



## Research Article

# Impact of NPK Fertilization on Growth and Yield of Sugarcane (*Saccharum officinarum* L.) under Different Planting Methods

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**Abstract** | The use of inorganic fertilizers in Pakistan is imbalanced and inappropriate. It is very important to use proper doses of balanced fertilizers to exploit the maximum yield potential of cane crop. This study focused on hypothesis that application of suitable planting methods and NPK level play a major role in improving sugarcane yield and quality. Experiment was performed under field conditions at Sugarcane Research Institute, Tandojam, Sindh, Pakistan (located at 25° 25.19' N 68° 32.07' E) during 2016-17, repeated in 2017-18 and data was averaged. The sugarcane variety PSTJ-41 was used for this study. The experiment was laid out in split plot design. Main-plot consisted of planting methods i.e. single set (parallel to furrow), double sett (parallel to furrow), single set (across furrow) whereas, sub-plot comprised of NPK levels i.e. 166-084-165 kg ha<sup>-1</sup> (25% < recommended), 225-112-220 kg ha<sup>-1</sup> (recommended), 281-140-275 kg ha<sup>-1</sup> (25% > recommended). Results exhibited significant effects of planting methods and NPK application on most studied parameters. In case of planting methods, substantially higher seed germination (%), crop growth rate (g m<sup>-2</sup> day<sup>-1</sup>), leaf area index (%), cane length (cm), internodes cane<sup>-1</sup>, cane yield (t ha<sup>-1</sup>), brix (%) and commercial cane sugar (%) were recorded under double sett (parallel to furrow). As regards NPK levels, 281-140-275 kg ha<sup>-1</sup> (25% > recommended) produced significantly increased in growth and yield characters particularly, cane yield (t ha<sup>-1</sup>) and brix (%). The findings of the study further suggested that interaction of double sett (parallel to furrow) with NPK levels 281-140-275 kg ha<sup>-1</sup> (25% > recommended) resulted in highest performance of crop especially yield and quality traits.

**Received** | June 29, 2020; **Accepted** | March 07, 2021; **Published** | May 04, 2021

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**Citation** | Kandhro, M.N., Mangrio, N., Soomro, A.A., Z-H. Shah, G.S. Mangrio, N. Mari, Z.A. Abbasi and S.P. Tunio. 2021. Impact of NPK fertilization on growth and yield of sugarcane (*Saccharum officinarum* L.) under different planting methods. *Pakistan Journal of Agricultural Research*, 34(2): 346-355.

**DOI** | <https://dx.doi.org/10.17582/journal.pjar/2021/34.2.346.355>

**Keywords** | NPK fertilizers, Growth, Yield, Sugarcane, Planting methods

## Introduction

Sugarcane (*Saccharum officinarum* L.) is world's largest crop in terms of total production and one of the Pakistan's major cash crop (Khan *et al.*, 2018). Sugarcane is the world's largest crop by production

quantity, with 1.8 billion tons produced in 2017, with Brazilian counting for 40% of the world total. In 2012, the Food and Agriculture Organization estimated it was cultivated on about 26 million hectares (64 million acres), in more than 90 countries (Wikipedia, 2020). Pakistan is the fifth largest sugarcane producer

in the world with an annual production of 63,800 thousand metric tons (TMTs), after Brazil, India, China and Thailand (Anonymous, 2019). Sugarcane is categorized as high fertilizer consumption crop that requires a lot amount of nutrients to have good growth and high yield (Cantarella and Rossetto, 2010). The sugar industry is the country's second largest agro industry after textile. Sugarcane produces essential products such as sugar, ethanol, and bagasse or lignocelluloses (Jorrat *et al.*, 2018). The reasons for low yield include traditional planting methods, expensive inputs, heavy weed infestation, improper land preparation, less than acceptable seed size, imbalanced application of fertilizer, scarcity of irrigation water, illiteracy and low income. Moreover, expensive inputs, poor fertilizer application method, natural calamities (Baloch *et al.*, 2002), late harvesting (Malik and Gurmani, 2005), poor management of ratoon and plantation geometry are a few of the causes of low yield of sugarcane (Majid, 2007). An even handed fertilization not only ensures the most favorable crop production but also gives the farmers to pay back and is the best choice for alleviating the dangerous effect of nutrient losses on the environment. Nitrogen (N), phosphorus (P) and potassium (K) are macro nutrients which have important role in supporting growth and yield of sugarcane (Costa *et al.*, 2016). For high yield and good juice quality, K fertilizers are required in amounts equal to or greater than N and P. In most sugarcane producing countries of the world, NPK ratios of 2:1:3 or 2:1:2 or 3:1:5 are commonly used (Wood, 1990). Integrated use of organic and inorganic fertilizer not only preserves soil and crop production, but also protects soil quality and avoids several deficiencies in soil nutrients (Umesh *et al.*, 2018). Nutrient application varies with soil types, seasons and conditions (Ghaffar *et al.*, 2011; Sarwar *et al.*, 2012). The application of chemical fertilizers has vital importance in sugarcane crop (Arain *et al.*, 2017). Higher productivity of the cane and sugar depends on the interactive effects of genetic potential of the cultivars and proper crop husbandry practices including application of fertilizer at appropriate rate and time (Ghaffar, 2009). Use of balanced fertilizer contributes to enhance crop yield, the increase may varies from 30 to 60 percent. One kg of fertilizer nutrient produces about 114 kg of stripped sugarcane (Ghaffar *et al.*, 2010). Khan *et al.* (2005) recommended 128-63-70 kg of NPK ha<sup>-1</sup> as a standard dose of sugar cane fertilizer. Rising Nitrogen (N) rates up to 225 kg ha<sup>-1</sup> significantly improved the yield of commercial

cane yield, while higher N levels reduced cane juice. Sugarcane has been described as retaining a higher sucrose when nitrogen is restricted to harvest 6 to 8 weeks earlier (Miller and Gilbert, 2006). Higher P application improved both cane yield and stalk weight. Differences in varieties have been identified for the sugarcane P fertilizer requirement (Sreewarome *et al.*, 2005). Nutrition with sufficient potassium (K) plays an exacting part in the physiology of stress. Potassium plays its part in the function of the enzyme and in the formation of reliable cell turgor for the movement of water and solutes in plants. Potassium also plays its role in conveying nitrate from the roots to the shoots and leaves (Krauss, 2003; Abbasi *et al.*, 2012). Planting methods are among the most important problem leading to sugarcane yield (Ehsanullah *et al.*, 2016). The most common method of sugar cane planting is "overlapping", "end to end" and "double set" methods (Nazir *et al.*, 2013). Planting dimensions has major affect on the quantitative parameters like number of tillers, number of millable cans, number of internodes cane<sup>-1</sup>, plant height, cane length, cane diameter, stripped cane weight, stripped and unstrapped cane yield, tops end trash weight and harvest index (Aamer *et al.*, 2017) while Ehsanullah *et al.* (2016) showed that the number of millable canes m<sup>2</sup>, polarity %, cane juice purity %, cane juice %, commercial cane sugar % and cane sugar recovery % remained non-significant by different planting techniques. Hence, the present trial was undertaken to evaluate the growth, yield and quality of sugarcane in response to planting patterns and NPK levels. The present study was therefore planned with the objectives to evaluate the comparative effects of row spacing and seeding densities on the yield and quality of sugarcane.

## Materials and Methods

### *Soil selection and experimental details*

A field experiment was carried out at Sugarcane Research Institute, Tandojam, Sindh, Pakistan during autumn 2016-17 and 2017-18. The soil of experimental area is clay loam, which according to USDA system belongs to Order *Aridisols* and Sub-group *Typic Camborthids*. The experimental field was ploughed two times with disc harrow, irrigated, dried to workable condition, leveled and finally seedbed was prepared by plowing with cultivator. The plot size was 13 m x 2.3 m (30 m<sup>2</sup>). The sugarcane candidate variety PSTJ-41 was planted. The planting materials used were the stem cuttings known as "sett". The experiment

was laid out under split plot design (randomizing the planting methods in main plots and NPK levels in sub plots) having three replications. The crop was planted on 22<sup>nd</sup> September 2016 and 25<sup>th</sup> September 2017. The field area was well managed prior to planting. The planting methods included single sett (parallel to furrow), double sett (parallel to furrow), single sett (across the furrow), while NPK levels comprised of NPK: 166-084-165 kg ha<sup>-1</sup> (25% <recommended), 225-112-220 kg ha<sup>-1</sup> (recommended) and 281-140-275 kg ha<sup>-1</sup> (25% >recommended). The recommended NPK fertilizers were applied in the form of Urea, DAP (diammonium phosphate) and SOP (sulphate of potash). All P and K, and 1/3<sup>rd</sup> of N were applied at the time of planting. The remaining two splits of N were applied at 1<sup>st</sup> earthing-up (3<sup>1/2</sup> months after sowing) on 7<sup>th</sup> January, 2017 and 9<sup>th</sup> January 2018. In the same way second, spilt dose was applied in next earthing-up (about 45 days after initial earthing up) on 23<sup>rd</sup> February, 2017 and 24<sup>th</sup> February 2018.



Figure 1: Single sett (parallel to furrow).



Figure 2: Double sett (parallel to furrow).



Figure 3: Single sett (across furrow).

### Cultural management

All routine cultural practices like weeding, hoeing and herbicide application were kept normal and uniform for all the treatments. The propagatory material was taken from upper 2/3<sup>rd</sup> portion of stalk of eight months old cane. Cane setts were soaked in Topsin-M at 150 g 100<sup>-1</sup> L water to protect them from many cane diseases like sugarcane smut. Dry method of planting was adopted for growing canes with ear-to-ear planting pattern. The cane setts were sown in furrows at 6-8 inches depth and covered with 5-6 cm soils. Immediately following coverings, the sets water was let into furrows. Irrigation was applied keeping in view the soil condition and crop need as farmer practice. In summer (April-August) irrigation was applied at the interval of 7-10 days while in winter (November-March) at the interval of 10-15 days. In all 28 irrigations were applied during the growing season (12 months). Earthing-up (putting soil on root zone) and tying of sugarcane were done after 105 days of plantation to protect the cane stalks from lodging against the possibility of strong wind. The herbicide (CLIO Combo pack at 3.75 kg ha<sup>-1</sup> was applied one month after planting when sufficient *moisture* was present in the soil. The insecticide Lorsban at 5 L ha<sup>-1</sup> was applied at 1<sup>st</sup> irrigation to control termites. Trichogramma cards were stapled against the borers. Insecticide Furadan 3G (Carbofuran) was broadcasted at 30 kg ha<sup>-1</sup> in case borers were not controlled by Trichogramma cards.

### Crop observations and measurement

The agronomic and physiological observations were recorded for parameters of economic importance such as seed germination (%), crop growth rate (g m<sup>-2</sup>

day<sup>-1</sup>), leaf area index, cane length (cm), internodes cane<sup>-1</sup>, brix (%), commercial cane sugar (%), cane yield (t ha<sup>-1</sup>). The germination percentage was calculated after 45 days of sowing by using the formula: Germination percentage = (No. of germinated buds ÷ Total number of buds) x 100. Crop growth rate (g m<sup>-2</sup> day<sup>-1</sup>) was recorded two times at the peak of vegetative growth. First time at the Tillering phase (130 days after planting) and second time at initial Grand Growth Phase (180 days after planting). The formula used was: (W2 – W1) ÷ (T2 – T1). The leaf area index was measured at peak vegetative growth stage (Grand Growth Phase) from randomly selected plants by the formula: Leaf area plant<sup>-1</sup> (cm<sup>2</sup>) ÷ Ground area plant<sup>-1</sup> (cm<sup>2</sup>). Cane length (cm) was measured with the assistance of measuring tape in centimeters from the surface of soil to the tips of the flag leaf. Within the harvest, internodes cane<sup>-1</sup> was counted, internodes of randomly selected canes from each treatment were reckoned. Thereafter, there average was taken. For Brix (%) cane juice sample was collected in a 500 ml beaker and then a drop of juice was taken from the beaker with the help of pipette and putted on the digital Refractometer's prism, then Brix% readings were verified. Commercial cane sugar (%) was premeditated by using the formula stated by Meade and Chen (1977).

$$CCS\% = \frac{3 \times P}{2} \left(1 - \frac{F + \%}{100}\right) - \frac{B}{2} \left(1 - \frac{F + 3}{100}\right)$$

### Harvesting

Harvesting was done when crop was physiologically mature i.e. ripening phase completed and brix was above 20%. The crop was harvested manually on 28<sup>th</sup> December, 2017 and 31<sup>st</sup> December, 2018, respectively. The entire plot was manually harvested, leaves were removed, canes were cut from the top, spring balance weighed the cane per plot and then the yield of cane ha<sup>-1</sup> was calculated. The pooled data for both years of each parameter (2016-17 and 2017-18) is given below in respective tables.

### Physico-chemical analysis of soil

Soil of the experimental area was analyzed before sowing and after harvesting (Table 1). Soil samples were taken with the help of soil auger at a depth of 45 cm from five locations of total experimental area before sowing and after harvesting of the crop. The soil samples were air-dried, ground, sieved (2 mm) and placed in plastic containers. The samples were

analyzed for various physical and chemical properties following the procedures of Ryan *et al.* (2001). Soil texture was measured by Bouyoucos hydrometer method. Electrical conductivity (EC) and soil pH was measured in 1:2 soil water extract using EC and pH meters, correspondingly. Walkley Black method was followed for the determination of organic matter content. Total N was calculated. However, soil was extracted for determining extractable P and K using Ammonium bicarbonate di-ethylene triamine penta acetic acid (AB-DTPA).

**Table 1:** Average physico-chemical properties of experimental soils (2016-17 and 2017-18).

Soil parameter	Values
<b>Soil texture</b>	
Sand (%)	19.5
Silt (%)	42.0
Clay (%)	38.5
Textural class	Silty clay loam
<b>Soil chemical analysis</b>	
EC (dS m <sup>-1</sup> )	0.23
Soil pH	8.20
Organic matter (%)	0.83
Total N (%)	0.09
Available P (mg kg <sup>-1</sup> )	8.80
Extractable K (mg kg <sup>-1</sup> )	0.88

### Statistical analysis

The data were statistically analyzed following ANOVA technique using software Statistix version 8.1 (Statistix, 2006). The least significant difference (LSD) test was used at alpha 0.05 for comparing differences of treatments.

### Meteorological data

The meteorological data of Tandojam during experimental seasons of both years (2016-17 and 2017-18) was obtained from Meteorological Station, Tandojam. The details of meteorological data on weekly basis regarding i.e. min and max: temperature(C) and Rainfall (mm) are presented in Figures 4 and 5.

## Results and Discussion

### Seed germination (%)

It is obvious from the statistical analysis of data that non-significant (*p*>0.05) effect was caused by planting methods on germination (%) whereas,

significant ( $p < 0.05$ ) by NPK levels. However, interactive effects were also non-significant (Table 2). Double sett (parallel to furrow) gave the highest seed germination (%), followed by single sett (parallel to furrow) having statistical equality with each other while lowest germination (%) was noticed in single sett (across furrow). NPK levels 281-140-275 kg ha<sup>-1</sup> resulted in greatest germination (%) seconded by 225-112-220 kg ha<sup>-1</sup> NPK levels. Although, lowest seed germination (%) was recorded under 166-084-165 kg ha<sup>-1</sup> NPK levels. The interaction of double sett (parallel to furrow) × 281-140-275 kg ha<sup>-1</sup> NPK levels produced enhanced seed germination (%) followed by single sett (parallel to furrow) × 281-140-275 kg ha<sup>-1</sup> NPK levels, whereas diminished results were recorded in single sett (across furrow) × 166-084-165 kg ha<sup>-1</sup> NPK levels. This may possibly be accredited to fundamental role of NPK in growth and development of sugarcane plants. Many studies have been carried out on the NPK requirement of sugarcane (Cheema *et al.*, 2010) which showed increase in germination rate by applying of NPK fertilizers.

levels but their interaction (planting methods × NPK levels) was found to be non-significant (Table 2). Double sett (parallel to furrow) gave highest crop growth rate followed by single sett (parallel to furrow) having statistical egalitarianism with each other while lowest crop growth rate was observed in single sett (across furrow). NPK levels: 281-140-275 kg ha<sup>-1</sup> resulted in greatest crop growth rate succeeding by 225-112-220 kg ha<sup>-1</sup> NPK levels. The minimum crop growth rate was noted under 166-084-165 kg ha<sup>-1</sup> NPK levels. The interaction of double sett (parallel to furrow) × 281-140-275 kg ha<sup>-1</sup> NPK levels produced better crop growth rate headed by single sett (parallel to furrow) × 281-140-275 kg ha<sup>-1</sup> NPK levels whereas shortest crop growth rate was recorded in single sett (across furrow) × 166-084-165 kg ha<sup>-1</sup> NPK. The results showed that there was noticeable increase in the crop growth rate in double sett (parallel to furrow) and in NPK levels: 281-140-275 kg ha<sup>-1</sup>. Similarly, Bashir and Saeed (2000) reported that physiological and quantitative traits of sugarcane are significantly affected by the planting methods.

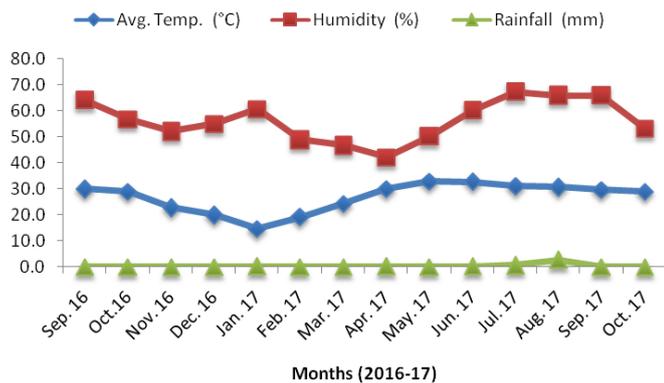


Figure 4: Weather data of Tandojam during sugarcane growing season (2016-17).

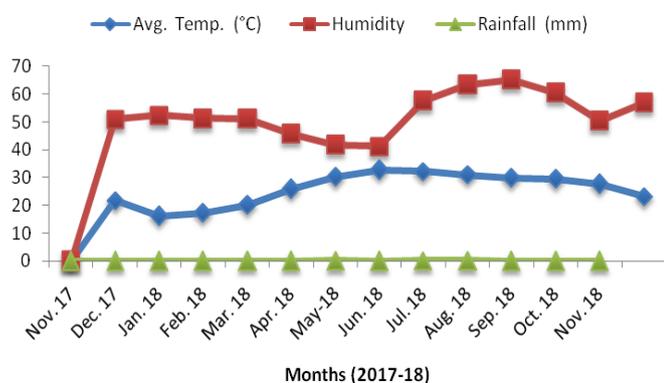


Figure 5: Weather data of Tandojam during sugarcane growing season (2017-18).

### Crop growth rate (g m<sup>-2</sup> day<sup>-1</sup>)

Crop growth rate (g m<sup>-2</sup> day<sup>-1</sup>) was affected significantly ( $p > 0.05$ ) by planting methods and NPK

### Leaf area index

Leaf area index responded significantly ( $p < 0.05$ ) to planting methods, NPK levels and their interaction (planting methods × NPK levels) (Table 3). Double sett (parallel to furrow) gave vibrant leaf area index followed by single sett (parallel to furrow) having statistical impartiality with each other while lowest leaf area index was noticed in single sett (across furrow). In case of NPK levels, 281-140-275 kg ha<sup>-1</sup> NPK levels intensely improved the leaf area index followed by 225-112-220 kg ha<sup>-1</sup> NPK levels, whereas 166-084-165 kg ha<sup>-1</sup> NPK levels registered least leaf area index. The interaction of double sett (parallel to furrow) × 281-140-275 kg ha<sup>-1</sup> NPK levels produced superior leaf area chased by single sett (parallel to furrow) × 281-140-275 NPK levels where as decreased results were recorded in single sett (across furrow) × 166-084-165 kg ha<sup>-1</sup> it showed that balanced use of fertilizers is strongly recommended to improve NPK levels. Sreewarome *et al.* (2005) stated that phosphorus application improved growth in terms of dry weight, crop growth rate, leaf area index, and cane height.

### Cane length (cm)

Cane length (cm) were affected non-significantly ( $p > 0.05$ ) by planting methods and significantly ( $p < 0.05$ ) by NPK levels but their interaction was

found to be non-significant ( $p>0.05$ ) (Table 3). Double sett (parallel to furrow) gave highest cane length followed by single sett (parallel to furrow) having statistical equality with each other while lowest millable canes was observed in single sett (across furrow). 281-140-275 kg ha<sup>-1</sup> NPK levels resulted in greatest cane length followed by 225-112-220 kg ha<sup>-1</sup> and 166-084-165 kg ha<sup>-1</sup> NPK levels. The interaction of double sett (parallel to furrow) × 281-140-275 kg ha<sup>-1</sup> NPK levels produced improved cane length (cm) lead by single sett (parallel to furrow) × 281-140-275 kg ha<sup>-1</sup> NPK levels, whereas reduced results were recorded in single sett (across furrow) × 166-084-165 kg ha<sup>-1</sup> NPK levels. As recorded by Srivastava *et al.*, (2008) who conducted an experiment on productivity and profitability of sugarcane in relation to organic nutrition under various cropping systems they found highest number of millable canes (82.7 and 95.2 thousands ha<sup>-1</sup>) and cane length (220.8 and 182.5 cm) were recorded with sulphitation press mud (SPM) 10

t ha<sup>-1</sup> + farmyard manure (FYM) 10 t ha<sup>-1</sup> in autumn and spring planted crops, respectively.

*Internodes cane<sup>-1</sup>*

Internodes cane<sup>-1</sup> responded non-significantly ( $p>0.05$ ) to planting methods and significantly ( $p<0.05$ ) to NPK levels, and their interaction (planting methods × NPK levels) affected non-significantly ( $p>0.05$ ) (Table 4). Double sett (parallel to furrow) gave dynamic internodes cane<sup>-1</sup> followed by single sett (parallel to furrow) having statistical equality with each other while lowest internodes cane<sup>-1</sup> was seen in single sett (across furrow). In case of NPK levels, 281-140-275 kg h<sup>-1</sup> NPK levels resulted in greatest internodes cane<sup>-1</sup> seconded by 225-112-220 kg ha<sup>-1</sup> NPK levels and 166-084-165 kg ha<sup>-1</sup> NPK levels. The interaction of double sett (parallel to furrow) × 281-140-275 kg ha<sup>-1</sup> NPK exposed improved internodes cane<sup>-1</sup> headed by single sett (parallel to furrow) × 281-140-275 kg ha<sup>-1</sup> NPK levels, whereas moderate

**Table 2:** Seed germination (%) and crop growth rate (g m<sup>-2</sup> day<sup>-1</sup>) of sugarcane as affected by planting methods and NPK levels.

Planting methods	Seed germination (%)				Crop growth rate (g m <sup>-2</sup> day <sup>-1</sup> )			
	NPK levels (kg ha <sup>-1</sup> )				NPK levels (kg ha <sup>-1</sup> )			
	166-084-165	225-112-220	281-140-275	Mean	166-084-165	225-112-220	281-140-275	Mean
Single sett (parallel to furrow)	71.3	74.7	80.0	75.3	5.7	7.4	9.0	7.4 B
Double sett (parallel to furrow)	71.7	76.7	83.3	77.2	6.2	7.8	9.3	7.8 A
Single sett (across furrow)	66.3	72.7	76.7	71.9	5.3	6.8	8.9	7.0 C
Mean	69.8 B	74.7 AB	80.0 A	-	5.7 C	7.3 B	9.1 A	-
Variables	S. E	P-value	LSD (5%)		S. E	P-value	LSD (5%)	
Planting methods (M)	8.5426	0.0969	-		0.1277	0.0085	0.3544	
NPK levels (F)	15.001	0.0148	32.683		0.1969	0.0000	0.4290	
M × F	22.869	0.9293	-		0.3063	0.7214	-	

**Table 3:** Leaf area index and cane length (cm) of sugarcane as affected by planting methods and NPK levels.

Planting methods	Leaf area index				Cane length (cm)			
	NPK levels (kg ha <sup>-1</sup> )				NPK levels (kg ha <sup>-1</sup> )			
	166-084-165	225-112-220	281-140-275	Mean	166-084-165	225-112-220	281-140-275	Mean
Single sett (parallel to furrow)	6.0 g	11.1 de	14.9 b	10.7 B	220.0	243.3	266.7	243.3
Double sett (parallel to furrow)	9.6 f	12.0 d	17.2 a	12.9 A	236.7	249.7	300.0	262.1
Single sett (across furrow)	5.8 g	10.5 ef	13.2 c	9.8 C	213.7	240.0	260.0	237.9
Mean	7.1 C	11.2 B	15.1 A	-	223.5 B	244.3 AB	275.6 A	-
Variables	S. E	P-value	LSD (5%)		S. E	P-value	LSD (5%)	
Planting methods (M)	0.1280	0.0000	0.3553		8.5426	0.0969	-	
NPK levels (F)	0.2764	0.0000	0.6022		15.001	0.0148	32.683	
M × F	0.4113	0.0056	1.0430		22.869	0.9293	-	

results were recorded in single sett (across furrow) × 166-084-165 kg ha<sup>-1</sup> NPK. The above results are in conformity with Dev *et al.* (2011) recorded that application of 210 Kg N ha<sup>-1</sup> linearly and significantly increase number of tiller (5.48 %), number of millable cane (1.12 %), weight of millable cane (5.85 %), cane length, number of internodes cane (7.59 %) and cane yield (5.93%).

**Cane yield (t ha<sup>-1</sup>)**

Cane yield was non-significant (*p*>0.05) regarding planting methods, significant (*p*<0.05) by NPK levels, however, interactive effects (planting methods × NPK levels) were non-significant (Table 4). Double sett (parallel to furrow) gave utmost cane yield followed by single sett (parallel to furrow) having statistical impartiality with each other while lowest cane yield was noticed in single sett (across furrow). 281-140-275 kg ha<sup>-1</sup> NPK levels resulted in greatest cane yield followed by 225-112-220 kg ha<sup>-1</sup> NPK levels and 166-084-165 kg ha<sup>-1</sup> NPK levels. The interaction of double sett (parallel to furrow) × 281-140-275 NPK levels produced improved cane yield lead by single sett (parallel to furrow) × 281-140-275 NPK levels whereas reduced results were recorded in single sett (across furrow) × 166-084-165 NPK levels. The use of nitrogen, phosphorus and potassium fertilizers play key role in development of cane and sugar yields These results agree to those of (Ali and Afghan, 2000) where stripped cane yield was significantly increased with 200-150-150 kg NPK against 168-112-112 kg NPK per hectare. (Ali *et al.*, 2000) also reported an increase in cane yield with maximum NPK dose (275-200- 200 kg/ha).

**Brix (%)**

Analysis of variance indicated that a significant (*p*<0.05) effect was induced by planting methods and NPK levels on brix (%) while, non-significant (*p*>0.05) by interaction (planting methods × NPK levels) (Table 5). Double sett (parallel to furrow) gave most productive brix (%) followed by single sett (parallel to furrow) having statistical parallelism with each other while lowest brix (%) noticed in single sett (across furrow). 281-140-275 kg ha<sup>-1</sup> NPK levels resulted in greatest brix (%) followed by 225-112-220 kg ha<sup>-1</sup> NPK levels and 166-084-165 kg ha<sup>-1</sup> NPK levels. The interaction of double sett (parallel to furrow) × 281-140-275 NPK levels produced improved brix (%) lead by single sett (parallel to furrow) × 281-140-275 NPK levels, whereas reduced results were recorded in single sett (across furrow) × 166-084-165 NPK levels that contrasted considerably from all other treatments. These results concur with those of Soomro *et al.* (2014) who observed that % brix, pol, purity, commercial cane sugar, NPK uptake and accumulation in sugarcane were higher when three-fourth of recommended rate of NPK fertilizer (169-84-261) were applied along with + 20 tons press mud ha<sup>-1</sup>.

**Commercial cane sugar (CCS %)**

The assessment of data showed that commercial cane sugar (%) were non-significantly (*p*>0.05) affected by planting methods and significantly (*p*<0.05) by NPK levels whereas, their interaction was non-significant (Table 4). Double sett (parallel to furrow) gave highest commercial cane sugar (%) followed by single sett (parallel to furrow) having statistical equality with each other while lowest commercial

**Table 4: Internodes cane<sup>-1</sup> and cane yield (t ha<sup>-1</sup>) of sugarcane as affected by planting methods and NPK levels.**

Planting methods	Internodes cane <sup>-1</sup>				Cane yield (t ha <sup>-1</sup> )			
	NPK levels (kg ha <sup>-1</sup> )				NPK levels (kg ha <sup>-1</sup> )			
	166-084-165	225-112-220	281-140-275	Mean	166-084-165	225-112-220	281-140-275	Mean
Single sett (parallel to furrow)	24.3	29.3	34.3	29.3	102.7	111.0	118.0	110.6
Double sett (parallel to furrow)	25.3	33.0	35.0	31.1	104.0	114.0	120.3	112.8
Single sett (across furrow)	23.3	28.0	33.3	28.2	95.0	110.0	116.0	107.0
Mean	24.3 C	30.1 B	34.2 A	-	100.6 C	111.7 B	118.1 A	-
Variables	S. E	P-value	LSD (5%)		S. E	P-value	LSD (5%)	
Planting methods (M)	1.0244	0.1094	-		1.9584	0.1090	-	
NPK levels (F)	1.0384	0.0000	2.2624		2.5223	0.0001	5.4957	
M × F	1.7905	0.6506	-		4.0694	0.7670	-	

**Table 5:** Effect of planting methods and NPK levels on brix (%) and commercial cane sugar (%) of sugarcane.

Planting methods	Brix (%)				Commercial cane sugar (%)			
	NPK levels (kg ha <sup>-1</sup> )				NPK levels (kg ha <sup>-1</sup> )			
	166-084-165	225-112-220	281-140-275	Mean	166-084-165	225-112-220	281-140-275	Mean
Single sett (parallel to furrow)	20.3	20.7	22.0	21.0 AB	8.3	8.6	10.1	9.0
Double sett (parallel to furrow)	20.3	21.2	23.5	21.7 A	8.4	8.8	10.5	9.2
Single sett (across furrow)	18.3	20.5	21.3	20.0 B	8.0	8.6	9.4	8.7
Mean	19.6 B	20.8 AB	22.3 A	-	8.2 B	8.7 B	10.0 A	-
Variables	S. E	P-value	LSD (5%)		S. E	P-value	LSD (5%)	
Planting methods (M)	0.4291	0.0481	1.1915		0.2288	0.1624	-	
NPK levels (F)	0.9553	0.0539	2.0814		0.3029	0.0002	0.6600	
M × F	1.4175	0.8963	-		0.4857	0.7711	-	

cane sugar (%) was noticed in single sett (across furrow). 281-140-275 kg ha<sup>-1</sup> NPK levels resulted in greatest commercial cane sugar (%) followed by 225-112-220 kg ha<sup>-1</sup> NPK levels and 166-084-165 kg ha<sup>-1</sup> NPK levels. The interaction of double sett (parallel to furrow) × 281-140-275 NPK levels produced improved commercial cane sugar (%) lead by single sett (parallel to furrow) × 281-140-275 NPK levels, whereas reduced results were recorded in single sett (across furrow) × 166-084-165 NPK levels. Aamer *et al.* (2017) also affirmed that planting dimensions in ratoon cane had no significant effect on length of internodes and most of the qualitative attributes. Sarwar *et al.* (2012) reported that inorganic fertilizer increases the sugar yield 54.92 % and juice 21.95 %. Similarly, when press mud was applied along with inorganic fertilizers, it resulted in increase in total soluble solid 7.83 %, sucrose 10.42 % purity 2.80 %, CCS 12.06 % and sugar recovery of juice 12.07 %.

### Conclusions and Recommendations

The results of this study concluded that growth, yield and quality traits of sugarcane were affected significantly by planting methods, NPK levels and their interaction. However, Double sett (parallel to furrow), 281-140-275 kg ha<sup>-1</sup> NPK levels and their interaction produced highest cane yield (t ha<sup>-1</sup>) and brix (%).

### Acknowledgements

This is original research paper and prepared from PhD thesis work conducted at Sindh Agriculture University, Tandojam, Pakistan.

### Novelty Statement

Planting of sugarcane under double sett (parallel to furrow) along with different NPK levels is a unique research under agro-climatic conditions of Sindh, Pakistan.

### Author's Contribution

MNK wrote manuscript and guided overall. NM designed and conducted experiment. AAS helped in collection of data. ZHS analyzed the data. GSM helped in writing of manuscript. NM provided research facility. ZAA reviewed article. SPT edited format of manuscript.

### Conflict of interest

The authors have declared no conflict of interest.

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