SUGARCANE CROP DEVELOPMENTAL STAGES AND WATER REQUIREMENT: A REVIEW

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ABSTRACT

Sugarcane, grown in the subtropical conditions of Pakistan, is a long-duration crop with a growth cycle lasting 10-15 months. The growth period commences 25-45 days after planting. The months of June to August mark the peak growth period, while September to October represent a transitory phase as the growth tapers off, making way for sugar accumulation. From November onward, the crop enters the maturity period. During the early stages of growth, particularly from April to June for spring planting and March to May for autumn planting, the crop's development is most critical in terms of plant growth and tiller formation. For successful germination and an initial healthy stand of the crop, it is vital to avoid soil moisture deficiency soon after planting. Such deficiency can have detrimental effects on the germination process. In irrigated agriculture, the yield of cane heavily relies on the availability of water, both in terms of quantity and frequency, precisely timed to meet the plant's water requirements at various physiological stages of development. The water needs exhibit significant variation as the crop progresses through its growth cycle. In this review, we will focus on the water requirement of sugarcane crop in different developmental stages and its impact on yield and sugar recovery.

INTRODUCTION

Sugar cane cultivation spans a wide range of regions worldwide, encompassing warm temperate areas to the humid tropics. Across many of these regions, effective water management plays a crucial role in the production system. For instance, in certain areas of Pakistan like Rahim Yar Khan and Bahawalpur irrigation is an indispensable factor for achieving profitable commercial production. Conversely, in other regions, irrigation serves as a supplementary measure to compensate for variable rainfall patterns. Numerous research efforts have been dedicated to studying the water relations and irrigation needs of sugar cane in Pakistan.

Sugar cane, being a perennial crop, aims to avoid flowering as it is undesirable for the cultivation process. To grow the crop, stalk cuttings known as setts are used. Each sett contains a node with an axillary bud and a band of root primordia, making it capable of giving rise to a new plant. The successful germination of setts necessitates moist soil surrounding the stem. In the initial stages, the developing bud relies on the sett for its nutrients and water supply. However, after approximately three weeks, it establishes its own root system.

Once the new plant is firmly established, roots start to emerge from underground nodes and the axillary buds at these nodes produce tillers (additional stalks). During the development of the crop, tillers occurs in peak numbers (reaching up to 25 m−2) around three to five months after planting. However, due to factors like shading, about 50% of these tillers may die off before reaching a stable stalk population, which typically takes about nine months.

Tiller senescence begins when the leaf canopy intercepts around 70% of incident radiation. The duration phases of the crop highlight that the autumn crop benefits from a longer period of tillering and robust growth compared to the spring crop. To achieve optimum yields, it is crucial to schedule water application at different growth

stages. Several factors affect irrigation scheduling like consumptive water needs, soil's moisture intake and retention capabilities.

Sugarcane exhibits a favorable response to ample irrigation. However, special attention must be given to the critical stage of plant growth (Table-1). Properly managing water during this crucial phase becomes even more essential to ensure the crop's successful development and yield.

Table-1 Critical stages of plant growth

Growth phases	Period – days	
	Spring crop - Days	Autumn crop - Days
Germination	15 Feb - 30 Mar., 25-45	15 Sep. – 25 Oct. 20-40
Tillering	1 Apr. – 15 May , 45-90	26 Oct. – 15 Mar. 40-180
Grand growth period-elongation phases	16 May – 30 Sep, 90-225	16 Mar. – 30 Sep. 180-380
Ripening phases	1 Oct. – 15 Nov. , 225-270	1 Oct. – 31 Oct. 380-410
Harvesting phases	16 Nov. – 15 Mar., 270-395	1 Nov – 31 Dec. 410-470

Germination Phase

For successful germination, maintaining soil moisture is important. Conditions of water stagnation or inadequate drainage can have adverse effects on germination. Thus, it is crucial to promptly irrigate the crop after planting and ensure that the irrigation level saturates the soil.

Accelerated germination is observed when the soil is kept at field capacity. Conversely, if irrigation is delayed, the moisture in the cane setts gradually depletes, significantly impacting bud emergence in a negative manner (Table-2).

Table-2 Delay in irrigation effects the germination % and cane yield t/ha

Delay in irrigation (days)	Germination %	Cane yield (t ha^{-1})
1	61.48	183.51
2	57.37	171.48
3	54.68	159.66
4	52.51	147.79
5	45.66	134.58
6	39.49	115.48

Source: Minhas *et al.,* (1992)

Maintaining appropriate soil moisture not only aids in nutrient mobilization for root uptake but also plays a vital role in preserving sett moisture, facilitating bud sprouting and initial root development. Any delay in the first irrigation by 0, 2, 4, 6, 8 days after planting resulted in a substantial reduction in both germination rates and, ultimately, the yield of the cane crop.

Tillering Stage

Despite the low consumptive use (crop coefficient 0.7-1.0) due to a relatively small leaf area index, sufficient water is still necessary to encourage tiller formation. However, excessive watering is detrimental to tillering. If subjected to moisture stress, more tillers may emerge, but these shoots tend to be weak and often perish soon after sprouting. Irrigation frequency should be balanced to promote both tillering and the growth of cane shoots. During the second order of tillering, delaying irrigation for 4-6 days can encourage more

tillers while promoting root development. Frequent irrigation at this stage would keep the root system shallow, potentially leading to lodging issues later in the crop's development. In the case of a spring crop, tillering phase completes around 90-100 days after planting. For autumn planting, this phase concludes by the month of March-April. During this pre-monsoon growth stage, irrigation frequency and quantity play a critical role in promoting both tillering and cane growth. Any delay in irrigation at this juncture cannot be compensated.

Grand Growth Phase

During this stage crops reach its peak growth and leaf canopy is fully developed. Water requirements are highest, measured by pan evaporation showing an ET/EP ratio greater than one. It is crucial to ensure adequate water availability during this period. In June crop daily consumptive water needs are 10 mm, while in May-June and June-July, it is around 9 mm. Lower water needs during July-August are due to the rainy season. Sugarcane still produces maximum biomass during this period by highest uptake of water and nutrients. This phase is critical for elongating the. Regions with low rainfall or no rains, longer intervals between irrigations may negatively affect cane growth. Severe moisture stress at this stage can drastically reduce the size and thickness of internodes. Since transpiration losses are high during this period, the frequency of water application should be increased, but with a lesser amount of irrigation water each time.

Ripening Phase

Sugarcane is a C4 plant and it undergoes a unique photosynthetic process. During flowering stage, water demand may decrease slightly compared to the grand growth stage. Ripening phase of sugarcane is a critical as it directly affects the quality and quantity of sugar. This phase is also known as the maturation stage or sucrose accumulation stage. During this period, the sugarcane plant undergoes physiological changes that lead to the accumulation of sucrose in the stalks, which is the primary product extracted for sugar production.

Maturity Phase

This stage begins around the end of October to early November. As temperature drops, water needs of crop decrease to approximately 2-3 mm daily. Frequent irrigations delay maturity and reduce the purity and sugar content (Pol) in cane juice. Limiting irrigation hastens maturity, improves juice quality, and increases sugar yield per unit area. Excessive long intervals between irrigations can increase fiber in the cane stalks, cause leaves to dry and reduce cane weight. In research conducted at Faisalabad, it was found that withholding irrigation for 30 days prior to harvesting led to enhanced sugar recovery by 1.37% in November, 0.94% in January, and 5.53% in March (Table-3). Conversely, sugar contents in cane decreased with frequent irrigation.

Table-3 Effect of irrigation before time of harvesting

Time of harvesting	***Sugar recovery %*** **Irrigation before harvesting**		**% increase in recovery**
	5 days	30 days	over 5 days
15 Nov.	10.95	11.1	1.37
15 Jan.	11.75	11.86	0.94
15 Mar.	12.47	13.16	5.53
Average	11.57	12.03	3.98

During winter, water needs of cane are at their minimum. Irrigation should still be applied during frosty nights. Irrigation water helps to raise the soil temperature to some degree, thus minimizing the detrimental effects of frost damage to the plants and aiding in their recovery. In subtropical regions, the maturity phase coincides with

the drop in temperature and decreasing soil moisture, which leads to sugar accumulation in the stalk. In tropical regions, achieving proper maturity is more challenging due to the moderate winter temperatures. In such cases, maturity is induced by controlling irrigation, with sheath moisture being a key criterion for irrigation application in several sugar-producing countries.

Potential Crop Water requirement of Sugarcane compared with other crops

The major climatic factors which influence the crop water requirement are: 1. Sunshine; 2. Temperature; 3. Rainfall; 4. Humidity and 5. Wind speed. The potential requirement of the different crops is given in table-4.

Table-4 Potential requirement of different crops

Sr. No.	Crops	Potential Requirement Range (mm)
1	Wheat	271-515
2	Cotton	627-1161
3	Sugarcane	1278-1887
4	Rice	587-1323

The potential requirement for the wheat, cotton, sugarcane and rice have the variation of 52%, 54%, 68% and 44% respectively.

CONCLUSION

Proper management at each stage is essential for achieving a successful sugarcane harvest. During early growth, providing adequate irrigation and nutrients promotes good establishment. Tillering can be stimulated by ensuring proper spacing and nutrient supply. During the grand growth stage, maintaining optimal soil moisture and nutrient levels is vital for vigorous vegetative growth.

As sugarcane reaches the ripening phase, farmers must closely monitor the crop to determine the optimal time for harvest. Delaying harvest beyond the maturity stage can lead to reduced sucrose content, while harvesting too early can result in lower sugar yields.

To maximize sugarcane yield and sugar content, farmers should adopt efficient irrigation methods, nutrient management, pest and disease control and timely harvesting. The choice of appropriate sugarcane varieties suited to the local climate and soil conditions can significantly impact the overall success of sugarcane cultivation. Combination of sound agronomic practices, knowledge of developmental stages and monitoring of crop's progress is essential for a successful and profitable sugarcane cultivation endeavor.

REFERENCES

Anon. (1982). Consumptive use of water for crops in Pakistan. Final technical report, Pk. ARS. 64/PG-Pa, 251, Pak. Agri. Res. Council Islamabad.

Bhatti, H.M., H.U. Malik, M.R. Khan and M.R. Gill (1986). Consumptive use of water for sugarcane. J. Agri. Res., 24 (1): 59-66.

Chang, H and J.S.Wang (1971). Evapo-transpiration and water requirements of sugarcane in Taiwan. Proc. Int. Soc. Sugarcane Tech., 12: 664-676.

Ellis, R. D. and Lankford, B. A. (1990).The tolerance of sugarcane to water stress during the main development phases. Agricultural Water Management 17:117–128.

Ellis, R. D., Wilson, J. H. and Spies, P. M. (1985). Development of an irrigation policy to optimise sugar production during seasons of water shortage. Proceedings of the South African Sugar Technologists Association 59:142–147.

Fonseca, J.R., and J. Egana (1989). Irrigation system and water use by sugarcane in Cuba. Proc Int. Soc. Sugarcane Tech., 20 (2): 514-521.

Gupta, R. and S.K. Tripathi (1998). Scheduling irrigation for sugarcane in India. Fert. News, 29 (10): 693-695.

Ham, G., P. McGuire and G. Kingston (2000). Irrigation of sugarcane in Manual of Cane Growing. Editor M. Hogarth and P. Allsopp. Bureau of Sugar Experiment Station, Indooroopilly, Brisbane, Australia.

Hapse, D.G, B.B.Gunjal and A.S.Deshmukh (1990). Irrigation management for sugarcane. In: Recent Advances in Sugarcane ed. P.N. Rao. 248-270 KCP Ltd. Vuyyura, Andhra Pradesh.

Inman-Bamber, N. G. (2004). Sugarcane water stress criteria for irrigation and drying off. Field Crops Research 89:107– 122.

Malik, K.B, F.G., Ali and A.R. Zahid (1992). Effect of different irrigation regimes on yield of some sugarcane varieties. Pak. Jour Soil Sci., 7 (1-2): 7-10.

Malik, K.B. (2000). Irrigation water management to sustain cane yields under drought stress conditions. Proc. Agriculture workshop, Pak. Soc. Sug. Tech.

Malik, K.B. (1996). Irrigation requirements of sugarcane Proc. Pak. Soc. Sug. Tech., 25: 215-227.

Meyer, J. (2013). Sugarcane Nutrition and Fertilization: in Good Management Practices for Cane Sugar Industry. South African Sugarcane Research Institute, Durban, S. Africa.

Minhas, Y.J., A.G, Khanzada and M.I. Memon (1992). Effect of delaying first irrigation after planting in sugarcane crop. Pak. Sugar J., 6 (2): 21-23.

Nageen, F and Shabbir H. Gheewala (2019). Water use and deprivation potential for sugarcane cultivation in Pakistan. J. of Sust. Energy & Environ. 10 (2019) 33-39.

Soopramanien, G.C. (1999). Sugarcane irrigation: A Review Proc. Int. Soc. Sugar Tech., 23 (2) 1-6 New Delhi.