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Response of Morphological and Physiological Characteristics of 4 Flood- tolerant Sugarcane (*Saccharum officinarum* L.) Cultivars to ZA (Zwavelzuur Ammoniac) Fertilizer Application in Jember and Bondowoso

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ABSTRACT

The business expansion of sugarcane can be done using marginal land, such as wet land. This study attempted to get the right doses of ZA fertilizer applied to several sugarcane cultivars, which are tolerant to flooding in two different locations. The research was carried out in Jubung Agrotechnopark garden, University of Jember and seed gardens of Dewisri Bondowoso, from November 2015 to November 2016. The experiment was arranged in factorial randomized complete block design. The first factor was the doses of ZA fertilizer (N), consisting of 3 levels of treatment, i.e. N0: 0 kg.ha^{-1} (without ZA fertilizer), N1: 500 kg.ha^{-1} and N2: 1000 kg.ha^{-1}. The second factor was 4 sugarcane cultivars (V), consisting of flood-tolerant sugarcane cultivars from 2014 screening result, i.e. V1: PSJT 941, V2: Bulu Lawang, V3: PS 865 and V4: Kidang Kencana. The results showed that the application of ZA fertilizer at 1000 kg.ha^{-1} affected the height of stems, the number of tillers, diameter of the stem and the number of segments. Meanwhile, the application of ZA fertilizer at 500 kg.ha^{-1} affected the number of leaves, fresh weight of shoots, dry weight of shoots, fresh weight of roots, dry weight of roots, brix content, and the content of sucrose and reducing sugar. Flood-tolerant sugarcane cultivars are shown by the highest brix and sucrose fertilizer, observed in PS 865, Bulu Lawang, PSJT 941, and Kidang Kencana, sequentially. The highest content of reducing sugar was found in PSJT 941, PS 865, Kidang Kencana, and Bulu Lawang, successively.

Keywords: Wetness, fertilizer, sugarcane, cultivars.

INTRODUCTION

Indonesia is a tropical country with a hot climate that can be used for the cultivation of sugarcane. Indonesia's geographical condition has the potential to become the largest sugar producer country in the world. Sugarcane crops, as industrial plants, have long been cultivated in Indonesia since the days of the Dutch government (Bambang, 2014). Indonesia's population in 2011 reached 240,845,720 peoples, requiring 2,642,078 tons of sugar (P3GI, 2008). In an effort to meet national sugar consumption needs, since 2009, the government has established the 2014 Sugar Self-Sufficiency Program. National Sugar Self-sufficiency is one of the four successful targets of the Ministry of Agriculture in 2014. National sugar needs are predicted to reach 5.7 million tons in 2014, consisting of the need for direct consumption of 2.97 million tons of white crystal sugar and the need for refined crystal sugar for the industry 2.74 million tons. Increased sugar production can be carried out by expanding the area, increasing sugarcane weight per hectare and increasing yield.

The main purpose of sugarcane cultivation is to obtain high crystal yields. Hablur is a crystallized sucrose sugar. In the sugar production system, sugar formation occurs in the metabolic processes of plants. This process occurs in the field (on farm) (Purwono, 2003). The amount of sucrose is largely determined by the difference between the synthesis and degradation of sucrose which is regulated by several enzymes, such as sucrose synthase, acid invertase, neutral invertase and alkaline invertase (Lontom, 2008). Invertase enzyme activity and increased protein content can have an impact on the sucrose content produced. A higher activity of the invertase enzyme produced causes a decrease in sucrose content as a result of the biosynthesis and degradation of sucrose that occurs.

Cultivar PS 865, formerly known as the CB 6979 series, is descended from the crossing of POJ 4947 x POJ 2946 in 1986. This cultivar was released based on the Decree of the Minister of Agriculture Number: 342/Kpts/SR.120/3/2008 on March 28, 2008 about the release of sugarcane cultivar CB 6979 with the name of PS 865. Sugarcane cultivar PS 865 shows satisfactory plant performance on Alluvial, Latosol, Podsolik and Grumosol fields. According to Sugiyarta (2008), cultivar Bululawang (BL) is more suitable for light lands (sandy clay) with good drainage systems and adequate N fertilization. On heavy land with disturbed drainage, the growth of the cultivar is very depressed. BL seems to need land with sufficient water conditions under good drainage conditions. Light land to the spring is preferred by this variety rather than heavy land.

Cultivar PSJT 941 has a high drought tolerance, thus, the cultivar shows a very real advantage in dry moorland. The initial growth is simultaneous and rapid, with fairly tight budding, erect growth, and medium to large diameter. PSJT 941 is descended from the crossing of BP 1854 Polycross in 1994 from PSJT 94-33 selection number, released based on the Decree of the Minister of Agriculture Number: 375/Kpts/SR.120/7/2007 on 5 July 2007 (P3GI, 2011).

According to P3GI PTPN X (2010), the spread of sugarcane cultivar PA 198, which was initially adapted and developed in Kidangkencana village, West Java, continued to increase and its productivity was quite good. In a relatively short time, the farmers in the Special Region of Yogyakarta and even in East Java began to be interested. The same cultivar also was also developed in the sugarcane smallholder plantations of the Bungamayang Lampung PG area known as BM 96–05, in the territory of PT Gunung Madu Plantation Lampung under the name of GM 25, and in the PG Cintamanis region of South Sumatra with the name of CM 47. Because the true origin of this cultivar is not known, the cultivar was legalized with the name Kidang Kencana (KK). Sugarcane cultivar KK was released based on the Decree of Minister of Agriculture Number: 334/ Kpts / SR.120 / 3/2008, on March 28, 2008, regarding the release of sugarcane cultivar PA 198. Cultivar KK shows satisfactory plant performance on clay soil (texture of moderate to heavy) with enough water available. Meanwhile on land without irrigation, it seems that cultivar KK shows a less satisfying performance so that the suitability of the typology of the development area is on the land available for sufficient soil moisture (irrigated rice fields).

The development of sugarcane cultivation is not limited to land that is suitable for the growing conditions. Marginal lands have the potential to be developed in an effort to expand the agricultural land, especially sugarcane plantation. Increased sugarcane production can be done by improving fertilization technology through cultivars management programs by paying attention to the balanced composition of the type of maturity of the cultivars planted (Sugiyarta *et al.*, 2000). One of the improvements is to improve the method of fertilization where fertilization is an action that must be carried out accurately and efficiently in accordance with the needs of sugarcane plants. Nitrogen is very important for growth and yield of sugarcane.

The main role of nitrogen in sugarcane crops is to stimulate overall growth, especially stems, tillers and leaves. Nitrogen fertilizer will affect leaf area, leaf area index, and photosynthesis rate, which will increase overall biomass production. Biomass plays a role in determining the final yield of sugarcane in the form of crystals (Gardner *et al.*, 1991). ZA fertilizer is supplier of nitrogen nutrients for sugarcane cultivation because it is more effective in increasing sugar content than other fertilizers containing nitrogen. Thus, this experiment aimed to determine the appropriate dose of ZA fertilizer applied to 4 cultivars of flood-tolerant sugarcane at two different locations, and to obtain morphological and physiological characteristics of 4 cultovars of flood-tolerant sugarcane in two different locations.

MATERIALS AND METHODS

The experiment was conducted at UPT Agrotechnopark Jubung University Jember Garden and Bondowoso Dewisri Seed Garden. The materials used in the experiment were sugarcane seeds of 4 cultivars which were screened in 2014, namely PSJT 941 and BL (flood-tolerant) and PS 865 and KK (sensitive to flooding), as well as chemicals needed for laboratory analysis. The equipment used in the experiment consisted of field equipment (roll meters, field knives, sample rings, etc.) and laboratory equipment (glassware, electronic scales, ovens, hotplates, spectrophotometers, Kjeldahl Apparatus, etc.). The experiment was arranged in factorial Randomized Complete Block Design (RCBD), consisting of 2 factors with 3 replications. The first factor was the dose of ZA fertilizer (N) with 3 levels of treatment, comprising N0 (0 kg.ha^{-1} ≈ without ZA fertilizer), N1 (500 kg.ha^{-1} ≈ 25 g per plant) and N2 (1000 kg.ha^{-1} ≈ 50 g per plant). Doses determination was based on ZA fertilization recommendations for sugarcane plants, which is 8 quintals.ha^{-1} (Kharisma Hapsarini Nasution *et al.*, 2013). The second factor was cultivar (V) of sugarcane from 2014 screening, consisting of V1 (PSJT 941), V2 (BL), V3 (PS 865) and V4 (KK).

The sugarcane used in the experiment was the result of nurseries for 2 months, which were then planted in Jember and Bondowoso locations. Flooding was carried out since 60 days after planting (dap) continuously for 3 months. Flooding condition was carried out at a height of 50 cm from the ground. Fertilization was carried out at 21 days after planting using SP36 fertilizer (10 g per plant), KCl (15 g per plant) together with the first application of ZA fertilizer as much as 40% of the doses according to the treatments. The second application of ZA, as much as 60% of the doses according to the treatments, was carried out at 49 days after planting. Sugarcane crops were harvested at 10 months after planting. Data obtained from Jember and Bondowoso locations were tested for normal distribution using data normality test. If the data are not normally distributed, then the data must be transformed. Homogeneity of variance was tested using the Bartlett Test. The results of Bartlett's test showed that some variables were not homogeneous so that the data were analyzed by Analysis of Variance (ANOVA) on the locations of Jember and Bondowoso. The difference between treatments was tested by Duncan's test at 5%.

RESULTS AND DISCUSSION

The general condition of the land used for the experiment in Jember has a soil pH of 6.55 and in Bondowoso 6.35. The pH is relatively acidic. Soil nitrogen content was 0.16% in Jember and 0.18% in Bondowoso, which are categorized as low (LPT, 1983).

Effect of ZA Fertilizer (Zwavelzuur Ammoniak) Doses

ZA fertilizer provides an element of N which is easily available in a relatively short time for plants (Putra, 2013). Even though the dominant appearance of tillers occurs, the pattern of growth is physical, reflected by the formation of leaves, roots and stems.

The doses of ZA fertilizer had a very significant effect on the height of the stems in Jember and Bondowoso. The dose of ZA fertilizer of 1000 kg.ha^{-1} or 50 g per plant (N2) resulted in the highest value of stem height of 284.47 cm in Jember and 263.17 cm in Bondowoso. The treatment of ZA fertilizer at a dose of 500 kg.ha^{-1} or 25 g per plant (N1) resulted in plant height of 264.92 cm in Jember and 246.42 cm in Bondowoso. Meanwhile, the plants without ZA fertilizer (N0) showed plant height of 231.06 cm in Jember and 215.78 cm in Bondowoso. The main role of nitrogen in sugarcane is to stimulate growth. Stem height indicates the growth process in the meristematic, end or apical regions. This increase in the height of the sugarcane stem will also increase the fresh weight of the shoot. Nitrogen plays a role in stimulating the growth of plants, especially stems, branches and leaves (Soepardi, 1977). The effect of increasing ZA fertilizer doses on the stem height in Jember and Bondowoso is presented in Figure 1.

Sugarcane plants store reserves in the stems. The larger the diameter of the sugarcane stems, the more sap will be produced. The treatment of ZA fertilizer at a dose of 1000 kg.ha^{-1} or 50 g per plant (N2) obtained an average stem diameter of 2.45 cm in Jember and 2.59 cm in Bondowoso, while the treatment of ZA fertilizer at 500 kg.ha^{-1} or 25 g per plant (N1) obtained an average diameter of 2.43 cm in Jember and 2.50 cm in Bondowoso. Meanwhile, the plants without ZA treatment had an average diameter of 2.30 cm in Jember and 2.35 cm in Bondowoso. The effect of increasing ZA fertilizer doses on the stem diameter oin Jember and Bondowoso is presented in Figure 2.

Sugarcane stems are segmented, along with internodes that have buds that will grow into new plants. Normally, one bud can appear in each segment. The treatment of ZA fertilizer at a dose of 1000 kg.ha^{-1} or 50 g per plant (N2) produced an average number of segments of 17.33 in Jember and 16.00 in Bondowoso. The treatment of ZA fertilizer at a dose of 500 kg.ha^{-1} or 25 g per plant (N1) resulted in an average number of segments of 17.42 in Jember and 15.42 in Bondowoso, while the plants without ZA treatment had an average number of segments of 15.67 in Jember and 14.58 in Bondowoso. The effect of increasing the ZA fertilizer doses on the number of segments in Jember and Bondowoso is presented in Figure 3.

Sugarcane productivity per unit of land is determined by the ability of plants to form saplings. Figure 4 shows that the treatment of ZA fertilizer at a dose of

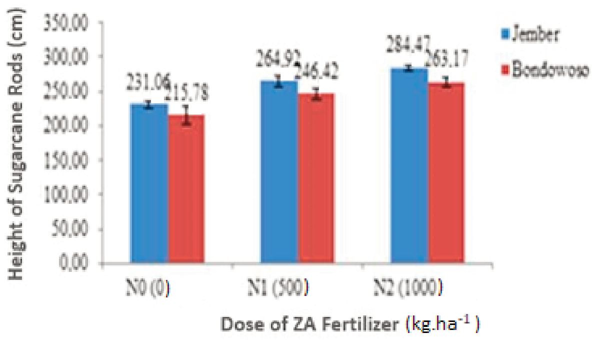

Figure 1. Effect of ZA fertilizer doses on average height of sugarcane stems (cm) in Jember and Bondowoso

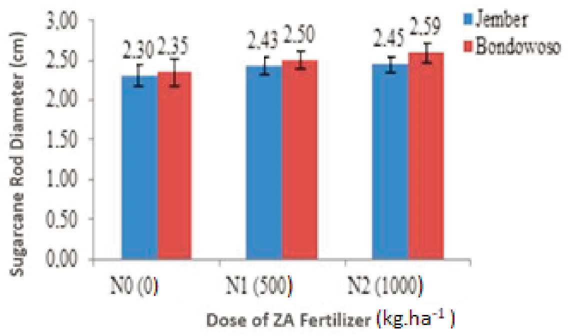

Figure 2. Effect of ZA fertilizer doses on average sugarcane stem diameter (cm) in Jember and Bondowoso

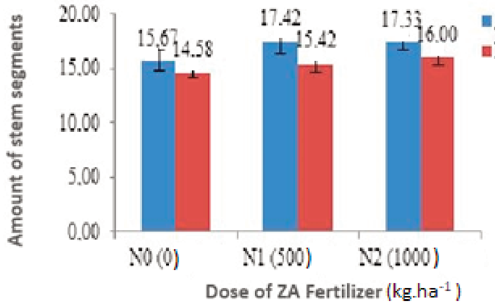

Figure 3. Effect of ZA fertilizer doses on average number of sugarcane stem segments in Jember and Bondowoso

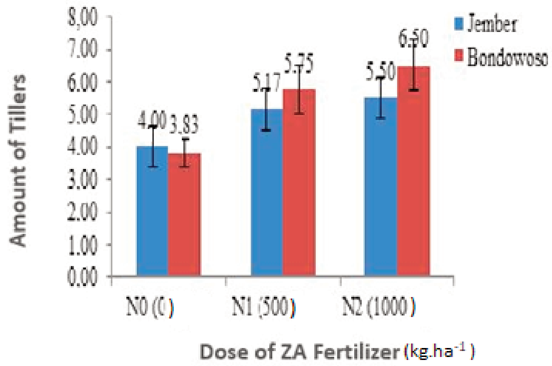

Figure 4. Effect of ZA fertilizer doses on average number of sugarcane tillers in Jember and Bondowoso

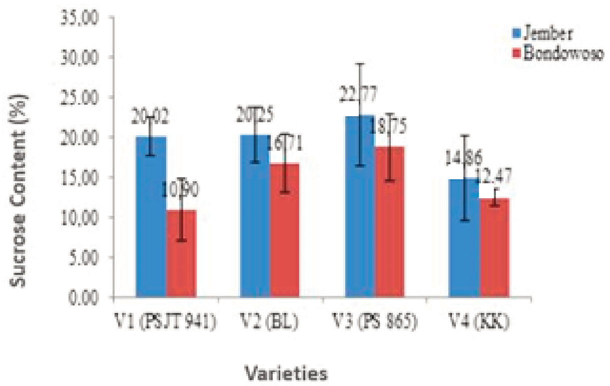

Figure 5. Effect of sugarcane cultivars on sucrose content in Jember and Bondowoso

1000 kg.ha^{-1} or 50 g per plant (N2) resulted in an average number of tillers of 5.50 in Jember and 6.50 in Bondowoso, and the treatment of ZA fertilizer at 500 kg.ha^{-1} or 25 g per plant (N1) obtained an average of 5.17 in Jember and 5.75 in Bondowoso. Meanwhile, the plants without ZA treatment had an average number of tillers of 4.00 in Jember and 3.83 in Bondowoso.

Effect of Cultivars

Sugarcane plants with high sucrose content will produce high yields. Figure 5 presents the sucrose content of the sugarcane crops in Jember and Bondowoso. The sucrose content of the sugarcane in Jember was 20.02% in cultivar PSJT 941 (V1), 20.25% in cultivar Bululawang (V2), 22.77 % in cultivar PS 865 (V3), and 14.86% in cultivar Kidang Kencana (V4). Meanwhile in Bondowoso, the sucrose content of cultivar PSJT 941 (V1), Bululawang (V2), PS 865 (V3) and Kidang Kencana (V4) was 10.90%, 16.71%, 18.75% and12.47%, respectively.

Based on the results, there was no interaction effect between the treatment of ZA fertilizer and cultivars. It is known that cultivar PS 865 (V3) has resistance to flooding in different locations, followed by cultivar Bululawang (V2), PSJT 941 (V1) and Kidang Kencana (V4). This is indicated by the higher sucrose content compared to other cultivars, as shown in Figure 5.

The treatment of ZA fertilizer at a dose of 1000 kg.ha^{-1} or 50 g per plant produced a better response of morphological and physiological characteristics compared to other treatments. Kharisma *et al.* (2013) stated that the treatment of NPK compound fertilizer at a dose of 400 kg.ha^{-1} and ZA fertilizer at a dose of 800 kg.ha^{-1} on sugarcane was the most effective treatment to produce a larger stem diameter.

Plants absorb nitrogen in the form of nitrate (NO_3 NO) and ammonium ($NH_4{}^+$). The relative efficiency of ammonium and nitrate absorption is influenced by soil pH and soil redox potential. Nitrate fertilizer is very mobile, quickly absorbed in the form of nitrate ions (NO^{3-}), and easily leached. Nitrogen in the form of nitrates can move up with capillary water during the dry season. Ammonium is not easily leached because this cation is bound by clay particles, making it not easily leached but still available for plants.

CONCLUSIONS

The application of ZA fertilizer at 1000 kg.ha^{-1} or 50 g per plant produced optimum response of morphological and physiological characteristics of four flood-tolerant sugarcane cultivars in two different locations. Cultivar PS 865 has the potential to be able to produce high sucrose if planted on wetlands compared to other cultivars.

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