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Effect of Sucrose on the Growth and Yield of Tomato (LycopersiconesculentumMill)

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ABSTRACT: In the quest to achieve sustainable production of tomato crop using biotechnology, this study was conducted to determine the effect of sucrose on the growth and yield of tomato plant. Experimental design was a completely randomized design structure with 5 replicates per sugar treatment level potted experiment. Five (5) treatment levels were applied to 8 days old seedlings and they included: S_{10g}, S_{20g}, S_{30g}, S_{40g} of granulated sugar to every 250ml of water and a control (C) which received no sugar treatment apart from water. Data were collected on seven (7) growth and yield parameters at maturity, and subjected to descriptive and inferential statistical analysis. Mean separation was done using LSD at 5% level of significance. Growth related data gave 10.22±0.47 as the optimal plant height achieved at 20g of treatment. More branches (7.2±0.34) were produced at 30g of treatments than in other levels. All sugar treatments gave higher plant branches than the control (without sugar). Longer leaves measuring 3.5-4.4cm were produced at 40g of treatments than in other treatments. Significant differences in treatments were recorded in plant height (F=4.92, P=0.006), leaf length (F= 5.12, P=0.005) and number of branches (F=4.69, P=0.008). Number of fruit produced was the same in all treatments and the control. However, fruits were longer in sizes and heavier in all treatments than the control. Sugar treatment at 30g most significantly increased the length (F=34.43, P=0.000) and weight (F=10.63, P=0.000) of tomato fruit since P<0.005. However, effects of treatments were not significant in number of fruit produced (F=0.44, P=0.781) and fruit width (F=0.59, P=0.671) since P>0.05 limit. Association among agronomic traits showed that fruit weight was highly correlated with fruit length (+0.731) but moderately correlated with number of branches produced in the vine (+0.59). Sucrose may be applied to enhance growth and boost the production of tomato fruits especially at 30g per 250ml of water since it had positive effect on size and weight of the fruit. This will contribute immensely in the achievement food security of Nigeria.

Key words: Biotechnology, Tomato production, Food security, Sucrose

I. INTRODUCTION

Tomato, a member of Solanaceae family, is one of the most important cultivated and versatile garden vegetable grown in the world (Kumar et al. 2013) and Nigeria is the largest producer with 126,000 ha and an annual production of 879,000 tons (van der Vossenet al., 2004). It is grown all over the world because of its high nutritive value and an excellent source of vitamins A and C (Mucksood and Khan, 2011).In Nigeria, the consumption rate of tomato fruit is high due to its use in soup and sauce preparation. This has placed a pressure on its production. The goal of plant biotechnology is to ensure food security or self-sufficiency in sustainable food production while ensuring the safety of the environment. The challenge here is that seeds of tomato varieties that have been improved for yield are scarce while inorganic fertilizers, as yield enhancers, have been criticized for their inimical effects on the environment (Aguoruet al., 2015). Scientifically, growers have been advised to focus their attention on how to enhance yield related parameters through environmentally friendly methods. Currently, use of organic fertilization is currently being tried in many crops. Experiments are also being conducted on the possibility of using sugar sources such as sucrose to increase growth and yield of short lived vegetable crops.

Sucrose is a disaccharide with the general formula $C_{12}H_{22}O_{11}$. It is formed by the combination of molecule of glucose with a molecule of fructose with the exclusion of a molecule of water (Peralta and Spooner, 2001). It is found in the stems of sugarcane and roots of sugar beet and in most plants, as a major product of photosynthesis and the

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major form of carbohydrate (Favatiet al., 2009). It has be shown that, sugar in the medium inhibits floral transition in at least two different ways and that, the stimulating and inhibiting effects of sugar on plant reproductive features depends on the concentration and time of addition of sugar and the genetic background of plants (Masa-akiet al., 2001). In the quest to achieve sustainable production of tomato crop, this study was conducted with the aim of determining the effect of sucrose on the growth and yield of tomato plant grown in Makurdi, Benue State, North Central Nigeria.

II. MATERIALS AND METHOD

Ten fresh and ripe tomato fruit samples were sourced. Fruits were washed and lysed in water to release the seed contents which were recovered and air dried for planting.Planting was done in 25 pots filled with humus soil. Seeds were sown at 5 seeds per pot in a completely randomized experimental design with five replicates per treatment (Olasanet al., 2008). Seedlings were thinned to 1 per bag 8 days after sowing ensuring that seedlings were of uniform growth and vigour. Treatments given to 8 days old seedlings were; S_{10g} (10g), S_{20g} (20g), S_{30g} (30g), S_{40g} (40g) of granulated sugar to every 250mls of water and a control which received no sugar treatment apart from water (Aguoruet al., 2004). Seedlings were watered and monitored from the day of allocation of treatments to harvesting.Data taken at day 50 of planting were: plant height, leaf length, leaf breadth, number of branches, number of fruits produced, fruit weight and fruit sizes. Data obtained were subjected to Analysis of Variance and mean separation using LSD at 5% level of significance. Results were tested using the correlation among the growth and yield parameters using the Pearson's method.

III. RESULTS AND DISCUSSION

Table 1 gives a description of tomato growth and yield at 10g of sugar treatment level. Plant height was 6.88±047 ranging from 5.6-8cm. Mean number of branches was 5.68±0.2 bearing leaves that measured 2.24 to 4.34cm long. Three fruits were produced at maximum. Fruits were 7.32±0.11 long and 9.8±075 wide on the average. Minimum fruit weight was 21.5 and maximum was 28.6. Coefficient of Variation (CV) was least in number of branches (7.71%) and highest in number of fruit produced (35.5%).Table 2 gives a description of tomato growth and yield at 20g of sugar treatment level. Plant height increased to 10.22±0.47 on the average ranging from 8.9-11.4cm. Mean number of branches was 5.96±0.35 bearing longer leaves that measured 3.58 to 4.4cm. Three fruits were produced at maximum. Fruits were 7.64±0.49 long and 10.36±0.49 wide on the average. Minimum fruit weight was 26 and maximum was 29.5. Coefficient of Variation (CV) was least in fruit length (6.71%) and highest in number of fruit produced (60.86%).

Table 3 describes tomato plant growth and yield at 30g of sugar treatment level. Plant height reduced to 7.4±0.5 ranging from 6.2-8.9cm. Mean number of branches increased to 7.2±0.34 bearing leaves that measured between 2.7 to 3.8cm. Three fruits were produced at maximum. Fruits were 7.66±0.26 long and 9.28±0.41 wide on the average. Minimum fruit weight was 25.6 and maximum was 29.4. Coefficient of Variation (CV) was least in fruit weight (5.97%) and highest in number of fruit produced (37.27%).Table 4 describes tomato plant growth and yield at 40g of sugar treatment level. Plant height increased to 9.37±0.62 ranging from 8.02-11.5cm. Mean number of branches decreased to 6.7±0.29 bearing large leaves that measured between 3.5 to 4.4cm. Three fruits were produced at maximum. Fruits were 7.66±0.25 long and 9.8±0.51 wide on the average. Minimum fruit weight was 26.6 and maximum was 28.8. Coefficient of Variation (CV) was least in fruit weight (2.83%) and highest in number of fruit produced (46.48%).Table 5 describes tomato plant growth and yield without sugar treatment (control) whereplant grew further to 10.07±0.60 ranging from 6.20-12.4cm. Mean number of branches decreased further to 5.32±0.29 while leaf length ranged from 2.27 to 4.28cm. Three fruits were produced at maximum. Fruits were short with mean of 4.58±0.29 long and 9.31±0.24 wide. Fruit weight was less with maximum value of 24g. Coefficient of Variation (CV) was least in fruit weight (5.66%) and highest in leaf breadth (36.35%).

Figure 1 shows that the optimal plant growth of 10.22cm was achieved at 20g of sugar treatment level followed by 10.07cm recorded in the control while the lowest growth was observed at 10g of treatment. More branches were produced at 30 and 40g of sugar treatments than in other levels. All sugar treatments gave higher plant branches than the control (without sugar). Longer leaves were produced at 20g and 40g of treatments than other treatments. Figure 2 shows that fruit production was the same in all treatments and the control. However, fruits were longer in sizes and heavier in all treatments (10g-40g) than the control. As given in table 6, Significant differences in sugar treatment were recorded at varying levels in plant height (F=4.92, P=0.006), leaf length (F= 5.12,

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P=0.005), number of branches (F=4.69, P=0.008), fruit length (F=34.43, P=0.000) and fruit weight (F=10.63, P=0.000) since P<0.005. The most important yield component in tomato plant is the fruit. Thus, sugar treatment significantly increased the length (30g and 40g) and weight of the tomato fruit (30g). However, effects of treatments were not significant in number of fruit produced (F=0.44, P=0.781) and fruit width (F=0.59, P=0.671) since P>0.05 limit. Association among agronomic traits (Table 7) shows that fruit weight was highly correlated with fruit length (+0.731) but moderately correlated with number of branches produced in the vine (+0.59). The observed relationship was positive.

Sugar effects on plants have often been attributed to sugar metabolism(Cocaliadiset al., 2014) but evidence has shown that sugars can act as regulatory signals. These are signals that can control the expression of diverse genes involved in many processes in the plant life cycle (Price et al., 2003).It is reported in literatures that sugar affects floral transition by activating or inhibiting genes that control floral transition, depending on the concentration of sugars (Masa-akiet al., 2001).Although, no effect was observed in quantity of fruit produced, but this theory might be responsible for the effect of sugar level on fruit length and weight. The two fruit characters (size and weight) are enhanced at high sugar level, thus there is a possible relationship between increase in protoplasmic content in the fruit and sugar level used by the plant to enhance its metabolic activities. Tomato comprises of water of about 90% of the fresh weight of tomato fruit and the size of the fruit is affected by the availability of water to the plant (Cocaliadiset al., 2014). It might have impacted on the fruit length which in turn affects the weight. This is supported by the outcome of correlation analysis where fruit size and weight are highly correlated in a positive direction. In most plants, sucrose is the major product of photosynthesis and the major form of carbohydrate needed in energy production that drives plant physiological functions (Aguoruet al., 2004; Favatiet al., 2009).Some metabolic functions are closest to the ripe fruit sugar trait. Biochemical pathways especially starch biosynthesis may influence tomato fruit sugars, thus influencing growth and yield(Cocaliadiset al., 2014).

Table 1: Description of tomato growth and yield at 10g of sugar treatment

Variables @ S10g of sugar	Mean	S.E	C.V	Minimum	Maximum
Plant height(cm)	6.884	0.4680	15.20	5.60	8.00
Leaf length (cm)	3.104	0.4240	30.52	2.24	4.34
Leaf breadth(cm)	1.472	0.0862	13.09	1.30	1.78
Number of branches	5.680	0.1960	7.71	5.20	6.40
Number of fruit	2.000	0.3160	35.36	1.00	3.00
Fruit length(cm)	7.320	0.1070	3.26	7.00	7.60
Fruit width(cm)	9.804	0.7490	17.09	8.00	11.50
Fruit weight(g)	25.340	1.3800	12.16	21.50	28.60

Table 2: Description of tomato growth and yield at 20g of sugar treatment

Variables @ S20g of sugar	Mean	S.E	C.V	Minimum	Maximum
Plant height(cm)	10.224	0.468	10.23	8.90	11.14
Leaf length (cm)	4.064	0.146	8.01	3.58	4.40
Leaf breadth(cm)	1.740	0.170	21.79	1.26	2.06
Number of branches	5.960	0.354	13.30	4.60	6.60
Number of fruit	1.800	0.490	60.86	1.00	3.00
Fruit length(cm)	7.640	0.229	6.71	6.90	8.20
Fruit width(cm)	10.360	0.493	10.63	9.20	11.50
Fruit weight(g)	27.500	0.612	4.98	26.00	29.50

Table 3: Description of tomato growth and yield at 30g of sugar treatment

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Variables @ S30g of sugar	Mean	S.E	C.V	Minimum	Maximum
Plant height(cm)	7.400	0.5000	15.11	6.20	8.90
Leaf length (cm)	3.140	0.1960	13.99	2.70	3.80
Leaf breadth(cm)	1.524	0.0924	13.56	1.32	1.86
Number of branches	6.720	0.3440	11.45	6.00	8.00
Number of fruit	2.400	0.4000	37.27	1.00	3.00
Fruit length(cm)	7.660	0.2620	7.65	7.00	8.30
Fruit width(cm)	9.280	0.4070	9.80	8.40	10.70
Fruit weight(g)	27.880	0.7440	5.97	25.50	29.40

Table 4: Description of tomato growth and yield at 40g of sugar treatment

Variables @ S40g of sugar	Mean	S.E	C.V	Minimum	Maximum
Plant height(cm)	9.368	0.6170	14.73	8.02	11.50
Leaf length (cm)	4.068	0.1580	8.66	3.50	4.40
Leaf breadth(cm)	1.740	0.0424	5.45	1.58	1.82
Number of branches	6.720	0.2940	9.78	6.20	7.80
Number of fruit	1.800	0.3740	46.48	1.00	3.00
Fruit length(cm)	7.656	0.2520	7.36	7.00	8.40
Fruit width(cm)	9.800	0.5050	11.52	8.80	11.60
Fruit weight(g)	27.532	0.3480	2.83	26.80	28.80

Table 5: Description of tomato growth and yield without sugar treatment (Control)

Variables @ Control (without sugar treatment)	Mean	S.E	C.V	Minimum	Maximum
Plant height(cm)	10.072	0.597	18.76	6.20	12.40
Leaf length (cm)	3.293	0.213	20.44	2.27	4.28
Leaf breadth(cm)	1.750	0.201	36.35	1.20	3.30
Number of branches	5.320	0.292	17.38	3.60	6.60
Number of fruit	2.200	0.249	35.86	1.00	3.00
Fruit length(cm)	4.582	0.286	19.73	3.02	6.00
Fruit width(cm)	9.310	0.244	8.30	8.00	10.50
Fruit weight(g)	22.220	0.398	5.66	20.70	24.00

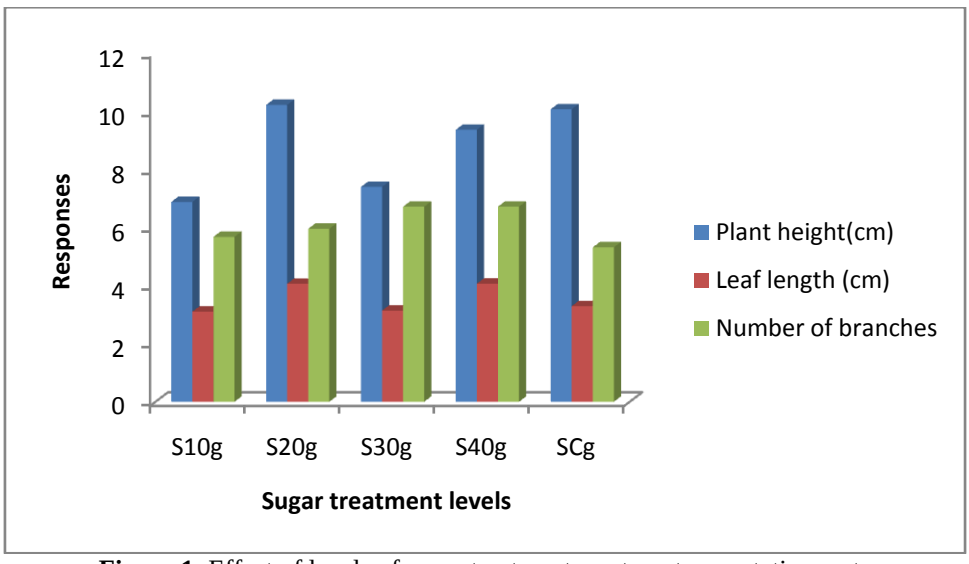

Figure 1: Effect of levels of sugar treatments on tomato vegetative parts

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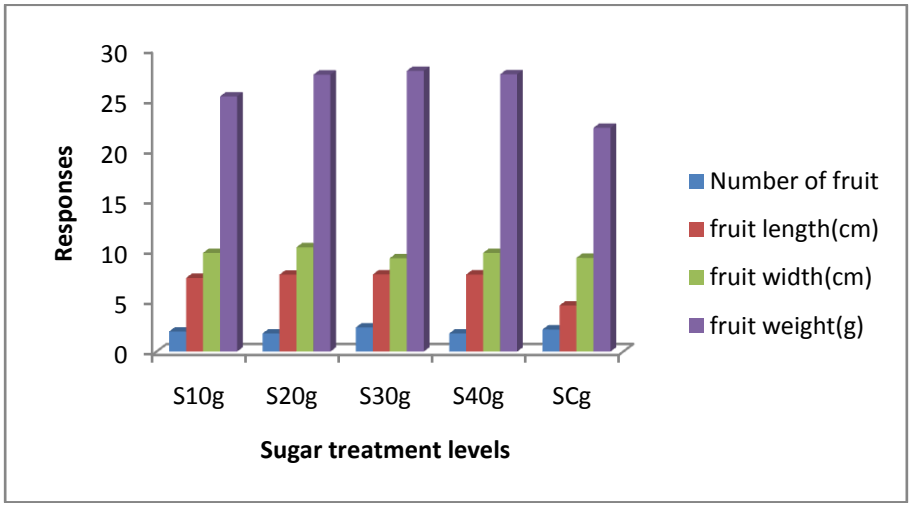

Figure 2: Effect of levels of sugar treatments on tomato fruit parameters

Table 6: Inferential Statistics (Analysis of Variance) of sugar treatment effectson growth and yield parameters of tomato

Treatment**	Plant height* (cm)	Leaf length * (cm)	Leaf breath* (cm)	No.of branches*	No.of Fruit*	Fruit length* (cm)	Fruit width (cm)*	Fruit weight* (g)
C	10.07^{a}	3.29^{b}	1.75^{a}	5.32^{b}	2.20^{a}	4.58^{b}	9.31^{a}	22.20^{c}
S10	6.88^{b}	3.10^{b}	1.47^{a}	5.68^{b}	2.00^{a}	7.32^{a}	9.80^{a}	25.34^{b}
S20	10.22^{a}	4.06^{a}	1.74^{a}	5.96^{b}	1.80^{a}	7.64^{a}	10.36^{a}	27.50^{a}
S30	7.40^{b}	3.14^{b}	1.52^{a}	6.72^{a}	2.40^{a}	7.66^{a}	9.28^{a}	27.88^{a}
S40	9.37^{a}	4.07^{a}	1.74^{a}	6.72^{a}	1.80^{a}	7.66^{a}	9.80^{a}	27.53^{a}
LSD@5%	1.48	0.62	0.63	0.86	0.72	1.22	0.96	1.98

F (plant height) =4.92, P=0.006 (P<0.05)
F (leaf length) =5.12, P=0.005 (P<0.05)
F (leaf breadth) =0.4, P=0.804 (P>0.05)
F (number of branches) =4.69, P=0.008 (P<0.05)
F (number of fruit) =0.44, P=0.781 (P>0.05)
F (fruit length) =34.43, P=0.000 (P<0.05)
F (fruit width) =0.59, P=0.671 (P>0.05)
F (fruit weight) =10.63, P=0.000 (P<0.05)

* Each value is a mean of 5 replicates. means with same superscript in each vertical column are not significant different (P > 0.05)
** C= Control, S_{10}= 10g of granulated sugar, S_{20}= 20g of granulated sugar, S_{30}=30g of granulated sugar and S_{40}= 40g of granulated sugar

Table 7: Pearson's correlation matrix among vegetative and fruit traits of tomato crop

	PH	LL	LB	NoB	NoF	FL	FW	FWT
PH	1							
LL	0.649	1						
LB	0.284	0.252	1					
NoB	0.082	0.408	-0.014	1				
NoF	0.003	-0.061	-0.093	0.049	1			
FL	-0.373	0.153	-0.139	0.379	-0.065	1		
FW	-0.123	0.031	0.275	-0.086	-0.443	0.109	1	
FWT	-0.108	0.316	0.015	0.590	-0.259	0.731	0.126	1

PH= Plant height, LL=Leaf length, LB=Leaf breadth, NoF=Number of fruit, FL=fruit length, FW=fruit width, FWT=fruit weight

IV. CONCLUSION

Significant differences in sugar treatments were recorded in plant, leaf length and number of branches. Number of fruit produced was the same in all treatments and the control. Sugar treatment at 30g most significantly increased the length and weight of tomato fruit. Weight of fruit was highly correlated with its length (+0.731) Sucrose may be applied to enhance growth and boost the production of tomato fruits.This will contribute immensely in the achievement of food security in Nigeria.

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