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Effect of irrigation and potash levels on growth, yield and quality of spring sugarcane (*Saccharum officinarum*)

RAJAN BHATT[1]*, JAGDISH SINGH[2] and LENIKA KASHYAP[1]

Regional Research Station, Gurdaspur, Punjab Agricultural University, Ludhiana, Punjab 143 521, India

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Sugarcane (*Saccharum* spp. hybrid complex) is a crop of industrial importance, grown in 110 countries, and is known for production of sugar, ethanol, jaggery and khandsari (Priya *et al.* 2015, Bhatt 2020). Sugarcane production in India is 362.33 million tonnes with 71.5 t/ha productivity. However, in Punjab, it is cultivated in 94,000 ha with an average cane yield of 81.25 t/ha, while sugar recovery of 9.78% (PAU 2020). For attaining a yield of 100 t/ha, canes removed 207 kg N, 30 kg P_2O_5 and 233 kg K_2O from the soil (Chohan *et al.* 2013), but the potash doses are still not recommended in the state, even for the deficient soils. Considering this fact, the present study was conducted at Regional Research Station, Gurdaspur in spilt-plot design, to standardize sustainable potash dose for the deficient soils during spring 2019–20.

In the water-stressed plots, irrigation was suspended after 3-weeks interval at critical growth stages of sugarcane, viz. germination, tillering, and grand growth stage. Experimental site was categorized with sandy loam texture, *p*H 7.3, EC 0.045 dS/m, OC 0.65% (medium), available P 26.5 kg/ha (high), and available K_2O was 97.5 kg/ha (low) (Bhatt *et al.* 2020). Sugarcane cultivar CoPb 91 was sown at 75 cm row spacing on 10 April 2019. As far as climate is concerned, a total of 927.5 mm of rainfall and 1396.4 mm of evaporation occurred during study period. Average air maximum and minimum temperature varied from 15.4–39.9°C and 6.4–25.2°C, respectively.

Stalk borer and top borer were counted from 100 plants at harvesting while early shoot borer was counted after 65 DAS. The whole plots were manually harvested at maturity, followed by de-trashing and de-topping, and the final yield was calculated in t/ha.

Finally, benefits over the cost of cultivation (B:C ratio) was calculated after considering the rate of murate of potash as ₹950 per 50 kg bag and price of sugarcane as ₹2950 per tonne (Kumar *et al.* 2019).

B:C ratio= Benefit due to applied additional K (₹/ha)/ Cost of fertilizer (₹/ha)

Growth-yield parameters and per cent insect-pests incidence: Cane width was recorded significantly better under irrigated conditions, unlike plant height where both irrigation treatments performed at par (Table 1 and Fig 1). I_1 plots had higher germination (5.61%), millable canes (9.09%) and brix near harvesting (5.19%), and yield (0.6%) as compared to I_2 plots (Table 1). Compared to K_1 plots, K_2, K_3, and K_4 plots had 13.98, 26.16, and 34% higher germination, 0.86, 4.28, and 4.45% higher NMC, and 1.87, 1.87, and 4.21% higher brix near harvesting, 0.89, 2.41, 3.31% higher yields (Table 1) as also observed by Ashraf *et al.* (2008), Shukla *et al.* (2009). Further, increments from K_2 to K_3 and K_3 to K_4 were reported to be 10.69 and 6.21%, 3.40 and 0.16%, 0 and 2.29%, 1.50 and 0.88%, respectively, in germination, NMC, brix near harvesting and yield, respectively (Table 1) which is due to role of potash in improving root growth (Kumar *et al.* 2015), water use efficiency (Quampah *et al.* 2011), N use efficiency (Padmanabhan *et al.* 2017) and condition specific stomatal opening (Kumar *et al.* 2019).

Treatment with 80 kg K_2O/ha had significantly higher germination, NMC, brix, and yields as compared to K_1 and K_2 plots. Increments were there in K_4 plots with 120 kg K_2O/ha, but that were statistically at par with K_3 plots (Bhatt *et al.* 2020). Irrigation levels were not able to affect the cane yield (Shukla *et al.* 2009).

Further, top borer and stalk borer were observed to be significantly higher under stressed conditions than the irrigated conditions, while the incidence of top borer only reduced significantly in the K_3 plots (80 kg K_2O/ha) compared to the other plots. Irrigated plots (I_1) had 21.33, 18.05, and 24.12% lesser incidence of early shoot borer, top borer, and stalk borer, respectively, as compared to the stressed plots (I_2) (Table 1). Data revealed that compared to K_1 plots, K_2, K_3, and K_4 plots had 9.96, 15.97, and 6%;

[1]Regional Research Station, Kapurthala, PAU, Ludhiana, Punjab; [2]Regional Research Station, Gurdaspur, PAU, Ludhiana, Punjab. *Corresponding author email: rajansoils@pau.edu

Table 1 Sugarcane germination, NMC, per cent incidence of insect-pests and yields as affected by different levels of irrigations and potash

Treatment	Germination (%)	NMC (000/ha)	Early shoot borer	Top borer	Stalk borer	Cane yield (t/ha)
Irrigation method						
I_1	48.78	62.4	6.75	7.58	7.08	77.89
I_2	46.19	57.2	8.58	9.25	9.33	77.43
CD (P=0.05)	NS	NS	NS	1.39	0.67	NS
Potash fertilization						
K_1	40.06	58.4	8.33	9.00	8.83	76.40
K_2	45.66	58.9	7.50	8.33	7.83	77.08
K_3	50.54	60.9	7.00	7.67	7.83	78.24
K_4	53.68	61.0	7.83	8.67	8.33	78.93
CD (P=0.05)	3.15	NS	NS	0.91	NS	0.70
K at same I	NS	NS	NS	NS	NS	NS
I at same K	NS	NS	NS	NS	NS	NS

I_1 and I_2 are irrigated and water stressed conditions while K_1, K_2, K_3, K_4 are 0, 40, 80 and 120 kg K_2O/ha.

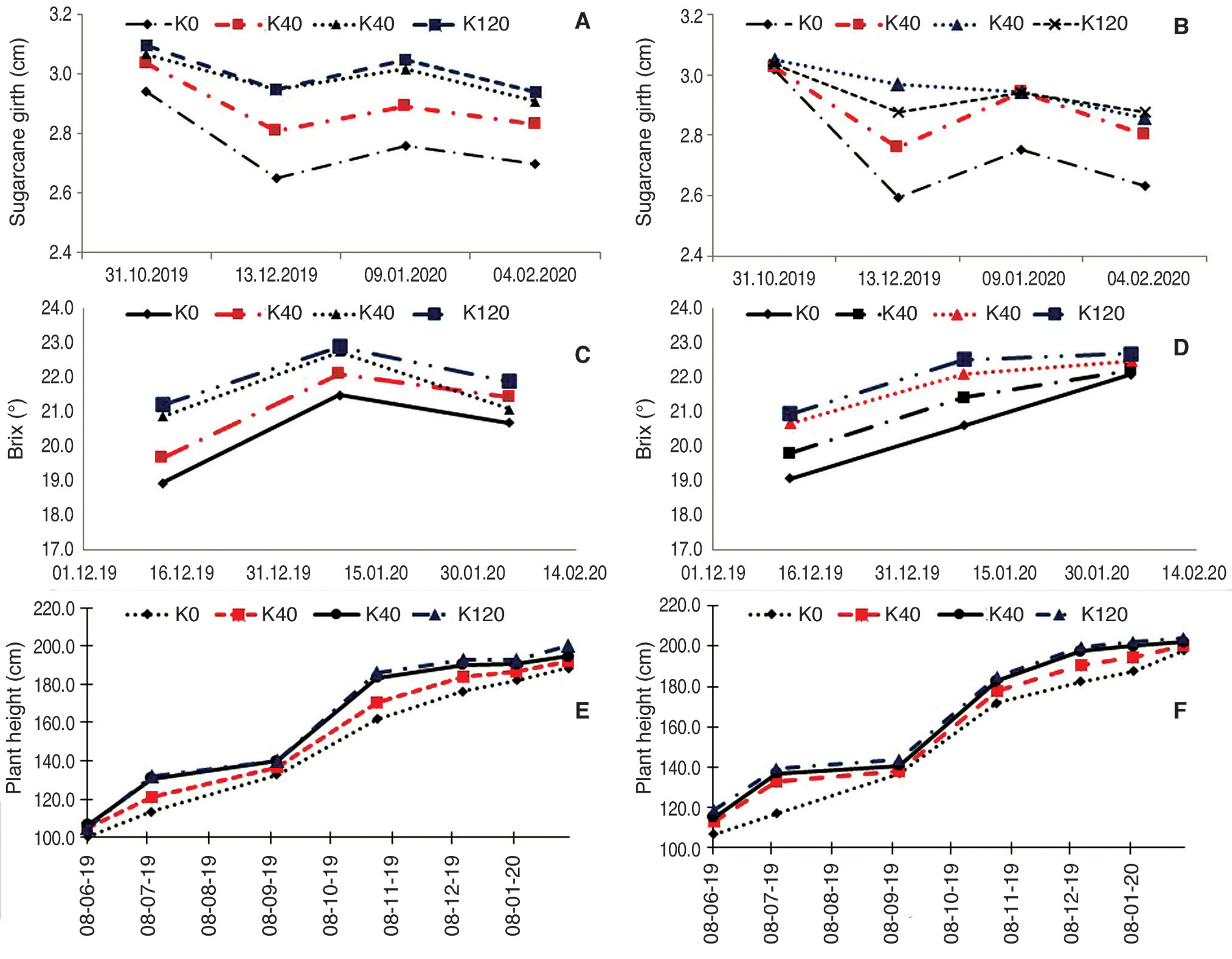

Fig 1 Effect of different levels of irrigation and potash on sugarcane girth (cm) at irrigated (A) and water-stressed (B) plots; periodic brix at irrigated (C) and water-stressed (D) plots; cane height at irrigated (E) and water-stressed plots (F).

7.44, 14.78, and 3.67%; 11.33, 11.33, and 5.66% lesser per cent incidence of early shoot borer, top borer, and stalk borer, respectively, which might be due to better translocation of sugars in plants and comparative bitter leaves (Shulka *et al.* 2009, Bhatt *et al.* 2020) (Table 1). Reduction in the incidence was reported to be 6.67, 7.92%, in K_2 to K_3

Table 2 Different sugarcane quality parameters 10^{th} and 12^{th} months after sowing as affected by different irrigation and potash levels

Treatment	10^{th} month after sowing				12^{th} month after sowing			
	Brix (°)	Pol (%)	Extraction (%)	CCS (t/ha)	Brix (°)	Pol (%)	Extraction (%)	CCS (t/ha)
Irrigation methods								
I_1	18.7	17.02	52.41	9.30	21.02	19.49	57.51	10.74
I_2	18.01	16.3	53.35	8.88	20.71	18.78	54.08	10.29
CD (P=0.05)	NS	NS	NS	0.43	NS	NS	NS	NS
Potash fertilization								
K_1	17.81	16.11	50.04	8.61	19.93	18.57	52.74	10.06
K_2	18.17	16.46	51.15	8.88	20.18	18.71	52.85	10.43
K_3	18.65	16.94	54.4	9.29	21.64	19.61	58.36	10.74
K_4	18.78	17.12	55.93	9.48	21.71	19.65	59.23	10.85
CD (P=0.05)	0.66	0.47	NS	0.38	0.69	0.45	4.46	0.41
K at same I	NS	NS	NS	NS	NS	NS	NS	NS
I at same K	NS	NS	NS	NS	NS	NS	NS	NS

I_1 and I_2 are irrigated and water stressed conditions while K_1, K_2, K_3, K_4 are 0, 40, 80 and 120 kg K_2O/ha.

respectively, for early shoot borer, top borer while under K_3 to K_4 plots, 11.86, 13.04 and 6.39% higher incidence of early shoot borer, top borer and stalk borer, respectively, were reported that might be due to excessive vegetative growth (McCray *et al.* 2017).

Quality parameters: I_1 plots at 10^{th} and 12^{th} months after sowing had 3.83, 4.42, 0.67, and 4.73% while 1.50, 3.78, 2.35 and 4.37% higher values of brix (°), pol (%), purity (%) and CCS (t/ha), respectively (Table 2). Brix (°), pol (%), extraction (%) and CCS (t/ha) were reported to be higher in K_2, K_3 and K_4 plots compared to K_1 plots by 2.02, 4.72 and 5.45%, 2.17, 5.15 and 6.27%, 2.22, 8.71 and 11.77% and 3.14, 7.90 and 10.10% after 10^{th} months and 1.25, 8.58 and 8.93%, 0.75, 5.60 and 5.82%, 0.21, 10.66 and 12.31% and 3.68, 6.76 and 7.85% at 12^{th} month after sowing, respectively (McCray *et al.* 2017) (Table 2). Increments in the brix (°), pol (%), extraction (%) and CCS (t/ha) from K_2 to K_3 and K_3 to K_4 plots were reported to be 2.64 and 0.70%, 2.92 and 1.06%, 6.35 and 2.81% and 4.62 and 2.05% at 10^{th} months while 7.23 and 0.32%, 4.81 and 0.20%, 10.43 and 1.49% and 2.97 and 1.02% at 12^{th} months after sowing, respectively. Similar results were also reported by Otto *et al.* 2010.

Table 3 Benefit:cost ratio of sugarcane crop under different treatments

Treatments	Cost of fertilizer (₹/ha)	Yield (t/ha)	Response over control	Benefit due to applied K (₹/ha)	Benefit cost ratio
I_1K_1	0	76.82	0.00	0.0	0.00
I_1K_2	1273	77.60	0.78	2305.9	1.81
I_1K_3	2546	78.15	1.33	3938.2	1.55
I_1K_4	3800	79.00	2.18	6445.7	1.70
I_2K_1	0	75.99	0.00	0.0	0.00
I_2K_2	1273	76.56	0.57	1671.7	1.31
I_2K_3	2546	78.32	2.33	6883.3	2.70
I_2K_4	3800	78.87	2.88	8481.3	2.23

Rate of Murate of potash: ₹950 per 50 kg bag; Price of Sugarcane: ₹2950/t. I_1 and I_2 are irrigated and water stressed conditions while K_1, K_2, K_3, K_4 are 0, 40, 80 and 120 kg K_2O/ha.

Under I_2 conditions, K_3 plots recorded higher benefits as compared to other plots, respectively, (Table 3) due to K role in helping canes withstand the drought conditions (Kenta *et al.* 2019).

Above discussions conclude K_3 plots with 80 kg K_2O/ha under water-stressed conditions most sustainable for enhancing growth, yield and quality parameters of sugarcane in the K-deficient sites of the region.

SUMMARY

I_1 plots had higher germination (5.61%), millable canes (9.09%), brix (5.19%), yield (0.6%) and CCS (t/ha) (2.35 and 4.37% at 10^{th} and 12^{th} months), respectively. K_3 plots reported significantly higher performance as compared to K_1 and K_2 treatments while being at par with the K_4 treatment. Benefits were reported to be highest at K_3 treatment under water stressed conditions. Hence, 80 kg K_2O/ha under water stressed and potash deficient soils prove to be a better option for better cane growth, yield and quality parameters.

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