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The effect of potassium addition to the vegetative growth of mutated sugarcane genotypes

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ABSTRACT

Mutated sugarcane genotypes have the potential yield of 15.57, 16.83, and 18.58 percent. The release of new varieties of sugar cane must be balanced with the proper method or cultivation technique. One component of an appropriate plant cultivation method is the dose of fertilization. This experiment was carried out to determine the optimum dose of Potassium (K) needed by sugar cane varieties BL mutation results in each genotype. The experiment was arranged using a completely randomized design (CRD) 2 factorial pattern with the first factor being sugarcane with 3 levels (M2, M3, M4), and the second factor was K dose of 5 levels with an increase of 10% (K0 = 130 kg K / ha, K1 = 143 kg K / ha, K2 = 156 kg K / ha, K3 = 169 kg K / ha, K4 = 182 kg K / ha), each treatment combination used a sample of 3 plant units and with 3 replications so in total 135 plants are used. Data from the experimental results were analyzed using analysis of variance and to find out the optimum dose of K fertilizer performed by quadratic polynomial regression analysis. The results - showed significantly different interactions on the variable number of chlorophyll, number of leaves and number of tillers. A single mutant factor (M) and a single factor of K dose (K) showed significant differences in leaf sucrose's variable values. M4K3 treatment produced the highest value on the leaf chlorophyll variable, number of leaves and number of tillers. Potassium (K) fertilizer dosages to reach the highest leaf sucrose values M2 (5.090%), M3 (5.175%) and M4 (5.181%) were 53.416 kg K / ha, 53.785 kg K / ha and 60.917 kg K / ha respectively.

Keywords: bululawang, potassium, sugarcane, varieties

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INTRODUCTION

The volume of Indonesian sugar imports is relatively high every year. The volume of sugar imports in 2010 to 2015 increased every year, only decreased in 2014, and increased again in 2015 amounted to 3,375,010 tons (Directorate General of Plantations, 2016). The main cause of the high volume of Indonesian sugar imports is the high level of consumption. Tarimo & Takamura (1998) also stated that sugar cane, a sugar producer, is an important food source and a type of commercial plant.

Genotype changes in BL varieties cane were carried out for Miswar et al. in 2016 to overcome the relatively low BL sugarcane yield. Breeding that has been done is by gene mutation techniques through induction using EMS. BL varieties of sugar cane have undergone mutations, consisting of three genotypes with a yield potential of 15.57%, 16.83%, and 18.58%. The formation of the three genotypes produced was influenced by the length of time during the mutation process using an EMS concentration of 16 mM.

Regulation of the Minister of Agriculture on the release of new plant varieties in 2017 states that to release new plant varieties must first undergo several tests, testing the plant on fertilization responsiveness. Cahyani et al. (2016) stated that inorganic fertilization could significantly increase the soil's availability of nutrients. K is a type of macronutrient that is needed by sugarcane to optimize its productivity. Endah (2001), mentions several functions of the K element in the body of the plant, including supporting the process of root formation; Role in translocation of sugars for the formation of starches and sugars; and Strengthening plant organs, so they do not quickly fall. Potassium deficiency will further cause an increase in the hydrolysis of the enzyme invertase (invertation reaction), thereby causing an increase in reducing sugars and making it low. If the content of sucrose is high; the reducing sugar content is low because the sucrose content of sugarcane is closely related to reducing sugar (Widodo, 2017).

Based on this, the research on the effect of (K) fertilizer on sugarcane plants resulting from this mutation needs to be done to determine the optimal dose.

MATERIAL AND METHOD

This research was conducted from March to These experiments were conducted in July 2019 - November 2019, and were located in Tegal Besar Village, Jember Regency. Experiments were performed by using Polybags or the like. The materials used include: sugarcane Bululawang variety consisting of M2 = yield of 15.5%; M3 = yield 16.8%; M4 = yield of 18.5%, and supporting material sugarcane cultivation. The tools used are 60 x 60 cm polybags, shovels, analytical scales, and laboratory support analytical tools.

The experiment was arranged using a completely randomized design (CRD) factorial pattern of 2 factors with the first factor being sugarcane with an M2 level (BL 15.5); M3 (BL 16.8) and M4 (BL 18.5). And the second factor is the dose of K with a level of K0 (130 kg K/ha); K1 (143 kg K / ha); K2 (156 kg K / ha); K3 (169 kg K / ha), and K4 (182 kg K / ha). Each treatment combination used a sample of 3 units of plants and three replications. A total of 135 units of experimental plants were used, and sub-sampling techniques did the data collection.

There are five observational variables, namely leaf sucrose value (%), leaf reducing sugar (%), number of leaves, amount of chlorophyll (SPAD), and number of tillers. Leaf sucrose value (%), leaf reducing sugar (%), number of leaves, amount of chlorophyll (SPAD), and number of tillers were selected as observational variables in this study.

RESULT

Analysis of the variance of all observed variables is shown in table 1. Three variables show interactions between significantly different treatments: the chlorophyll content of leaves, number of leaves, and number of tillers.

Leaves Chlorophyll

Based on the analysis of variance (Table 1), leaf chlorophyll values were significantly different at each K dose tested and very significantly different in the interaction of M and K dose but not significantly different in the sugarcane genotype (M).

Based on the 5% DMRT test results (Table 2), the highest chlorophyll content was found in the M4K3 treatment combination with a value of 40.74 and the lowest content in the M3K4 treatment combination with a value of 34.20.

Number of Leaves

Based on the analysis of variance (Table 1), the number of leaves wasvery significantly different at each K dose tested and very significantly different in the interaction of M and K dose but not significantly different in the sugarcane genotype (M).

Based on the 5% DMRT test results (Table 3), the highest number of leaves was found in the M4K3 treatment combination with 17.00 leaf counts, and the least number of leaves was the

Table 1. Summary of middle craters (variants) of all observed variables

No	Variables	KT			
		M	K	M x K	Galat
1	Leaf Sucrose	0.0388 **	0.0568 **	0.0123 ns	0.0055
2	Leaf Reducing Sugar	0.0009ns	0.0054ns	0.0095ns	0.0070
3	Chlorophyll	12.02ns	16.61**	12.83**	3.68
4	Number of Leaves	0.52ns	9.72**	6.05**	1.22
5	Number of Tillers	2.83**	11.64**	3.62**	0.5
6	Rod Diameter	0.16 **	0.10 ns	0.007 ns	0.015
7	Stem Length	35.49 ns	5.03 ns	3.77 ns	15.04

Note: * = Different; ** = Significantly different. ns = Not significantly different

Table 2. Interaction of M and K dosages on sugarcane chlorophyll values

Mutant	K									
	K0		K1		K2		K3		K4	
M2	34.6	ef	39.5	abc	36.2	def	35.1	def	34.5	ef
M3	35.0	def	37.2	bcdef	39.7	ab	36.6	cdef	34.2	f
M4	35.2	def	36.0	def	37.5	abcde	40.4	a	38.1	abcd

Note: Figures followed by the same letter indicate no significant difference in the 5% DMRT test.

M4K0 treatment combination with 12.44 leaf counts.

Sugarcane Saplings

The results of the analysis of variance (Table 1) showed that the number of tillers was very significantly different in M and K's interactions, differed very significantly in M as well as differed very significantly in K.

Based on the 5% DMRT test results (Table 4), the highest number of tillers was found in the M4K3 treatment combination with 13.00 tillers, and the least number of tillers was in the M3K0 treatment combination with the number of tillers 8.33.

Leaves Sucrose

Variance analysis results (Table 1) showed that leaf sucrose content was significantly different in (M) and also very significantly different in (K) dose.

Based on the 5% DMRT test results (Table 5), the highest M2 leaf sucrose content was 5.183%,

Table 3. Interactions of (M) and (K) fertilizer doses on the number of sugarcane leaves

Mutant	K									
	K0		K1		K2		K3		K4	
M2	12.78	de	16.00	ab	15.22	abc	13.22	cde	12.8	de
M3	12.56	e	14.78	bcd	16.22	ab	14.33	bcde	13.7	cde
M4	12.44	e	13.00	de	13.56	cde	17.00	a	13.9	cde

Note: Figures followed by the same letter indicate no significant difference in the 5% DMRT test.

Table 4. Interactions of (M) and (K) fertilizer doses on the number of sugarcane tillers

Mutant	K									
	K0		K1		K2		K3		K4	
M2	9.44	fgh	10.67	cdef	11.00	cde	12.78	ab	9.6	fgh
M3	8.33	h	9.11	gh	11.78	bc	10.11	efg	9.89	defg
M4	8.89	gh	9.33	fgh	9.78	efg	13.00	a	11.22	cd

Note: Figures followed by the same letter indicate no significant difference in the 5% DMRT test.

Table 5. Average sugarcane leaf sucrose content (%)

Mutant	K									
	K0		K1		K2		K3		K4	
M2	4.952	a	5.183	a	5.140	b	5.113	b	5.062	a
	B		A		A		AB		AB	
M3	5.022	a	5.283	ab	5.221	a	5.215	ab	5.135	a
	C		AB		A		AB		B	
M4	5.081	a	5.086	b	5.304	ab	5.248	a	5.186	a
	B		B		A		A		AB	

Note: a = Vertical; A = Horizontal

Table 6. Average sugarcane diameter (cm)

Mutant	K									
	K0		K1		K2		K3		K4	
M2	2.20	b	2.42	a	2.41	a	2.37	a	2.38	a
M3	2.44	a	2.49	a	2.51	a	2.49	a	2.50	a
M4	2.41	ab	2.42	a	2.47	a	2.54	a	2.53	a

Note: Figures followed by the same letter indicate no significant difference in the 5% DMRT test.

significantly different from 4.952%. The highest leaf sucrose content of M3 was 5.283% and significantly different from 5.022. The highest leaf sucrose content of M4 is 5.248% and is significantly different from 5.081. The content of leaf sucrose was also significantly different in the treatment dose K (K1, K2, and K3), which was 5.183% significantly different from 5.086% for K1; 5,221% is significantly different from 5,140% for K2; 5,248% is significantly different from 5,113% for K3, while K0 and K4 show no significant difference.

Various doses of K give different effects on the variables tested. Each mutant sugarcane requires an optimum dose of different K in achieving the highest leaf sucrose content, which is 3.205 g / tan or 53.416 kg / ha for M2 (5.090% leaf sucrose); 3,227 g / tan or 53,785 kg / ha for M3 (leaf sucrose 5,175%); and 3,655 g / tan or 60,917 kg / ha for M4 (leaf sucrose 5,181%). The dose is based on the results of the regression analysis shown (Figure 1).

Sugarcane Diameter

The analysis of variance (Table 1) showed that the parameters of the rod diameter differed very significantly on (M). The 5% DMRT test results (Table 6) showed that the most prominent stem diameter was in M4 sugarcane with a dose of K4 fertilizer (diameter 2.53 cm), and the smallest was M2 with a fertilizer dosage of K0 (diameter 2.20 cm). The stem diameter of the sugarcane has a significant positive correlation with chlorophyll content. The stem's diameter is not yet clearly visible, although the results of further tests

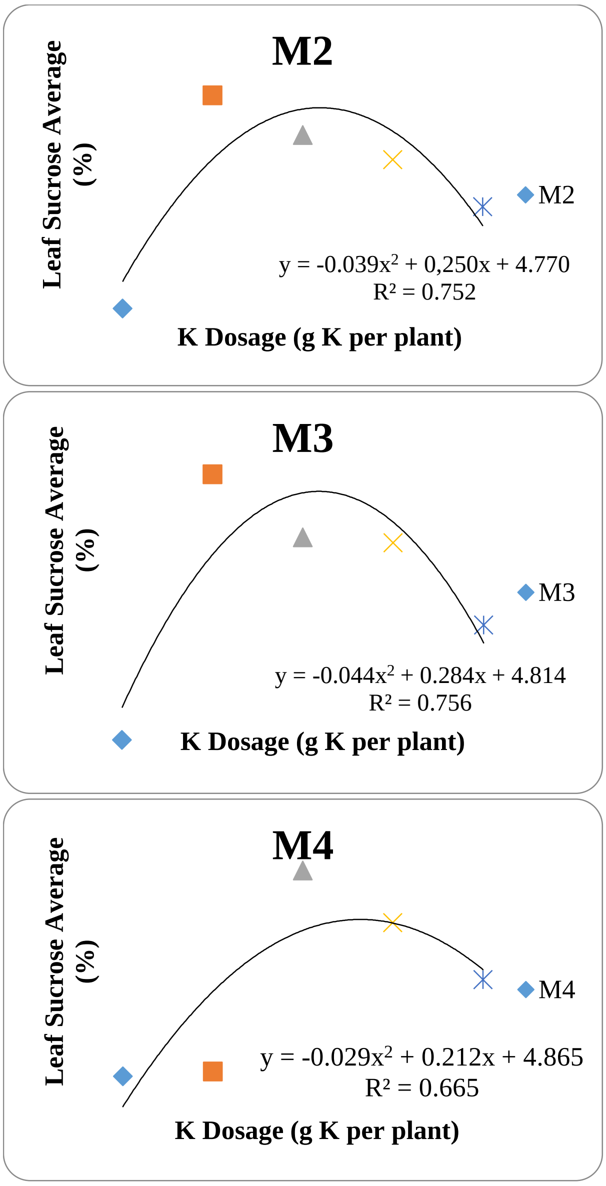

Figure 1. Regression analysis of sucrose variable in sugarcane leaf

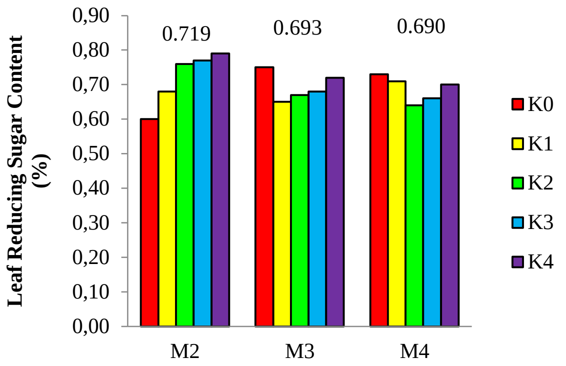

Figure 2. Average of sugar reducing content

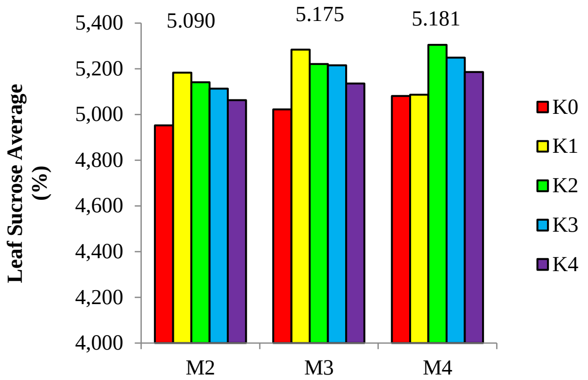

Figure 3. Average sucrose content of sugarcane leaf

revealed a very significant difference in the treatment of (M).

Leaves Sugar Reduction

The content of leaf reducing sugars in (M) or (K) doses showed no significant differences based on the results of various analyzes (Table 1).

The highest leaf reducing sugar content was M2 (0.719%), followed by M3 (0.693%) and M4 (0.690%) (Figure 2). The leaf reducing sugar content was associated with leaf sucrose content (figure 2: figure 3) because the reducing sugar is the result of sucrose hydrolysis.

DISCUSSION

Potassium (K) is one of the essential nutrients needed by all plants including sugarcane. Each plant requires different amounts of K. The difference in the need for K element in each sugarcane variety is one of the yield determinants. Sugarcane which has undergone genetic changes (mutated), also requires different K doses to reach its highest yield. Recommendations for K fertilizer application in conventional sugarcane cultivation have been widely reported; however, specific recommendations for varieties are limited. K plays an active role in plant photosynthesis activity (Sumiarti, 2010), so the sucrose content, which is the final result of photosynthesis, is closely related to leaves' chlorophyll content. In line with this opinion Rosyidah et al. (2017), the chlorophyll content in leaves is positively correlated with K nutrients' administration. Availability of K in the soil and also the ability of plants to absorb K will also determine the amount of leaf chlorophyll content; besides that according to Widodo (2017), genetic differences, especially in sugarcane plants, will also lead to metabolic differences, one of which is chlorophyll biosynthesis.

The results showed that high K dose (K4) results in a significant decrease in chlorophyll in M2 and M3. The decrease in chlorophyll value due to high K also occurs in M4, although it was not significant. The sucrose synthesis in sugarcane is strongly influenced by the amount of chlorophyll (Hamida and Suhara, 2019). The highest chlorophyll value in K dose was related to the leaf sucrose content. The low chlorophyll content in K4 also results in a tendency to the lower sucrose content in leaves (K4) resulting from photosynthesis (Figure 4.3). Chlorophyll, which is available in large enough quantities on sugarcane leaves, will increase the ability of the leaves to absorb sunlight so that the photosynthesis process will run smoothly (Cahyani et al., 2016). Photosynthesis produced from the process of photosynthesis is then overhauled again to produce energy used as a growth substrate (Widodo, 2017), such as the formation of tillers and sugarcane shoot growth.

Chlorophyll, which functions to capture solar energy, will supply energy used for macromolecular synthesis in cells, such as carbohydrates (Cahyani et al., 2016). The synthesis results will then undergo several changes and become a food reserve and will also be accumulated in young tissues and growth points due to the number of leaves and sapling formation. The number of leaves will affect in the ability of plants to absorb sunlight so that it can increase the results of photosynthesis (Zaini et al., 2017), then the formation of tillers will be more active (Cahyani et al., 2016). Sugarcane productivity per unit of land is determined by plants' ability to form saplings (Rokhman et al., 2014).

This experiment indicates that the higher the amount of leaf chlorophyll the number of sapling leaves formed will be more and vice versa. Giving the highest dose of K, which shows the amount of leaf chlorophyll tends to decrease, also impacts the formation of tillers and the number of leaves, which also tends to decrease. Maximum nutrient absorption carried out by sugarcane plants will impact increasing plant growth so that the number of leaves grows more (Wardoyo et al., 2017) and photosynthate yields will continue to increase then accumulation towards the growing point of sapling formation will also be more active. The large number of tillers formed will further increase the productivity of sugarcane.

Erlina et al. (2017) states that sucrose's accumulation determines the success of a sugarcane cultivation in economic terms. Moreover, one of the key factors determining the yield of sugarcane cultivation is the number of tillers (Rokhman et al., 2014). The formation of active saplings is carried out by sugarcane when the vegetative phase is then followed by stem elongation and stem sucrose filling. The M4K3 treatment obtained the highest number of tillers which was 13.00, and the lowest was M3K0 with the number of tillers 8.33. The higher the number of tillers produced in one clump, the more cane yield (Zaini et al., 2017).

Increasing the K dose in M2, M3 and M4 elevates the leaf sucrose content to a certain point; then the leaf sucrose content continues to decrease (Figure 2). The K supply needed for sugarcane is around 130 kg K /ha (McCray et al., 2011). Mutated sugarcane genotypes is estimated to be able to absorb and use K efficiently. The sucrose content of sugarcane leaves is opposite to the reduced sugar content; the higher the sucrose value, the lower the sugar content will be (Figure 2 and 3). A good sugarcane plant is high in sucrose content and has low sugar content (Hemalatha, 2015).

Each mutant sugar requires an optimum dose of different K in achieving the highest leaf sucrose content, which is 3.205 g K /plant (53.416 kg K /ha) for M2 (leaf sucrose 5.090%); 3,227 g K /plant (53,785 kg K /ha) for M3 (leaf sucrose 5,175%); and 3,655 g K /plant (60,917 kg K /ha) for M4 (leaf sucrose 5,181%). The dosage is based on the results of the regression analysis shown in Figure 1. Photosynthate will be transplanted to the stems as food reserves. The biggest stem diameter is sugarcane M4 with a dose of K4 fertilizer (2.53 cm in diameter), and the smallest is M2 with a dose of K0 fertilizer (diameter of 2.20 cm). The stem diameter of the sugarcane is tightly correlated with chlorophyll content. The stem's diameter is not yet clearly visible, although the results of further tests revealed a very significant difference in the treatment of mutants (M). Stem elongation and enlargement processes in the new sugarcane occur t the age between 3 - 9 months (Erlina et al., 2017); therefore, the real difference in stem diameter only occurs due to mutant’s influence

Rosidah's statement (2016) regarding the correlation of chlorophyll is in line with this study's results. Chlorophyll content in sugarcane leaves is positively correlated with the number of leaves, tiller number, sucrose content in the leaf, stem length, and stem diameter. The chlorophyll content, which is positively correlated with the number of leaves and sucrose leaves, will certainly impact the length of the stem and the stem's diameter. Sucrose on the leaves is also positively correlated with the length of the stem and the diameter of the stem, so the higher the sucrose in the leaf, the yield of the stem will also be higher if it is assumed that all the yields will not experience voos (cabes).

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