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The Effects of Different Irrigation Intervals on Stalk Height and Circumference of the Sugarcane (Saccharum Officinarum L)

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Abstract – A field experiment on the effect of different irrigation intervals on the stalk height and circumference of sugarcane was conducted during the cropping season in Eswatini. It was done following the irrigation water deficits due to the decline in the amount of rainfall received. This project was carried out at the Mgulugulu and Sihlase Investments Farm, a scheme under Lower Usuthu Smallholder Irrigation Project (LUSIP 1) run by Eswatini Water and Agricultural Development Enterprise (ESWADE). The experimental design was a RCBD with four replications. There were five irrigation intervals serving as treatments which were the 6-day irrigation interval; 12- day irrigation interval; 18-day irrigation interval; 24- day irrigation interval and 30- day irrigation interval. The results obtained showed that the highest stalk growth was obtained from the 6 day irrigation interval while the lowest was obtained from the 30 day irrigation interval at 12; 24 and 36 weeks after sprouting. However, due to the fact that there was no significant difference between the stalk growth obtained between the 6-day and 12-day irrigation interval, the 12- day interval is recommended and could be used for irrigation to save water, resources and inputs and at the same time reap higher yields.

Keywords – Irrigation interval, sugarcane, stalk height, stalk circumference

I. Introduction

Stalk height and circumference determine the yield of sugarcane significantly and they are greatly influenced by water (Bhingardeve *et al*, 2017). Under water stress conditions the height and yield of sugarcane are negatively affected hence yield also reduces (Ethan *et al*, 2016). In Swaziland, sugarcane is mostly grown under irrigation with the sprinkler irrigation system being the most common method. The objective of this study was to assess stalk height and circumference subjected to different irrigation intervals where the sprinkler irrigation system was used. This study is meant to provide information to sugarcane growers and help them apply the most suitable irrigation intervals to their sugarcane crops.

II. Background

Sugarcane (*Saccharum officinarum*) is a C4 perennial grass which produces a large quantity of disaccharide sucrose which is processed and refined into granulated sugar and it accounts to nearly 70% of the world's sugar (Salassi & Legendre ,2007). Sugarcane production significantly contributes to economic growth and development and in Eswatini (Ndlovu, 2013). By 2014–15 it accounted for almost 60% of agricultural output, 35% of agricultural wage employment and contributed about 18% to Eswatini's GDP (Terry and Ogg, 2016). The Government of Eswatini (GoS) realised that commercialization of smallholder sugarcane farming was one of the main element in its policy to alleviate poverty

(Vasudeva, 2006). The smallholder farmers in the Lower Usuthu basin were the poorest in the country as compared to other rural areas with US$ 96 per capita income per annum whilst the average per capita income of Eswatini is estimated at US$ 200 per annum (MNM- Consultants, 2002). Through ESWADE the Government of Eswatini came up with the LUSIP (Lower Usuthu Smallholder Irrigation Project) with two phases namely LUSIP I and LUSIP II. The project constituted construction of two dams, intake structure, canals, and pipelines mainly meant for irrigation (Mkhonta, 2016). This enabled thousands of farmers, who formerly relied on rain-fed practices, to consolidate their individual farms into commercial irrigated sugar cane farms (Terry and Ogg, 2016). Sugarcane is mostly grown as an irrigated crop. Eswatini has a semi-arid to arid climatic conditions in the sugarcane producing regions and this makes irrigation a key component of successful production. The irrigation of sugarcane has been and still is under continuous modification to match the changing climate, economy and technique of sugarcane production (Mazibuko, 2003). Presently the sprinkler irrigation system covers about 54% of sugarcane production in Eswatini (Mazibuko, 2003). Many irrigation schemes in Eswatini are not performing up to the expected standard of performance and the challenges range from technical, economic, social and ecological level and due to that there is a decline in sugarcane production (Ndlovu, 2013). One of the technical challenges involve incorrect irrigation intervals (timing of water application) which results in either under-irrigation or over-irrigation. Under-irrigation results in plant water stress reduced crop growth and reduced yields while over- irrigation may result in misuse of water and electricity, leaching of expensive inorganic fertilisers, erosion of top soil and anaerobic soil conditions resulting in yield reductions (SASRI, 2016). Proper irrigation interval can play a major role in increasing the water use efficiency and the productivity by applying the required amount of water when it is needed. On the other hand, the poor irrigation interval can lead to the development of crop water deficit and result in a reduced yield due to water and nutrient deficiency (Masuku, 2011). In India, the highest yield was obtained when the crop was irrigated at eight-day day interval during early growth and at sixteen-day interval during tillering and then every twelve days to maturity (Yahaya *et al*, 2010). In Sudan, short interval of 7 days was found to be the one that gave the highest cane yield at the Guneid Research Station when compared with 10 or 14 day interval trial (Ibrahim, 2013).

Thus this experiment is designed to find the knowledge on the correct irrigation intervals in order to minimise water losses through runoff, drainage and evaporation from the soil.

III. Problem Statement

Small-holder farmers still lack agricultural skills, and one characteristic of sugarcane farming is that irrigation has to be done following the correct irrigation interval where water will be applied to the field and be fully utilised by the plants, thus conserving water and energy (Masuku, 2011). Annual rainfall received was low during the 2015/16 season (500mm) and as a result some rivers ran dry and dam levels lowered and this has negatively affected sugarcane production (SWADE, 2016). Moreover, the temperatures have been high and this resulted in more evapo-transpiration hence reduced sugarcane yields as a result of water stress (SSA, 2015/16). Drought has resulted in shortage of water to be stored for irrigation and this has a detrimental effect on sugarcane production. Proper application of irrigation water may be adopted as a strategy to deal with drought and conserve water, hence there is need to assess and establish the most appropriate irrigation interval with which optimum yields are obtained under the environmental conditions of Eswatini (Mandla and Masuku, 2012).

IV. Objectives

Specific objectives of this study were to:

- To assess the effects of different irrigation intervals on the stalk height of sugarcane; and
- To evaluate the effect of different irrigation intervals o the stalk circumference

V. Literature Review

The literature in this study will be reviewed in relation to irrigation intervals as presented below;

1. Effect of irrigation intervals on the growth of sugarcane

Sugarcane is a long duration crop, with a high water requirement. Its growth is mainly by means of irrigation in areas with adequate temperature and rainfall (Yahaya *et al*., 2007). A field experiment was conducted in 2008-2010 in Nigeria to evaluate irrigation intervals and the treatments were 7, 14 and 21 days. Irrigation at 7 days interval had the longest stalk lengths and circumference while the shortest stalk lengths and circumference were obtained from irrigation interval of 21 days (Ethan *et al*, 2013). In a study conducted by Qureshi et al. in 2002 there was no significant difference in the stalk circumference of sugarcane at irrigation intervals of 14 and 21 day this suggesting that the sugarcane some degree of tolerance to water stress (Qureshi et al. 2002).

Lower irrigation intervals result in higher nutrient uptake due to availability of water frequently. Nutrients are taken up in solution leading to growth of cane components hence higher yields (Bhingardeve *et al*, 2017). Most growth of the stalk occurs during the grand growth phase, lack of moisture results in lower nutrient uptake as nutrients are taken up in solution. This affects the elongation of internodes negatively resulting in reduced growth of stalk height and circumference, leaves responsible for photosynthesis, the production of sugar storage tissues and ultimately stalk weight which all significantly restrict sugarcane yield (Ethan *et al*, 2016). During this phase, irrigation intervals can be extended, but amounts applied need to be increased This implies good water availability results in high growth rate in terms of stem elongation, thickness and weight in sugarcane while water deficits reduces (Mazibuko, 2003).

VI. Materials And Methods

The materials and methods used in this study included experimental site and design as well as various agronomic practices done on the crop together with the data collection and data analysis processes;

1. Experimental Site

The research was carried out at Mgulugulu and Sihlase Investment sugarcane farm which is located in the Lowveld of Swaziland at Siphofaneni area. Geographically, it is located between Latitudes 26°46'57.60"S and 26°43'46.28"S and Longitudes 31°38'2"E and 31°42'54.45"E (Mhlanga et al., 2012) The Lowveld of Swaziland is characterized by prolonged dry spells and high temperatures whereby rainfall usually falls over a short period of time, with high intensities hence irrigation water has to be stored (Mhlanga et al., 2012). Average mean temperature ranges from 19ºC to 30ºC whereby the hottest months are December and January with maximum temperatures of 40ºC (Manyatsi and Brown, 2009). The experimental site is characterised by deep red Class 1 soils specifically the Rondspring (Ro) which is a red to reddish brown well-structured clay soil, with slightly mottled subsoil (Nixon, 2006).

2. Experimental design and treatments

The experiment used Randomised Complete Block Design with four replications. The treatments were irrigation intervals and the levels were 6,12,18,24 and 30 days.

3. Variety description of sugarcane cultivar and agronomic practices

The variety of sugarcane used was the N-23 in its fourth ratoon which originates from SASRI in Kwa-Zulu Natal, South Africa. N-23 yields well under most growing conditions, ratoons well and responds exceptionally well to chemical ripening. It also has an added advantage of being tolerant to smut. Its disadvantage is that it flowers profusely therefore harvesting is restricted to no later than mid-October (SASRI, 2015). The agronomic practices done on the crop included:

4. Weed and pest control

Pre-emergent herbicides were used which were Ametryn at 3litres/ha which controls broad leaves and Lava at 2.5litres/ha which controls both grasses and broad leaves. They were sprayed using knapsack sprayer before sprouting of the crop. Rouging was done to prevent the levels of smut from reaching critical level (4%) which would require ploughing out of the whole field.

5. Fertilizer application

Basal fertiliser application was done using Di-Ammonium Phosphate (DAP) with 18%N and 46% P2O5 was applied at 50kg/ha. Top dressing was done using Urea at 300kg/ha whereby 200kg/ha was applied just after sprouting and the balance was applied 120 days after sprouting.

6. Irrigation

Irrigation was done throughout the growing season strictly following the treatments of the experiment. The sprinkler irrigation system was used to water the plants .The stand time for the sprinkler was 12hours and the sprinkler discharge was 52mm, however because the sprinkler is 75% efficient approximately 39mm was applied to the plants.

7. Ripening and Harvesting

Cane was dried off for eight weeks before harvesting. Ethephon (hormonal) and fusilade forte (non- hormonal) were applied to aid in sucrose accumulation. Ethephon (with active ingredient 2- chloroethyl phosphonic acid) under the brand name Ethrel was applied at a 12 week spray-to-harvest interval. At an application rate of 1.5litreof the product per hectare. Fusilade forte (with active ingredient fluazifop-p-butyl) which is a 15% Emulsifiable Concentrate was applied at a 6 week spray-to-harvest interval. At an application rate of 250ml of the product per hectare. Cane was burnt before cutting and cut at ground level using a bush knife, de-topping was done at harvesting to remove immature internodes (toppices) as these have an insignificant amount of sucrose.

8. Data collection and data analysis Height of stalk (m)

The sugarcane height was measured as the stalk distance from the soil to the insertion of the Top Visible Leaf every fortnight using a tape measure. For each treatment 10 stalks were randomly selected and measured, average plant heights determined by calculating the average. The selected stalks were randomly chosen at least 10m from any field edge, in order to eliminate the edge effect. Eac0h treatment was covered by a single sprinkler which irrigates a circumference of 18m**.**

9. Stem circumference of cane (m)

The circumference of the stalk was measured every month until harvesting. This was done using a tape measure on the bottom internodes of the cane.

10. Data analysis

Analysis of Variance (ANOVA) was done using GenStat 14th edition software. Treatments means were separated using Least Significance Difference (LSD) test at 5% level of significance.

VII. Results

The results obtained from this study were as follows; Effect of irrigation intervals on stalk height at 12, 24 and 36 weeks after emergence.

There was a significant difference (P<0.05) among the treatments on stalk height of sugarcane. The 6- day irrigation interval gave the highest stalk height at 12WAE while the 18, 24 and 30- day interval gave the lowest stalk height. Generally stalk height growth decreased as the irrigation interval increased as shown in Table 7.1 below.

There was no significant difference (P<0.05) among the treatments on stalk height of sugarcane at 24WAE. Lower irrigation interval which was the 6-day interval gave the highest growth and the highest irrigation interval which was the 30-day interval gave the lowest growth. Stalk height growth decreased as irrigation interval increased as shown in Table 7.1 below.

There was no significant difference (P<0.05) among the treatments on the growth of stalk height 36 weeks after emergence. Lower irrigation interval, the 6- day interval gave the highest growth and the highest irrigation interval, the 30-day interval gave the lowest growth. Stalk height growth decreased from the lowest interval, the 6- day interval to the highest interval 30- day interval as shown in table.

1. Effect of irrigation interval sugarcane stalk height (m) at 12, 24 and 36 weeks after emergence.

Treatment (Irrigation intervals)	12WAE	24WAE	36WAE
6 Days	1.0500^{c}	1.7300^{d}	2.2000^{d}
12 Days	0.8500^{b}	1.2720^{c}	1.7500^{c}
18 Days	0.7575^{ab}	1.1550^{c}	1.5750^{c}
24 Days	0.6825^{a}	1.9950^{b}	1.2250^{b}
30 Days	0.6725^{a}	0.8300^{a}	1.0220^{a}

LSD	0.1274	0.1252	0.1836
CV%	8.2	8.7	8.9
P value	0.01	0.01	0.01

Means accompanied by the same superscript in the column are not significantly different.

2. Effect of irrigation interval on the growth of stalk circumference at 12, 24 and 36 weeks after emergence

There was no significant difference (P>0.05) in the stem circumference growth among all treatments. Stalk circumference decreased for the lowest irrigation interval (6 day interval) to the highest irrigation interval (30 day interval). At 12WAE the lowest mean stalk circumference was 0.049m received from the 30-day interval and the highest was 0.077m received from the 6-day interval. At 24WAE the lowest mean stalk circumference was 0.065m received from the 30-day interval and the highest was 0.095m received from the 6-day interval. At 36WAE the lowest mean stalk circumference was 0.08m received from the 30-day interval and the highest was 0.116m received from the 6-day interval.

VIII. Discussion

Below is a discussion of the findings of the study in relation to the literature review;

1. Effect of irrigation intervals on the stalk height at 12, 24 and 36 weeks after emergence.

Stalk height is the most important yield function of sugarcane contributing to the final output of the cane crop. Taller and thicker stalks are greater in weight and have more capacity of storing cane juice and sugars (Akhtar et al, 2000). In all the treatments, lower irrigation interval (6 day interval) gave the highest growth and the highest irrigation interval (30 day interval) gave the lowest growth because water availability promotes good vegetative growth, furthermore irrigation promotes increase in productivity of stalks while water deficits limits sugarcane growth (Robson *et al*, 2017). Nutrient uptake from soil solution relates to plant root and water availability. A decline in soil moisture is associated reduction in nutrient uptake and transpiration therefore this resulting in reduced growth (Mujtaba and Alam, 2002), this might have been the cause of low stalk growth obtained from the 30 day interval. Canes subjected to water stress often have shorter internode lengths (Qureshi et al. 2002), therefore shorter internodes result in reduced height of cane and this might also explain the results obtained from the 30 day interval.

In an experiment done Nigeria in 2013 the results showed that irrigation interval of 7 days at soil had the highest stalk yield. However, irrigation at 14 days interval witnessed a decline in stalk yield. The lowest yield was obtained at irrigation interval of 21 days and the results indicated irrigation interval of 7 days is suitable for most sugarcane varieties this agreeing with the study conducted by Qureshi (Qureshi *et al*, 2002) who observed 7 days irrigation interval as suitable for sugarcane production However, irrigation at 14 days interval could be used in situations of scarce water supply with little decline in yield. (Ethan, 2013).

Internode length contributes to stalk height, long internodes result in long stalks while short internodes result in short stalks, in the study conducted by Qureshi irrigation interval of 7 days had the longest internodes while the shortest was recorded from irrigation interval of 21 days. This was expected because irrigation interval of 7 days had adequate soil moisture for growth and development. Sugarcane subjected to water stress often have shorter internode lengths (Qureshi *et al*, 2002). This might also explain why higher stalk height was obtained in the 6-day irrigation interval and lower stalk height obtained in the 30-day irrigation interval in all the treatments.

2. Effect of irrigation intervals on the stalk circumference at 12, 24 and 36 weeks after emergence

Stalk circumference decreased for the lowest irrigation interval (6 day interval) to the highest irrigation interval (30 day interval) after 12; 24 and 36 weeks after emergence. This was expected because the 6 day irrigation interval had adequate soil moisture for growth and development. Water availability promotes stalk growth while water scarcity results in reduced stalk growth, however there was no significant difference among all the treatments.

In a study conducted by Qureshi (Qureshi *et al*, 2002) there was no significant difference in stalk circumference of the canes at irrigation intervals of 14 and 21 days. This suggesting that sugarcane has some degree of tolerance to water stress

IX. Conclusion And Recommendations

The conclusion and recommendations are as follows;

1. Conclusion

Based on the results of this study, the 6 day interval had the highest stalk height and circumference. The 30 day irrigation interval had the lowest stalk height and circumference.

2. Recommendations

The study recommends that growers use the 12- day interval instead of the 6-day interval as it results in no significant reduction in yield and so as to save water, inputs, resources and increase profits on the other hand maximizing the potential growth, yield and quality of sugarcane.

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