Research Article

Influence of Planting Date on Yield and Quality of Sugarcane under the Agro-Climatic Conditions of Mardan

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Abstract | Sustainable sugarcane productivity is among the challenges in the era of climate change and food security. Planting dates being an ecological factor can be utilized for allowing cane cultivation in different cropping patterns. The losses in yield due to reduction in crop cycle or delay planting can be compensated by increasing the cropping intensity on same field. A field experiment was carried out during the year 2015-16 at Palatoo Research Farm of Amir Muhammad Khan Campus Mardan, The University of Agriculture Peshawar. The experiment was consisted of traditional cultivation of sugarcane both in winter season (20th September, 10th October, 30th October and 20th November) and spring season (20th February, 10th March and 30th March). Randomized complete block design was used having four replications. The sub-plot size was kept 5m × 5 m having six rows with length of 5 m. The effect of different planting dates revealed that planting dates had significant effect on tillers m^{-2}, plant height, number of leaves tiller^{-1}, mean leaf area, leaf area index, stem diameter, number of nodes tiller^{-1}, internodes length, cane yield, total dry matter, cane yield, pol and sugar recovery. Higher number of tillers (14.0), number of nodes tiller^{-1} (15.3) mean leaf area (466.3 cm^2), leaf area index (10.47), internode length (14.3 cm), thicker canes (2.48 cm), total dry matter (105.8 t ha^{-1}), cane yield (82.5 t ha^{-1}) and higher sugar recovery (13.49 %) was achieved when sugarcane setts were sown on 20th September. The performance of plots sown on 30th March was found not promising as compared to all other sowing except POL and sugar recovery which were comparatively better compared to rest of sowing dates.

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Introduction

Sugarcane is an economically important crop which serves as a rich source of sucrose, alcohol and organic matter wastes which can be utilized as organic fertilizer (Soomro et al., 2013). It is an essential item of daily consumption (Azam and Khan, 2010). There are about 27.4% of the growers in the country who plant sugarcane in February, 20.7 % in October, 15.8 % in March and 11.1 % in September while 25% of the growers plant sugarcane in spring (Feb-March) and in autumn (Sept-Nov) seasons (Nazir et al., 2013). In Khyber Pakhtunkhwa, sugarcane is particularly grown in Mardan due to the most suitable agro-climatic conditions and the availability of crushing facilities in the region. In spite of all major efforts rendered by relevant agencies, the cane yield in the province as well as in the country has not yet reached to the level as expected. In Pakistan sugarcane is cultivated on about 1.13 M hectares with total production of 65.5 million tones with an average yield of 57.9 ton ha^{-1} (PBS, 2017). The national average yield of sugarcane is about 56 t ha^{-1}, which is far below to the world average of 63.70 t ha^{-1} (Oad et al., 2009).

Planting date is one of the important variables that affects sugarcane stand establishment (Garrison et al., 2000; Matherne, 1976; Viator et al., 2005). Stalk height and maturity of sugarcane are highly associated with planting date that may influence its productivity (Hoy et al., 2006). Under later planting, the cane germination and tiller density become lowered consequently resulted in lesser millable stalk population with reduced cane height and hence reduced final cane yield (Omoto et al., 2005). According to Viater et al. (2005), sugarcane planted in mid of August resulted in higher yield as compared to those planted on mid-September and October dates. The results of Hoy et al. (2006) showed that early (beginning of August) and late (October) planting had resulted in reduced yield of sugarcane. Ahmad et al. (1991) also found that sugarcane planted in mid of August had the highest yield followed by early and mid Sep and October, respectively. A progressive decrease in sucrose content of cane juice was recorded with delay in each planting date from 15th August.

Sugarcane planted during the first week of November gave higher cane yield (Jintrawet et al., 2000). Cane planted in August provided a higher yield as compared to the cane planted in September (Ahmad et al., 1991). Nazir et al. (2013) also reported that October planting has very luxuriant growth however lodging severely affected the final yield due to windstorm and excessive rainfalls in July and August. Shukla and Singh (2011) also evaluated that summer planting of sugarcane resulted in higher cane yield. Mohamed and El-Taib (2007) also reported that it is possible to maintain higher cane and sugar yield all over the milling season by selecting proper growing season for each genotype. However, reducing the growing season by delaying planting date reduced sugar yield as a result of reduction in cane yield throughout the reduction in number of millable cane. The present study was conducted with aim to compare spring and autumn cane plantations for higher yield and related traits and to find the appropriate planting time of cane cultivation both in spring and autumn for higher yield of sugarcane under the agro-ecological conditions of Mardan region.

Materials and Methods

The experiment was conducted at Amir Muhammad Khan Research Farm, The University of Agriculture Peshawar, situated at latitude of 32.2° north and longitude of 72.05° east and its elevation above sea level is 285 m. Mardan comes under sub-tropical regions where temperature ranges remains about 10-20° C in winter and 35-45° C in summer season. It is a sub humid region and receives about 500-600 mm precipitation annum^{-1} and the soil type is clay loam. The experiment was consisted of cultivation of sugarcane both in winter (20th September, 10th October, 30th October and 20th November) and spring (20th February, 10th March and 30th March) with setts cane at rate of 6-8 tons ha^{-1}. The experiment was laid out using randomized complete block design replicated four times. The sub-plot size was kept 5 m × 4.5 m having six rows with length of 5 m. The distance between rows was 75 cm and plant to plant distance was 60 cm. Likewise, land was thoroughly prepared using cultivator thrice followed by rotavator for preparation of smooth seedbed and the recommended dose of NPK at rate of 150: 100: 100, respectively was applied to each experimental unit. Potash and phosphorous were applied at sowing time and nitrogen was applied in three splits i.e. the basal dose of urea (1/3rd) was applied as side dressing at 30 days after sowing (DAS). The rest of urea was applied as top dressing in two equal splits at 120 and 180 DAS to each planting date. For control of termites Rector super was applied at rate of 30 kg acre^{-1} in trenches. For control of weeds both grassy and broadleaf, the herbicide Voltril was applied at rate of 1000 mL acre^{-1}. Earthing-up and tying of sugarcane were done after 140 days after each sowing to give protection to cane stalks from lodging against the possibility of strong wind during the period from July to September. Total of 19 irrigations were applied to each sowing date. Harvesting was done after 13 months of each sowing.

Data were recorded on tillers m^{-2}, plant height (cm), number of leaves tiller^{-1}, leaf area tiller^{-1} (cm^2) leaf area index, stem diameter, number of nodes tiller^{-1}, internode length (cm), total dry matter yield (t ha^{-1}), cane yield (t ha^{-1}) pol (%) and sugar recovery (%) and POL.

Data on tillers m^{-2} were recorded by counting number of tillers in two rows having one meter length in each plot and was converted to tillers m^{-2} by the formula

$$Tillers\ m^{-2} = \frac{(Number\ of\ tillers\ counted\ in\ two\ rows)}{Number\ of\ row \times (r - r\ distance) \times (row\ length)}$$

Data on number of nodes tiller^{-1} were recorded by selecting 5 tillers randomly in each plot and then number of nodes were counted in each tiller. Average of data were taken from selected tillers in each plot was estimated. Data on plant height were recorded by selecting five tillers randomly in each experimental unit

and then their heights were measured by the help of measuring tape. Average of the plant height data were taken from selected tillers in each plot was worked out. Leaf area tiller^{-1} was recorded by randomly selected five tillers from each plot and then their area was recorded by the mentioned formula as per prescribed by Muller (1991).

$$LA = Length\ of\ leaf \times Width\ of\ leaf \times CF\ (0.75)$$

Leaf area index data were calculated by using the following formula:

$$Pol\ \% = \{Brix\ \% - (Brix\% - Sucrose\%) \times 0.4\} \times 0.73$$

Number of leaves tiller^{-1} data was recorded by randomly selecting five tillers in each sub-plot through a random selection and then number of green leaves on each tiller were counted and averaged. For recording stem diameter data, five tillers from each plot were selected randomly and their stem diameter was measured by of Vernier Calliper. Average stem diameter was then calculated. Data on internode length, five tillers were selected at random in each experimental unit and the internodes length was measured with the help of measuring tape and the average internode length was calculated. For obtaining cane yield, the whole plot was harvested at maturity and was weighed in kg. The data were then converted to cane yield t ha^{-1}. Sugar recovery was calculated according to the method outlined by procedure adopted for Sugar and Integrated Industries. The formula is given as under.

$$Sugar\ recovery\% = \left\{Pol\% - \frac{0.8}{Purity\%\ juice} \times Purity\%\ juice - \frac{40}{100} - 60\right\}100$$

Pol in the cane juice was calculated by the following formula.

$$Pol\ \% = \{Brix\ \% - (Brix\% - Sucrose\%) \times 0.4\} \times 0.73$$

Statistical analysis

The recorded data was subjected to analysis of variance (ANOVA) in a procedure relevant to randomized complete block design. The least significant difference (LSD) test was used upon significant F test for means comparison at 5% level of probability (Jan et al., 2009).

Results and Discussion

Tillers m^{-2}

Table 1 represents data related to tillers m^{-2} of conventional sowing sugarcane. Statistical analysis of the data showed that different planting dates had significant influence on tillers m^{-2}. More number of tillers m^{-2} (14) were observed in plots sown on 20th September though it was similar to plots sown on 30th October and 10th November and 20th February. The lesser tillers (12) were recorded in plots sown on 30th March though it was similar to both 10th March and 10th October sowing plots. Tiller m^{-2} consequently affects the yield of sugarcane and is therefore considered to be an important parameter of sugarcane crop (Loganandhan et al., 2013). Early sown plots resulted in 14.28% higher tillers as compared to late sown plots. The possible reason for lower tillers in late sowing could be that delay in planting date might result in reducing germination percent due to low temperature which will consequently produce lesser number of tillers. Similar results were also obtained by Omoto et al. (2005) who also reported that delaying planting date will reduces number of tillers. Phadnawis and Saini (1992) also reported that low temperature due to late planting may result in fewer tillers.

Table 1: *Tillers m^{-2}, plant height (cm) and leaves tiller^{-1} as influenced by different sowing dates.*

Sowing dates	Tillers m^{-2}	Plant height	leaves tiller^{-1}
20th September	13.8 a	204.3 a	15.5 a
10th October	12.8 bc	196.3 ab	14.0 b
30th October	13.3 ab	187.8 b	14.5 ab
20th November	13.0 abc	193.3 ab	14.0 b
20th February	13.5 ab	185.0 b	14.5 ab
10th March	12.8 bc	187.0 b	13.8 b
30th March	12.3 c	166.3 c	14.8 ab
$LSD_{0.05}$	0.89	15.76	1.02

Plant height (cm)

Data on plant height of sugarcane was presented in Table 1. Planting dates has significant effect on plant height of sugarcane. Taller plants (204.3 cm) were recorded in plots sown on 20th September which was statistically similar to plants sown on 10th October and 20th November. Short stature plants were recorded in plots sown on 30th March (166.3 cm). The possible reason for taller canes in early sown plants may be the longer spell in the field than late planted plants. The early sown plants due to the extended vegetative growth and better development consequently resulted in taller plants. Our results are in lined with that of El-Gergawy and El-Shafai (2000) who found that delay in sowing resulted in significant reduction in stalk height.

Number of leaves tiller^{-1}

Number of leaves tiller^{-1} of sugarcane as affected by sowing dates is presented in Table 1. Significant differences were recorded for number of leaves tiller^{-1} of sugarcane due to different planting dates. More number of leaves plant^{-1} (15.5) was recorded by plots sown on 20th September while rest of planting dates produced less number of leaves tiller^{-1} but statistically similar among each other. The reduction in leaves tiller^{-1} in late sowings may be due to lower temperature during early growth stage than that of early sowing. Maga et al. (2015) also found significant differences in number of leaves sown on different sowing dates and found that early sowing gave the highest number of leaves plant^{-1}, while the least number of leaves plant^{-1} was obtained in late sowing. The reduction in leaves tiller^{-1} in late sowings may be due to lower temperature during early growth stage than that of early sowing. Ferdous et al. (2015) also reported that genotypes sown in November produced the highest number of leaves tiller^{-1} and the leaf number reduced with delay in sowing.

Leaf area tiller^{-1} (cm^2)

Leaf area tiller^{-1} of sugarcane as affected by different sowing dates is presented in Table 2. Leaf area tiller^{-1}was significantly affected by different sowing dates. Higher mean leaf area tiller^{-1} (466.3 cm^2) was recorded by plots sown on 20th September which was statistically similar to plots sown on 10th October, 20th November, 20th February and 10th March followed by 30th October, while lower leaf area tiller^{-1} (427.5 m^2) was recorded in plots sown on 30th March. Leaf area development is crucial in crop production to maximize interception of solar radiation and accumulation of crop mass. Slow development of leaf canopies may be critical in limiting the ultimate yield produced by sugarcane crops (Inman-Bamber, 1994). Development of leaf area is critical in the establishment of a full leaf canopy to maximize interception of solar radiation and achieve high crop productivity. In sugarcane, leaf area development is especially important because the rate of leaf area increase is relatively slow. The higher leaf area tiller^{-1}in early sowing throughout the growing season might be due to the presence of favorable environmental conditions for vegetative growth than that of late sowing.

Leaf area index

Data concerned with leaf area index of sugarcane as influenced by different sowing dates is shown in Table 2. Statistical analysis of the data revealed that leaf area index has significant effect on different sowing dates. Higher leaf area index (10.43) were recorded when sowing was carried out on 20th September followed by plots sown on 20th February which was statically similar to plot sown on 30th October or 20th November. The capacity of the crop to intercept photo-synthetically active radiation and synthesize carbohydrates for growth is a nonlinear function of LAI (Andrade et al., 2002). Lower leaf area index (7.71) was recorded by plots sown 30th March. 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.

Table 2: *Mean leaf area (cm^2), leaf area index and stem diameter (cm) as influenced by different sowing dates.*

Sowing dates	Mean leaf area	Leaf area index	Stem diameter
20th September	466.3 a	9.95 a	2.48 a
10th October	459.9 ab	8.21 cd	2.40 ab
30th October	453.9 b	8.73 bc	2.08 c
20th November	462.6 ab	8.40 bcd	2.20 bc
20th February	461.8 ab	9.03 b	2.35 ab
10th March	454.4 ab	7.96 d	2.38 ab
30th March	427.5 c	7.71 d	2.08 c
$LSD_{0.05}$	12.36	0.75	0.23

Stem diameter (cm)

Influence of planting dates on stem diameter of sugarcane is shown in Table 2. Statistical analysis of the data showed that different planting dates had significantly affected stem diameter. Thicker canes (2.48) were recorded in plots sown on 20th September and though it was at par with plots sown on 10th October, 20th February and 10th March whereas those planted on 30th March resulted in thinner plants (2.08) however it was statistically similar to plots sown on 30th October and 20th November. Channabasappa et al. (1997) also reported that sugar cane planted during the month of September resulted in thicker canes which is primarily responsible for its higher yield over other months of planting.

Number of nodes tiller^{-1}

Data concerned with number of nodes tiller^{-1} is presented in Table 3. Substantial differences were recorded for number if nodes tiller^{-1}. More number of nodes tiller^{-1} (15.3) were recorded in plots sown on 20th November which was statistically similar to all other sowing dates except 30th March which resulted in lower nodes tiller^{-1}. Number of nodes plant^{-1} is controlled mainly by the genetic character of a cultivar, though it may also be affected by the growing conditions (Shahzad et al., 2002).

Table 3: *Number of nodes tiller^{-1}, internode length and total dry matter (TDM) as influenced by different sowing dates.*

Sowing dates	Number of nodes tiller^{-1}	Internode length (cm)	TDM (t ha^{-1})
20th September	14.5	14.1 a	105.8 a
10th October	14.0	13.8 ab	102.5 ab
30th October	14.0	13.1 bc	101.1 abc
20th November	15.3	13.1 bc	97.8 abcd
20th February	15.0	13.5 abc	95.3 bcd
10th March	13.6	13.3 bc	93.9 cd
30th March	12.5	12.9 c	91.1 d
LSD $_{(0.05)}$	Ns	0.77	8.27

Internode length (cm)

Table 3 represents data concerned with internode length of sugarcane as affected by different sowing dates. Statistical analysis of the data showed significant differences for internode length of sugarcane. Higher internode length (14.3 cm) was recorded in plots sown on 20th September followed by 10th October and 20th February. However, these were significantly different from each other. Lower values for internode length (13 cm) were recorded by plots sown on 30th March. Shahzad et al. (2012) reported that the internode distance is generally controlled by the genetic potential of genotype; however, it may also be influenced by environmental factors.

Total dry matter (t ha^{-1})

Total dry matter of sugarcane is presented in Table 3. Statistical analysis of the data revealed that planting dates has significantly affected total dry matter of sugarcane. Higher dry matter was recorded when sowing was carried out on 20th September (105.8 t ha^{-1}) though it was statistically simile to plots sown on 10th and 30th October, while lower dry matter was recorded by plots sown on 30th March (91.9 t ha^{-1}) tough it was not significantly different from sowing done on 10th March and 20th February. The higher total dry matter in early sowings might be due to increased photosynthesis resulted by higher leaf area in early sowing and thereby increased TDM production. The results are in lined with those of Ferdous et al. (2015) which also state that TDM production was significantly higher in September sowings.

Cane yield (t ha^{-1})

Influence of planting dates on cane yield of sugarcane is shown in Table 4. Statistical analysis of the data revealed that cane yield had significantly affected by sowing dates. Higher cane yield (82.5 t ha^{-1}) was recorded for cane cultivation on 30th September which was similar to plots sown on 20th October these were followed by 30th October and 20th November. The lower cane yield was recorded both in 10th and 30th March sowings (66.1 t ha^{-1}). The possible reason for this reduction with delay in sowing might be due to the reduction in tiller, number of nodes, stem diameter, internode length and plant height. The results are in lined with that of Jintrawet et al. (2000) who investigated that sugarcane planted in month of September gave higher cane yield. Early sowing resulted in higher yield of 19.87% as compared to late sowing. Garrison et al. (2000) also found the benefit from cane planted in mid-August than mid-October although no significant differences were noted between sowing of cane in mid-August and mid-September.

Table 4: *Can yield (t ha^{-1}), POL (%) and sugar recovery (%) as influenced by different sowing dates.*

Sowing dates	Can yield (t ha^{-1})	POL (%)	Sugar recovery(%)
20th September	82.5 a	18.95	13.65 a
10th October	80.1 ab	18.51	13.50 ab
30th October	79.3 b	19.05	13.03 abc
20th November	78.9 b	19.27	13.49 ab
20th February	72.2 c	18.83	12.92 abc
10th March	68.4 d	18.92	12.35 c
30th March	66.1 d	19.18	12.76 bc
LSD$_{0.05}$	3.10	Ns	0.74

Pol (%)

Pol (%) of sugarcane as affected by different sowing dates is shown in Table 4. Statistical analysis of the data showed that sowing dates had significant effect on POL (%) of sugarcane. Higher values were recorded for Pol when sowing was done on 20th September (19.27%) which was statistically similar with all sowings except sowing done on 10th October whereas POL was reduced up to 18.83%. Sanghera et al. (2016) also reported that sowing from 15th October to 30th October resulted in low Pol (%) while sowing on 15 November showed promising results for enhancement of Pol (%). Abbas et al. (2015) also reported that POL decreased from 12% to 6.71 % by delay in planting. Almodares et al. (2006) also reported that higher pol, brix and purity was recorded in early plantings.

Sugar recovery (%)

Table 4 represents data regarding sugar recovery (%) of sugarcane. Different planting dates have significant effect on sugar recovery (%). Sugar recovery was higher in plots sown on 20th September (13.65 %) followed by those plots sown on 10th October and 30th October. While the lower sugar recovery (12.35 %)

were recorded when the cane was sown on 10th March which is statistically similar to plots sown on 30th March. Sugar recovery is an important parameter for both the industry and for producers, since industrial plants elaborate the price paid to producers based on it (Costa et al., 2011). The final sugar recovery in sugarcane determines the amount of sugar to be recovered from sugarcane. The desirable effect of sowing on sugar yield might be attributed to the seasonable environmental conditions during this period (Sanghera et al., 2016). This might be due to longer span where photosynthesis took place in early planting as compared to late planting. Increasing sugar recovery due to longer growth season was also observed by Alexander and Mathew (2003); Mohamed and El-Taib (2007) and White et al. (2010).

Conclusions

The results indicated that sugarcane variety CP 77/400 when traditionally sown by cane setts from September to October resulted in higher cane yield while delay in sowing resulted in decrease in cane yield from 3 to 20% over September sowing. Thus, sowing of cane setts in the month of September and October is recommended for obtaining higher yield of Sugarcane.

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Author's Contribution

Fazal Munsif: Conceived the idea, supervised the research work and write up of manuscript.
Muhammad Zahid: Conducted the experiment, collected data and write up of manuscript.
Muhmmad Arif: Helped in experimental design, edited and corrected the manuscript.
Kawsar Ali: Performed statistical analysis of the data and helped in manuscript write up.
Ijaz Ahmad: Helped in data collection throughout the experiment and edited the manuscript.

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