MORPHOLOGICAL RESPONSES OF AUTUMN PLANTED SUGARCANE TO PLANTING GEOMETRY AND NUTRIENT MANAGEMENT ON DIFFERENT SOILS UNDER ARID CONDITIONS

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ABSTRACT

In a field experiment morphological response of sugarcane cultivar HSF 240 to different NPK doses like F_1 =0-0-0, F_2 =100-100-100, F_3 =150-150-100, F_4 =200-200-100 and F_5 =250-200-100 kg NPK ha^{-1} and different planting patterns like G_1 =60, G_2 =75 cm, spaced single row Planting pattern, G_3 =30/90, and G_4 =30/120cm spaced paired row strip Planting pattern were studied at the research area of the Gomal University Rukh Bibi campus Dera Ismaiel Khan and Main Line Lower Land Reclamation Research Station Chak No 37 TDA (Thal Development Authority) Bhakkar during 2003-04 and 2004-05. The experiment was laid out according to a randomized complete block design (RCBD) with a split plot arrangement in four replications giving more importance to planting patterns. The analysis of pooled data of D.I Khan and Bhakkar showed that all the NPK doses affected the yield, contributing parameters to a significant level. The maximum number of mill able canes m^{-2}, weight per stripped cane was recorded in 250-200-100 kg NPK ha^{-1} which were statistically non significant to those recorded in 200-200-100 kg NPK ha^{-1}. However maximum stripped-cane yield was recorded in 250-200-100 kg NPK ha^{-1} during both years. Among the planting patterns significantly higher mill able canes, cane weight, and stripped-cane yield were recorded in 30/90cm spaced paired row strip planting pattern followed by 75 and 60cm spaced single row planting pattern with minimum in 30/120cm spaced paired row strip planting pattern. Significantly higher mill able canes, cane weight and stripped-cane yield were recorded in the interaction of 250–200-100 kg NPK ha^{-1} x 30/90 cm spaced paired row strip planting pattern which were at par with 200–200-100 kg NPK ha^{-1} x 30/90cm spaced paired row strip planting pattern and minimum in control x 30/120 cm spaced paired row strip planting pattern during both years. Therefore it is recommended that under arid conditions on Silt clay and sandy loam soils optimum stripped cane yield was obtained from nutrient dose of 200–200-100 kg NPK ha^{-1} and 30/90cm spaced paired row strip planting pattern.

Key words: *Saccharum officinarum L*., NPK management, planting geometry, yield components, autumn planted sugarcane, Pakistan.

INTRODUCTION

In Pakistan the average cane yield is much lower than production potential of our existing sugarcane cultivars due to improper nutrient management and planting geometry. Being a long duration crop 125 t ha^{-1} of Sugarcane removes an average 83 kg N, 37 kg P_2O_5, 168 kg K_2O (Yadava, 1991), therefore an adequate and balanced supply of all these nutrients in the effective root zone of crop is essential for obtaining sustainable cane yield. Ali and Afghan (2000) recorded the maximum number of mill able canes m^{-2}, weight per cane and stripped cane yield at 200-150-150 kg NPK ha^{-1}. On the other hand Iqbal *et al*. (2002) recorded the highest stripped-cane yield from the plots fertilized @ 200-150-0 kg NPK ha^{-1}. Moreover El-Tilib *et al*, (2004) reported that Phosphorus addition reflected a significant effect on stalk height, number of internodes and plant density of cane. Where as Shukla, (2003) reported that the highest level of nitrogen 187.5 kg ha^{-1} resulted in better tiller vigor, number and retention, besides better expression in growth parameters during both cropping seasons.

The economic yield is determined by the capability of plant to produce Photosynthates and their distribution to economically valuable plant parts. In order to realize the full benefits of the land and environmental resources, it is necessary to place the plants over the field in such a pattern that there is a least competition among them for essential growth factors. Mali and Singh (1985) recorded the maximum thickness of cane 7.48cm at 120cm spaced rows as compared to 90cm and 60cm spacing but opposite results had been reported by Fasihi *et al* (1974) that sugarcane planted in 60cm spaced rows produced a significantly greater number of mill able canes ha^{-1} than that planted either in 90cm or 120cm spaced rows Romas (1975) stated that 90cm inter-row spacing gave significantly higher cane yield than 150cm spacing. Similarly Kanwar *et al*. (1990) obtained significantly more cane yield from the crop planted in 90cm spaced rows than 60cm or 120cm spaced rows. On the other hand El-Geddawy *et al*. (2002) obtained significantly higher cane yield at a row spacing of 100cm than 120cm or 140cm spacing.

It is very important to mentioning that in past autumn planted sugarcane crop was totally neglected by research workers therefore it was considered worth with to develop concrete information on planting patterns and nutrient needs of the autumn sugarcane crop under the edaphic and agro climatic conditions of Dera Ismaiel Khan situated at (031^0 28.40 N ^{0} and 071^0 58.54 E ^{0}) with Silt clay soil in NWFP and Bhakkar situated at (031^0 36.365 N ^{0} and 071^0 9.844 E ^{0}) with sandy loam soil in Punjab.

MATERIALS AND METHODS

The studies were conducted at the research area of the Gomal University Rukh Bibi campus Dera Ismaiel Khan (D.I Khan) and Main line Lower Land Reclamation Research Station Chak No 37 TDA (Thal development authority) Bhakkar during 2003-04 and 2004-05.

Table-1 Soil analysis of both experimental sites

	DI Khan		Bhakkar	
	2003-04	2004-05	2003-04	2004-05
Soil Texture	Silt clay	Silt clay	Sandy Loam	Sandy Loam
N %	0.03	0.035	0.044	0.049
P ppm	8	8.5	3.55	4.75
K ppm	80	92.5	55	60

Analysis; by the soil and water testing laboratory, Directorate of Land reclamation Punjab; Canal Bank Mughal Pura Lahore

The NPK doses were F_1 =0-0-0, F_2 =100-100-100 kg NPK ha^{-1}, F_3 =150-150-100 kg NPK ha^{-1}, F_4 =200-200-100 kg NPK ha^{-1} and F_5 =250-200-100 kg NPK ha^{-1}. The planting patterns comprising G_1=60cm, G_2=75cm spaced single row Planting pattern, G_3=30/90cm and G_4=30/120cm spaced paired row strip planting pattern. The seed was used at the rate of 70,000 double-budded setts ha^{-1}. Cane cultivar "HSF 240" was used as test crop. The experiment was laid out in a randomized complete block design (RCBD) with a split plot arrangement keeping the NPK doses in main plots and planting patterns in sub-plots. The net plot size was $24m^2$ with four replications. Each year the crop was planted during the 1^{st} week of September and harvested during the first week of December next year. All the phosphorus, potassium and 1/4 of total N was applied at the time of seed bed preparation while remaining nitrogen was applied in two equal splits each at completion of germination and at the start of cane formation. The crop was kept free of weeds and irrigated as and when needed. All other agronomic practices were kept normal and uniform for all the treatments. The observations on number of mill able canes m^{-2}, individual stripped cane weight, and stripped-cane yield were recorded using standard procedures. The data were analyzed statistically using Fisher's analysis of variance technique and LSD test at 0.05 percent level of probability was employed to compare the differences among the treatment means (Steel and Torrie, 1984).

Table-1.1 Water received by the crop

D.I Khan		Bhakkar	
2003-04	2004-05	2003-04	2004-05
Water Received in mm			
1900	1700	2700	2700
Rainfall Received in mm			
328.00	584.00	373.23	380.24
Total number of Irrigations applied each of 100 mm			
19	17	27	27

RESULTS AND DISCUSSION

Mill able canes

The analysis of pooled data of D.I Khan and Bhakkar at mill able cane m^{-2} presented in Table-2 showed that different NPK doses significantly affected the mill able cane m^{-2}. The maximum number of mill able canes m^{-2} (13.46 and 13.58) during 2004 and 2005, respectively were recorded at 250-200-100 kg NPK ha^{-1}, (F_5) which were at par with those recorded at 200-200-100 kg NPK ha^{-1} (F_4) and minimum number of mill able canes m^{-2} (4.01 and 4.12) during 2004 and 2005, respectively were recorded in control (F_1). It was observed that 70.21, 69.74, 54.84, 42.88% and 69.66, 69.21, 54.32 and 43.48% higher number of mill able canes m^{-2} during 2003-04 and 2004-05, respectively were recorded in F_5, F_4, F_3 and F_2 respectively than control (F_1). It showed that optimum numbers of mill able canes at 200-200-100 kg NPK ha^{-1} may be due to increased nutrient availability which reduced shoot mortality and improved cane development and increase in Nitrogen level more than 200 kg ha^{-1} had no significant effect on number of mill able canes m^{-2}. Increase in NPK dose increased the number of mill able canes per unit area have been reported by Akhtar *et al*. 2000, Ali *et al*. 2000.

The effect of different planting patterns on mill able canes m^{-2} was highly significant. Maximum number of mill able canes m^{-2} (10.39 and 10.46) during 2003-04 and 2004-05, respectively in 30/90cm paired row strip Planting pattern (G_3) followed by 75cm (G_2) and 60cm single row planting pattern (G_1) and minimum (8.17 and 8.3) during 2003-04 and 2004-05, respectively in 30/120cm paired row strip Planting pattern (G_4) were recorded. It was examined that 21.37, 15.69, 9.52% and 20.65, 16.08, 10.37% higher number of mill able canes m^{-2} during 2003-04 and 2004-05, respectively were obtained in G_3, G_2, and G_1 respectively than G_4. It was also noted that too much increase in inter strip spacing as in 30/120 cm paired row strip planting pattern number of plants per unit area had to increase to maintain optimum plant population, due to which inter plant competition increased causing adverse effects on number of mill able canes m^{-2}. Higher number of mill able canes per unit area at 100 cm apart rows than 120 or 140cm were reported by El-Geddawy *et al*. 2002.

Interactive effects of planting patterns and NPK doses on number of mill able canes were highly significant. Maximum number of mill able canes m^{-2} (11.75 and 11.77) during 2003-04 and 2004-05, respectively were recorded in 250–200-100 kg NPK ha^{-1} x 30/90 cm spaced paired row strip planting pattern (F_5xG_3) which were at par with 200–200-100 kg NPK ha^{-1} x 30/90 cm spaced paired row strip planting pattern (F_4xG_3) and were minimum (3.73 and 3.77) during 2003-04 and 2004-05, respectively in control x 30/120 cm spaced paired row strip planting pattern (F_1xG_4). This increase in number of mill able canes m^{-2} may be ascribed to complimentary effect of increased nutrient availability and improved air circulation and light penetration in (F_4xG_3) which resulted in reduced shoot mortality and better cane development.

Individual stripped cane weight

The analysis of pooled data of D.I Khan and Bhakkar regarding individual stripped cane weight presented in Table-2 revealed that significantly different individual striped cane weight was recorded at different NPK doses. The highest individual stripped cane weight (0.99 and 1.03kg) during 2003-04 and 2004-05 was recorded at 250-200-100 kg NPK ha^{-1}, (F_5) but it was at par with that obtained from 200-200-100kg NPK ha^{-1}(F_4) and the lowest individual stripped cane weight (0.30 and 0.32kg) during 2003-04 and 2004-05, respectively was recorded in control (F_1). It was also observed that 69.70, 69.39, 52.38 42.31% and 68.93, 68.63, 53.62, and 42.86% higher individual stripped cane weight during 2003-04 and 2004-05 was recorded in F_5, F_4, F_3 and F_2, respectively than control F_1. It was seen that higher individual stripped cane weight at 200-200-100 kg NPK ha^{-1} may be due to increased nutrient availability which improved cane growth and development and increase in Nitrogen level more than 200 kg ha^{-1} had no significant effect on individual stripped cane weight. Ali and Afghan (2000) recorded maximum individual stripped cane weight with 200-150-150 kg NPK ha^{-1}.

The Effect of different planting patterns on individual stripped cane weight was significantly different and maximum individual stripped cane weight (0.76 and 0.80kg) during 2003-04 and 2004-05 was recorded in 30/90cm paired row strip Planting pattern (G_3) followed by 75 (G_2) and 60cm single row planting pattern (G_1) and minimum individual stripped cane weight (0.59 and 0.63kg) during 2003-04 and 2004-05, respectively was recorded in 30/120cm paired row strip Planting pattern (G_4). It was noted that 22.37, 18.06 11.94% and 21.25, 16, and 10% higher individual stripped cane weight during 2003-04 and 2004-05, was recorded in G_3, G_2, and G_1 respectively than G_4. It was further noted that higher individual cane weight at 30/90cm spaced paired row planting pattern may be due to improved air circulation and light penetration which improved photosynthetic efficiency and too much increase in inter strip spacing as in 30/120cm paired row strip planting pattern number of plants per unit area had to increase to maintain optimum plant population, due to which inter plant competition increased causing adverse effects on individual stripped cane weight.

Interactive effects of NPK doses and planting patterns on individual stripped cane weight were significantly different. Maximum individual stripped cane weight (0.85 and 0.89kg) during 2003-04 and 2004-05, respectively was recorded in the interaction of 250–200-100 kg NPK ha^{-1} x 30/90cm spaced paired row strip planting pattern (F_5xG_3) which was also at par with 200–200-100 kg NPK ha^{-1} x 30/90 cm spaced paired row strip planting pattern (F_4xG_3) and minimum individual stripped cane weight

(0.29 and 0.30kg) during 2003-04 and 2004-05, respectively was recorded in control x 30/120cm spaced paired row strip planting pattern (F_1xG_4). It was examined that increase in individual stripped cane weight in (F_4xG_3) may be ascribed to complimentary effect of increased nutrient availability and improved air circulation and light penetration in (F_4xG_3) which resulted in increased cane growth and development due to improved photosynthetic efficiency.

Stripped-cane yield

The analysis of pooled data of D.I Khan and Bhakkar in Table-2 revealed that cane yield was significantly different under different NPK doses and planting patterns. The highest stripped-cane yield of 147.81 and 149.37 t ha^{-1} during 2003-04 and 2004-05, respectively was recorded in 250-200-100 kg NPK ha^{-1} (F_5) followed by 200-200-100 kg NPK ha^{-1} (F_4), 150-150-100 kg NPK ha^{-1} (F_3), 100-100-100 kg NPK ha^{-1} (F_2) and the lowest stripped-cane yield of 44.06 and 45.37 t ha^{-1} during 2004 and 2005, respectively in control (F_1). It was also noted that 70.19, 69.76, 54.87, 42.94% and 69.63, 69.18, 54.29 and 43.42% higher stripped cane yield was obtained during 2003-04 and 2004-05, in $F_{5,}$ $F_{4,}$ F_3 and F_2 respectively than control (F_1). The increased stripped cane yield at 200-200-100 kg NPK ha^{-1} may be ascribed to increased nutrient availability and complementary effect of N, P, and K which resulted in higher number of mill able canes m^{-2} and improved individual cane weight. These results have also been supported by Ali (1999), Ayub (1999), Akhtar *et al* (2000) Ali and Afghan (2000), Ramesh (2000), Pandey and Shukla (2000), Sundara, *et al* (2002), Rana *et al*. (2003), El-Tilib *et al* (2004).

The highest stripped-cane yield of 114.2 and 115.10 t ha^{-1} during 2003-04 and 2004-05, respectively was recorded in 30/90cm (G_3) followed by 75cm (G_2), 60cm spaced single row planting pattern (G_1) and the lowest stripped-cane yield of 89.75 and 91.30 t ha^{-1} during 2004 during 2005, respectively in 30/120cm spaced paired row planting pattern (G_4). It was also noted that 21.41, 15.83, 9.66% and 20.68 16.12 and 10.36% higher stripped cane yield during 2003-04 and 2004-05, respectively was recorded in G_3, G_2 and G_1 respectively than G_4. It was observed that improvement in stripped cane yield in 30/90cm spaced paired row planting pattern was due to better air circulation and light penetration which enhanced the photosynthetic efficiency of plants, which reduced shoot mortality and increased number mill able canes m^{-2} and individual cane weight. It was also noted that too much increase in inter strip spacing as in 30/120 cm paired row strip planting pattern number of plants per unit area had to increase to maintain optimum plant population, due to which inter plant competition increased causing adverse effects on yield and yield components of crop. Kanwar *et al.* (1990) and El-Geddawy *et al* (2002) also reported significantly higher stripped-cane yield in 90cm and 100cm row spacing respectively.

Table-2 Morphological response of autumn planted sugarcane to nutrient management and planting geometry on different soils under arid CONDITIONS

Treatments	Number of mill able Canes (m^{-2})		Individual stripped Cane weight (kg)		Stripped cane yield t ha^{-1}	
	Pooled data of D I Khan and Bhakkar					
	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05
(A)-N:P:K Fertilizer nutrient Doses (kg ha^{-1})						
F_1 = 0 : 0 : 0	4.01d	4.12d	0.3d	0.32d	44.06e	45.37e
F_2 = 100:100:100	7.02c	7.29c	0.52c	0.56c	77.22d	80.19d
F_3 = 150:150:100	8.88b	9.02b	0.63b	0.69b	97.63c	99.25c
F_4 = 200:200:100	13.25a	13.38a	0.98a	1.02a	145.69b	147.19b
F_5 = 250:200:100	13.46a	13.58a	0.99a	1.03a	147.81a	149.37a
LSD	0.63	0.63	0.04	0.04	0.67	1.28
(B)-Planting patterns (G)						
G_1 = 60 cm	9.03c	9.26c	0.67c	0.70c	99.35c	101.85c
G_2 = 75 cm	9.69b	9.89b	0.72b	0.75b	106.63b	108.85b
G_3 = 30/90 cm	10.39a	10.46a	0.76a	0.80a	114.20a	115.10a
G_4 = 30/120 cm	8.17d	8.3d	0.59d	0.63d	89.75d	91.30d
LSD	0.56	0.56	0.03	0.03	0.60	1.14
(C)-F x G						
F_1 x G_1	3.86k	4i	0.29j	0.30i	42.50r	44.00n
F_1 x G_2	4.07k	4.27i	0.31j	0.32i	44.75q	47.00m
F_1 x G_3	4.36K	4.45i	0.33j	0.34i	48.00p	49.00m
F_1 x G_4	3.73K	3.77i	0.28j	0.29i	41.00s	41.50n

F_2 x G_1	6.77ij	7.18gh	0.51hi	0.54gh	74.50n	79.00k
F_2 x G_2	7.51hi	7.68fg	0.56gh	0.58g	82.65m	84.50j
F_2 x G_3	7.89hi	7.98fg	0.58gh	0.61fg	86.75l	87.75i
F_2 x G_4	5.91j	6.32h	0.44i	0.48h	65.00o	69.50l
F_3 x G_1	8.64fgh	8.86ef	0.62fg	0.67ef	95.00k	97.50h
F_3 x G_2	9.18fg	9.36e	0.66f	0.71e	101.00j	103.00g
F_3 x G_3	9.73f	9.82e	0.69f	0.74e	107.00i	88.50i
F_3 x G_4	7.95ghi	8.05fg	0.57gh	0.61fg	87.50l	88.50i
F_4 x G_1	12.84cd	13.02bc	0.96d	0.99c	141.25f	143.25d
F_4 x G_2	13.75bc	13.93ab	1.02bcd	1.06bc	151.25d	153.25c
F_4 x G_3	14.89ab	14.98a	1.09ab	1.14a	163.75b	164.75a
F_4 x G_4	11.5e	11.59d	0.83e	0.88d	126.50h	127.50e
F_5 x G_1	13.05c	13.230b	0.97cd	1.00bc	143.50e	145.50d
F_5 x G_2	13.95abc	14.23ab	1.04abc	1.08ab	153.50c	156.50b
F_5 x G_3	15.09a	15.090a	1.12a	1.14a	165.50a	166.00a
F_5 x G_4	11.75de	11.77cd	0.85e	0.89d	128.75g	129.50e
LSD	1.26	1.26	0.08	0.08	1.33	2.56

Means followed the same letter in a column do not differ significantly at 5 % level of probability

Interactive effects of NPK doses and planting patterns on stripped cane yield were significantly different during both years. The maximum stripped cane yield of 165 and 166 t ha^{-1} during 2003-04 and 2004-05, respectively was obtained in the interaction of 250–200-100 kg NPK ha^{-1} x 30/90cm spaced paired row strip planting pattern(F_5 x G_3) which was at par with 200–200-100 kg NPK ha^{-1} x 30/90cm spaced paired row strip planting pattern (F_4 x G_3)and was minimum 41 and 41.5 t ha^{-1} during 2003-04 and 2004-05, respectively in control x 30/120 cm spaced paired row strip planting pattern (F_1xG_4). The optimum stripped cane yield in (F_4xG_3) may be due to complimentary effect of increased nutrient availability and improved air circulation and light penetration which enhanced the photosynthetic efficiency which resulted in accelerated growth and development.

CONCLUSION

It was concluded that under arid conditions on Silt clay and sandy loam soils optimum stripped cane yield was obtained in the interaction of 200–200-100 kg NPK ha^{-1} x 30/90 cm spaced paired row strip planting pattern. The plating pattern of 30/90cm paired row strip planting had few advantages over other planting patterns like, it facilitates interculture and earthing up of the crop without damaging the roots, 50% reduction in the number of inter-strip ditches/furrows, thus conserving irrigation water and saving almost 50% in labor and time required for earthing up, allows efficient and expeditious interculture and earthing up with tractor or bullock-drawn implements, permits systematic planting and handling of intercrops without affecting the associated cane crop. Moreover, planting of the main and intercrops in separate and independent strips not only reduces intercrop competition, but also enables the grower to meet the varying fertilizer requirements, growth patterns, and planting times of different crops, facilitates easy application of herbicides since the strips are well spaced, prevents lodging in case of unusual wind or rain since the strips provide plant support to each other, improves the air circulation and light penetration which enhances the photosynthetic efficiency of plants and reduces crop damages from trampling by wild animals looking for a space to rest.

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