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Research Article

Impact of Sowing Dates on the Yield and Quality of Sugar beet (*Beta vulgaris* L.) cv. California-KWS

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Abstract: The rapid changes in the global climate have endangered many countries including Pakistan. In this context, sowing dates play an imperative role in yield enhancement. Keeping in view the role and importance of sowing dates, five dates of sowing on 1st October, 11th October, 21st October, 1st November and 11th November were evaluated for sugar beet cv. California-KWS at the experimental research area, Faculty of Agriculture, Gomal University, Dera Ismail Khan during 2013-14, and 2014-15. The study was carried out in RCBD and replicated thrice. Data on the following parameters i.e. days to germination, germination percentage, plant height, number of leaves plant^{-1}, leaf area plant^{-1}, leaf and root weights plant^{-1}, total soluble solids (%), sucrose (%), root and sugar yields (t ha^{-1}) were included in this study. The results revealed that there were significant variations among the sowing dates treatments for all the parameters. Among sowing dates, 1st October sowing showed minimum days (7.31 & 6.46) to seed germination with maximum germination percentage (92.88 & 90.83%) during both years while sowing done on 11th October produced maximum plant height (43.46 & 43.43 cm), number of leaves plant^{-1} (43.63 &43.48), leaf area plant^{-1} (500.46 & 493.58 cm^2), leaf weight plant^{-1}(485.42 & 485.44 g), root weight plant^{-1} (14.73.5 & 1473.4 g), sucrose (16.54 & 16.59 %), total soluble solids (18.46 & 18.43%), root yield (63.61 & 62.44 t ha^{-1}) and sugar yield (10.57 & 10.64 t ha^{-1}) during both years. The comparative assessment of the sowing dates showed that 11th October sowing showed better performance over all other sowing dates during both the study years. The results depict that a profitable yield can be obtained when seeds are sown on 11th October under Dera Ismail Khan conditions and hence recommended.

Keywords: Sugar beet, sowing time, quality, root yield, sugar yield.

1. INTRODUCTION

Sugar beet (*Beta vulgaris* L.) positions the second most important sugar crops after sugar cane with a production of 30% sugar annually all over the world. Europe remains at the top regarding sugar beet production (70%). Russia is at the top with the production of 42.07 t ha^{-1} [1]. Brazil is the biggest sugar-producing country, while Pakistan ranks in 9th position with a production of 5 million tons annually. In terms of sugar consumption, India is at the top while Pakistan is the 8th biggest sugar consuming country in the world. In Pakistan, most of the sugar production is dependent on sugar cane while a very small portion goes to sugar beet. The sugar beet plant consists of a crown, neck, and root. The crown produces leave and the root stores the sugar [2]. Its roots contain 16-20% sucrose concentration [3]. Sugar beet pulp is used to make high fiber dietary food extracts while its syrup is used as a spread for sandwiches, cakes, (sweetening) sauces, and desserts. In addition to the beetroot, the leaves are a good source of carbohydrates, protein, and vitamin A. Besides, leaves are also beneficial as green manure [4]. Loam and clay loam soils are best for its cultivation. Sugar beet once established is tolerant of alkaline conditions. It is comparatively resistant to cold and drought [5]. Sugar beet production depends upon certain factors like environmental conditions such as soil textures, moisture, temperature, cultural practices, weeds, and diseases. Among these factors, the

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sowing dates are crucial for the enhancement of the yield of sugar beet [6]. Sugar beet needs a comparatively long growing period from 140 to 160 up to 200 days [7]. Sowing either too early or too late is unfavorable for growth and yield [8, 9, 10]. The impact of optimum sowing dates on yield improvement has also been reported by various researchers [11,12]. Leilah, *et al*[13] at Egypt and Bhullar *et al*[14] at Ludhiana noted maximum root weight and sugar yield ha^{-1} in an early sown beet crop. Reduction in yield commonly occurs due to late sowing because it delays maturity and shortens the fruiting period [15].

In Pakistan, during 2015-16, sugar beet was cultivated on an area of 2720 hectares with a production of 128766 tons, while in Khyber Pakhtunkhwa, it was cultivated on an area of 568 hectares with an annual production of 21436 tons ha^{-1} [16]. It is a good alternative sugar crop in the region. Despite numerous advantages over sugarcane, it is still restricted to Khyber Pakhtunkhwa only but the area under this crop is continuously on decline. Moreover, due to lack of technical knowledge its average yield is also reducing.

In Pakistan, the availability of agricultural water is unceasingly declining due to which sugarcane cultivation has become a difficult task in some areas. Under such circumstances, the sugar beet is a suitable solution as it has the potential of giving two-time higher sugar yield per hectare as compared to sugarcane in a short period of 5-6 months. Now only two sugar beet crushing mills (Premier in Charsadda and Al-Moiz in D. I. Khan) are working in Khyber Pakhtunkhwa, while the other two have stopped operation due to shortage of raw material. In a short time, sugar beet provides more financial returns per acre than sugar cane [17].

In Khyber Pakhtunkhwa province, sugar beet is commercially grown mostly in areas of Peshawar, Charsadda, Mardan, and the whole District of D. I. Khan. Generally, its sowing is done in October to November and harvested in April to May. Harvesting cannot be delayed from April to the 1st week of May, as a sudden boost in temperature reduces yield and recovery due to root rot causing huge economic losses to the growers. To reduce these losses there is a great need to find out the best sowing time to hasten maturity earlier for harvesting. In Pakistan, agronomic studies with sugar beet are rare. Thus, it is much needed to study the time of sowings under the prevailing conditions of the area. In this context, a study was designed to evaluate the physiological response of sugar beet cv. California-KWS in five sowing dates under Dera Ismail Khan conditions.

2. MATERIALS AND METHODS

2.1 Experimental spot

A field experiment was performed at the Horticulture research area, Faculty of Agriculture, Gomal University D. I. Khan during winter season 2013-14 and 2014-15.

2.2 Weather

Monthly mean temperature; total rainfall and relative humidity of the trial (from sowing to harvesting) are shown in Figure 1

2.3 Design and treatments

The study was performed in an RCBD having five dates of sowing and replicated thrice. The soil of the study area was clay loam in texture. Soil Physico-chemical characteristics were determined before sowing. The detail is given in table-1. The field was ploughed to a fine tilth and plotting was made according to the experimental treatment. The hybrids cv. California-KWS seeds were obtained from Al-Moiz Sugar Mills, D. I. Khan. Treatments included five sowing dates i.e. sowing at 1st October, 11th October, 21st October, 1st November and 11th November. The crop was sown on ridges with P×P and R×R spacing of 20 cm and 50 cm by dibbling 2-3 seeds per hole, respectively. The plot size was 2.7×4 m^2. Plots were irrigated immediately after sowing and then fortnightly. Thinning was done 20 days after germination leaving one healthy plant. Recommended doses of N.P.K fertilizers were given at the rate of 120,100 and 75 kg ha^{-1}, respectively [18]. Urea, triple super phosphate (TSP), and sulphate of potash (SOP) were the sources of NPK respectively. Half dose of N and full doses of P and K were applied at the time of soil preparation while the rest of the half dose of N was applied one and a half months after seed germination. Weeds were controlled manually. All cultural practices (earthing

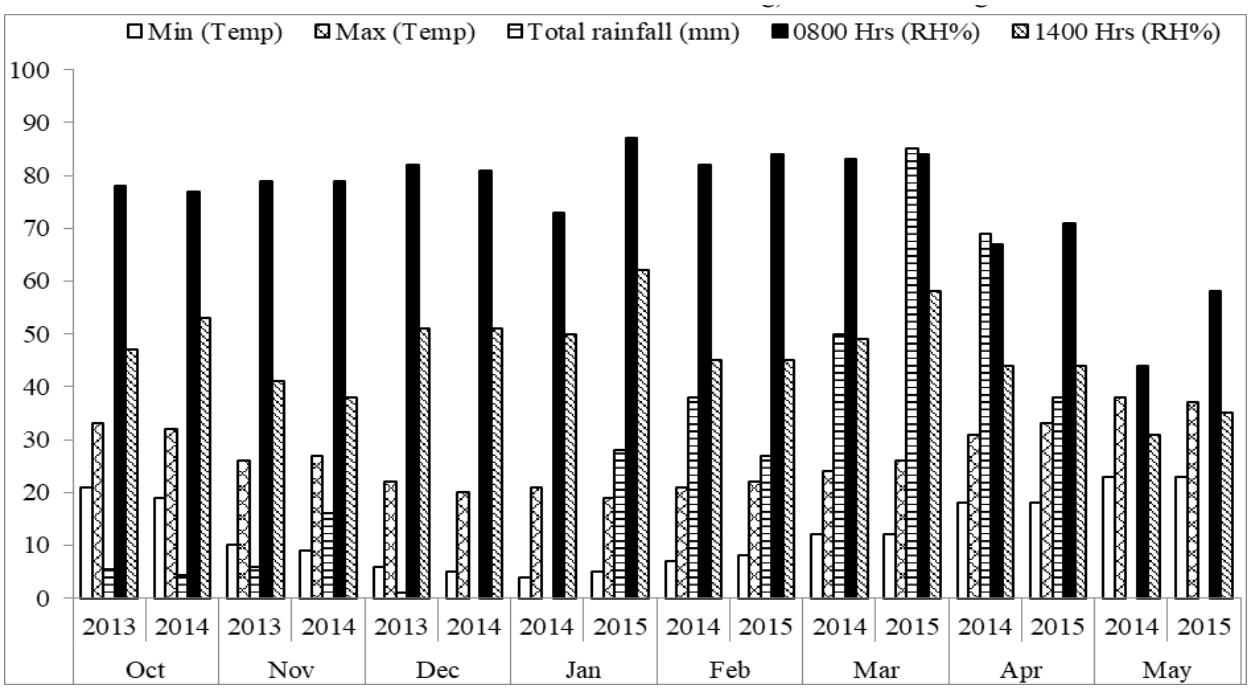

Fig. 1. Meteorological data of spot from October to May (2013-14 and 2014-15)
Source: Arid Zone Research Institute (AZRI), PARC, Dera Ismail Khan, Pakistan.

Table 1. Soil Physico-chemical properties of the experimental area.

Soil analysis	2013	2014
EC (ds/m)	4.07	4.06
pH	7.6	7.7
Texture	Clay loam	Clay loam
Saturation%	56	55
Organic matter (%)	0.62	0.63
N (%)	0.04	0.06
P ppm	8	8.02
K ppm	250	256

Source: Soil Chemistry Laboratory Agriculture Research Institute, Ratta Kulachi, D. I. Khan (KPK), Pakistan.

up, spraying) as required were carried out uniformly during the study.

2.4 Data recorded

Data on the following parameters were recorded:

2.4.1 Days to germination: Days were counted from seed sowing till 80% germination and mean was computed.

2.4.2 Germination percentage: It was calculated by the following formula

$$\text{Germination percentage} = \frac{\text{number of seeds germinated} \times 100}{\text{number of seeds sown}}$$

2.4.3 Plant height (cm): Randomly selected ten plants from each replication were used to measure height with measuring tape and the mean was computed.

2.4.4 Number of leaves plant^{-1}: Leaves were counted from randomly selected ten plants from each replication and the mean was computed.

2.4.5 Leaf area plant^{-1} (cm^2): It was determined using the following equation [18].

$$A = 159.52 - 21.95L + 21.33W + 1.59LW + 0.22LL - 1.41WW$$

2.4.6 Leaf weight plant^{-1}: At maturity, ten plants chosen randomly from each treatment to determine the weight of leaves (g) by a digital scale (0.01-g precision) and mean was considered.

2.4.7 Root weight plant^{-1}: At maturity, ten plants chosen randomly from each treatment to determine the root weight (g) by a digital scale (0.01-g precision) and mean was considered.

2.4.8 Total soluble solids (%): TSS(%) were measured using a hand refractometer as per AOAC[19].

2.4.9 Sucrose (%): Sucrose % was assessed by Lane and Eynon method as described in AOAC [19].

2.4.10 Root yield (t ha^{-1}): At harvest, roots were separated, cleaned and weighed in kilograms, then were converted to estimate root yield ton ha^{-1} as below;

$$\text{Root yield (ton ha} - 1) = \frac{\text{Root yield (kg) x 10000}}{\text{1000 x Plot size}}$$

2.4.11 Sugar yield (t ha^{-1}) was assessed by the following equation

$$\text{Sugar yield} = \frac{\text{Root yield} \times \text{sucrose\%}}{100}$$

2.5 Statistical Analysis

The measured data were analyzed as stated by Steel and Torrie [20] using the "STATISTIX-8.1" Software package.

3. RESULTS AND DISCUSSION

3.1 Days to germination

Significantly minimum days to germination (7.31 & 6.46) were taken by early sowing on 1st October while maximum days to germination (12.83 & 13.16) were taken by late sowing on 11th November during 2013-14 and 2014-15 respectively (Table 2). The early sowing took minimum days to germination probably due to more suitable environmental conditions such as light and temperature and due to high-temperature soil become warmer that hasten germination early and vice versa [21]. Mangala *et al* [22] and Sanghera *et al* [23] reported similar results.

3.2 Germination Percentage

The germination percentage observed in different sowing dates was significant. The highest germination percentage (92.88 & 90.83%) was recorded in early sowing on 1st October while the lowest (81.14& 79.46 %) was recorded in late sowing on 11th November during both years (Table-2). The low germination observed in late sowing might be due to the low temperature that might have led to reduced seed viability [24]. Sheshama *et al* [25] reported similar results in soybean.

3.3 Plant height (cm)

Plant height was significantly affected by various sowing dates (Table-2). Significantly tallest plants (43.46 cm & 43.43 cm) were found on 11th October sowing during both years. It was followed by 21st October sowing with plant height (43.40 cm & 43.36 cm) which was statistically similar to 1st November sowing during the second year. Whereas the shortest plants (43.28 & 42.91 cm) were recorded on 11th November sowing during both years of study. The tallest plants observed at early planting might be due to the reason that a longer growth period promotes more photosynthetic activities that induced more carbohydrates and stimulates growth [26,27]. Karhale *et al* [28], Ahmed *et al* [29], Zaremohazabieh *et al* [30], and Liaqat *et al* [31] reported similar results in other crops at early sowing.

3.4 Number of leaves plant^{-1}

Significantly highest number of leaves plant^{-1} (43.63 & 43.48) were found in 11th October sowing followed by 21st October sowing (43.25 & 43.13). Minimum leaves count plant^{-1} (41.90 & 39.57) were observed in late sowing i.e. 11th November during both years (Table 2). Leaf reduction per plant in late sowing might be due to lower temperature that prevails during vegetative growth periods which resulted in reduced photosynthetic activities and low rate of assimilation [32,33]. Results are similar to those observed by Sanghera *et al* [23]. Similarly, Karhale *et al* [28] recorded the maximum number of leaves in early sown sorghum. Zaremohazabieh *et al* [30] stated delay in sowing decreased significantly the leaf number in corn.

3.5 Leaf area plant^{-1} (cm^2)

Leaf area (cm^2) differed significantly due to sowing dates (Table 3), maximum leaf area plant^{-1} (500.46 & 493.58 cm^2) was found on 11th October sowing during both years. Significantly shortest leaf area

Table 2. Effect of sowing dates on days to germination, germination percentage, plant height (cm) and number of leaves

Sowing dates	Days to germination	Germination percentage	Plant height (cm)	Number of leaves
		Year 2013-14		
1st October	7.31 c	92.88 a	43.38 c	42.58 c
11th October	8.14 c	92.82 a	43.46 a	43.63 a
21st October	9.78 b	89.84 b	43.40 b	43.25 b
1st November	10.17 b	85.81 c	43.35 d	42.73 c
11th November	12.83 a	81.14 d	43.28 e	41.90 d
LSD	1.12	2.19	0.02	0.17
		Year 2014-15		
1st October	6.46 d	90.83 a	43.29 c	41.03 d
11th October	8.15 c	90.50 a	43.43 a	43.48 a
21st October	9.16 c	89.82 a	43.36 b	43.13 b
1st November	11.53 b	86.79 b	43.34 b	42.05 c
11th November	13.16 a	79.46 c	42.91 d	39.57 e
LSD	1.01	1.96	0.03	0.17

Means sharing similar letters do not differ ($P \leq 0.05$)

plant^{-1} (497.20 & 483.19 cm^2) was found on 11th November sowing during both years. Leaf area gradually increased with 11th October might be due to favorable environmental conditions that allow for early development of an optimal leaf surface with maximum assimilation of energy and subsequent transfer of photosynthate to storage root and also due to a higher number of functional leaves [33]. Ghonema [34] recoded the maximum leaf area in October sown beet compared to other planting dates. Zaremohazabieh *et al* [30] reported similar results in corn and Liaqat *et al* [31] in maize.

3.6 Leaf weight plant^{-1} (g)

Maximum significant leaf weight plant^{-1} (485.42 & 485.49 g) was observed in 11th October sowing whereas the minimum leaf weight plant^{-1} (485.26 & 485.28 g) was found in 11th November (late sowing) during both years (Table 3). Leaf weight correlates with the leaf area. The result might be because earlier dates than late due to more leaf area, stimulate more photosynthetic activities that produce more leaf size [28]. Results concur with those found by Badawi [35], Abd El-Gawad *et al* [36], and Leilah *et al* [13].

3.7 Root weight plant^{-1} (g)

The highest root weight plant^{-1} (1473.5 & 1473.4 g) was measured in 11th October sowing, while the lowest (1470.8 & 1471.9 g) root weight plant^{-1} was observed in 11th November sowing during both years (Table 3). Results might be due to the reason that early sowing increases the length of time and plants accumulate more biomass by taking advantage of highly favorable growing temperatures, which translocate more assimilate to the roots which caused maximum root weight [30]. Similar results were reported by Leilah *et al* [13], Sanghera *et al* [23], Ferdous *et al* [33], and Abd El-Gawad *et al*[36].

3.8 Sucrose (%)

Data showed that significantly the highest sucrose (16.54 & 16.59%) was observed when seeds were sown on 11th October during both years (Table 3). Whereas, minimum sucrose% of 16.44 & 16.40 was noted on 11th November sowing. After emergence, the growth and development activities are largely influenced by air temperature and crop nutrition. 20-22°C temperature is best for proper plant growth and sugar accumulation. There is no self-regulatory mechanism to promote sugar accumulation in sugar beet but it is dependent on light, temperature, moisture, and day length [37]. Our results agree with Ghonema [34], Badawi [35], Safina *et al* [38], and Nemeata Alla *et al* [39] who noted maximum sucrose content in early sowing.

3.9 Total Soluble Solids (TSS) (%)

Amongst sowing dates significantly maximum TSS (18.46 & 18.43%) was observed in 11th October sowing that was statistically at par with 21st October sowing during both years (Table 4). Minimum TSS (18.38& 18.29 %) was observed on 11th November sowing during both years. It might be due to variations in climatic conditions. The results are in line with those observed by Badawi [35]. Ratnavathi *et al* [40]reported similar results in sorghum.

3.10 Root yield (t ha^{-1})

Maximum root yield (63.91 & 64.13 t ha^{-1}) was observed in 11th October sowing treatment while Minimum (63.61 & 62.44 t ha^{-1}) was observed on 11th November sowing during both years (Table 4). Root yield is related to root size (data not given), which was maximum in 11th October sowing date which is early, due to favorable long periods for vegetative growth promoted early vegetative growth, ultimately produced high yield. In the case of late sowing due to late maturity in hot months decreased tuber yield through reduced leaf area, several leaves, and size of tuber [41]. Findings are akin to Abd El-Gawad *et al*. [36], Leilah *et al* [13], Sanghera *et al* [23]. Ahmed *et al* [29] reported similar results in sunflower and Zaremohazabieh *et al* [30] in corn.

3.11 Sugar yield (t ha^{-1})

It was significantly affected by sowing dates during 2013-14 and 2014-15 (Table 4). Significantly highest sugar yield (t ha^{-1}) (10.57 & 10.64) was observed in 11th October sowing followed by 21st October sowing with 10.54 t ha^{-1} sugar yield during both years. 1st October sowing produced statistically similar results with 1st November sowing during 2013-14. Minimum sugar yield (t ha^{-1}) (10.48 & 10.24) was observed on 11th November sowing during both years. Sugar yield correlates with root yield. Both sucrose and root yields were maximum in 11th October sowing hence maximum sugar yield was recorded on 11th October sowing during both years. The results validate the results of Abd El-Gawad *et al*. [36], Leilah *et al* [13], Karbalaei *et al* [42], and Abou Mostafa *et al* [43] who recorded maximum sugar yield in early planting than late.

4. CONCLUSION

This work revealed that sowing dates significantly affected almost all the considered traits during both years. It can be deduced from the results that early sowing of sugar beet from 2nd to 3rd week of October is best for sugar beet under Dera Ismail Khan conditions.

Table 3. Effect of sowing dates on leaf area, leaf weight plant^{-1}, root weight plant^{-1} and sucrose

Sowing dates	Leaf area Plant^{-1} (cm^2)	Leaf weight (g)	Root weight (g)	Sucrose%
Year 2013-14				
1st October	497.38 c	485.31 c	1472.5 c	16.46 c
11th October	500.46 a	485.42 a	1473.5 a	16.54 a
21st October	499.43 b	485.38 b	1472.8 b	16.50 b
1st November	499.30 b	485.34 c	1471.9 d	16.48 c
11th November	497.20 c	485.26 d	1470.8 e	16.44 c
LSD	0.85	0.03	0.09	0.02
Year 2014-15				
1st October	487.99 d	485.28 c	1472.2 c	16.41 d
11th October	493.58 a	485.49 a	1473.4 a	16.59 a
21st October	493.13 b	485.42 b	1472.6 b	16.55 b
1st November	491.18 c	485.30 c	1472.6 b	16.44 c
11th November	483.19 e	485.28 c	1471.9 d	16.40 e
LSD	0.19	0.03	0.11	0.02

Means sharing similar letters do not differ ($P \leq 0.05$)

Table 4. Effect of sowing dates on TSS%, Root yield and Sugar yield

Sowing dates	TSS%	Root yield (t ha^{-1})	Sugar yield (t ha^{-1})
Year 2013-14			
1st October	18.43 b	63.80 c	10.50 c
11th October	18.46 a	63.91 a	10.57 a
21st October	18.45 a	63.88 b	10.54 b
1st November	18.40 c	63.76 d	10.49 c
11th November	18.38 d	63.61 e	10.48 d
LSD	0.0137	0.0190	0.0131
Year 2014-15			
1st October	18.42a	63.37 d	10.34 d
11th October	18.43 a	64.13 a	10.64 a
21st October	18.43 a	63.66 b	10.54 b
1st November	18.38 b	63.52 c	10.44 c
11th November	18.29c	62.44 e	10.24 e
LSD	0.02	0.04	0.01

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