ASEAN
Journal of Scientific and Technological Reports
Online ISSN:2773-8752

Research article

Early Root Development and Yield Performance of Different Corn (*Zea mays* L.) Varieties Under Alkaline Soil

Elvira D. Jamio[1*], Bernie C. Bacalso[1], Noriel Jay A. Magsayo[1], Melissa I. Canunayon[1], Daniel B. Tangpos[1], Julius D. Caritan[1], and Pet Roey L. Pascual[2]

[1] Graduate School, Cebu Technological University – Barili Campus, Barili, Cebu, 6036, Philippines
[2] Agribusiness and Development Communication, Cebu Technological University– Barili Campus, Barili, Cebu, 6036, Philippines
* Correspondence: jamioelvira28@gmail.com

Citation:
Jamio, D.E.; Bacalso, C.B.; Pascual, L.P.R. Early root development and yield performance of different corn (*Zea mays* L.) varieties under alkaline soil. *ASEAN J. Sci. Tech. Report.* **2026**, *29*(2), e259735. https://doi.org/10.55164/ajstr.v29i2.259735.

Article history:
Received: June 10, 2025
Revised: October 11, 2025
Accepted: November 15, 2025
Available online: January 20, 2026

Abstract: Early root vegetative stages of corn are critical in transitioning to the independent phase, wherein roots support development and improved nutrient uptake that may influence yield. Thus, the study assessed the root development of different corn varieties at the vegetative 4 (V4) stage and its relationship to yield, and to evaluate its performance under alkaline soil using a Randomized Complete Block Design. Data on root morphological traits were measured at the V4 stage, while yield parameters were assessed after harvest. Data were analyzed using ANOVA in RCBD, and the relationship between early root growth and yield was assessed using Pearson's correlation. The results showed that varieties TCT 476A and TCT 1868 significantly outperformed, producing higher yields across parameters, with computed yields of 9.23 t/ha and 9.27 t/ha, respectively, while CGUARD VII-002 exhibited reduced performance, having significantly lower yield. Results demonstrated that differences in yield performance among varieties can be attributed to genotype-environment interactions. Moreover, root morphological traits at the V4 stage showed no significant differences, indicating that all varieties exhibit comparable root morphological characteristics at this stage. However, root morphological traits at the V4 stage revealed no significant linear relationship with yield and yield components, suggesting that the early vegetative stage is not a reliable predictor of yield. The findings highlight that the V4 stage primarily supports establishment rather than yield formation, and fertilizer application strategies must align with efficient nutrient demand to optimize yield. Further research on later stages of root development is suggested to corroborate the preliminary findings.

Keywords: V4 stage; corn; alkaline soil, root morphological traits, yield performance

1. Introduction

Corn (*Zea mays* L.), a member of the Poaceae family, is the most widely produced and consumed cereal globally, with multiple uses primarily for feed and food crops [1]. According to the USDA (United States Department of Agriculture), worldwide corn production in 2024 was 1.23 billion metric tons, with the United States, China, and Brazil being the top-producing countries [2]. In the Philippines, corn is considered the second most important crop after rice [3], with a production decrease of 0.3% from 2.533 to 2.526 metric tons in the third quarter of 2024. In Cebu, corn is a vital component of the rural community, with the white corn variety predominantly grown for human consumption, underscoring its significance to the local diet and economy [4]. The diverse uses of corn, including its significant role in human consumption, industrial purposes, and livestock feed, solidify it as a fundamental commodity that plays a vital role in global food security [5]. Environmental condition plays a significant role in crop production. Abiotic stresses are one of the constraints that substantially limit corn production growth and development [6]. According to the study of [7], maize grown in saline-alkaline soil can experience a yield reduction of 20-46% and inhibit root penetration. In alkaline soil conditions, the utilization of essential nutrients by plants is limited due to decreased solubility. The edaphic condition in Barili, Cebu, Philippines, exhibits an alkaline pH above 7.5 and a CaCO3 content greater than 70%, resulting from a limestone parent material, as reported by [8].

The root system sustains plant life by anchoring in the ground and serving as a storage organ, absorbing and translocating water and nutrients from the soil, which are the primary fuel for plant productivity. Reports from [9] highlighted that root growth is little influenced by external pH in the range of 5.0–7.5. Abiotic stress factors may influence the growth and development of crops at any stage. In corn, the critical growth phase occurs during the vegetative stages of V4, V6, and V8, during which plants can take up nutrients and water that directly influence the crop yield, according to [10]. Notably, the V4 stage marks the onset of rapid dry matter accumulation, during which available resources directly influence biomass and reproductive potential. At this phase, the plant shifts from relying on seed reserves to actively absorbing nutrients through the newly developed nodal roots. This process initiates stalk elongation, which establishes the structural and physiological foundation necessary for succeeding growth and optimal yield formation [11, 12]. This is supported by [13], which states that the root-to-shoot ratio of cereal crops is significantly affected by plant age, being higher during the vegetative growth stage (21-40 days of growth period), indicating that more photosynthetic products are translocated to the roots and decrease during the reproductive or grain-filling stage. At this stage, the mesocotyl root plays a crucial role below the soil, which is accompanied later by nodal roots [14]. The mesocotyl is described as a structure similar to the stem in young maize seedlings that links the first true leaves and the seed. Its primary role is to facilitate the development of the shoot from the soil surface by securing the seedling as it emerges, allowing it to begin photosynthesis, which permits the plant to access light and establish itself more efficiently. Additionally, mesocotyl roots exhibit a distinct response to abiotic stress [15]. Meanwhile, nodal roots serve as the foundation of the whole root system, making the uptake of water and nutrients efficient.

These root systems are essential for the better transition in order to achieve optimal development and productivity of crops, ensuring they can prosper in diverse soil conditions. However, the majority of previous studies have focused on shoot development, while only a few have assessed the yield by examining root systems. Therefore, this study aims to evaluate the development of roots at the vegetative 4 (V4) stage of different corn varieties and their relationship with yield, and to evaluate varieties that potentially performed well under alkaline soil conditions. It is hypothesized that enhanced root development at the V4 stage will lead to increased dry matter accumulation and yield.

2. Materials and Methods

2.1 Experimental Site

The study was conducted at Cebu Technological University – Barili Campus, Barili, Cebu, Philippines, located at coordinates 10°07′53″ N, 123°32′45″ E from September 2024 to January 2025. The soil in the area is classified as alkaline with a pH above 7.5.

2.2 Land Preparation and Planting of Corn

The land area was plowed twice to eliminate weeds and harrowed to provide enough soil aeration and drainage. A basal application was made before planting to provide the optimum nutrients required by the seeds during germination. During planting, seeds were soaked with water to hasten germination by providing enough moisture to break their dormancy. The planting distance used in the study was 75 cm x 25 cm, with two seeds per hill.

2.3 Fertilization

The split fertilizer application was used in the study. The first fertilizer application was made ten days after planting, using a complete fertilizer. After one month, a mixture of complete and urea fertilizers was applied, and the final application was made during the flag leaf stage using urea and potash.

2.4 Collection of roots

Root samples were obtained through destructive sampling using a shovel by carefully extracting the roots from the soil during the V4 stage (four leaves with a visible collar were present) at a depth of 20 cm and a diameter of 40 cm around the stem, providing an overall root biomass per unit volume of soil following the methods of [16]. The gathered roots were rinsed under running water to eliminate any excess soil. After cleansing, root length, root diameter, and fresh weight were measured. Subsequently, the root samples were dried in an oven at 70°C until a constant weight was reached, and the root dry weight was obtained.

2.5 Experimental design and Treatments

The experiment was laid out in a Randomized Complete Block Design (RCBD) with a land area of approximately 100 m^2, divided into three blocks to separate each replication. Each block contained three rows with twenty plants per row. Three different corn varieties were used: CGUARD VII-002 (Variety 1), TCT 476A (Variety 2), and TCT 1868 (Variety 3). Each variety was replicated three times, and a total of ten (10) samples were collected for each variety per replication.

2.6 Data Collection

2.6.1. Root Parameters

Length of mesocotyl (cm). The length of the mesocotyl was carefully measured from the root base to the tip using a digital caliper at the V4 stage.

Diameter of mesocotyl (cm). It was taken at the midpoint of the mesocotyl, as this point provides a representative measure of the overall thickness of the structure.

Length of nodal root (cm). The measurement was taken from the base of the node to its tip using a digital caliper.

Diameter of nodal root (cm). The measurement was taken at the midpoint along the root axis using a digital caliper to ensure consistency.

Fresh weight (g). The fresh weight was carefully measured immediately after cleaning, using a digital weighing scale to ensure accuracy.

Dry weight (g). It was obtained after drying the samples in an oven.

2.6.2. Yield Parameters

Weight of ears (g). All harvested ears in each plot were weighed using a digital weighing scale.

Ear length (cm). The measurement was taken from the base of the ear to the tip using a ruler.

Ear diameter (cm). The measurement was taken at the midpoint of the ears using a ruler.

Weight of kernels (g). All the threshed kernels in every ear in a plot were weighed using a digital weighing scale.

Grain moisture content (%). Grain samples were placed in a calibrated grain moisture meter to record moisture content.

Computed yield (t/ha). It was calculated using the formula below:

$$Computed\ Yield = \frac{shelled\ weight(g)\ x\ 55{,}000\ x\ (100 - MC)}{(100 - 18)\ x\ \ (1{,}000{,}000)}$$

Where:

55,000 = plant population per hectare
MC = actual harvest moisture
18 = standard moisture basis used
1,000,000 = grams to metric tons conversion

2.7 Statistical Analysis

The data was analyzed using the analysis of variance (ANOVA) in RCBD, and further tests were done using Tukey's Honestly Significant Difference (Tukey's HSD) for significant differences between treatment means using Statistical Tool for Agricultural Research (STAR) software.

To evaluate the linear association between root development and corn yield across all treatments, Pearson's correlation coefficient was measured using SPSS (*Ver. 25*).

r	Interpretation
>0.70	Very strong positive correlation
0.40 to 0.69	Strong positive correlation
0.30 to 0.39	Moderate to strong correlation
0.20 to 0.29	Weak positive correlation
0.01 to 0.19	No relationship
-0.01 to -0.19	No relationship
-0.20 to -0.29	Weak negative correlation
-0.30 to -0.39	Moderate negative correlation
-0.40 to -0.69	Strong negative correlation
<-0.70	Very strong negative correlation

3. Results and Discussion

3.1 Yield and yield components of different corn varieties

The performance of three different corn varieties—CGUARD VII-002 (Var1), TCT 476A (Var2), and TCT 1868 (Var3)—was evaluated based on yield and yield component traits. Statistical analysis (Table 1) revealed that TCT 476A and TCT 1868 produced significantly higher yields across all measured parameters, with computed yields of 9.23 t/ha and 9.27 t/ha, respectively. In contrast, CGUARD VII-002 exhibited reduced performance in alkaline soil, showing a significantly lower yield compared to TCT 476A and TCT 1868.

Table 1. Analysis of variance for yield traits of different corn varieties.

Variety	Ear weight (g)	Ear length (cm)	Ear diameter (cm)	Weight of Kernels (g)	Moisture Content (%)	Computed yield (t/ha)
1. CGUARD VII-002	132.91^{b}	14.10^{b}	4.35^{b}	111.01^{b}	15.00^{b}	5.88^{b}
2. TCT 476A	223.95^{a}	17.50^{a}	4.85^{a}	186.16^{a}	20.76^{a}	9.23^{a}
3. TCT 1868	225.80^{a}	17.85^{a}	4.89^{a}	186.77^{a}	21.09^{a}	9.27^{a}
Mean	194.22	16.49	4.70	161.31	18.95	8.12
Cv (%)	5.56	2.74	0.73	8.69	7.22	4.45

This means that the columns with the different letters are significantly different from each other at a 5% level of significance in Tukey's Honest Significant Difference (HSD) Test.

The differences in yield performance among the three different corn varieties can be attributed to genotype-environment interactions, wherein not all varieties exhibit similar performance under abiotic conditions. This is further supported by the findings of [17], which showed that certain corn varieties consistently outperformed others under varied irrigation and moisture conditions, demonstrating their adaptability. Additionally, the yield performance of three different corn varieties under alkaline soil conditions aligns with the findings of [18], which indicated significant differences in morpho-physiological traits of corn hybrids under Claveria conditions. Moreover, TCT 476A and TCT 1868 showed remarkable yield performance under alkaline soil. This may be due to their improved nutrient uptake and root adaptability. These findings align with [19], who found that corn varieties applied with ammonium fertilizers in alkaline soils show significant differences in yield traits. In particular, high-performing genotypes demonstrate better nitrogen absorption and greater physiological resilience. These findings highlight the genetic variability among different corn varieties and emphasize the importance of selecting suitable varieties to optimize productivity under alkaline soil conditions.

3.2 Root morphological traits of different corn varieties at the V4 stage

Table 2 shows the statistical analysis of root traits in maize at the V4 stage. The findings revealed no significant differences among varieties across all the measured parameters. The results suggest that all varieties exhibited comparable root morphological characteristics at the V4 stage, indicating similar responses under the given growing conditions. Similar results were reported by [20], who state that early vegetative stages showed conserved root morphology across different genotypes.

Table 2. Analysis of variance for root morphological traits of different maize varieties during the V4 stage

Variety	Mesocotyl length (cm)	Mesocotyl diameter (cm)	Nodal root length (cm)	Nodal root diameter (cm)	Root fresh weight (g)	Root dry weight (g)
1. CGUARD VII-002	46.19	0.44	177.42	0.24	0.62	0.18
2. TCT 476A	40.90	0.51	196.12	0.24	0.60	0.18
3. TCT 1868	42.80	0.31	175.84	0.08	0.50	0.17
Mean	43.29	0.42	183.13	0.19	0.57	0.18
Cv (%)	33.22	31.36	6.73	68.85	13.87	14.19

Early-stage assessments are incapable of detecting genotypic differences under stress conditions, indicating that varietal divergence becomes more evident in later stages. According to the findings of [21], abiotic stress tolerance influences significant morphological differences in root traits as plants mature. This is further supported by the results of [22], suggesting that root morphology changes over time, highlighting its relevant differences at a later growth stage. It implies that the genetic differences of corn varieties do not influence root morphological traits during the early vegetative stage under alkaline soil, reinforcing the importance of evaluating root morphological traits beyond the early vegetative stages to fully understand the tolerance of different corn varieties.

3.3 Relationship between mesocotyl root traits and yield parameters of corn

The influence of mesocotyl root traits, specifically diameter and length, during the early vegetative (V4) stage on corn yield parameters was assessed. Results found that mesocotyl root diameter showed no significant relationship with any measured yield traits, including ear weight, ear length, ear diameter, kernel weight, computed yield, or grain moisture content. The correlation coefficients (r) values range from –0.103 to 0.077, indicating that mesocotyl thickness does not affect yield parameters. This conforms with the findings of Zhan [23], who reported that mesocotyl and root thickness primarily contribute to early seedling establishment rather than final yield outcomes. Likewise, mesocotyl root length showed no significant correlations with yield components, with r-values ranging from –0.122 to –0.068. This indicates that variations in mesocotyl elongation do not directly influence ear development, kernel weight, or grain moisture during the V4 stage. Furthermore, previous studies corroborate these findings, indicating that mesocotyl elongation is more critical for seedling emergence, particularly under deep sowing or compacted soil conditions, than for yield formation [24, 25]. Overall, mesocotyl development at the V4 stage is not a reliable predictor of yield. Instead, root characteristics, including length density, branching, and nutrient uptake efficiency, may be more reliable indicators of productivity, particularly under stress such as drought or nutrient limitations.

3.4 Relationship between nodal root traits and yield parameters of corn

Correlation analysis between nodal root diameter and yield-related parameters showed no significant relationships, with correlation coefficients ranging from -0.031 to -0.183. Similarly, nodal root length at the V4 stage showed correlation coefficient values between -0.050 and -0.134, which indicates that variations in nodal root length and diameter do not directly affect yield performance under the studied conditions in corn. The findings confirm that nodal root diameter during the early vegetative (V4) stage does not have a significant linear relationship with yield or morphological traits. While roots are essential for water and nutrient uptake, the minimal correlations observed suggest that variation in nodal root diameter does not directly impact yield performance. This observation aligns with previous findings indicating that root structural traits are more important under stress adaptation, such as during drought or low nitrogen conditions, than under optimal growth environments [26].

3.5 Relationship between root biomass and yield parameters of corn

The relationship between root fresh and dry weight and various yield-related traits in corn was evaluated to determine the influence of root biomass at the early vegetative stage (V4) on yield-related performance. Root fresh weight did not exhibit a significant relationship with six yield parameters: ear weight, ear length, ear diameter, kernel weight, and computed yield. The correlation coefficients (r) ranged from -0.164 to -0.062, indicating no associations. Similarly, root dry weight showed no significant relationships with yield parameters, with r values ranging from -0.019 to -0.102. Generally, root fresh and dry weight showed no linear associations with corn yield parameters. While root biomass indicates early plant vigor, it does not directly predict final yield at the V4 stage. Instead, root functional traits, including root length density, nutrient uptake efficiency, and stress-responsive architecture, are likely more critical for determining yield outcomes under environmental stress, as supported by previous research [24, 25].

4. Conclusions

Corn varieties, TCT 476A and TCT 1868, significantly outperformed, having higher yields across all the measured parameters, implying that these varieties are suitable for cultivation in alkaline conditions. Furthermore, all root morphological traits of different corn varieties at the V4 stage show no significant differences, reinforcing the importance of assessing root morphological traits beyond early vegetative stages. On the other hand, root morphological traits at the V4 stage show no significant linear relationship with yield and yield components, suggesting that yield outcomes cannot be reliably predicted at this stage. In relation to this, fertilizer application during the V4 stage has minimal benefits, as it does not significantly influence the final yield. Thus, it is strongly advised to evaluate root development in later stages, and fertilizer application strategies should be well-timed as nutrient demand increases during the early reproductive stage. To optimize nutrient efficiency and improve yield outcomes, nutrient assimilation analysis will provide valuable insights into nutrient utilization and uptake dynamics.

5. Acknowledgements

The authors extend their sincere gratitude to Cebu Technological University – Barili Campus, for letting them use the land in conducting the research, to DOST-Strand N and CTU – Barili Campus, Graduate School, for the remarkable opportunity offered in making this study possible.

Author Contributions: Conceptualization, P.R.P., and E.J.; methodology, E.J., and B.B.; software, E.J.; validation, E.J.; formal analysis, E.J.; investigation, E.J., and B.B.; resources, E.J., and B.B.; data curation, E.J.; writing—original draft preparation, E.J.; writing—review and editing, E.J., and P.R.P; visualization, E.J.; supervision, P.R.P.; project administration, E.J., and B.B. All authors have read and agreed to the published version of the manuscript**.**

Funding: The research was made possible through the support of the Department of Science and Technology – Science Education Institute (DOST-SEI) under the STRAND-N Scholarship Program.

Conflicts of Interest: The authors declare no conflict of interest.

References

[1] Erenstein, O.; Jaleta, M.; Sonder, K.; Mottaleb, K.; Prasanna, B. M. Global maize production, consumption and trade: Trends and R&D implications. *Food Secur.* **2022,** *14*(5), 1295–1319. https://doi.org/10.1007/s12571-022-01288-7

[2] U.S. Department of Agriculture, Foreign Agricultural Service. *Corn: Production Data*; USDA: Washington, DC, 2024. https://www.fas.usda.gov/data/production/commodity/0440000

[3] Biñas, E. E., Jr. The use of organic and inorganic fertilizers and its effect on the quality of corn products in the Philippines: A review. *Galaxy Int. Interdiscip. Res. J.* **2021,** *9*(5), 83–100. https://doi.org/10.17605/osf.io/puc7a

[4] Amper, B. M., Jr.; Amper, Z. H. S. Precarity among corn farmers in the uplands of Cebu, the Philippines. *Aghamtao* **2021,** *29,* 42–57.

[5] Amanullah; Fahad, S. Corn – Production and Human Health in Changing Climate; *IntechOpen*, **2018**. https://doi.org/10.5772/intechopen.74074.

[6] Gaikwad, D. J.; Ubale, N. B.; Pal, A.; Singh, S.; Ali, M. A.; Maitra, S. Abiotic stresses impact on major cereals and adaptation options—A review. *Res. Crops* **2022,** *23*(4), 913–920. https://doi.org/10.31830/2348-7542.2022.roc-913

[7] Fu, J.; Xiao, Y.; Wang, Y.-F.; Liu, Z.-H.; Yang, K. Saline–alkaline stress in growing maize seedlings is alleviated by *Trichoderma asperellum* through regulation of the soil environment. *Sci. Rep.* **2021,** *11*(1), 11546. https://doi.org/10.1038/s41598-021-90675-9

[8] Enojada, G. R.; Asio, V. B. Morphological, physical, and chemical characteristics of soils derived from limestone rocks in Barili, Cebu. *ResearchGate* **2015.** https://www.researchgate.net/publication/327366666

[9] Lynch, J.; Marschner, P.; Rengel, Z. Effect of internal and external factors on root growth and development. In *Marschner's Mineral Nutrition of Higher Plants*; Marschner, P., Ed.; Elsevier Ltd.: London, 2012; pp 331–346. https://doi.org/10.1016/B978-0-12-384905-2.00013-3

[10] De Araujo Rufino, C.; Fernandes-Vieira, J.; Martín-Gil, J.; De Souza Abreu Júnior, J.; Tavares, L. C.; Fernandes-Correa, M.; Martín-Ramos, P. Water stress influence on the vegetative period yield components of different maize genotypes. *Agronomy* **2018,** *8*(8), 151. https://doi.org/10.3390/agronomy8080151

[11] Nleya, T.; Chungu, C.; Kleinjan, J. Chapter 5: Corn growth and development. In *iGrow Corn: Best Management Practices*; *South Dakota State University*, **2016**. Chapter 5.

[12] Penn State Extension. Corn Growth Stages; *Penn State College of Agricultural Sciences*, **n.d**. https://extension.psu.edu/corn-growth-stages (accessed October 8, 2025).

[13] Fageria, N. K. The Role of Plant Roots in Crop Production; *CRC Press: Boca Raton, FL*, **2012**. https://doi.org/10.1201/b12365

[14] Rodríguez, M. N. S.; Cassab, G. I. Primary root and mesocotyl elongation in maize seedlings: Two organs with antagonistic growth below the soil surface. *Plants* **2021,** *10*(7), 1274. https://doi.org/10.3390/plants10071274

[15] Niu, L.; Hao, R.; Wu, X.; Wang, W. Maize mesocotyl: Role in response to stress and deep-sowing tolerance. *Plant Breeding* **2020,** *139* (3), 466–473. https://doi.org/10.1111/pbr.12804

[16] Poffenbarger, H. J.; Barker, D. W.; Helmers, M. J.; Miguez, F. E.; Olk, D. C.; Sawyer, J. E.; Six, J.; Castellano, M. J. Genotypic variation on root growth and nutrient uptake in corn and soybean. *Agric. Environ. Lett.* **2019,** *4*(1), 180018.

[17] Gu, S.; dos Santos Diniz, M. H.; Mukhametov, A.; Kondrashev, S. Comparative study on the response of corn hybrids to different irrigation techniques and moisture levels. *Arch. Agron. Soil Sci.* **2025**, *71*(1), 1–15.

[18] Elmundo, E. M.; Alcantara, C. G.; Bautista, E. R. Yield performance of ten white corn hybrids under Claveria condition. *Mindanao J. Sci. Technol.* **2011,** *9*(1), 45–58.

[19] Puyod, S.E.G.; Pascual, P.R. Varietal performance of hybrid corn fertilized with ammonium fertilizers in an alkaline soil under drought conditions. *ASEAN J. Sci. Tech. Report.* **2025**, *28*(4), e257403. https://doi.org/10.55164/ajstr.v28i4.257403

[20] Vilas-Boas, J. K.; Steiner, F.; Zuffo, A. M.; González Aguilera, J.; Zaratin Alves, C. Tolerance of high-yielding corn hybrids to drought stress during the early growth stage. *Rev. Ciênc. Agron.* **2025**, *56*, e20250040. https://doi.org/10.5935/1806-6690.20250040

[21] Tripathi, S.; Tiwari, K.; Mahra, S.; Victoria, J.; Rana, S.; Tripathi, D. K.; Sharma, S. Nanoparticles and root traits: Mineral nutrition, stress tolerance, and interaction with rhizosphere microbiota. *Planta* **2024,** *260*(2), 409.

[22] Rasheed, A.; Li, H.; Tahir, M. M.; Mahmood, A.; Nawaz, M.; Shah, A. N.; Aslam, M. T.; Negm, S.; Moustafa, M.; Hassan, M. U.; Wu, Z. The role of nanoparticles in plant biochemical, physiological, and molecular responses under drought stress: A review. *Front. Plant Sci.* **2022,** *13,* 976179.

[23] Zhan, A.; Lynch, J. P. Reduced frequency of lateral root branching improves water and nitrate capture in maize (*Zea mays* L.) under low nitrogen stress. *Plant Physiol.* **2015,** *168*(1), 117–129.

[24] Gao, Y.; Lynch, J. P. Reduced crown root number improves water acquisition under water deficit stress in maize (*Zea mays* L.). *J. Exp. Bot.* **2016,** *67*(15), 4545–4557. https://doi.org/10.1093/jxb/erw243

[25] Hund, A.; Trachsel, S.; Stamp, P. Rooting depth and water use efficiency of tropical maize inbred lines differing in drought tolerance. *Plant Soil* **2009,** *318,* 311–325. https://doi.org/10.1007/s11104-008-9843-6

[26] Magsayo, N. J.; Jamio, E.; Canunayon, M.; Tangpos, D.; Caritan, J.; Pascual, P. R. Root length and diameter at flag leaf stage correlate with important yield parameters in corn (*Zea mays* L.) grown in alkaline soil under drought conditions. *ASEAN J. Sci. Technol. Rep.* **2025,** *28*(5), e259419. https://doi.org/10.55164/ajstr.v28i5.259643