A NEW FORMULATED SILICON FERTILISER FOR BETTER SUGARCANE PRODUCTION

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Abstract

SILICON (Si) is an important beneficial element for sugarcane and is absorbed by sugarcane, more than any other mineral nutrient. Si is known to promote sugarcane yield, enhance resistance to biotic and abiotic stresses, improve leaf and stalk erectness, and increase P availability. A new Si fertiliser namely SiPlusHS was formulated from sugar mill boiler ash, furnace slag, rock phosphate, zeolite, oxalic acid and humic substance. It formed granules of 3–5 mm in diameter and contained 8–10% soluble Si, 10–12% soluble phosphate and 3–5% humic substance. The effectiveness of this fertiliser was tested under field conditions on irrigated and non-irrigated sugarcane areas, covering areas of 1 and 2 ha, respectively. The fertiliser was applied at the rate of 0, 250 and 500 kg/ha. Results showed that application of 250 kg/ha SiPlusHS could increase cane yield from 2 to 52% and sugar yield by as much as 15–58%. There were no significant differences between applications of 250 kg/ha and 500 kg/ha SiPlusHS. In some areas, SiPlusHS could significantly decrease stem borer attacks. Recently, this new silicon fertiliser has been tested on about 1000 ha in various regions in Indonesia.

Introduction

Sugarcane is an important cash crop in Indonesia and is grown over about 440 000 hectares to produce 2.65 million tonnes of sugar. The average sugar productivity in Indonesia is about 6.17 t/ha, and is the lowest among the sugarcane growing countries of the world. The average of sugar productivity is much lower than its potential yield as, in some areas, sugar productivity could reach 11.0 t/ha (Toharisman, 2009a). Unbalanced and inappropriate fertiliser use seems to be one of the factors responsible for low sugar productivity in Indonesia. Sugarcane fertilisation is still focussed on the use of nitrogen (N), phosphorus (P), and potassium (K).

Sugarcane is capable of rapidly depleting soil nutrients, particularly Si. The aerial parts of an adequately fertilised 12 months old sugarcane crop have been reported to absorb 500–700 kg/ha of Si, compared with 100–300 kg/ha of N, 40–80 kg/ha of P, and 100–300 kg/ha of K (Anderson, 1991). It is thus clear that for the long term and sustainable use of sugarcane lands, the removal of such large quantities of Si has to be balanced by adequate inputs of Si in the form of silicon fertilisers. The removal of Si could be even more important under intensive sugarcane cultivated areas in Indonesia. Mulyadi *et al.* (2005) reported that the main sugarcane areas in Java are deficient in Si. Matichenkov and Calvert (2002) reported that Si deficiency in sugarcane would not only cause a reduction in sugar yield but would also reduce disease and pest resistance and reduce the tolerance to biotic and abiotic stresses.

Boiler ash and furnace slag can be a source of Si to sugarcane soils in Indonesia but, in view of its low Si availability, a high rate of 1–3 t/ha would be required. In this context, the Indonesian Sugar Research Institute developed a new Si fertiliser namely SiPlusHS, using boiler ash and furnace slag supplemented with rock phosphate and humic substances. The object of this study was to evaluate the effects of SiPlusHS on sugarcane yields in different climatic zones in Indonesia.

Materials and methods

Silicate fertiliserformulation

SiPlusHS was prepared by mixing boiler ash (20%), furnace slag (15%), zeolite (10%), rock phosphate (52%), humic substances (2%) and oxalic acid (1%). The addition of oxalic acid enhances the solubility of Si. The mixture was left overnight and was granulated to produce granules of 3–5 mm in diameter. The granulated formulation contained 22–25% of SiO_2, 14–17% of P_2O_5 and 2% of humic substance.

Fertiliser application

Field experiments were conducted to evaluate the effect of SiPlusHS in the rainfed upland areas at Bungamayang Sugar Factory (SF), Lampung, and Tersana Baru SF, West Java as well as in irrigated areas at Tjukir SF, East Java. At Bungamayang SF, SiPlusHS was applied at three rates (1, 250 and 500 kg/ha) in combination with urea, TSP, KCl and dolomite (Table 1). Each treatment was replicated three times in a randomised complete block design. Each plot consisted of 10 cane rows, 50 m long and spaced at 1.3 m.

At Tersana Baru and Tjukir SF, silicate fertiliser was applied at two rates (0 and 250 kg/ha) and each plot size was 2 ha. At planting, all the Si, 30% of urea, and 100% of TSP were applied in the furrows and the remaining 70% of urea and 100% of MOP were applied 2 months after sowing of cane setts. Sugarcane variety PS 864 was planted at Bungamayang SF, whereas varieties PS 851 and PA 190 were planted at Tersana Baru SF and Tjukir SF, respectively. The growth, yield and quality parameters were measured at appropriate stages of growth of sugarcane using standard procedures.

Table 1—Rates of fertilisers applied at Bungamayang SF.

Treatment	Rate (kg/ha)				
	Urea	TSP	KCl	Dolomite	SiPlusHS
I	300	350	300	2500	250
II	300	350	300	2500	500
III	300	250	300	2500	250
Control	300	350	300	2500	0

Results and discussions

As shown in Table 2, the application of SiPlusHS fertiliser increased cane and sugar yields at Bungamayang SF. The highest sugar yield (5.60 t/ha) was obtained at 500 kg/ha of SiPlusHS, compared to the control treatment where no SiPlusHS was applied. There was no significant difference in sugar yields between treatments II and III.

The data also suggest that SiPlusHS could reduce phosphate fertiliser (treatment III), from 350 to 250 kg/ha of TSP. Indeed Mulyadi *et al.* (2005) reported that Si promotes the transformation of slightly soluble phosphates into plant-available phosphates. The increase in sugar yield with the addition of SiPlusHS was associated with a rise of sugar content (rendement) and cane yield. The average sugar yield at Bungamayang SF in 2007/2008 growing season was about 4.8 t/ha.

Table 2—Cane yield, rendement and sugar yield as affected by SiPlusHS treatments at Bungamayang SF.

Treatment	Cane yield (t/ha)	Rendement (%)	Sugar yield (t/ha)
I	86.83 a	6.15 ab	5.34 ab
II	87.77 a	6.38 b	5.60 b
III	87.19 a	6.09 ab	5.31 ab
Control	86.51 a	5.78 a	5.00 a

Field experiments at Tjukir and Tersana Baru SF also showed similar results to the experiment at Bungamayang SF (Table 3). The application of 250 kg/ha of SiPlusHS at Tjukir SF increased sugar yield by 58.1%, whereas at Tersana Baru the increase was about 15.6%. The effect of Si on irrigated land on sugar yield was higher than that in the upland area. Soil moisture seems to play an important role in Si solubility (McKeague and Cline, 1963).

Table 3—Cane yield, rendement and sugar yield as affected by SiPlusHS treatments at Tjukir and Tersanabaru SFs.

Sugar factory area	SiPlusHS (kg/ha)	Cane yield (t/ha)	Rendement (%)	Sugar yield (t/ha)
Tjukir	0	103.98 a	8.04 a	8.36 a
	250	157.76 b	8.38 b	13.22 b
Tersana Baru	0	85.61 a	7.02 a	6.01 a
	250	87.53 a	7.94 b	6.95 b

Si fertiliser could also increase resistance of sugarcane to shoot and stem borers, as indicated in Table 4. In the control plots, shoot and stem borers attacked about 1.17% and 0.81% of sugarcane, respectively. The addition of Si could dramatically reduce shoot borer between 10–76% and stem borer between 48–79%. The presence of Si crystals in shoot and stem tissues of plants acts as a defence against feeding by insects having a rather fragile mandible. High levels of Si in tissues of sugarcane plant would confer a higher level of resistance to infections by pests as reported by Elawad *et al*. (1985). Toharisman *et al.* (2009b) also reported that the application of SiPlusHS at Jatitujuh, Karangsuwung and Subang SF areas could reduce shoot and stem borers by 75%.

Table 4—Borer incidence with SiPlusHS treatments at Bungamayang SF.

Treatment	Borer incidence	
	Shoot (%)	Stem (%)
I	0.91	0.23
II	0.28	0.17
III	1.05	0.42
Control	1.17	0.81

At this time, the new Si fertiliser has been widely used in almost 1000 ha of sugarcane areas in Indonesia, including East Java, Central Java, West Java, Lampung and South Sumatera Provinces.

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UNE NOUVELLE FORMULATION D'ENGRAIS A BASE DE SILICIUM POUR UNE MEILLEURE PRODUCTION DE CANNE A SUCRE

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MOTS-CLES: Engrais à base de Silicium, Cendre de Chaudière, Scorie de Four, Substance humique, Productivité de la Canne à Sucre.

Résumé

LE SILICIUM (Si), un élément important pour la canne à sucre, est absorbé en quantités plus importantes que pour les autres éléments. Si améliore les rendements de la canne, augmente sa résistance aux stress biotiques et abiotiques, améliore la rigidité de sa tige et de ses feuilles et accroît la disponibilité en phosphore. SiPlusHS a été formulé à partir de cendres provenant des chaudières de sucrerie, de scories de four, de phosphate de calcium naturel, de zéolite, d'acide oxalique et de substance humique. Cette formulation est constituée de granules de 3 à 5 mm de diamètre et contient 8 à 10% de Si soluble, 10 à 12 % de phosphate soluble et 3 à 5% de substance humique. L'efficacité de cet engrais a été testée sur des cultures de canne à sucre en conditions irriguées et pluviales et sur des surfaces respectives de 1 et 2 ha. L'engrais fut épandu aux doses de 0, 250 et 500 kg/ha. Les résultats ont montré qu'une application de 250 kg/ha de SiPlusHS pouvait accroître les rendements canne de 2 à 52% et augmenter le tonnage de sucre /ha de 15 à 58%. Il n'y pas eu de différence significative entre les applications de 250 et 500 kg/ha de SiPlusHS. Dans certaines zones, SiPlusHS a pu diminuer significativement les attaques de borer de la tige. Récemment, cette nouvelle formulation a été testée sur environ 1000 ha dans différentes régions d'Indonésie.

UNA NUEVA FORMULACIÓN DE FERTILIZANTE SILÍCICO PARA UNA MEJOR PRODUCCIÓN DE CAÑA DE AZÚCAR

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PALABRAS CLAVE: Fertilizante Silícico, Ceniza de la Caldera, Residuos del Incinerador de la Caldera, Substancias Húmicas, Productividad de Caña de Azúcar.

Resumen

EL SILICIO (Si) es un elemento benéfico importante para la caña de azúcar y la planta lo absorbe más que cualquier otro nutriente mineral. Se sabe que el silicio promueve el rendimiento de la caña de azúcar, aumenta la resistencia a estreses bióticos y abióticos, promueve la formación de hojas y tallos erectos y aumenta la disponibilidad de fósforo. Se formuló un nuevo fertilizante silícico, denominado SiPlusHS, a partir de ceniza proveniente de la caldera del ingenio, residuos del incinerador de la caldera, roca de fosfato, zeolita, ácido oxálico y substancias húmicas. Se formaron gránulos de 3–5 mm de diámetro que contenían 8–10% de Si soluble, 10–12% de fosfato soluble y 3–5% de sustancias húmicas. Se evaluó la efectividad de este fertilizante bajo condiciones de campo en áreas cultivadas con caña de azúcar con y sin riego, de 1 y 2 ha, respectivamente. El fertilizante se aplicó en dosis de 0, 250 y 500 kg/ha. Los resultados muestran que la aplicación de 250 kg/ha de SiPlusHS podría incrementar el rendimiento de caña de 2 a 52% y el rendimiento de azúcar en 15–58%. No hubo diferencias significativas entre aplicaciones de 250 y 500 kg/ha de SiPlusHS. En algunas áreas, el SiPlusHS podría disminuir significativamente el ataque de barrenador. Este fertilizante se evaluó recientemente en aproximadamente 1000 ha en varias regiones de Indonesia.