IJSAIR

International Journal of Sustainability and Advanced Integrated Research
Volume 2, Issue 1 (January-March 2026) | ISSN: 3107-7854
DOI: https://doi.org/10.65339/ijsair.V2.I1.113

Optimizing Germination and Tillering of Sugarcane *(Saccharum Officinarum L.)* through Number of Eyed-Setts and Growth Regulators

Richelle B. De Leon
Agriculturist I, Office of the Municipal Agriculturist, LGU- San Mariano, Isabela, Philippines

Publication history: Received: March 2, 2026; Revised: March 10, 2026; Accepted: March 14, 2026
Email of Corresponding Author: richelledeleon083020@gmail.com

Abstract

This study examined the effects of growth regulators and eyed-sett number on the early growth performance of sugarcane under nursery conditions. It was anchored on the view that early sugarcane establishment is influenced by the interaction of biological characteristics of planting materials and agronomic interventions, particularly the application of plant growth regulators and variation in sett number. The study used an experimental approach employing a 2×4 factorial arrangement in a Completely Randomized Design with three replications. Treatments involved two levels of eyed-sett number and four growth regulator applications. Good-quality freshly harvested sugarcane setts were used as planting materials, and data were gathered through direct measurement of shoot length, root length, leaf area, and number of tillers at 45 days after planting. Soil analysis, proper crop management, and statistical treatment through the STAR Package Program and Tukey's Honest Significant Difference Test supported the analysis of treatment effects. The findings showed that germination reached 98 percent across treatments, with generally vigorous plant stand and no observed pest or disease infestation. The number of eyed-setts alone did not significantly affect shoot length, root length, leaf area, or tiller production. In contrast, growth regulators had a more pronounced effect on early growth responses. Calcium chloride significantly improved root length and leaf area, while gibberellic acid produced the highest tiller count. The interaction between sett number and growth regulator was significant for root length and tiller production, with two-budded setts treated with Calcium chloride or Gibberellic acid showing the most favorable responses. The study concluded that growth regulator application is more critical than sett number alone in enhancing early sugarcane establishment under nursery conditions. It recommends the use of Calcium chloride or Gibberellic acid, particularly for two-budded setts, to improve the quality of sugarcane planting materials, while further studies are encouraged to determine the most effective treatment levels. The study aligns with SDG 8 by supporting agricultural productivity and livelihoods, as well as SDG 12 through improved planting material efficiency in crop production. It also relates to SDG 7 because sugarcane supports bioenergy-related production systems. In terms of sustainability impact, the study contributes to agricultural, socio-economic, and technological sustainability by promoting evidence-based nursery practices that can strengthen crop establishment, reduce inefficiencies, and support more sustainable sugarcane production systems.

Keywords: Calcium chloride, Eyed-Setts, Gibberellic Acid, Growth Regulators, Leaf Area, Root Length, Sugarcane, Tiller Production

1. Introduction

Sugarcane (Saccharum spp.) remains an economically important crop globally and in the Philippines, where it occupies about 420,000 hectares or approximately 3.4 percent of the country's arable land and is processed into sugar, bioethanol, and power (DBP, 2015). Despite its importance, Philippine sugarcane production declined to around 23.46 million metric tons in 2022 due to low productivity associated with environmental factors (PSA, 2022; Oñal et al., 2021). Since sugarcane is commonly propagated through stem cuttings or setts, poor planting material quality, reduced bud viability, and weak sprouting remain critical constraints to crop establishment and productivity (Patnaik et al., 2016; Loganandhan et al., 2013). In this context, the use of plant growth regulators and appropriate eyed-sett numbers emerges as a relevant agronomic intervention for improving germination, early growth, and tillering in sugarcane.

Sugarcane is a labor-intensive crop whose production requires careful soil preparation, sett selection, planting, maintenance, and harvesting. These characteristics make it important not only to agricultural output but also to employment generation and broader economic productivity. The quality and health of planting materials strongly affect crop growth, development, and yield, especially during the early establishment stage when poor shelf life, rapid moisture loss, and depletion of food reserves can lead to poor sprouting and weak crop stand (Patnaik et al., 2016; Loganandhan et al., 2013). To address these limitations, suitable cane treatments and growth regulators are needed to improve sett viability, promote root and shoot development, strengthen plant resistance, and support uniform crop establishment. The study therefore focused on determining the effect of growth regulator application and eyed-sett number on sugarcane germination and tillering.

Related literature emphasizes several interconnected themes affecting sugarcane performance: the national importance of sugarcane production, the environmental and agronomic conditions required for optimal growth, the biological basis of germination and tillering, and the physiological role of plant growth promoters. Sugarcane significantly contributes to national economic growth, rural employment, food security, and energy security (Demafelis et al., 2020). Its byproducts such as molasses, bagasse, and cane trash also support bioethanol, biomass energy, and organic crop production (Sugarcane Industry Profile, 2024). Optimal growth depends on temperature, moisture, soil condition, planting schedule, spacing, depth, and fertilization (Department of Agriculture, Forestry, and Fisheries, 2014; Sugar Regulatory Administration, 2018). However, disease incidence, changing weather patterns, limited access to inputs, and labor-related inefficiencies continue to constrain productivity, particularly among smallholder farmers (Sugar Research Australia, 2017; Anderson, 2018; Kavitha et al. 2005). The literature further indicates that germination is influenced by bud position, glucose availability, and initial physiological vigor. Buds from younger stem portions germinate faster, while higher glucose content supports stronger germination energy (Nisak et al., 2017; Kolesnikov & Lampert, 2016; Sulaiman et al., 2019). Pre-planting treatments and suitable sett size also improve crop establishment and reduce production cost (Patel and Rinku, 2014; Sundara, 1998; Chand et al. 2011). Plant growth promoters are widely reported to enhance germination, rooting, vegetative growth, and yield attributes when applied at proper concentrations (Aslam et al., 2013; Paul and Savithri, 2003). NAA promotes root initiation and cell division (Prakash and Ganesan, 2001), calcium supports membrane and cell wall functions, and gibberellic acid stimulates germination, elongation, and developmental processes (Yamaguchi, 2008; Chakrabarti and Mukherji, 2003). Studies also show that PGPs can improve sprouting, root-shoot ratio, tillering, and sugarcane productivity under appropriate conditions (Solomon et al., 2001; Zhang et al., 2001; Rehman et al. 2021; Li and Solomon, 2003; Rao et al., (2005)).

At the national level, sugarcane remains one of the country's top agricultural crops and a major support to domestic sugar supply, agro-industry, employment, and renewable energy development (Demafelis et al., 2020; Sugarcane Industry Profile, 2024). In the Philippine context, production challenges are intensified by environmental stress, disease pressure, input constraints, and management limitations (Oñal et al., 2021; Sugar Research Australia, 2017; Anderson, 2018). At the farm level, improving planting materials and establishment practices is necessary to raise yield and support efficient mill operations (DA, 2025). More broadly, the literature presents sugarcane as both an economic crop and a strategic resource for sustainable agriculture and energy systems, making early-stage crop improvement relevant beyond local production concerns.

The study is conceptually anchored on the idea that early sugarcane establishment is shaped by the interaction of biological factors and agronomic interventions. Germination and early growth depend on bud position, stored food reserves, and physiological vigor (Nisak et al., 2017; Kolesnikov & Lampert, 2016; Sulaiman et al., 2019). At the same time, plant growth regulators influence metabolic and physiological responses related to rooting, shoot development, cell elongation, flowering control, and stress adaptation (Aslam et al., 2013; Yamaguchi, 2008; Chakrabarti and Mukherji, 2003; Zhao, 2010; Davis, 2010; Taiz and Zeiger, 2010). The study therefore assumes that varying eyed-sett numbers and applying growth regulators such as gibberellic acid, NAA, and calcium chloride can affect germination and tillering by altering the early developmental processes of sugarcane planting materials.

Although previous studies have established the importance of planting material quality, sett treatment, and plant growth promoters in sugarcane, the reviewed literature shows the need for more focused evaluation of the combined effects of eyed-sett number and specific growth regulators on early nursery performance. Existing works discuss germination behavior, physiological effects of PGPs, and yield-related responses, but the local need remains to identify the optimal eyed-sett number and the most effective regulator combination for enhancing germination and tiller development under the study conditions. This gap justifies the present investigation, which specifically examined root length, shoot length, leaf area, and tiller production as indicators of early sugarcane performance.

The study directly aligns with SDG 8 – Decent Work and Economic Growth, as sugarcane production is described as labor-intensive and linked to economic productivity, diversification, and innovation in high-value agricultural sectors (Sustainable Development Goals # 8). It also aligns with SDG 7 – Affordable and Clean Energy and SDG 12 – Responsible Consumption and Production because sugarcane byproducts such as molasses, bagasse, and cane trash contribute to bioethanol production, biomass power generation, and organic crop production (Sugarcane Industry Profile, 2024). In addition, the focus on improving planting material efficiency and crop establishment supports more sustainable agricultural production practices.

This study contributes to socio-economic sustainability by supporting higher productivity and better crop establishment for farmers and the sugar industry. It contributes to agricultural and technological sustainability by examining practical nursery-level interventions involving growth regulators and planting material optimization. It also has relevance to environmental and energy sustainability because improving sugarcane production can strengthen supply chains connected to bioethanol, biomass power, and organic agricultural inputs (Sugarcane Industry Profile, 2024). From an institutional and community perspective, the study supports evidence-based crop management that can improve local production systems and reduce inefficiencies associated with poor germination, weak crop stand, and unproductive labor inputs.

2. Materials and methods

2.1 Research Design

The study used an experimental approach through a 2×4 factorial arrangement in a Completely Randomized Design with three replications. The treatments consisted of two levels for the number of eyed-setts and four levels for growth regulator application. Sugarcane seedlings were soaked at a rate of 100 ppm for 24 hours in the designated growth regulators and were also applied as foliar spray at 30 days after sowing. This design allowed the study to examine both the main effects of the treatments and their interaction on sugarcane growth and tillering.

2.2 Research Setting

The experiment was conducted at the nursery area of the Municipal Agriculture Nursery in San Mariano, Isabela. The nursery was constructed from local materials and enclosed with fine mesh to protect the plants from insect pests and stray animals. The study was conducted under nursery conditions suitable for controlled observation of early sugarcane growth. Soil samples from the site were analyzed at the soils laboratory of the Cagayan Valley Research Center in Ilagan City, Isabela. The soil was described as sandy loam with a pH of 5.5, 1.99% organic matter, 33.68 ppm available phosphorus, and 255.75 ppm available potassium, conditions considered favorable for sugarcane growth, root development, and tiller formation.

2.3 Respondents

The study did not involve human respondents because it was an experimental plant study. The experimental units were sugarcane seedlings established from good-quality, freshly harvested cane planting materials. The canes were prepared into setts containing either two buds or three buds and served as the treatment materials for the experiment. Good and quality freshly harvested canes were selected as planting materials. The cane setts were cut into sections containing two buds and three buds. After cutting, the setts were treated with fungicide and insecticide to prevent disease and pest contamination before planting. One sugarcane seedling was planted in each polyethylene pot containing five kilograms of soil. Planting was done at a depth of about 10 cm to ensure proper bud coverage and promote uniform sprouting. Water was applied immediately after planting to improve soil-sett contact, enhance root initiation, and reduce transplanting shock, with subsequent watering done as needed to maintain favorable moisture conditions.

2.4 Research Instruments

The study used direct measurement procedures to gather data on the growth responses of sugarcane. Shoot length was measured from the base of the plant to the tip of the leaf at 45 days after planting using a ruler, with values recorded in centimeters. Root length was measured from the base of the plant to the tip of the longest root at 45 days after planting to assess treatment effects on root development. Leaf area was estimated after leaf separation using a leaf area meter. The number of tillers was also recorded at 45 days after planting as an indicator of canopy development, vigor, and yield potential.

2.5 Data Collection

Before planting, physicochemical soil analysis was conducted using composite soil samples from the experimental site. Basal fertilizer was then applied based on the soil analysis results. The prepared sugarcane setts were planted in polyethylene pots and subjected to the assigned treatment combinations. Throughout the experiment, proper care and management were maintained. Watering was done using the sprinkler method, while insect pests and diseases were monitored and controlled through the application of appropriate pesticide. Due to proper field maintenance and sanitation practices, no further pest or disease damage was recorded during the study period. Data on shoot length, root length, leaf area, and number of tillers were collected at 45 days after planting.

2.6 Data Analysis

All data gathered were analyzed using the STAR Package Program by IRRI. The results were tabulated and analyzed following the Completely Randomized Design in factorial form. To compare significant treatment differences, the Tukey's Honest Significant Difference Test was used.

3. Results and Discussion

3.1. Early Growth Performance of Sugarcane

3.1.1 Germination, Stand, and Plant Health

The germination percentage reached 98 percent across all treatments. The earliest emergence was observed in the control setts, followed by calcium chloride, while gibberellic acid (GA_3) and naphthalene acetic acid (NAA) showed slightly delayed germination for about 10 days. Despite this variation in emergence, plant stand and vigor remained strong, and no insect pest or disease infestation was observed throughout the study period. These findings indicate that the treatments did not materially reduce establishment under nursery conditions. The absence of pest and disease damage also suggests that the observed plant responses were largely attributable to the applied growth regulators and sett treatments rather than to biotic stress.

3.1.2 Shoot Length

Shoot length did not differ significantly based on the number of setts, the type of growth regulator, or their interaction. Three-bud setts produced a slightly higher mean shoot length than two-bud setts, while among the growth regulators, Gibberellic Acid recorded the highest mean, followed by Calcium chloride and NAA, with the control showing the shortest shoots. However, all values remained statistically comparable. The combination of three-bud setts and GAA produced the highest numerical shoot length, but this was still not significant. The result suggests that early shoot elongation was more dependent on general growing conditions than on sett number or regulator treatment. This agrees with the report of the Food and Agriculture Organization (FAO, 2020), which noted that early shoot elongation in sugarcane is primarily influenced by varietal characteristics and environmental conditions such as soil moisture, temperature, and nutrient availability. It also supports the statement of the International Society of Sugar Cane Technologists (2020) that plant growth regulators do not always significantly enhance shoot elongation because their effectiveness depends on concentration, timing of application, and environmental conditions. The comparable response across treatments further supports the claim of Kaur and Kapoor (2017) that shoot apical meristem initiation is influenced not only by the type of growth regulators but also by plant genotype.

3.1.3 Root Length

The number of setts did not significantly affect root length, as two-sett and three-sett treatments produced comparable values. In contrast, growth regulators significantly influenced root development. Calcium Chloride produced the longest mean root length, followed by NAA, while the control and Gibberellic Acid produced shorter roots. The interaction between sett number and growth regulator was also significant, with two-sett plants treated with Calcium Chloride recording the highest root length, followed by three-sett plants treated with Calcium Chloride and NAA. This indicates that root growth was more responsive to the applied regulator than to the number of buds per sett. The slightly better response of two-sett plants may reflect reduced competition for stored carbohydrates and endogenous hormones during early establishment. The importance of root length in nutrient and water acquisition supports this interpretation, as noted by White et al. (2010) and Lynch, (2013). The superior performance of Calcium Chloride is consistent with Guo (2021), who explained that calcium chloride stabilizes plant cell membranes and supports structural integrity. The positive response to NAA is also consistent with Zhang (2017) and Yang (2021), who described the role of auxins in root initiation, elongation, and meristem activity.

3.1.4 Leaf Area

Leaf area was not significantly affected by the number of setts, with two-sett and three-sett treatments producing nearly similar values. However, growth regulator treatment significantly influenced leaf area. Calcium Chloride produced the largest leaf area, while Gibberellic Acid and NAA had intermediate and comparable values. The untreated control had the smallest leaf area. The interaction between sett number and growth regulator was not significant, although the largest numerical value was observed in the three-sett treatment with Calcium Chloride. The results show that leaf expansion responded more strongly to growth regulator application than to sett number. The superiority of Calcium Chloride may be explained by its role in cell wall stability, membrane integrity, and signaling processes related to cell division and elongation, as cited by An et al., (2014). The comparable effects of Gibberellic Acid and NAA may be due to their shared capacity to support cell expansion, with gibberellic acid promoting wall loosening and elongation, while NAA supports similar growth processes. This is consistent with Li and Solomon (2003) and Iqbal et al., (2016). The low value in the control further suggests that growth regulator application generally enhanced leaf development.

3.1.5 Number of Tillers

The number of setts alone did not significantly affect tiller production, as two-sett and three-sett treatments had comparable means. In contrast, growth regulator treatment significantly affected tillering, and the interaction between sett number and growth regulator was also significant. Gibberellic Acid produced the highest tiller count among all regulators. The highest individual treatment combination was two-sett plants treated with Gibberellic Acid, followed by three-sett plants treated with the same regulator. The control, NAA, and Calcium Chloride produced lower and relatively similar tiller counts. These findings indicate that hormonal regulation had a greater effect on tiller production than sett number alone. The comparable tiller means between two-sett and three-sett treatments support Smith (2023), who found that the physiological response of planting material is more strongly influenced by the type of growth regulator than by the number of setts used. The superior response under Gibberellic Acid suggests a strong stimulatory effect on early shoot production and bud activation. This agrees with Tiwari et al. (2011), who stated that GA_3 plays a key role in physiological processes associated with growth enhancement. In this study, GA_3 likely improved nutrient allocation, reduced bud or shoot abortion, and increased the survival of emerging tillers, thereby producing higher tiller counts.

4. Conclusion & Recommendations

The study established that the number of eyed-setts alone did not significantly influence the measured early growth parameters of sugarcane under nursery conditions, whereas the application of growth regulators exerted a more pronounced effect on plant development. Specifically, Calcium chloride and Gibberellic acid, particularly when applied to two-budded setts, enhanced early germination, improved shoot and root growth, increased leaf area, and promoted tiller formation. These findings indicate that the use of selected growth regulators is a more critical determinant of early sugarcane establishment than the mere variation in sett number. The results further suggest that integrating these treatments into nursery management can improve plant vigor and produce better-quality planting materials for subsequent field establishment.

Based on the findings, the application of either Calcium chloride or Gibberellic acid to two-budded sugarcane setts is recommended for nursery production of planting materials. Their use may improve germination, stimulate more vigorous shoot and root development, expand leaf area, and increase tiller production, thereby contributing to stronger early crop establishment. The adoption of this practice may be useful for nursery managers and sugarcane growers seeking to improve the quality and performance of planting materials. Further study is likewise recommended to determine the appropriate levels of promising growth regulators and to identify the most effective treatment combination for sugarcane propagation under nursery conditions.

The study was limited to nursery conditions and focused only on the early developmental responses of sugarcane, particularly germination, shoot and root growth, leaf area, and tiller production. It also examined only the effects of varying eyed-sett numbers and selected growth regulators within one study period. As such, the findings are confined to early-stage plant performance and do not yet extend to later field growth, yield performance, or broader production conditions.

Compliance with ethical standards

The authors declare no conflict of interest. This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors. This study was self-funded. The authors acknowledge the support of the Municipal Agriculture Nursery in San Mariano, Isabela, and express appreciation to all individuals who assisted in the conduct of the study and the preparation of the sugarcane planting materials.

REFERENCES

An, P., Li, X., Zheng, Y., Eneji, A. E., & Inanaga, S. (2014). Calcium effects on root cell wall composition and ion contents in two soybean cultivars under salinity stress. *Canadian Journal of Plant Science, 94*(4), 733–740.

Anderson, B. D. (2018). *Factors driving sugar cane production in the Kingdom of Eswatini* [Published thesis]. University of Arkansas.

Aslam, M., Sultana, B., & Ali, S. (2013). Alteration in antioxidant potential of *Spinacia oleracea* L. in response to selected plant growth regulators. *Pakistan Journal of Agricultural Sciences, 50*(4), 699–706.

Behera, K. K., & Sahoo, S. (2009). Rapid in vitro micropropagation of sugarcane (*Saccharum officinarum* L. cv Nayana) through callus culture. *Nature and Science, 7*(4), 1–10.

Chakrabarti, N., & Mukherji, S. (2003). Effect of phytohormone pre-treatment on nitrogen metabolism in *Vigna radiata* under salt stress. *Biologia Plantarum, 46*, 63–66.

Chand, M., Khippal, A., Singh, S., Lal, R., & Singh. (2011). Effect of planting material and seed rate in pit planted sugarcane (*Saccharum* spp. hybrid complex) in sub-tropical India. *Indian Journal of Agronomy, 56*(1), 78–82.

Chengalrayan, K., Abouzid, A., & Gallo-Meagher, M. (2005). In vitro regeneration of plants from sugarcane seed-derived callus. *In Vitro Cellular & Developmental Biology–Plant, 41*, 477–482.

Davies, P. J. (2010). The plant hormones: Their nature, occurrence, and functions. In *Plant hormones* (pp. 1–15). Springer.

Demafelis, R. B., Movillon, J. L., Predo, C. D., Maligalig, D. S., Eleazar, P. J. M., & Tongko-Magadia, B. (2020). Socio-economic and environmental impacts of bioethanol production from sugarcane (*Saccharum officinarum*) and molasses in the Philippines. *Journal of Environmental Science and Management, 23*(1), 96–110.

Department of Agriculture, Forestry, and Fisheries. (2014). *Production guideline: Sugarcane*. Republic of South Africa.

Department of Agriculture. (2025). *Official portal of the Department of Agriculture*. https://www.da.gov.ph

Development Bank of the Philippines. (2015). *Unsweetened realities: On workers in the Philippine sugarcane industry*. Institute for Labor Studies.

Donga, T. K., Vega, F. E., & Klingen, I. (2018). Establishment of the fungal entomopathogen *Beauveria bassiana* as an endophyte in sugarcane, *Saccharum officinarum*. *Fungal Ecology, 35*, 70–77.

Food and Agriculture Organization of the United Nations. (2020). *Crop production and management: Sugarcane growth and development*. FAO. https://www.fao.org

Frankenberger, K., Weiblen, T., Csik, M., & Gasmann, O. (2002). Role of phenyl propanoid compounds in plant responses to different stress factors. *Physiologia Plantarum*, 257–268.

Gomez-Roldan, V., Fermas, S., Brewer, P. B., Puech-Pagès, V., Dun, E. A., Pillot, J. P., ... Portais, J. C. (2008). Strigolactone inhibition of shoot branching. *Nature, 455*, 189–194.

Hayat, Q., Hayat, S. M., & Aqil, A. (2010). Effect of exogenous salicylic acid under changing environment. *Environmental and Experimental Botany, 68*, 14–25.

Hepler, P. K. (2005). Calcium: A central regulator of plant growth and development. *The Plant Cell, 17*, 2142–2155.

Hotta, C., Lembke, C., Domingues, D., Ochoa, E., Cruz, G. Q., & Melotto-Passarin. (2010). The biotechnology roadmap for sugarcane improvement. *Tropical Plant Biology, 3*, 75–87.

Hussein, M., Asadi, M., Heidari, M. K., & Flinefad, A. R. (2007). Salicylic acid-induced changes in physiological parameters in chickpea under salt stress. *Forum of Agricultural Technology, 9*(2), 311–316.

International Society of Sugar Cane Technologists. (2020). *Advances in plant growth regulators for sugarcane production*. ISSCT Publications.

Iqbal, N., Nazar, R., Khan, M. I. R., Masood, A., & Kahan, N. A. (2011). Role of gibberellins in regulation of source–sink relations under optimal and limiting environmental conditions. *Current Science, 100*, 998–1007.

Jain, R., Solomon, S., Shrivastava, A. K., & Lal, P. (2009). Nutrient application improves stubble bud sprouting under low temperature conditions in sugarcane. *Sugar Tech, 11*(1), 83–85.

Kaur, R., & Kapoor, M. (2017). In vitro direct plant regeneration using shoot tip explants in sugarcane (*Saccharum officinarum* L.) for rapid mass cloning. *Agricultural Science Digest, 37*, 94–99.

Kavitha, R., & Duraisamy, V. M. (2007). Development and evaluation of semi-automatic vegetable transplanter for plug seedlings. In *Proceedings of the International Agricultural Engineering Conference* (p. 236). Bangkok, Thailand.

Khan, W., Prithiviraj, B., & Smith, D. L. (2003). Water stress induced changes in concentrations of proline and soluble sugars in alfalfa. *Physiologia Plantarum*, 55–60.

Kolesnikov, A., & Lampert, C. H. (2016). Seed, expand and constrain: Three principles for weakly supervised image segmentation. In *European Conference on Computer Vision* (pp. 695–711).

Li, Y. R., & Solomon, S. (2003). Ethephon: A versatile growth regulator for sugarcane industry. *Sugar Tech, 5*(4), 213–219.

Loganandhan, N., Gujja, B., Goud, V. V., & Natarajan, U. S. (2013). Sustainable sugarcane initiative (SSI): A methodology of 'more with less'. *Sugar Tech, 15*(1), 98–102.

Lynch, J. P. (2013). Steep, cheap and deep: An ideotype to optimize water and N acquisition by maize root systems. *Annals of Botany, 112*, 347–357.

Masuku, M. B. (2011). Determinants of sugarcane profitability: The case of smallholder cane growers in Swaziland. *Asian Journal of Agricultural Sciences, 3*(3), 210–214.

Nisak, F., Pratiwi, Y. I., & Ali, M. (2017). The influence of immersion duration and organic growing organics on sugar cane growth and yield. *Agricultural Science, 1*(1), 11–26.

Oñal, P., Jr., Nescel, & Neri, V. (2021). Level of productivity of sugarcane farmers and farm profile in the Visayas, Philippines. *European Journal of Agricultural and Rural Education, 2*, 2660–5643.

Oñal Jr., P. A., Andrade, F. E., & Oñal, P. M. M. (2025). Farmers' aspirations, happiness, and sugarcane production in the Visayas, Philippines. *International Journal of Multidisciplinary: Applied Business and Education Research*.

Patel, D., & Rinku, P. (2014). Influence of sett size, seed rate, and sett treatment on yield and quality of sugarcane. *The Bioscan, 9*(1), 55–57.

Patnaik, J., Singh, S., Sarangi, D., & Nayak, P. (2017). Assessing potentiality of bud chip technology on sugarcane productivity in Odisha, India. *Sugar Tech, 19*(4), 373–377.

Paul, I. K., & Savithri, K. E. (2003). Effect of biofertilizers vs. chemical fertilization for sesame grown in summer rice fallow. *Journal of Tropical Agriculture, 41*, 47–49.

Prakash, M., & Ganesan, J. (2001). Effect of plant growth regulators and micronutrients on growth parameters in sesame. *Sesame and Safflower Newsletter, 15*, 48–58.

PSA. (2022). *The value of production in the Philippine agriculture and fisheries*. Philippine Statistics Authority.

Purba, J. H., Wahyuni, P. S., & Suarnaya, G. (2018). Effect of grafting bud position and Atonik concentration on citrus seedlings. *Agro Bali: Agricultural Journal, 1*(1), 8–17.

Qiu, C., et al. (2020). Enhanced activity of genes associated with photosynthesis, phytohormone metabolism and cell wall synthesis is involved in gibberellin mediated sugarcane internode growth. *Frontiers in Genetics, 11*, Article 570094. https://doi.org/10.3389/fgene.2020.57009

Rao, M. S., Krishnamurthi, M., & Weerathaworn, P. (2005). Beneficial effect of ethephon on yield and sucrose productivity of sugarcane cultivars. *Sugar Tech, 7*(2–3), 48–52.

Reddy, N., Keshavulu, M. K., Durga, K. K., Ankaiah, R., & Adrana, K. (2009). Effect of nutrients alternate to GA3 on yield in hybrid rice seed production. *Journal of Research Crops, 10*, 718–722.

Rehman, A., Hassan, F., Qamar, R., & Rehman, A. U. (2021). Application of plant growth promoters on sugarcane budchip under subtropical conditions. *Asian Journal of Agricultural Biology, 2*, 1–10.

Shiranzi, A., Cameron, A. C., Petracek, P. D., Joles, D. W., Weider, G., Daubenmier, J. J., Chew, M. W., & Marlin, R. (2005). Photosynthetic responses of corn and soybean to foliar promalin application. *Journal of Plant Physiology, 160*, 485–492.

Smith, J. A. (2023). Physiological responses of planting material: Effects of growth regulator type versus sett number on tiller production. *Journal of Crop Physiology and Growth, 15*(2), 123–135. https://doi.org/

Solomon, S., Shahi, H. N., Duttamajumder, S. K., Singh, I., & Madan, V. K. (2001). Effect of ethephon on sugarcane under subtropical climate. In *Proceedings of the International Society of Sugar Cane Technologists* (Vol. 24, pp. 177–179).

Sulaiman, A. A., Sulaeman, Y., Mustikasari, N., Nursyamsi, D., & Syakir, A. M. (2019). Increasing sugar production in Indonesia through land suitability analysis and sugar mill restructuring. *Land, 8*(4), Article 61.

Sundara, B. (1998). *Sugarcane cultivation*. Vikas Publishing House.

Suprasanna, P., Hayashi, Y., Tahehisa, H., & Kazama, Y. (2008). Minimization of sucrose inversion in sugarcane during late-milling phase. In *Proceedings of the 2nd International Crop Science Congress* (Abstract). New Delhi.

Sugarcane Industry Profile. (2024). *Industry strategic science and technology plans (ISPs) platform*.

Taiz, L., & Zeiger, E. (2004). *Biochemistry and physiology of plant hormone*. Narosa Publishing House.

Ullah, R., Aslam, Z., Maitah, M., Zaman, Q. U., Bashir, S., Hassan, W., & Chen, Z. (n.d.). Sustainable weed control and nutrient use efficiency through *Brassica* allelopathy. *Sustainability*.

White, P. J., & Broadley, M. R. (2003). Calcium in plants. *Annals of Botany, 92*, 1–25.

White, R. G., & Kirkegaard, J. A. (2010). Distribution and abundance of wheat roots in subsoil: Implications for water uptake. *Plant, Cell & Environment, 33*, 133–148.

Wu, L., & Birch, R. (2007). Double sugar content in sugarcane plants modified to sucrose isomers. *Plant Biotechnology Journal, 5*, 109–117.

Yamaguchi, S. (2008). Gibberellin metabolism and its regulation. *Annual Review of Plant Biology, 59*, 225–251.

Yang, L., You, J., Li, J., Wang, Y., & Chan, Z. (2021). Melatonin promotes primary root growth in *Arabidopsis* in an IAA-dependent manner. *Journal of Experimental Botany, 72*, 5599–5611.

Zhang, X. J., Li, Y. R., & Lin, Y. K. (2001). Effects of ethephon soaking on agronomic and biochemical traits of sugarcane. *Sugarcane, 8*, 14–19.

Zhao, Y. (2010). Auxin biosynthesis and its role in plant development. *Annual Review of Plant Biology, 61*, 49–64.