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Organic mulching and irrigation management for improving water use efficiency and productivity of sugarcane

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ABSTRACT

Organic mulches such as sugarcane trash, soybean straw and wheat straw are used to conserve soil moisture as a result of decreased evaporation from the soil surface. Sugarcane is a long-duration crop with a relatively high water requirement compared with many other field crops. The experiment on plant cane and ratoon crop was conducted at research farm of Vasantdada Sugar Institute, Pune during the year 2023-24 and 2024-25 respectively. The treatments were of irrigation levels 1.0 ET_c , 0.8 ET_c and 0.6 ET_c and different organic mulches practices such as sugarcane trash with and without shredding, wheat straw and soybean straw mulch with strip plot design and three replications. The results showed that the moisture conservation in sugarcane trash without shredding, with shredding, wheat and soybean straw were 9.24 %, 7.99 %, 5.07 % and 6.97 % respectively. The highest moisture conservation was recorded in sugarcane trash without shredding. The significantly higher cane yield of 128.20 t/ha recorded in 1.0 ET_c irrigation level. Among the mulching treatments, sugarcane trash mulching with shredding recorded highest cane yield (120.00 t/ha). The highest water use efficiency was recorded in sugarcane trash mulching with or without shredding under irrigation level 0.6 ET_c .

Keywords: Organic mulch, Moisture conservation, Irrigation

Introduction

Sugarcane (*Saccharum* spp.) is an important commercial crop cultivated extensively in tropical and subtropical regions and serves as a major raw material for the sugar and bioenergy industries. Being a long-duration and high-biomass-producing crop, sugarcane requires a substantial amount of water throughout its growth period. However, increasing variability in rainfall, recurrent droughts, declining groundwater resources and growing competition for irrigation water are emerging as major constraints to sustainable sugarcane production. Therefore, improving water-use efficiency through appropriate irrigation scheduling and soil-moisture conservation practices has become essential for maintaining sugarcane productivity under water-limited conditions. Recent studies have emphasized the importance of water-saving and climate-resilient production practices in sugarcane, particularly the integration of deficit irrigation with conservation measures.

Among the different agronomic practices available for conserving soil moisture, surface mulching is considered a simple, economical and environmentally sustainable approach. Organic mulches reduce direct evaporation from the soil surface, moderate soil temperature, suppress weed growth, improve soil structure and contribute organic matter and nutrients to the soil during decomposition. Sugarcane trash is particularly suitable as an organic mulch because considerable quantities of leaves and tops remain in the field after harvesting. Instead of burning or removing this residue, its retention on the soil surface can provide an effective means of conserving soil moisture and recycling plant nutrients. Recent research has demonstrated that in-situ sugarcane trash mulching can conserve soil moisture, moderate soil temperature and improve crop growth and productivity. In one recent study, trash mulching conserved approximately 0.70–5.92% soil moisture and improved several yield-related parameters of sugarcane.

The effectiveness of trash mulching becomes particularly important when irrigation water is limited. Mulching reduces evaporation losses from the soil and thereby increases the proportion of applied water available for crop use. Kumar *et al.* (2024) [1] reported that trash mulching combined with appropriate irrigation management improved sugarcane productivity, water use efficiency and water productivity. practices.

Recent research has also demonstrated the importance of optimizing irrigation under water-limited conditions. Singh and Sharma (2024/2025) evaluated different irrigation levels in sugarcane and reported that irrigation at 0.8 IW/CPE could save considerable quantities of irrigation water while maintaining cane yield comparable with higher irrigation levels.

Similarly, Patnaik *et al.* (2024) [2] evaluated irrigation scheduling in combination with trash-mulching practices under furrow-planted sugarcane and emphasized the potential of integrating residue management with irrigation scheduling to enhance cane productivity and water-use efficiency.

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In Maharashtra, where sugarcane is an economically important crop and irrigation water availability becomes increasingly critical during summer, efficient utilization of available water is of particular importance. The adoption of suitable organic mulches may reduce evaporative losses and prolong the availability of soil moisture in the crop root zone. However, the effectiveness of different locally available organic mulch materials may vary depending on their physical characteristics, decomposition rate, thickness and interaction with irrigation regimes. Therefore, evaluation of different organic mulch materials under varying irrigation levels is necessary to identify suitable combinations for improving soil-moisture conservation and sustaining sugarcane productivity.

Considering these aspects, the present investigation was undertaken to evaluate the effect of different organic mulches under varying irrigation regimes on soil moisture conservation, cane yield and water use efficiency of sugarcane.

Methodology

The experiment was conducted at the Research Farm of Vasantdada Sugar Institute (VSI), Pune, during 2023-24 and 2024-25. The experiment was laid out in a strip-plot design with three replications. Three irrigation levels, viz., 1.0 ET_c , 0.8 ET_c and 0.6 ET_c , were evaluated in combination with different organic mulching practices.

The irrigation treatments:

I_1 : 0.60 ET_c

I_2 : 0.80 ET_c

I_3 : 1.00 ET_c

The moisture conservation treatments:

T_1 : Sugarcane trash mulching without shredding

T_2 : Sugarcane trash mulching with shredding

T_3 : Wheat straw mulching

T_4 : Soybean straw mulching

T_5 : No mulching

The total experimental area was 60 × 56 m, and the individual plot size was 4.10 × 18 m. The sugarcane variety VSI 08005 (VSI 12121) was used for the experiment. The soil of the experimental site was medium deep black soil with a pH of 8.40, electrical conductivity (EC) of 0.32 dS m⁻¹ and organic carbon content of 0.72%.

The mulching treatments were imposed after germination in the plant crop and 15 days after harvesting in the ratoon crop. Soil physical and chemical properties were analyzed before planting and after harvesting to assess changes associated with the moisture conservation practices.

The quantity of irrigation water applied under each treatment was calculated based on daily pan evaporation and the respective irrigation

treatment. The actual quantity of water applied was measured using water meters installed separately for each treatment.

Growth and yield attributes, including number of internodes, cane diameter, millable cane height, number of millable canes (NMC), cane yield and quality parameters, were recorded during the crop period. Soil moisture content was determined by the gravimetric method using the following formula:

$$\text{Moisture content (\%)} =$$

$$\frac{\text{Initial weight} - \text{final weight}}{\text{Final weight}} \times 100$$

Water use efficiency (WUE) was calculated as:

$$\text{Water use efficiency (t ha}^{-1} \text{ cm}^{-1}) =$$

$$\frac{\text{Cane yield (t ha}^{-1})}{\text{Total water applied (cm)}}$$

Results and discussion

Cane yield and sugar yield

The irrigation regimes and moisture conservation practices significantly influenced cane yield and sugar yield. Among the irrigation levels, 1.00 ET_c (I_3) recorded the highest cane yield of 128.20 t ha⁻¹ and sugar yield of 20.00 t ha⁻¹, and was significantly superior to the lower irrigation regimes. Irrigation at 0.80 ET_c (I_2) recorded a cane yield of 114.55 t ha⁻¹, whereas the lowest cane yield of 85.50 t ha⁻¹ was recorded under 0.60 ET_c (I_1).

Among the different mulching practices, sugarcane trash mulching with shredding (T_2) recorded the highest cane yield of 120.00 t ha⁻¹ and sugar yield of 18.76 t ha⁻¹. It was statistically at par with sugarcane trash mulching without shredding (T_1), which recorded a cane yield of 118.14 t ha⁻¹ and sugar yield of 18.08 t ha⁻¹. Wheat straw (T_3) and soybean straw (T_4) mulching also improved cane yield over the no-mulching treatment (T_5), which recorded the lowest cane yield of 96.56 t ha⁻¹.

The beneficial effect of sugarcane trash mulching may be attributed to reduced evaporation losses, improved soil moisture conservation, moderation of soil temperature and improved soil physical conditions. Shredding of sugarcane trash facilitates more uniform distribution of the mulch layer and its gradual decomposition, thereby contributing to improved soil conditions and crop growth.

These results demonstrate that adequate irrigation coupled with effective moisture conservation through sugarcane trash mulching can enhance sugarcane productivity.

Table 1. Cane and sugar yield contributing characters

Treatments	Cane yield, t/ha	NMC per ha	CCS, %	Sugar yield, t/ha
A) Irrigation Practices				
I_1	85.50	71366	15.67	13.39
I_2	114.55	74945	15.56	17.84
I_3	128.20	77575	15.60	20.00
SE ±	1.41	1046.25	0.12	0.26
C.D. at 5%	2.89	2143.13	NS	0.54
B) Different Mulching Practices				
T_1	118.14	77125	15.32	18.08
T_2	120.00	77980	15.60	18.76
T_3	103.44	72865	15.78	16.25
T_4	108.95	74557	15.78	17.17
T_5	96.56	70616	15.60	15.13
SE ±	1.82	1350.70	0.15	0.34

(continued on next page)

Treatments	Cane yield, t/ha	NMC per ha	CCS, %	Sugar yield, t/ha
C.D. at 5%	3.73	2766.77	NS	0.70
C) Interaction A X B				
SE ±	3.16	2339.46	0.26	0.59
C.D. at 5%	6.47	4792.18	NS	1.21

Quality parameters

The CCS percentage was not significantly influenced by irrigation levels or different mulching practices.

Water use efficiency and water applied

The quantity of irrigation water applied under the three irrigation regimes was 80.05 cm, 106.73 cm and 133.41 cm for 0.60, 0.80 and 1.00 ET_c , respectively.

The highest water use efficiency of 1.22 t ha⁻¹ cm⁻¹ was recorded with 0.60 ET_c irrigation combined with shredded sugarcane trash

mulch (I_1T_2). This was followed by 0.60 ET_c with unshredded sugarcane trash mulch (I_1T_1), which recorded a WUE of 1.21 t ha⁻¹ cm⁻¹. Under 0.80 ET_c , WUE ranged from 0.95 to 1.14 t ha⁻¹ cm⁻¹, with the highest value recorded under shredded sugarcane trash mulch. Under 1.00 ET_c , WUE ranged from 0.87 to 1.06 t ha⁻¹ cm⁻¹, again with shredded sugarcane trash mulch recording the highest value. Among all treatments, shredded sugarcane trash mulch consistently improved WUE compared with the other mulching practices.

Table 2. Water use efficiency

Treatment	Quantity of Water applied, ha-cm	Cane yield, t/ha	Water use efficiency, t/ha-cm
I_1T_1	80.05	96.84	1.21
I_1T_2	80.05	97.33	1.22
I_1T_3	80.05	79.34	0.99
I_1T_4	80.05	83.41	1.04
I_1T_5	80.05	70.61	0.88
I_2T_1	106.73	118.06	1.11
I_2T_2	106.73	121.46	1.14
I_2T_3	106.73	114.96	1.08
I_2T_4	106.73	116.67	1.09
I_2T_5	106.73	101.63	0.95
I_3T_1	133.41	139.52	1.05
I_3T_2	133.41	141.23	1.06
I_3T_3	133.41	116.03	0.87
I_3T_4	133.41	126.78	0.95
I_3T_5	133.41	117.46	0.88

Soil moisture conservation

The moisture conservation achieved through sugarcane trash without shredding, sugarcane trash with shredding, wheat straw and soybean straw mulching was 9.24, 7.99, 5.07 and 6.97%, respectively. The highest moisture conservation was recorded under sugarcane trash mulch without shredding (T_1).

The improved moisture status under trash mulching can be attributed to the physical barrier formed by the mulch layer, which reduced direct evaporation from the soil surface and helped maintain favourable soil moisture conditions for a longer period. Although unshredded trash showed the highest moisture conservation, shredded trash resulted in the highest cane yield and water use efficiency, indicating its potential for both moisture conservation and improved crop productivity.

Conclusions

The study demonstrated that irrigation regime and organic mulching practices have an important role in improving sugarcane productivity and water-use efficiency.

Among the irrigation treatments, 1.00 ET_c recorded the highest cane yield (128.20 t ha⁻¹) and sugar yield (20.00 t ha⁻¹). However, reducing irrigation to 0.60 ET_c considerably reduced the quantity of irriga-

tion water applied and resulted in higher water use efficiency, particularly when combined with effective mulching.

Among the moisture conservation practices, shredded sugarcane trash mulch (T_2) recorded the highest cane yield (120.00 t ha⁻¹) and sugar yield (18.76 t ha⁻¹) and was at par with unshredded sugarcane trash mulch. The highest water use efficiency (1.22 t ha⁻¹ cm⁻¹) was recorded with 0.60 ET_c irrigation combined with shredded sugarcane trash mulch (I_1T_2).

Sugarcane trash mulching without shredding, sugarcane trash mulching with shredding, wheat straw and soybean straw resulted in 9.24, 7.99, 5.07 and 6.97% moisture conservation, respectively, with the highest moisture conservation recorded under unshredded sugarcane trash mulch.

Overall, the study indicates that sugarcane trash mulching, particularly shredded trash, is an effective moisture conservation practice that can improve cane productivity and water use efficiency. Under deficit irrigation with sugarcane trash mulching can help conserve irrigation water while maintaining comparatively higher cane yield

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