ISSN 2808-3229
Journal of Biodiversity and Biotechnology. 5(2), 51–56,
2025 URL: https://jurnal.uns.ac.id/jbb/article/view/111756
doi: http://dx.doi.org/10.20961/jbb.v5i2.111756

The Effect of Various Fertilizer Doses on Sugarcane Seed Growth and Productivity

Deny Bagus Surendra[1]*, Dony Agung Wicaksono[1], Febry Ari Marpaung[2], Nanik Tri Ismadi[1]

[1]Sugarcane Research Center Sukosari, Jatiroto, Lumajang, Indonesia
[2]PT Sinergi Gula Nusantara (Sugar Company), Jakarta, Indonesia

*Corresponding Author: denybagussurendra12@gmail.com

Abstract
Fertilization plays a crucial role in promoting plant growth, increasing yield, and improving crop quality. Current fertilization recommendations for sugarcane are generally based on production-oriented cultivation with a 12-month growth period, while specific fertilization requirements for seed sugarcane remain insufficiently studied. This study aimed to determine the optimal fertilizer dosage for sugarcane seed by evaluating the effects of different fertilizer combinations on plant growth and productivity. The research was conducted at the Experimental Farm of Puslit Sukosari. The experimental area covered 0.046 ha, with planting rows 8 m in length and a row factor of 1042 rows/ha. Four fertilizer treatments were applied: (A) ZA 640 kg/ha, SP 36 48.1 kg/ha, and KCl 255 kg/ha; (B) ZA 531 kg/ha, SP 36 40 kg/ha, and KCl 213 kg/ha; (C) ZA 427.5 kg/ha, SP 36 31.9 kg/ha, and KCl 171 kg/ha; and (D) ZA 321.3 kg/ha, SP 36 23.9 kg/ha, and KCl 129 kg/ha. The results showed that increasing fertilizer dosage did not result in a linear increase in seed sugarcane productivity. The highest seed productivity and optimal growth performance, including the number of stalks, stalk height, stalk diameter, and seed weight per hectare, were obtained under Treatment B. In contrast, the lowest productivity was observed under Treatment D. Considering both fertilization efficiency and production costs during the vegetative growth phase, seed sugarcane plantations may be fertilized using the complete fertilizer combination in Treatment B or solely with nitrogen fertilizer at a rate of ZA 531 kg/ha.

Keywords: Fertilization, Nitrogen, Productivity, Seed Sugarcane, Vegetative Growth

Cite this as: Surendra, D.B., Wicaksono, D.A., Marpaung, F.A., Ismadi, N.T. (2025). The Effect of Various Fertilizer Doses on Sugarcane Seed Growth and Productivity. 5(2), 51–56. doi: http://dx.doi.org/10.20961/jbb.v5i2.111756

Introduction

Sugarcane (*Saccharum officinarum* L.) is one of the most essential plantation commodities in tropical and subtropical regions, including Indonesia. Approximately 65% of the world's sugar production comes from sugarcane. The need for cane-based sugar in Indonesia continues to increase year after year, both for direct consumption of sugar and as a raw material for the food and beverage industry (1). In addition to sugar production, sugarcane is also utilized in the pharmaceutical and food industries, as well as in other sectors that use by-products of sugar processing, such as livestock feed, paper manufacturing, and as a raw material for biofuel (ethanol) production. The demand for sugar in Indonesia continues to increase in line with population growth; however, a decline in sugar production from sugarcane has been observed in recent years. Sugarcane also plays a vital role in the national economy by providing extensive employment opportunities for the Indonesian people (2). Improper nutrient management is a primary constraint on sugar production. This includes the application of sub-optimal fertilizer rates (reduced dosage), asynchronous application that fails to match crop demand (improper timing), the use of imbalanced or inappropriate fertilizer sources (fluctuating quality), and a lack of integrated nutrient strategies that maintain soil health (limited soil conservation). These poor practices are directly linked to decreased nutrient use efficiency, lower cane tonnage, and reduced sugar yield (3).

In addition, the use of low-quality seed canes, inadequate technical cultivation practices, poor transportation management, and suboptimal agronomic techniques also contribute to the decline in production.

Sugarcane production and productivity do not only depend on genotypic factors (varieties) and crop cultivation management practices, but also relate to biotic and abiotic environments that can be affected by climate change (4). Climate change affects global food production and agricultural productivity, both directly and indirectly (5). Climate change triggers various abiotic and biotic stresses that ultimately threaten agricultural production and global food security (6). This issue is important to note because food security is one of the strategic issues in achieving sustainable development (7). Climate change can increase the incidence of drought, water deficits, desertification, and evapotranspiration, ultimately reducing crop yield potential and cultivable land area for agriculture (8). The use of superior seed canes is essential to enhance productivity as part of efforts to achieve national sugar self-sufficiency. Continuous improvement in the quality of seed canes is necessary to improve production performance. The determination of fertilizer dosage, either inorganic or organic, should ideally be based on soil analysis results, followed by leaf analysis to evaluate the effectiveness of the applied fertilizer. Currently, fertilizer recommendations for sugarcane cultivated for 12 months after planting (MAP) are generally determined based on soil and leaf analysis of the field to be planted.

Fertilizer is a substance applied to ensure the availability of nutrients for sugarcane plants, which is essential to support vegetative growth, as well as to increase production quantity and sugar yield quality (9). Balanced fertilization is critical for farmers because its application is closely related to both cost efficiency and the effectiveness of fertilizers in supporting plant growth and yield. The current fertilizer recommendations are primarily designed for sugarcane cultivated for milling (production) with a growth period of 12 months. In contrast, detailed studies on fertilizer requirements for seed sugarcane have not yet been conducted. Therefore, to determine more precisely the fertilizer requirements for seed sugarcane cultivation, this study was carried out to examine the effects of fertilizer dosage on the growth performance of seed sugarcane plants. Sugarcane requires sufficient nutrients in adequate amounts to grow and develop optimally (10).

The research problem in this study is to determine which combination of single fertilizers, nitrogen (N), phosphorus (P), and potassium (K), produces the highest growth performance in seed sugarcane plants, and to evaluate how different combinations of these single fertilizers affect the growth of seed sugarcane (11)(12). This challenge is particularly acute in Indonesian seed production systems, where imbalanced single nutrient applications often result in suboptimal vegetative development, such as reduced tiller formation and stem elongation in bud chip seedlings, due to varying soil nutrient baselines in nursery sites (13).

Material and Methods

Location and Time

This research was conducted at the Sukosari Experimental Station of the Sugar Research Center (Puslit Sukosari), located within the Jatiroto Sugar Estate (HGU PG. Jatiroto), Sukosari Plantation Block 3, from March 2023 to September 2023 (a duration of six months). The experimental area covered 0.046 hectares, with a row length of 8 meters and a row factor of 1,042 rows per hectare. The experimental layout and field design were arranged as illustrated in the following figure:

D	C	B	A
B	A	D	C
C	B	A	D

Figure 1. Plotting and Experimental Layout in the Field

Materials and Tools

The materials used in this study included:

- ✓ Two-budded sugarcane setts (seed cuttings) of the VMC 7616 variety.
- ✓ Single fertilizers consisting of ammonium sulfate (ZA), superphosphate (SP-36), and potassium chloride (KCl), each applied at different dosage levels according to the treatment combinations.

Table 1. Fertilizer Dosage per Treatment

No	Treatment	Fertilizer Dose Per Ha		
		ZA	SP36	KCL
1.	A	640	48	255
2.	B	531	40	213
3.	C	427	32	171
4.	D	321	24	129

- ✓ Herbicides with active ingredients 2,4-D and Ametryn, applied at dosages of 1.5 L/ha and 2.0 L/ha, respectively.

Results and Discussion

Germination Phase

The germination phase in sugarcane begins when the previously dormant buds on the seed setts start to grow into young shoots equipped with leaves, stems, and roots. This stage is strongly influenced by internal factors of the seed cane, such as variety, seed age, number of buds, length of cuttings, seed placement orientation, pest and disease infection, and nutrient availability. It is referred to as the tillering phase because, during this period, sugarcane exhibits vigorous horizontal growth characterized by the gradual formation of new shoots, starting from primary to tertiary tillers. At this stage, lateral growth continues until the maximum number of shoots is reached, typically around three months after planting. Although the emergence of new shoots dominates the tillering process, the growth pattern is also physically represented by the formation of leaves, roots, and stems. Table 2 presents the average number of sugarcane shoots (*Saccharum officinarum* L.) and the percentage of germination at 1.5 months after planting (MAP) based on field observations.

Table 2. Average number of sugarcane shoots (*Saccharum officinarum* L.) and percentage of germination at 1.5 months after planting (MAP) based on field observation

No	Treatment	Number of Buds Planted (per ha)	Number of Shoots (per ha)				Germination (%)
			Rep. 1	Rep. 2	Rep. 3	Mean	
1	A	54.528	32.092	28.968	31.524	30.861 a	57
2	B	54.528	34.648	32.376	30.104	32.376 a	59
3	C	54.528	29.536	32.092	34.364	32.997 a	59
4	D	54.528	37.204	31.524	37.204	35.311 a	65

Note: Numbers followed by the same letter in the same row or column group are not significantly different according to the Least Significant Difference (LSD) test at the 5% significance level. Treatment A (ZA 640 kg/ha, SP-36 48.1 kg/ha, KCl 255 kg/ha); Treatment B (ZA 531 kg/ha, SP-36 40.0 kg/ha, KCl 213 kg/ha); Treatment C (ZA 427.5 kg/ha, SP-36 31.9 kg/ha, KCl 171 kg/ha); and Treatment D (ZA 321.3 kg/ha, SP-36 23.9 kg/ha, KCl 129 kg/ha)

Based on the results of the analysis of variance (ANOVA) at a 95% confidence level, the treatments showed no significant effect on the number of sugarcane shoots at 1.5 months after planting (MAP). This was indicated by the P-value of 0.233 (> 0.05) in the ANOVA table. The highest average number of shoots per hectare at 1.5 MAP was observed in treatment D, which produced 35.311 shoots per hectare with a germination percentage of 65%. A study by Supandji et al. (14) found that the application of various doses of ZA fertilizer did not show a significant effect on the percentage of sugarcane bud germination at the initial observation. Tillering, as part of the vegetative growth process, is strongly influenced by various intrinsic factors within the sugarcane plant, including genetic characteristics and the hormonal balance that regulates bud development. In addition, extrinsic environmental factors such as sunlight intensity, water availability, nutrient supply, and temperature also play a crucial role in determining the success and vigor of shoot emergence. When environmental temperatures rise, the rate of evaporation from the soil surface and transpiration from leaves increases, thereby accelerating the loss of water reserves that are essential for plants (15).

Vegetative Growth

Lateral growth, characterized by the emergence of new shoots, ceased at around three months after planting (MAP). In other words, the number of shoots reached its maximum at approximately three months of age. At this stage, sugarcane plants began to enter the stem elongation phase, which became the dominant growth process during this period. This condition is heavily influenced by the complex interaction between the plant's intrinsic genetic potential (genotype) and the extrinsic environmental conditions (E), often studied as a Genotype x Environment (GxE) interaction (16). The following table presents the average number of sugarcane stalks observed at three months after planting (3 MAP).

Table 3. Average number of stalks and stalk height of sugarcane (*Saccharum officinarum* L.) at three months after planting (3 MAP)

Treatment	Number of Stalks (per ha)				Stalk Height (cm)			
	Rep. 1	Rep. 2	Rep. 3	Mean	Rep. 1	Rep. 2	Rep. 3	Mean
A	51.120	30.195	40.328	40.548 a	47.66	56.33	50.66	51.55 ab
B	53.392	41.748	40.044	45.061 a	61.33	54.00	57.66	57.66 a
C	42.884	43.736	44.588	43.736 a	47.66	55.33	47.66	50.22 ab
D	45.724	42.600	38.340	38.813 a	55.33	35.00	42.66	44.33 b
Mean	45.724	39.570	40.825	42.040	53.00	50.17	49.66	50.94
BNT 5%				NS				NS

Note: Numbers followed by the same letter in the same row or column group are not significantly different according to the Least Significant Difference (LSD) test at the 5% significance level. Treatment A (ZA 640 kg/ha, SP-36 48.1 kg/ha, KCl 255 kg/ha); Treatment B (ZA 531 kg/ha, SP-36 40.0 kg/ha, KCl 213 kg/ha); Treatment C (ZA 427.5 kg/ha, SP-36 31.9 kg/ha, KCl 171 kg/ha); and Treatment D (ZA 321.3 kg/ha, SP-36 23.9 kg/ha, KCl 129 kg/ha).

Based on the results of the analysis of variance (ANOVA) at a 95% confidence level, the treatments showed no significant effect on the average number of sugarcane stalks at three months after planting (3 MAP). This was indicated by the P-value of 0.656 (> 0.05) in the ANOVA table. The highest average number of stalks at 3 MAP was observed in treatment B with 45.061 stalks per hectare, followed by treatment C (43.736 stalks/ha), treatment A (40.548 stalks/ha), and treatment D (38.813 stalks/ha). Similarly, for the parameter of average stalk height, the ANOVA results at the 95% confidence level also indicated no significant effect among treatments at 3 MAP. The highest average stalk height was recorded in treatment B, reaching 57.66 cm, which was greater than that observed in the other treatments.

The process of stalk elongation essentially represents a growth phase supported by the development of several plant components, including leaf canopy expansion, root development, and stem elongation itself. Two dominant factors influence the stalk elongation phase: differentiation and internode elongation, both of which are strongly influenced by limiting environmental factors such as sunlight intensity, water availability, and nutrients (especially nitrogen), as well as the plant's internal physiological factors (17). The results of observations on vegetative growth parameters, including the number of stalks, stalk height, and stalk diameter at six months after planting (6 MAP), are presented in Table 4 below.

Table 4. Vegetative Growth Performance of Sugarcane (*Saccharum officinarum L.*) at 6 Months After Planting and Stem Borer Infestation Level

Treatment	Number of Stalks per Hectare	Stalk height	Stalk diameter	Average number of internodes per stalk	Stalk weight	Stem borer infestation (%)
A	49.675 ab	172 a	2.59 a	9.1 a	456.3 ab	34.4 a
B	56.843 a	173 a	2.64 a	8.7 ab	521.9 a	12.2 a
C	52.912 ab	169 a	2.63 a	8.1 ab	470.7 ab	16.7 a
D	40.023 b	170 a	2.59 a	7.9 a	364.4 b	14.4 a
Mean	49.863	171	2.61	8.5	453.3	19.4
BNT 5%	NS	NS	NS	NS	NS	NS

Note: Numbers followed by the same letter in the same row or column group are not significantly different according to the Least Significant Difference (LSD) test at the 5% significance level. Treatment A (ZA 640 kg/ha, SP-36 48.1 kg/ha, KCl 255 kg/ha); Treatment B (ZA 531 kg/ha, SP-36 40.0 kg/ha, KCl 213 kg/ha); Treatment C (ZA 427.5 kg/ha, SP-36 31.9 kg/ha, KCl 171 kg/ha); and Treatment D (ZA 321.3 kg/ha, SP-36 23.9 kg/ha, KCl 129 kg/ha)

The analysis of variance results for the parameters of stalk number, stalk height, stalk diameter, average number of internodes, stalk weight, and borer infestation at 6 months after planting (6 MAP) showed that the fertilizer dosage treatments, as presented in Table 6 above, had no significant effect on any of these parameters. Similarly, in field trials with inorganic fertilizer applications, higher doses beyond a certain threshold failed to produce notable differences in stalk height, diameter, and weight per stalk compared to moderate doses, indicating a plateau in vegetative responses (18). The highest average number of stalks per hectare was found in treatment B (56.842 stalks/ha), followed by treatment C (52.912 stalks/ha), treatment A (49.675 stalks/ha), and treatment D (40,023 stalks/ha). The average stalk height from the highest to the lowest was 173 cm (treatment B), 172 cm (treatment A), 170 cm (treatment D), and 169 cm (treatment C). The highest average stalk diameter was observed in treatment B (2.64 cm), followed by treatment C (2.63 cm), treatment A (2.59 cm), and treatment D (2.59 cm). These three parameters, stalk number, stalk height, and stalk diameter, showed no positive correlation, meaning that increasing the combined doses of N, P, and K fertilizers did not result in higher values for each parameter, and vice versa. This pattern aligns with findings from trials on new sugarcane varieties under standard NPK applications, where fertilizer doses beyond moderate levels (e.g., 400 kg/ha Phonska) exhibited no significant linear increases in stalk metrics, attributed to plateauing nutrient uptake efficiency in tropical soils (19).

The number of stalks per hectare, stalk height, and stalk diameter are components that are directly proportional in supporting the total stalk weight per hectare. The average stalk weight (quintals/ha), or in other words, the productivity per hectare as shown in the table above, indicates that Treatment B produced the highest productivity of 521.9 quintals/ha, followed by Treatment C (470.7 quintals/ha), Treatment A (456.3 quintals/ha), and Treatment D (364.4 quintals/ha). Regarding the parameter of stem borer infestation in sugarcane at 6 months after planting (MAP), the table above shows that the highest infestation level of 34.4% occurred in Treatment A, while Treatment B showed only 12.2% infestation. Treatments C and D experienced infestation levels of 16.7% and 14.4%, respectively.

Conclusions

The results of this study indicate that increasing fertilizer dosage does not lead to a proportional increase in sugarcane seedling productivity. The highest productivity was achieved under Treatment B, with fertilizer application rates of ZA 531 kg ha^{-1}, SP 36 40 kg ha^{-1}, and KCl 213 kg ha^{-1}. In contrast, the lowest productivity was observed under Treatment D, which applied ZA 321.3 kg ha^{-1}, SP 36 23.9 kg ha^{-1}, and KCl 129 kg ha^{-1}. Optimal seedling growth, as reflected by the number of stalks, plant height, stem diameter, and seed weight per hectare, was also obtained with the fertilizer combination used in Treatment B. Considering both cost efficiency and fertilization effectiveness during the vegetative growth phase of sugarcane seedlings, it is recommended that seed nurseries apply either complete fertilization at the rates used in Treatment B or nitrogen fertilization alone in the form of ZA at a dosage of 531 kg ha^{-1}.

References

[1] Putra RP, Ranomahera MRR, Rizaludin MS, Supriyanto R, Dewi VAK. Investigating the environmental impacts of long-term monoculture of sugarcane farming in Indonesia through the DPSIR framework. Biodiversitas J Biol Divers. 2020;21(10).

[2] Putra RP, Ranomahera MRR, Arini N, Afrianto WF. Tindakan pengembalian residu panen tebu untuk meningkatkan kualitas tanah dan produktivitas tebu (*Saccharum officinarum* L.). Buletin Tanaman Tembakau Serat Minyak Industri. 2021;13(1):48.

[3] Abhiram G, Gopalasingam T, Inthujan J. Enhancing sustainability in sugarcane production through effective nitrogen management: a comprehensive review. Nitrogen. 2025;6(3):69.

[4] Putra RP, Dewi VAK, Rahma MJ. Strategi adaptasi dan mitigasi perubahan iklim pada perkebunan tebu rakyat di Indonesia: tinjauan literatur. Agroteknika. 2025;8(2):382–408.

[5] Zhu P, Burney J, Chang J, Jin Z, Mueller ND, Xin Q, et al. Warming reduces global agricultural production by decreasing cropping frequency and yields. Nat Clim Change. 2022;12(11):1016–1023.

[6] Arifien Y, Putra RP, Wibaningwati DB, Anasi PT, Masnang A, Rizki FH, Indrawati E. Pengantar Ilmu Pertanian. Padang: Get Press; 2022.

[7] Faizah N, Haris A, Muhajirin A, Putra RP. Analisis potensi ekonomi pertanian perkotaan oleh Kelompok Wanita Tani Puspitasari Kota Semarang. J Pertanian Agros. 2024;26(2):1396–1407.

[8] Onyeneke RU, Nwajiuba CA, Emenekwe CC, Nwajiuba A, Onyeneke CJ, Ohalete P, Uwazie UI. Climate change adaptation in the Nigerian agricultural sector: a systematic review and resilience check of adaptation measures. AIMS Agric Food. 2019;4(4):967–1006.

[9] Kusumawati A, Rahman I, Ekawati R. Respon pertumbuhan tebu (*Saccharum officinarum* L.) pada kedalaman juringan dan dosis pupuk P yang berbeda. AGROISTA J Agroteknologi. 2022;6(1):52–60. doi:10.55180/agi.v6i1.230.

[10] Puspitasari AR, Ariyani D, Putra RP. Aplikasi pupuk nano cair pada fase pertumbuhan vegetatif tebu. Indonesian Sugar Research Journal. 2023;3(2):64–71.

[11] Apriscia CY, Barunawati N, Wicaksono KP. Pengaruh pemberian pupuk kompos limbah domestik terhadap pertumbuhan vegetatif tanaman tebu (*Saccharum officinarum* L.) asal bibit bud chip. Plantropica J Agric Sci. 2018;1(2).

[12] Rahman I, Ekawati R, Kusumawati A. Respons pertumbuhan tebu (*Saccharum officinarum* L.) pada kedalaman juringan dan dosis pupuk P yang berbeda. AGROISTA J Agroteknologi. 2022;6(1):52–60.

[13] Palmasari SR, et al. Respons pertumbuhan bibit tanaman tebu (*Saccharum officinarum* L.) pada pemberian pupuk organik dan pupuk anorganik. Klorofil J Penelitian Ilmu-Ilmu Pertanian. 2021;16(2):1–8.

[14] Supandji, Muharram M, Agusty V, Yuliana L. Pengaruh pemberian dosis pupuk ZA terhadap pertumbuhan awal tanaman tebu (*Saccharum officinarum*) varietas PS 80-148. Agrotrop J Agric Sci. 2024;14:126. doi:10.24843/AJoAS.2024.v14.i01.p14.

[15] Dai X, Yu Z, Matheny AM, Zhou W, Xia J. Increasing evapotranspiration decouples the positive correlation between vegetation cover and warming in the Tibetan Plateau. Front Plant Sci. 2022;13:974745.

[16] Rahardiansyah W, Budi S, Lailiyah W. Agronomic performance and sugar yield potential of seven promising sugarcane (*Saccharum officinarum* L.) clones in second ratoon cultivation. Jurnal Ilmiah Pertanian. 2025;22:45–56.

[17] Kusumawati A, Ismail MRI. Analisis faktor pembatas pertumbuhan tebu (*Saccharum officinarum* L.) di Cangkringan, Yogyakarta. AGROISTA J Agroteknologi. 2023;6(2):93–100.

[18] Ridwan AF, Widodo WD. Pertumbuhan dan hasil tebu (*Saccharum officinarum* L.) keprasan pertama pada residual kompos blotong dan residual pupuk anorganik. J Agronomi Indonesia. 2022;50(3):357–364.

[19] Wibisono VB, Avivi S, Ubaidillah M, Hartatik S. Morphological, physiological, and molecular characteristics of tolerant sugarcane to waterlogging stress. J Agronomi Indonesia. 2022;50(2):217–224. doi:10.24831/jai.v50i2.40760.