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BIOMETRIC AND PHYSIOLOGICAL CHARACTERISTICS OF SUGARCANE RATOON UNDER WATERLOGGING CONDITION

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Abstract

Biometric and physiological attributes of sugarcane variety CoC (Sc) 24 in ratoon crop under water-logging stress condition was investigated at Sugarcane Research Station, Cuddalore, Tamil Nadu Agriculture University, Coimbatore during November 2014. Various morphological attributes were recorded in sugarcane variety CoC(Sc) 24 growing in water-logged and normal condition. Data were collected on plant height and stalk diameter, which shows decreased result by 7.22% and 16.38%, respectively. Leaf growth parameters *viz*., LAI, leaf production and specific leaf weight of 7.69%, 5.76% and 8.53%, respectively and the values were statistically increase over control. Mean value of all the growth and quality parameters are furnished in many unfavourable deviations were observed in most of the morphological traits when the cane was grown under waterlogging condition. But considerable improvement was observed in number of nodes (14.8%); internodal length (17.65%); nodes carrying roots (42.86%); number of roots (62.72%) and root volume (49.29%) conferring tolerance to waterlogging stress. Quality of sugarcane *viz*., brix percentage, purity percentage, pol percentage and recoverable sugar were 12.31%, 4.63%, 14.153% and 49.17%, respectively. Normally ratoon has an additional advantage in giving better juice quality and sugar recovery in comparision to the plant crop of the same varieties under similar conditions. Cane yield shows no difference over control this might be due to rapid canopy development, early development of adequate stalk numbers for increased interception of light in the early growth, stability of harvested stalk weights to maintain yield. The growth parameters of sugarcane *viz*., tiller production, millable cane, cane yield and sugar yield were higher in CoC(Sc)24 ratoon (2.38%, 1.727%, 0.5% and 49.41%, respectively) in waterlogged sugarcane than control. Based on the results, it is suggested that CoC(Sc)24 sugarcane ratoon tolerance under waterlogged condition. This study also indicates that ratoon crop need certain Post-waterlogging Crop Management.

Key words : Post-waterlogging crop management, sugarcane, physiological and biometric characters, ratoon cropping.

Introduction

Ratooning of sugarcane is a common practice throughout the world and ratoon occupies almost 50 per cent of the total area under sugarcane cultivation and contributes 30% of the total cane production in the country (Sundara, 2008). The decline in cane yield in successive ratoons is common in most of the sugarcane growing areas. The average yield gap between plant and ratoon crop in the country is 20% - 25%. One of the major bottlenecks in increasing the productivity of ratoon crops in the subtropics is the poor sprouting of stubbles in winter-harvested cane. Poor ratoon management is the most important constraint, which comes in the way of sugarcane productivity. Ratoon cropping of sugarcane is prevalent in about 50%-55% of the total cane area in tropical region than in the sub-tropical region (40%-45%). However, the yields of ratoon cane are comparatively much poor (30-35 t/ha) as compared to plant crop (65-75 t/ha). Ratoon productivity is the ultimate expression of interplay of several factors such as the rationing ability of a given variety, the influence of environment and ratoon management. Ratooning ability is one of the important economic considerations in many sugarcane growing countries to decide the suitability of sugarcane varieties for commercial cultivation. Ratoon has an additional advantage in giving better juice quality and sugar recovery in comparison to the plant crop of the same varieties under similar conditions.

Good rationing ability of cane cultivars is an essential pre-requisite determined by a number of factors. Various plant characters were associated with rationing ability of

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sugarcane varieties and successes of the variety depend on its ability to give more profitable ratoons (Chapman *et al*., 1992). The yield and quality effect due to water-logging depends upon the genotypes, environmental conditions, stage of development and the duration of stress. In sugarcane cultivation, water logging is an acute problem particularly, where surface drainage facilities are not adequate. Nutrient uptake is affected under water logging where aerobic respiration by sugarcane root system is poor (Singh, 1990). Furthermore, under longer duration of inundation, some morphological, anatomical, physiological and biochemical changes take place in the plant for sake of adaptation and / or survival. The levels of sucrose, glucose and fructose however were found to higher during anaerobic growth, but there was no correlation between sugar levels and flooding tolerance among different plants (Rahman *et al*., 1985). Moreover, excess rainfall during late summer and monsoon quite often creates flooding problem and rears have no option but to use flood affected sugarcane ratoon. However, information is lacking on the effect of water. So, an effort has been made to comparative study to potential of commercial ratoon variety leading to higher yield and sugar yield per hectare. The aim of the experiment is to study on sugarcane ratoon under waterlogging condition.

Materials and Methods

A field experiment was conducted with commercial variety CoC (Sc) 24 under natural and waterlogged condition at Sugarcane Research Station, Cuddalore during the year 2014-2015 cropping seasons. The crop experienced natural water logging during September to December with a water level of 30-60 cm height for three months coinciding with the formative and grand growth phase. Control field was maintained with same variety CoC 24 for one year. Physiological and biometric characters were compared between control and water logging at grand growth phase and yield attributes were recorded at maturity phases. The experiment was laid out in Randomized Block Design (RBD) with five replications.

Morphological attributes

The height was measured from the base to the leaf tip of each plant were recorded using roller (cm) *viz*., leaf area, stalk diameter, number of internodes, length of internodes, number of nodes, number of tillers and nodes carrying roots. Roots from flooded and control plants were collected to study the changes in root length, number of roots and root volume. A relative water content (RWC) was estimated as follows: the third leaves from an apex were cut, weighed (FW) and floated in distilled water in closed Petri plates for 5 hrs at 25^0C and then Turgid weights (TW) were measured. The discs were then dried in oven at 70^oC for 24 h to calculate dry weight (DW). Relative water contents were calculated by using the following formula: RWC (%) = (FW-DW)/(TW-DW) × 100. Water retention capacity (WRC) = TW/DW. The LAI was worked out by the method suggested by William (1946). The SLA was worked out by the method suggested by Kvet *et al*. (1971). Specific leaf area is a measure of the leafiness of the plant on a dry weight basis and is commonly reported as (cm^2 g^{-1}). It is the ratio of leaf area to leaf dry weight. Specific leaf weight (SLW), Pearce *et al*. (1968) is a measure of dry leaf weight per unit leaf area. Hence, it is a ratio expressed as g cm^{-2}.

Chemical analysis of sugarcane juice

Sugarcane juice quality parameters such as Brix (%), pol (%), purity (%) were done during harvest. Brix was determined by hand refractrometer and sucrose was done with automatic Polarimeter (ADP-220) by Horne's dry lead acetate method. **Brix (%):** Percentage of total soluble solids per cent in solution (juice). **Purity (%) :** Percentage of pure sucrose in dry matter = Pol/Brix × 100. **Pol % Cane :** Percentage of sucrose content in whole cane. **Recoverable Sucrose :** The recoverable sucrose (%) was calculated by using the following formula: Recoverable sucrose % = {pol- (Brix - pol)} × Juice factor where, juice factor was 0.65 (extraction percentage). **Sugar Yield : (t ha^{-1})** = Cane yield (t ha^{-1}) × Recoverable sucrose / 100. Data on different parameters were subjected to statistical analysis and mean values were compared using LSD at 5% level of significance (Gomez and Gomez, 1984).

Results and Discussion

At grand growth phase, under waterlogging condition CoC(Sc)24 recorded an average reduction in plant height and stalk diameter to 7.22% and 16.38%, respectively (table 1). Among the physiological attributes, the leaf area had significant positive association with cane yield and dry matter. In the present study, leaf growth parameters *viz*., LAI, leaf production and specific leaf weight of 7.69%, 5.76% and 8.53%, respectively and the values were statistically increase over control (table 3). The rate of leaf production of ratoon crop increased as age advanced and it continued even during the maturity phase of the crop as that of earlier report (Gupta *et al*., 2010). Thus, ratoon crop significantly influenced the source – sink relationship. Higher reduction in total dry matter production in ratoon crop might be due to higher reduction in tiller production, shoot growth and cane girth.

Table 1 : Effect of water logging on biometric characters in sugarcane ratoon cultivar CoC(Sc)24.

Condition	Plant height (cm)	Stalk diameter (cm)	Number of tillers	Number of green leaves	Number of dry leaves	Leaf areas (cm^2)
Ratoon crop control	388	9.52	7	11.4	8.2	441
Ratoon crop waterlogged	360	7.96	7	10.8	3.8	468
S.Ed.	17.09	0.49	0.57	1.18	0.42	49.40
CD	67.09	1.94	2.22	4.21	1.24	193.93
P (0.05)	**NS**	**NS**	**NS**	**S**	**S**	**NS**

Table 2 : Effect of water logging on root characteristic in sugarcane cultivar CoC (Sc)24.

Condition	No. of roots	Root length (cm)	Root volume (ml)	Nodes carrying roots	Number of internodes	Number of nodes
Ratoon crop control	148	31	144	8	23	27
Ratoon crop waterlogged	397	33	284	14	26	23
S.Ed.	14.64	3.37	14.65	4.05	2.14	2.14
CD	55.12	13.24	53.24	15.89	8.39	8.42
P (0.05)	**S**	**NS**	**NS**	**NS**	**NS**	**NS**

Table 3 : Effect of water logging on the physiological attributes in sugarcane cultivar CoC(Sc)24.

Conditions	Relative water content (%)	Water retention capacity	Leaf area index	Specific leaf weight(g/cm^2)	Specific leaf area (cm^2/g)
Ratoon crop control	94	5	0.048	0.418	2.387
Ratoon crop waterlogged	94	4	0.052	0.457	2.183
S.Ed.	0.08	0.13	0.01	0.16	0.52
CD	0.51	2.30	0.02	0.63	2.06
P (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**

Sugarcane variety, which has well adapted to areas prone to water logging and possesses tolerant in water-logged condition. Development of aerial roots and profuse rooting was observed under stressed condition, but not in normal condition of cultivation. Various morphological attributes were recorded in sugarcane variety CoC 24 growing in water-logged and normal condition. Mean value of all the growth and quality parameters are furnished (table 2) many unfavourable deviations were observed in most of the morphological traits when the cane was grown under waterlogging condition. But considerable improvement was observed in number of nodes (14.8%), internodal length (17.65%), nodes carrying roots (42.86%), number of roots (62.72%) and root volume (49.29%) conferring tolerance to waterlogging stress.

Waterlogged sugarcane plants, undergo structural changes leading to cell lysis and the formation of aerial roots. Development of adventitious roots in response to waterlogging is considered to be a tolerance mechanism to increase root aeration that allows the plant to maintain root functions during flooding and to avoid O_2 deficiency. These above ground roots tend to grow horizontally to remain near the water-air interface. Sugarcane root system developed a dense mat of aero-tropic, small diameter roots when flooded. Significant increase in aerial root formation was also observed in sugarcane subjected to longer duration of water logging (Gilbert *et al*., 2007).

Increase in internode length and decrease in cane diameter was observed, when the cane was subjected to longer duration of inundation. In many cases, it is this characteristic of the shoot that contributes most strongly in securing oxygen when the usual supply-route is blocked by flooding or submergence. Achieving unusually fast rate of extension to make contact with a source of oxygen, and also light and carbon-di-oxide is a major feature contributing to survival in standing water stress conditions (Gilbert *et al*., 2007).

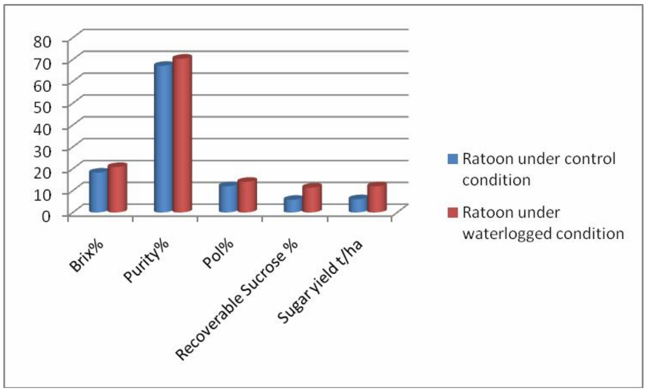

Fig. 1 : Effects of water logging on juice quality of CoC 24 sugarcane ratoon.

Fig. 2 : Nodes carrying roots in sugarcane variety CoC 24 under waterlogged condition.

Fig. 3 : Roots structure in sugarcane variety CoC 24 under waterlogged condition and normal condition.

Juice quality and yield

Quality of sugarcane *viz*., brix percentage, purity percentage, pol percentage and recoverable sugar were 12.31%, 4.63%, 14.153% and 49.17%, respectively (fig. 1). Sucrose percentage juice reached a peak at 11th month under water logging, while in control condition maximum sucrose was recorded at 12th month. Normally ratoon has an additional advantage in giving better juice quality and sugar recovery in comparision to the plant crop of the same varieties under similar conditions. Cane yield shows no difference over control this might be due to rapid canopy development, early development of adequate stalk numbers for increased interception of light in the early growth, stability of harvested stalk weights to maintain yield over ratoon cycles (Chapman *et al*., 1992; Sundara, 1996 and Sundara *et al*., 1992).

The growth parameters of sugarcane *viz*., tiller production, millable cane, cane yield and sugar yield were higher in CoC 24 ratoon (2.38%, 1.727%, 0.5% and 49.41%, respectively) in waterlogged sugarcane than control (table 4).

Conclusion

From the study, it concluded that CoC 24 variety of sugarcane ratoon proved that tolerant potential under natural water-logging stress condition in respect of juice quality, sugar yield and cane yield. Water logging reduced plant growth, but study of root growth, dry matter partition showed differences in their responses. Co C 24 variety, maintaining the higher shoot growth associated with the ability to develop higher nodal root and retain or least affect leaf area. But, it is related to biomass partitioning to shoot during long-term flooding, early nodal root development, accompanied with the ability to conserve root surface area for water and nutrient uptake as well as the ability to remobilize nutrients from older parts to support shoot growth. Based on the results, it is suggested that CoC (Sc) 24 could tolerate waterlogged condition. This study also

Table 4 : Effect of water logging on the cane yield attributes in sugarcane cultivar CoC(Sc)24.

Conditions	Single cane weight (Kg)	Tillers × 10^3/ha	Millable cane × 10^3/ha	Cane yield (t/ha)
Ratoon crop control	2.057	254.1	113.28	104.64
Ratoon crop waterlogged	1.848	260.3	115.8	105.17
S.Ed.	0.48	15.13	10.01	10.16
CD	1.51	62.30	50.02	49.63
P (0.05)	**NS**	**NS**	**NS**	**NS**

indicates that plant crops need certain post-water logging crop management.

Benefits of cane ratooning

1. It mature earlier than plant cane.
2. Early supply of cane to the factory.
3. It helps in improving sugar recovery.
4. The cost of production per tonne of ratoon cane is less than the plant crop.
5. Ratoons are economical by 25-30% in the operational cost because of saving in seed material and initial preparatory cultivation.

Post-waterlogging crop management

1. Arrangement should be made to drain out the field as quickly as possible by clearing the drainage channels, furrows and natural drainage outlets from the field.
2. Crop which is likely to be harvested late may be given additional dose of nitrogen and potassium (125 kg urea + 60 kg muriate of potash) to rejuvenate the root system, improve crop survival and reduce the pith formation.
3. Split application helps in minimizing nitrate leaching, the chances of which are high under water logging.
4. Foliar spray of 2.5% urea during water logging increases the yield of cane.

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