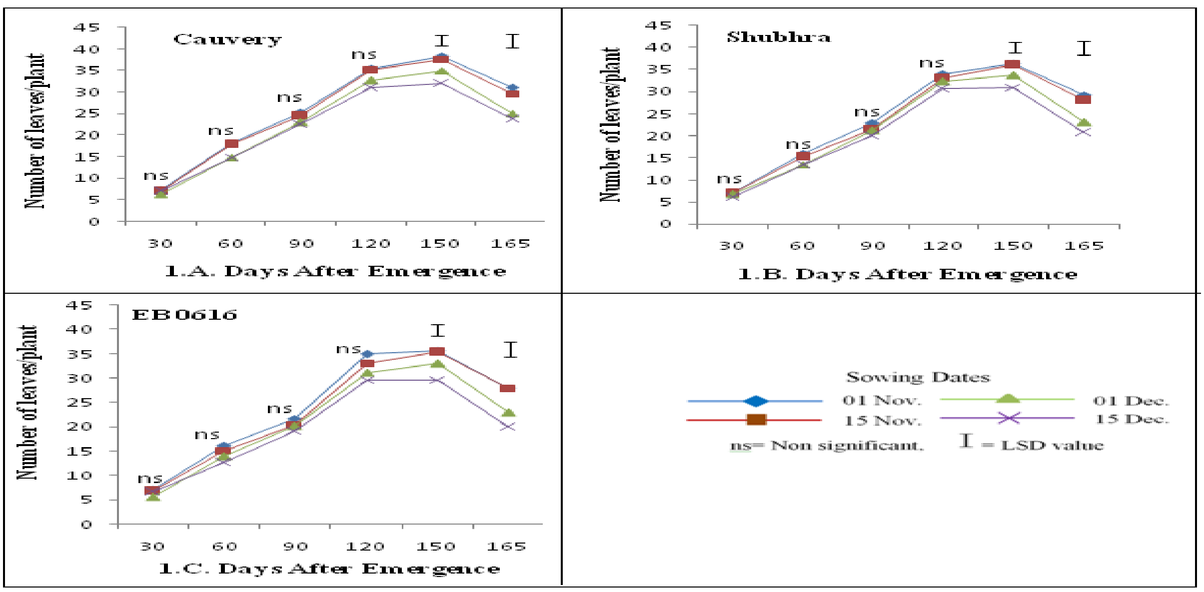

Fig. 1. Number of leaves in three tropical sugar beet genotypes over time as influenced by different sowing dates.

It might be due to increased photosynthesis resulted by higher leaf area and thereby increased TDM production. Irrespective of genotypes the TDM production was significantly higher in November sowings than in December sowings. Consistently larger amount of dry matter was produced in the genotype EB 0616 sown on 01 November and it was similar to that of 15 November sowing. The lowest dry mater was found throughout the growing season in the plants sown on 15 December which is supported by the smaller root size and lower shoot development in late sowing plants. Among the genotypes, EB0616 produced higher amount of total dry matter followed by Shubhra.

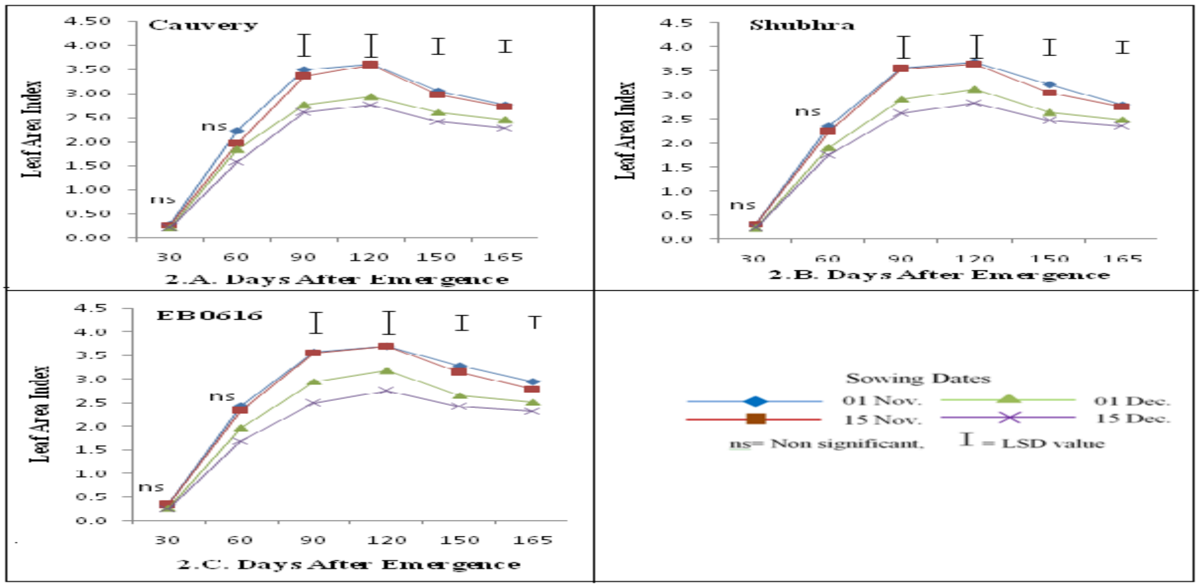

Fig.2. Leaf area index in three tropical sugar beet genotypes over time as influenced by different sowing dates.

Root dry matter

Different sowing dates caused significant variation in dry matter accumulation into root of 3 tropical sugar beet genotypes throughout the growth periods as shown in Fig. 4. Irrespective of sowing dates and genotypes, during the first few weeks of growth the rate of root dry matter accumulation was very slow, and from 60 DAE the roots began to accumulate dry matter more rapidly up to 150 DAE and thereafter slowly till final harvest at 165 DAE. Similar results were also reported by Theurer (1979) in sugar beet. At early stages of growth root dry matter did not differ markedly due to difference in sowing dates, but the difference became greater in later part of growth in all the 3 genotypes. Irrespective of genotypes, the highest root dry matter (2787.31 gm^{-2}) was found at 165 DAE on 01 November sowing which was statistically identical to that of 15 November sowing, while 15 December sown plants gave the lowest root dry matter (1597.26 gm^{-2}). This might be due to prevailing higher temperature during root formation stages of later sown plants compare to early sown plants. This might affect the sugar translocation to the root and cause high respiration loss. Among 3 genotypes, the genotype EB0616 maintained the highest and Cauvery produced the lowest dry matter in all sowing dates except 15 December sowing.

Crop growth rate

Different sowing dates significantly influenced crop growth rate in 3 tropical sugar beet genotypes as shown in Fig. 5. The CGR increased sharply up to 90 DAE then slowly with the increase in plant age reaching the peak at 120 DAE, and declined sharply thereafter till harvest irrespective of sowing dates and genotypes. Such declining tendency was due to cessation of vegetative growth, senescence of leaves (Theurer, 1979). During early vegetative period the increase in CGR was slow and it might be due to poor growth and development of leaf and root.

Among the sowing dates 01 November sowing showed the highest CGR in EB0616 during the growth periods. The CGR in EB0616 was identical to that of Shubhra and- Cauvery under 01 November and 15 November sowing. High CGR corresponds to the high LAI in tropical sugar beet genotypes. The same result was reported by Missa *et al.* (1994) in pea nut.

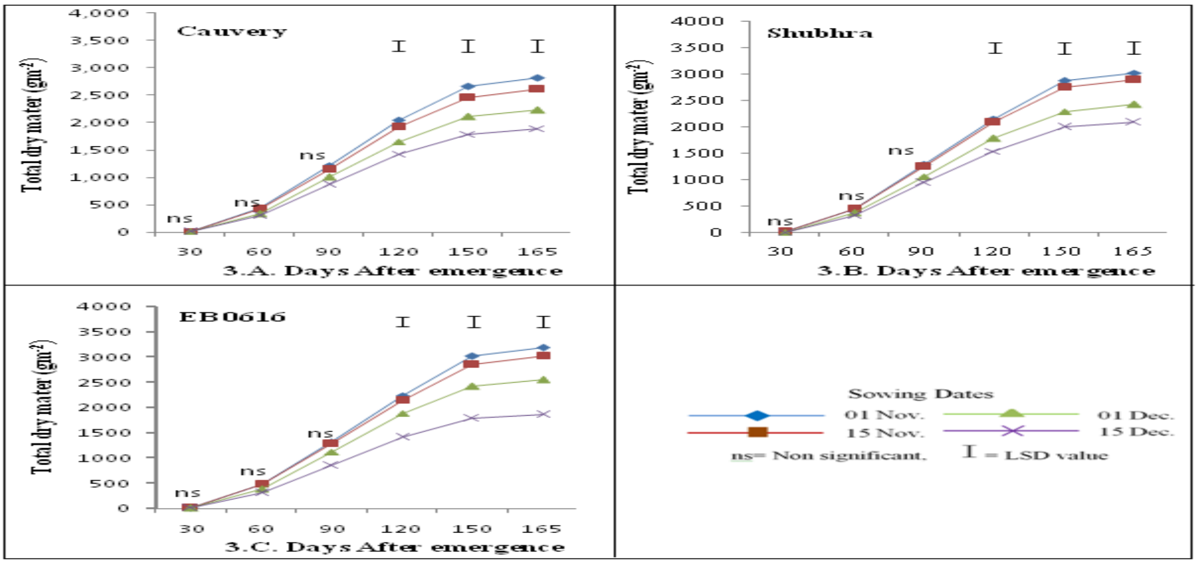

Fig.3. Total dry mater of three tropical sugar beet genotypes over time as influenced by different sowing dates.

Root weight per plant

The result revealed that the root fresh weight per plant was significantly influenced by sowing dates and genotypes (Table 2). In general the early sown plants produced the heavier individual roots than the late sown ones. The highest individual root weight (1252 g) was obtained in genotype EB0616 when sown on 01 November followed by 1214 g in the same genotype when sown on 15 November. The genotypes Shubhra and Cauvery produced significantly heavier individual roots in November sowings than in December sowings. Plants sown on 15 December produced the lightest individual roots in all 3 genotypes. This may probably be supported by the prevailing higher temperature during root development in the plants of 15 December sowing than in the plants of 01 November and 15 November sowing (Table 2). This high temperature may cause less translocation of assimilates to the developing roots and more respiratory loss of assimilates. Tsialtas (2008) also found the higher respiratory loss in sugar beet at higher temperature.

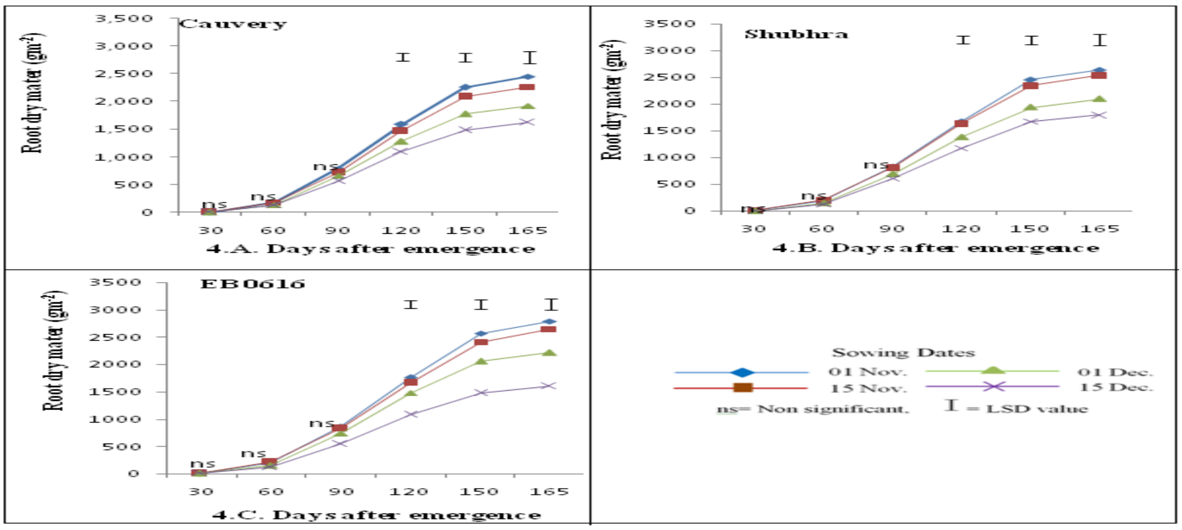

Fig.4. Root dry mater of three tropical sugar beet genotypes over time as influenced by different sowing dates.

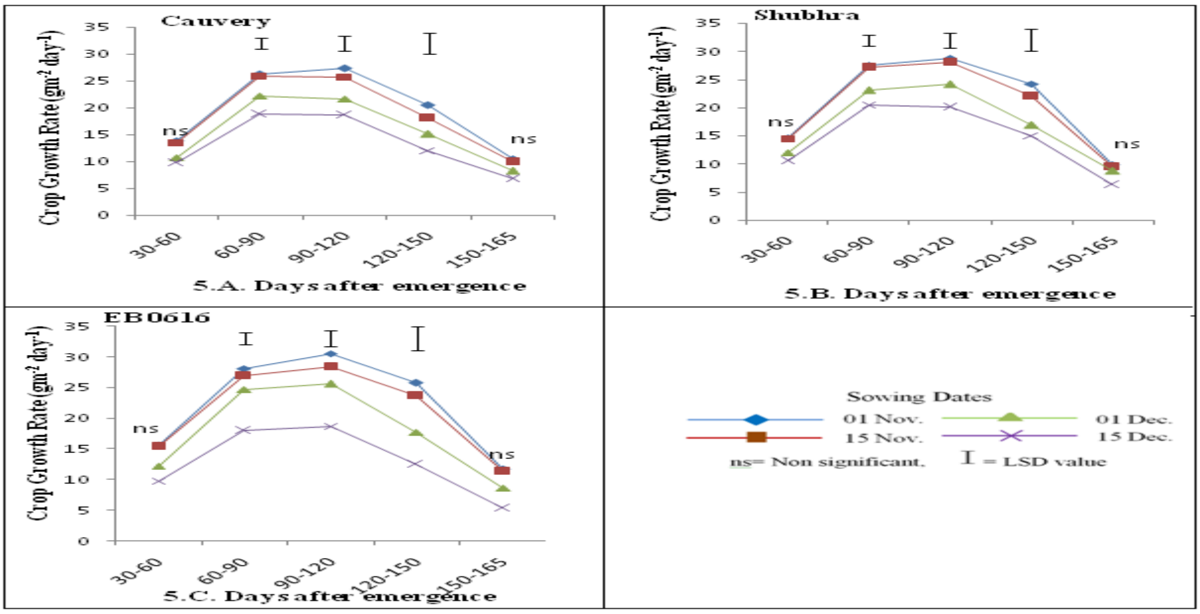

Fig.5. Crop growth rate of three tropical sugar beet genotypes over time as influenced by different sowing dates.

Root yield

A significant variation in root yield was observed due to interaction effect of sowing dates and genotypes (Table 2). The highest root yield was obtained in genotype EB0616 when sown on 01 November (103.5 t ha^{-1}) and on 15 November (100 t ha^{-1}). The genotype Cauvery and Shubhra gave identical root yield when sown on 01 November and 15 November and their root yield significantly decreased with delay in sowing. The genotype EB0616 gave the highest root yield at all sowing dates except 15 December sowing. The results revealed that root yield of tropical sugar beet genotypes significantly decreased with delay in sowing. Almost similar result was found by Rahman (2011) at Bangladesh Sugarcane Research Institute farm Ishurdi, Pabna, Bangladesh; Rahman *et al.* (2006); BRAC (2010) in Gazipur, Dinajpur, Rajshahi, Thakurgaon, Patuakhali; BSRI (2005) in Pabna, Bangladesh.

Conclusion

From the results of the present study it may be concluded that the tropical sugar beet genotypes *viz.* Cauvery, Shabhra and EB0616 can be grown under Bangladesh agro-ecological conditions. For high root and sucrose yield the optimum sowing date for tropical sugar beet genotypes in Bangladesh seems to be early November. Among the genotypes, EB0616 performed better in terms of root yield (103.5 t/ha). For high root yield the crop should be harvested at around 165 DAE if sown in early November.

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