Effect of natural and synthetic soil supplements on qualitative parameters of sugarcane under water scarcity

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Abstract: The present study was performed to check the effect of irrigation levels and soil amendments practices on sugarcane under field conditions at Agronomic Research Farm area, University of Agriculture, Faisalabad Pakistan during growing season 2017- 18. The experiment was performed under RCBD with split plot arrangement and three replications. Planting was sown in 120 cm wide trenches using two eyed cane setts in dual rows @ 75,000 setts ha^{-1} by hand placement. Sugarcane variety CPF-249 was planted on Last week of March 2017. All agronomic practices were performed uniformly except (N) nitrogen and (P) phosphorus fertilizers and time of irrigations. In experiment, potash @112 kg ha'1 was applied in trenches at the time of planting while Nitrogen and phosphorus fertilizer was applied as per treatment plan from organic and inorganic sources with irrigation combinations viz. I_0T_0 = 100% of Recommended Irrigation (16 Irrigations) + Control, I_0T_1 = 100% of Recommended Irrigation (16 Irrigations) + Press-mud, I_0T_2 = 100% of Recommended Irrigation (16 Irrigations) + Polymer Coated SSP, I_0T_3 = 100% of Recommended Irrigation (16 Irrigations) 50% Cane Trash boiler ash+50% SOP, I_1T_0 = 75% of Recommended Irrigation (12 Irrigations) + Control, I_1T_1 = 75% of Recommended Irrigation (12 Irrigations) + Press-mud, I_1T_2 = 75% of Recommended Irrigation (12 Irrigations) + Polymer Coated SSP, I_1T_3 = 75% of Recommended Irrigation (12 Irrigations) + 50% Cane Trash boiler ash+50% SOP, I_2T_0 = 50% of Recommended Irrigation (08 Irrigations) + Control, I_2T_1 = 50% of Recommended Irrigation (08 Irrigations) + Press-mud, I_2T_2 = 50% of Recommended Irrigation (08 Irrigations) + Polymer Coated SSP, I_2T_3 = 50% of Recommended Irrigation (08 Irrigations) + 50% Cane Trash boiler ash+50% SOP. All quality parameters like Brix (%), Sucrose content in juice (%), cane juice purity (%), and cane fiber (%) exposed non-significant effect of irrigation levels and soil amendments techniques in spring planted sugarcane. Maximum commercial cane sugar (CCS) (15.00 %) and cane sugar recovery (14.53 %) was recorded at I_0T_2 (100% of recommended irrigation + polymer coated SSP).

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Introduction:

Sugarcane is a warm and moist region crop that growth well in the radiant, hot zones where abundance of basis components and parameters of climate such as humidity, light and temperature are present. These parameters have main importance as they control yield of sugarcane crop (Humbert, 1968). The ideal environment for optimum cane yield would be under 4-5 months having average temperature 30°C to 35°C during daytime to increase the improvement and 1.5-2 months of cold temperature for maximum production and accumulation of sucrose. Sugarcane is sensitive to cold temperature and growth and development of crop reduces at low temperature, even stops below 12°C. Most outrageous photosynthesis rate occurs at an air temperature of around 34°C. The maximum rate of photosynthesis starts when air temperature crosses the 34°C. (Reddy, 2004). Ratoon crop as well as planted crop of sugarcane are extremely exhaustive crops as they having higher request for nitrogenous soil fertilizer because of immobilization of nitrogen, emerging of stubble buds, rottenness of old roots and shallow root system of cane plant (Lal and Singh, 2008). Mostly two or more than two ratoons are reserved by the main cane producing countries. Many researchers have observed changing behavior of various sugarcane genotypes to rationing regarding sprouting, growth and production of commercial cane sugar from millable canes (Singh and Dey, 2002). Water scarcity is important factor in restraining production of sugarcane in semi-dry and dry regions of the world as it considers a key part in plant metabolism. Reportedly the uptake of plant nutrients through soil and soil applied material in plant is constrained in water deficit conditions (Tahir et al., 2018). Sugarcane (*Saccharum officinarum* L.) is an essential harvest all around for sugar production, and in addition logically as a bio energy alter as a result of its astounding dry matter creation restrict (Surendran *et al*., 2016). Sugarcane requires plenty of water for its optimum growth and the land should be fertile for the period of ten to eighteen months. Sugarcane response well to shortage of water and can tolerate the water stress to some extend (Inman-Bamber and Smith, 2005). Water application of sugarcane crop through flood irrigation system is another problem in production of crop as it cause leaching of mineral ions through deep percolation of water or run off of nutrients through surface flow of water, finally these nutrients fall into river systems (Davis *et al*., 2013). Organic manures are outstanding to enhance soil condition and availability of plant nutrients. In developing state certain of the carbon-based wastes are operated to some range in farming but farthest of them are burnt or remain un-utilized. These advanced practices seriously harm the environment by warming the surroundings and also deteriorate the beneficial necessary nutrient pool which are essential for plants. There is huge availability of organic based resources in the form of industrial wastes (cotton, sugar, rice and other food industries), poultry litter, municipal waste materials and farm excess (Aslam et al., 2018). Water and air pollution is increasing due to continuous addition of these waste materials (Economic Survey, 2006). Sugarcane is a special purpose and long duration crop (Paul *et al*., 2005). According to researchers, production of 85 tons. biomass of crop uptake about 122.24-142 kg NPK per hectare from the soil (Bokhtiar *et al*., 2001). Maximum cost of production of this crop is due to maximum nutrients requirement and highly investment on artificial chemical fertilizers (Gholve *et al*., 2001). Likewise, increasing costs joined with small accessibility of fertilizers (Khandagave, 2003) and less availability of organic matter and nutrients owing to continuously sugarcane production with inorganic and organic fertilizers (Ibrahim *et* al., 2008) requires the combined application of inorganic and organic supplements. So, use of press-mud as a source of organic fertilizer can be useful (Bokhtiar *et al*., 2001) and an alternative way of soil management and crop nutrients supply (Razzaq, 2001). Total sugar production and dry matter of cane increases by enhancing press-mud cake units and nitrogen level (Bangar *et al*., 2000). Consumption of urea and press-mud cake in integrated way with 1:1 ratio @ 180 kg per hectare for the production of suagrcane in calcareous soil type is beneficial (Sharma *et al*., 2002). Application of press-mud increases the cation exchange capacity (CEC) of soil after thirty months of its use (Rodella *et al*., 1990) and its remaining effects remains for 04 years after application (Viator *et al*., 2002). Press mud (PM) derived from cane sugar during its processing has multiple uses such as a livestock feed and industrial construction lime production. In India, pressmud is being used as a source of fertilizer. Pressmud is a formless, light and undefined cocoa to earthy white important coagulated colloids having sticky wax and fiber along with soil necessary components (Satisha *et al*. 2007). Performance of filter cake in reclaiming saline-sodic and sodic soils as well as improving the solubility and availability of nutrients to soil is of significance (Rangaraj *et al*., 2007). Application of press-mud to soils as a manure is preferred in India and Pakistan. It is mostly preferred because addition of press-mud is suitable and feasible practice to improve soil properties. Press-mud is a valuable source of organic matter, nitrogen, phosphorus, potash, and other essential nutrients and considered an important source for improving viability of nutrients, physical and chemical estate of agricultural soils (Rangaraj *et al*., 2007). Application of polymers is considered useful in saving water and holding nutrients. Incorporation of these polymers improve the soil and better the crop yield by enhancing availability of nutrients. Thus, it is possible to improve the productivity of crop in those soils which are water deficient (Islam *et al*., 2011). Johnson (1984) described that incorporation of polymers integrated with coarse sand enhance the moisture contents and water retention from 171 to 402%. Application of a polymer to the peat reduced water shortage issues (Karimi *et al*., 2009). The ability of absorption of a SAP is helpful to better the physical properties of agricultural soils (El-Amir *et al*., 1993), increased sprouting and emergence of seeds as well as improving growth and yield of crop (Yazdani *et al*., 2007) and decreased the water requirement of crop through water retention (Islam *et al*., 2011). So the present research was performed to evaluate the yield response of sugarcane ratoon to natural and synthetic soil supplements / composts under water scarcity.

Materials and methods

An experiment was conducted on directorate farm of University of Agriculture Faisalabad during 2017-18 to estimate the impacts of soil amendments practices on qualitative attributes of spring planted sugarcane (Saccharum Officinarum L.) under water deficit conditions. The soil analysis was done before sowing of the sugarcane crop. The analysis of soil expose that the field trial site was slightly alkaline and loam soil. However, the experimental area, selected for crop husbandry was deficient in major primary nutrients NPK (nitrogen, phosphorus and potash). The field trial was done in Randomized Complete Block

Design (RCBD) under split plot arrangements having three replications. The net plot sizes were 10.00 m × 6.0 m with 5 rows.

Treatments:

Factor A. Irrigation Scheduling:

I_0 =100% of Recommended Irrigation (16 Irrigations), I_1 =75% of Recommended Irrigation (12 Irrigations). I_2 =50% of Recommended Irrigation (08 Irrigations).

Factor B. Organic and Coated Fertilizer

T_0 = Control, T_1 =Press-mud (obtained from sugar mills), T_2 = Polymer Coated Single Super Phosphate (SSP), T_3 = 50% Cane Trash boiler ash + 50 % Sulphate of Potash (SOP).

Preparation of seed bed

The experimental soil was prepared well. by deep ploughing through disk and well-rotted farmyard manure (FYM) was applied to increase the efficiency of soil. Moreover, all the optional doses of press mud, bio organic phosphorus, and polymer coated SSP and chopped cane leaves with artificial fertilizer with the ratio of 50:50 percent respectively applied at the time of sowing.

Sowing of Crop:

Sugarcane ratoon crop with variety CPF-249 was selected for experimental purpose. However, crop was planted during mid of March 2017 and harvested during 15th February, 2018 and kept as a ratoon crop for the next year. During next year 2019, ratoon crop of sugarcane was harvested at 20th of February and data regarding parameters were recorded from that crop.

Fertilization and Earthing up:

Synthetic fertilizer, integrated with organic amendments were applied @ 168 kg/ha of nitrogen, 112 kg/ha of P_2O_5, and 112 kg/ha of K_2O. However, resources for synthetic fertilizers include urea, SOP and K_2O and for organic based fertilizers these were bioorganic phosphorus, polymer coated SSP, chopped cane leaves and press mud. At the time of sowing all recommended dose of synthetic fertilizers including phosphorous and potash and 1/3rd of nitrogen were applied as a basal dosage and broadcasted. However, remaining amount of nitrogen was used to crop in two splits, 1/3rd at initial stage of tillering. Moreover, after 90 days of germination earthing-up of sugarcane was done.

Harvesting of Crop

At physiological maturity the harvesting was done manually on 18th Feb. 2019.

Recording Observations

Data pertaining to the subsequent parameters were measured by applying standard procedures during the course of study. Following observations were recorded like brix (%), Sucrose contents in juice (%), Cane juice purity, Cane fiber percentage, Pol. (%), commercial cane sugar (%), cane sugar recovery (%).

Results and discussion

Brix percentage

The total amount of solutes absorbed in a cane juice (a natural solution) is defined as the 'brix degree' and expressed in percentage. Brix degree of cane juice is an important component to represent the maturity of cane. Data presented in (table 1) revealed that irrigation levels had not significantly affected the brix (%) of cane. Although brix percentage in cane juice was different in cane grown at various irrigation levels but this difference could not have reached to the level of significance and it ranged between 20.15% and 19.83% recorded in I_1 (12 irrigations) and I_2 (08 irrigations), respectively.

The soil amendments effect on the brix percentage was statistically significant and its ranges the maximum brix percentage value (21.56%) found in the T_2 (polymer coated SSP) and the minimum value recorded at T_0 (control) having (18.76%) of cane brix percentage. While the interactive effect of irrigation and different fertilizers has also non-significant on birx percentage of all treatment means.

Sucrose content in juice (%)

Gross carbohydrate i.e. pol % (total sugars of all classes in the cane juice) is another most important quality yield-determining factor and usually precise by genetic make-up of a variety and conservational conditions under which the cane crop grown. Treatment means revealed a non-significant effect of various irrigation levels on sucrose contents. However, the sucrose contents ranged between 19.06% and 18.42%.

The soil amendments have also affect statistically non-significant on the sucrose content in the juice %, the maximum value recorded in 19.17% in the T_1 (control) against the lowest value found in T_3 (cane trash boiler ash + 50% SOP) having 18.18% sucrose content in cane juice. While the interactive effects of irrigation and soil amendments remain also non-significant on the pol %.

Cane juice purity (%)

Data expressed in Table 3 exposed that the influence of various irrigation regimes on purity (%) of cane juice was found non-significant. However, cane juice purity affected by various levels of irrigation ranged from 89.63 to 89.78 %.

In table 3, data concerning purity (%) of cane juice were given which indicated that soil amendments practices affected the purity of cane juice non-significantly. The highest cane juice purity (90.10%) was recorded at T_1 (press-mud) and the minimum cane juice value recorded (89.37%) at T_3 (50% cane trash +

50 SOP). The shared effect of irrigation and fertilizers was also non-significant.

Cane fiber percentage

Data given in Table 4 revealed that influence of various irrigation levels as well as soil amendments on the cane fiber percentage was statistically non-significant. However, in their interaction the highest fiber percentage was observed in I_0T_2 (16 irrigations + polymer coated SSP) that is (12.30%) and the lowest fiber percentage was recorded (12.03%) found in I_0T_3 (16 irrigations + 50% Cane Trash boiler ash+50% SOP).

Table A: Analysis of Variance and effect of different irrigation level and soil applied amendments on understudied traits of sugarcane

SOV	Brix %	Pol. %	Cane juice purity %	Fiber %	CCS %	Cane sugar recovery
Replication						
Irrigation (IR)	0.47NS	3.31NS	0.02NS	0.54NS	0.13NS	16.47*
Error Rep*IR						
Fertilizer (FR)	10.49**	2.33NS	0.71NS	0.02NS	1.82NS	1.98NS
IR*FR	0.14NS	0.71NS	0.65NS	0.65NS	0.45NS	0.34NS
Error Rep*IR*FR						
Total						

Table 1: Effect of different irrigation level and soil applied amendments on brix (%) of sugarcane

A. Comparison of treatment means

Number of irrigations	Organic and Synthetic Supplements				Mean
	T_0	T_1	T_2	T_3	
I_0	18.80	19.20	21.67	20.92	20.15
I_1	18.97	19.40	21.58	20.40	20.08
I_2	18.50	19.40	21.43	20.00	19.83
Mean	18.76 C	19.33 BC	21.56 A	20.44 AB	

T_0 = Control **I_0 = 100% of REC. Irrigation (16 Irrigations)**
T_1 = Press-mud **I_1 = 75% of REC. Irrigation (12 Irrigations)**
T_2 = Polymer Coated SSP **I_2 = 50% of REC. Irrigation (8 Irrigations)**
T_3 = 50% Cane Trash boiler ash+50% SOP

HSD value for FR: 1.53

Means not sharing the common letter vary significantly at 5% probability level.

Table 2: Effect of different irrigation level and soil applied amendments on pol (%).

A. Comparison of treatment means

Number of irrigations	Organic and Synthetic Supplements				Mean
	T_0	T_1	T_2	T_3	
I_0	18.83	19.63	19.19	18.58	19.06
I_1	18.63	19.33	19.23	17.55	18.69
I_2	18.37	18.53	18.37	18.40	18.42
Mean	18.61	19.17	18.93	18.18	

T_0 = Control **I_0 = 100% of REC. Irrigation (16 Irrigations)**
T_1 = Press-mud **I_1 = 75% of REC. Irrigation (12 Irrigations)**
T_2 = Polymer Coated SSP **I_2 = 50% of REC. Irrigation (8 Irrigations)**
T_3 = 50% Cane Trash boiler ash+50% SOP

Means not sharing the common letter vary significantly at 5% probability level.

Table 3: Effect of different irrigation level and soil applied amendments on cane juice purity % of sugarcane
A. Comparison of treatment means

Number of irrigations	Organic and Synthetic Supplements				Mean
	T_0	T_1	T_2	T_3	
I_0	89.10	90.20	90.33	89.17	89.70
I_1	90.00	89.70	90.10	89.33	89.78
I_2	89.50	90.42	89.00	89.60	89.63
Mean	89.53	90.10	89.89	89.37	

T_0 = Control **I_0 = 100% of REC. Irrigation (16 Irrigations)**
T_1 = Press-mud **I_1 = 75% of REC. Irrigation (12 Irrigations)**
T_2 = Polymer Coated SSP **I_2 = 50% of REC. Irrigation (8 Irrigations)**
T_3 = 50% Cane Trash boiler ash+50% SOP

Means not sharing the common letter vary significantly at 5% probability level.

Table 4: Effect of different irrigation level and soil applied amendments on cane fiber % of sugarcane
A. Comparison of treatment means

Number of irrigations	Organic and Synthetic Supplements				Mean
	T_0	T_1	T_2	T_3	
I_0	12.10	12.12	12.30	12.17	12.17
I_1	12.20	12.13	12.10	12.06	12.11
I_2	12.03	12.10	12.07	12.12	12.10
Mean	12.13	12.12	12.14	12.11	

T_0 = Control **I_0 = 100% of REC. Irrigation (16 Irrigations)**
T_1 = Press-mud **I_1 = 75% of REC. Irrigation (12 Irrigations)**
T_2 = Polymer Coated SSP **I_2 = 50% of REC. Irrigation (8 Irrigations)**
T_3 = 50% Cane Trash boiler ash+50% SOP

Means not sharing the common letter vary significantly at 5% probability level.

CCS (%)

The actual sugarcane quality is represented by its (CCS%) commercial cane sugar. Commercial cane sugar (CCS %) is the finishing goal to attain maximum sugar produce. It is mainly well-ordered by genetic make-up of a variety and ecological conditions prevailing during the growth and development of sugarcane crop. Commercial cane sugar was nonsignificantly affected by different irrigation levels and soil amendments. However, it is clear from Table 5 which showed that the maximum value of commercial cane sugar (14.94%) and (15.04%) was found in I_0 (16 irrigations) and T_2 (polymer coated SSP).

Whereas, the soil amendments and its interactive effects with irrigation levels was also non-significant on commercial cane sugar, the maximum cane sugar recorded (15.10%) in I_1T_2 (75% of recommended irrigation + polymer coated SSP) and the minimum commercial cane sugar (14.65%) was observed in I_2T_0 (50% of recommended irrigation + control).

Cane sugar recovery (%)

Cane sugar recovery is an important quality index of cane components which depends upon many factors like plant genetic make-up, environmental situations, and the instrument used for the cane sugar recovery percentage. Data regarding the sugar recovery given in Table 6 indicates that different irrigation levels had significant effect on sugar recovery in cane grown under different soil amendments treatments. Cane sugar recovery effects statistically equally in I_0 (100% of recommended irrigation) and I_1 (75% of recommended irrigation) that giving the values of (14.40 %) and (14.38 %) respectively. But statistically differed cane sugar recovery percent (13.93%) was gathered in I_2 (50% of recommended irrigations). However, the soil amendments and its shared effects has non-significant on the cane sugar recovery that's ranges between the values of 13.92 % to 14.53%.

Table 5: Effect of different irrigation level and soil applied amendments on commercial cane sugar percentage of sugarcane

A. Comparison of treatment means

Number of irrigations	Organic and Synthetic Supplements				Mean
	T_0	T_1	T_2	T_3	
I_0	14.85	14.88	15.00	15.02	14.94
I_1	14.70	15.00	15.10	14.82	14.91
I_2	14.65	14.75	15.02	15.04	14.87
Mean	14.73	14.88	15.04	14.96	

T_0 = Control **I_0 = 100% of REC. Irrigation (16 Irrigations)**
T_1 = Press-mud **I_1 = 75% of REC. Irrigation (12 Irrigations)**
T_2 = Polymer Coated SSP **I_2 = 50% of REC. Irrigation (8 Irrigations)**
T_3 = 50% Cane Trash boiler ash+50% SOP

Means not sharing the common letter vary significantly at 5% probability level.

Table 6: Effect of different irrigation level and soil applied amendments on cane sugar recovery % of sugarcane

A. Comparison of treatment means

Number of irrigations	Organic and Synthetic Supplements				Mean
	T_0	T_1	T_2	T_3	
I_0	14.47	14.20	14.53	14.42	14.40 A
I_1	14.44	14.20	14.52	14.36	14.38 A
I_2	13.92	13.96	13.96	13.92	13.93 B
Mean	14.29	14.10	14.34	14.23	

T_0 = Control **I_0 = 100% of REC. Irrigation (16 Irrigations)**
T_1 = Press-mud **I_1 = 75% of REC. Irrigation (12 Irrigations)**
T_2 = Polymer Coated SSP **I_2 = 50% of REC. Irrigation (8 Irrigations)**
T_3 = 50% Cane Trash boiler ash+50% SOP

HSD value for IR = 0.32

Means not sharing the common letter vary significantly at 5% probability level.

Conclusion

All quality parameters like Brix (%), Sucrose content in juice (%), cane juice purity (%), and cane fiber (%) exposed non-significant effect of irrigation levels and soil amendments techniques in spring planted sugarcane. Maximum commercial cane sugar (CCS) (15.00 %) and cane sugar recovery (14.53 %) was recorded at I_0T_2 (100% of recommended irrigation + polymer coated SSP).

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