Maize Journal (October 2026) 15(2): 201-205

SHORT COMMUNICATION

Soil constraints and baseline performance of sweet corn (*Zea mays* var. *saccharata*) under rainfed, no-input conditions in Manipur, Northeastern Hill region of India

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Abstract: Sweet corn (*Zea mays* var. *saccharata*) production in Manipur, Northeastern Hill Region of India, is constrained by acidic, clay-textured soils, erratic monsoon distribution, and low inherent nitrogen availability. This short note characterizes the pre-crop soil properties, growing-season weather, and unfertilized baseline agronomic performance of sweet corn (cv. Golden Cob) at the Integrated Farming System Research Field, Central Agricultural University, Imphal (*Kharif* 2025; 24.81°N, 93.88°E; 780 m MSL). The initial soil characteristics showed high acidity (pH 5.71), clay texture (64.61% clay), moderate organic carbon (0.71%), and low availability of nitrogen (213.37 kg ha^{-1}). Total rainfall during the growing season was 636.4 mm in August-September. In the no-input treatment, sweet corn produced a yield of 98.53 q ha^{-1} of fresh cob production and 198.01 q ha^{-1} of green stover, with delayed phenology (tasseling 67.33 days and silking 71.00 days). These baseline data establish a documented productivity floor for nutrient-responsive experimental comparisons and provide a reference for agro-advisory development in rainfed NEH systems.

Keywords: Rainfed sweet corn • Soil acidity • NEH region • Baseline productivity • Agronomic constraints • Manipur

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Received: 26 September 2026/ Accepted: 19 October 2026

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Introduction

Maize (*Zea mays* L.) is the second most important food crop in Manipur after rice, grown in an area of 24.53 thousand hectares, having a yield of 54.37 thousand tons with a productivity of 2,216 kg ha^{-1}, which is significantly low compared to the national average of 3,590 kg ha^{-1} (NER Databank, 2024-25; UPAG, 2025). Due to increasing popularity in north-east India, sweet corn (*Zea mays* var. *saccharata*) has become a high-value crop, offering better income for farmers from fresh cob sales. Because of its short duration and suitability for rainfed agriculture, it is ideal for agricultural cropping practices in Manipur's small-farm environment.

Sweet corn productivity in the North Eastern Hill (NEH) region seems to be hindered due to prevailing constraints resulting from soil, climate, and socio-economic problems. The soils in the sub-tropical NEH-IV agro-climatic zone in Manipur are mostly acidic, clayey, and low in available nitrogen, resulting in poor nutrient uptake, fixation of phosphorus under low pH conditions, and chances of soil compaction because of excessive rainfall (von Uexküll and Mutert, 1995; Penn and Camberato, 2019; Ramesh *et al*., 2025). Findings from the long-term field experiments conducted in this region have shown that soil acidity significantly limits yield stability irrespective of any treatment without the use of organic sources such as green manure (Ansari *et al*., 2022). The rainfed crop production system is influenced by the start and end of the monsoon season, where rains in August and September result in waterlogging and leaching of nutrients, and later on moisture stress occurs

in November to December. The above constraints make the already poor productivity of the non-managed plots even worse.

It is one of the most critical aspects of nutrient management studies; however, baseline soil characteristics before cropping and performance of crops without any inputs are rarely published. Lack of a well-characterized baseline productivity level makes it difficult for the extension agents to interpret the response of nutrients and calibrate appropriate input recommendations for the rain-fed farmers. The purpose of this short note is to fill this gap with information on the baseline soil characteristics, growing-season agrometeorological profile, and no-input agronomic performance of sweet corn from the experimental field at CAU, Imphal, during *kharif* 2025.

Materials and methods

The study was conducted at the Integrated Farming System (IFS) Research Field, CAU, Imphal, Manipur (24.81°N, 93.88°E; 780 m MSL) during *kharif* 2025. The experimental field falls within the Eastern Himalayan (II) agro-climatic zone, the sub-tropical NEH-IV region. Sowing was done on 25 August 2025 using sweet corn cv. Golden Cob at 60 × 25 cm spacing. The experiment was laid out in a Randomized Block Design (RBD) with eight nutrient management treatments and three replications (24 plots; 3.6 × 2.5 m each). The absolute control (T1: no fertilizer, no biochar) was the focus of the present note.

Pre-experiment composite soil samples were collected from 0-15 cm depth, air-dried, and analyzed for texture (Bouyoucos, 1962), pH (Jackson, 1973), organic carbon (Walkley and Black, 1934), available nitrogen (Subbiah and Asija, 1956), and available phosphorus and potassium (Jackson, 1973). Soil microbial counts (bacteria, fungi, actinomycetes) were estimated by serial dilution plate count (Sinclair and Dhingra, 1995; Martin, 1950; Williams and Cross, 1971; Kapoor and Paroda, 2007). Daily meteorological data were obtained from the Experimental Agromet Advisory Service, ICAR Research Complex for NEH Region, Manipur Centre, Lamphelpat.

Biometric observations in the control treatment used five randomly tagged plants per plot, recorded at 30, 60, and 90 days after sowing (DAS) and at harvest. Plant height (cm), dry matter accumulation (g plant^{-1}), days to 50% tasseling and silking, yield attributes (cob length, girth, cobs plant^{-1}, rows cob^{-1}, grains row^{-1}, cob weight), fresh cob yield (q ha^{-1}), and green stover yield (q ha^{-1}) were recorded. Quality parameters, total soluble solids (TSS, °Brix), and crude protein content (%) were estimated. Economics were computed at prevailing market prices (Rs. 8 per cob <250 g; Rs. 10 per cob ≥250 g).

Results and discussion

Baseline soil characterization

The pre-experiment soil properties were given in Table 1. The soil was clay in texture (64.61% clay, 25.56% silt, 9.83% sand). Soil pH of 5.71 indicates a moderately acidic reaction, common in the NEH region, where high annual rainfall and organic matter decomposition drive progressive leaching and acidification. With this pH, there will be significant fixation of phosphorus with iron and aluminum oxides, making it less available to crops despite having sufficient levels of phosphorus (Penn and Camberato, 2019). In acid soil, it becomes more significant, owing to the fact that secondary clay minerals and iron-aluminum oxides have enough binding sites for phosphates because of their hydroxyl groups (Ma *et al*., 2025).

The level of organic carbon of 0.71% is a medium level, showing moderately active biological activity but a lack of humified carbon that can maintain nutrients in the heavy clay soil. Available nitrogen of 213.37 kg ha^{-1} is at a low level, showing a slow rate of mineralization occurring in acid soil that is subject to waterlogging and thus high denitrification. Available P_2O_5 was 16.87 kg ha^{-1}, and K_2O was 190.58 kg ha^{-1}, both of which were at the medium level. The pre-crop microbial population included bacteria (20.67 × 10^5 CFU g^{-1}), fungi (17.00 × 10^4 CFU g^{-1}), and actinomycetes (12.33 × 10^3 CFU g^{-1}). The higher number of bacteria compared to fungi at pH 5.71 can be explained by the effects of soil pH on the composition of microorganisms, because the number of bacteria increases with an increase in soil pH, while fungi have a wider tolerance for soil pH variations (Rousk *et al*., 2010). Overall, the soil profile represents a common constraint in NEH smallholder fields: structurally heavy, deficient in labile nitrogen, and with limited biological capacity to mineralize organic nutrients efficiently.

Table 1. Baseline physicochemical and biological properties of the experimental soil (0-15 cm depth), IFS Research Field, CAU Imphal, *kharif* 2025

Soil Property	Value	Status	Method / Reference
Sand (%)	9.83	-	Bouyoucos (1962)
Silt (%)	25.56	-	Bouyoucos (1962)
Clay (%)	64.61	Clay	Bouyoucos (1962)
Soil pH (1:2.5)	5.71	Acidic	Jackson (1973)
Organic Carbon (%)	0.71	Medium	Walkley and Black (1934)
Available N (kg ha^{-1})	213.37	Low	Subbiah and Asija (1956)
Available P_2O_5 (kg ha^{-1})	16.87	Medium	Jackson (1973)
Available K_2O (kg ha^{-1})	190.58	Medium	Jackson (1973)
Bacteria (CFU $g^{-1} \times 10^5$)	20.67	-	Sinclair and Dhingra (1995)
Fungi (CFU $g^{-1} \times 10^4$)	17.00	-	Martin (1950)
Actinomycetes (CFU $g^{-1} \times 10^3$)	12.33	-	Williams and Cross (1971); Kapoor and Paroda (2007)

Source: Laboratory analyses, College of Agriculture, CAU Imphal

Growing-season agrometeorological profile

Monthly weather data were given in Table 2. Mean maximum and minimum temperatures across the growing season were 27.94°C and 17.08°C, respectively, with the highest maximum (30.2°C) in September, the critical period for vegetative growth and tassel initiation, and the lowest minimum (7.2°C) in December, post-harvest. Total growing-season rainfall was 636.4 mm, of which 476.7 mm (74.9%) fell in August-September. The amount of rainfall drastically decreased from 143.4 mm in October to 16.3 mm in November and then to zero mm in December, thereby causing moisture stress in the grain-filling and maturation stage.

This rainfall distribution has direct implications for agriculture. The August-September rains facilitate early vegetative growth but pose a risk of soil waterlogging since the soil consists of heavy clay that hinders aerobic nitrogen mineralization and encourages denitrification losses. October moisture shortage occurs during the reproductive stage when water plays a critical role in silk emergence and kernel-filling stages. Morning relative humidity averaged 91.88% throughout the season, favoring foliar disease pressure at early stages; evening RH declined from 69.6% in August to 48.5% in December. These patterns should inform planting-date decisions to optimize the overlap between critical crop water demand and reliable monsoon rainfall supply in the NEH-IV zone.

Unfertilized baseline agronomic performance

Under absolute control conditions (no fertilizer, no biochar), sweet corn cv. Golden Cob produced a fresh cob yield of 98.53 q ha^{-1} and a green stover yield of 198.01 q ha^{-1}. Plant height at harvest was 131.01 cm; 50% tasseling occurred at 67.33 DAS and 50% silking at 71.00 DAS, substantially delayed relative to fertilized treatments in the same trial. Cob length and girth were 16.35 cm and 13.05 cm, respectively, with a mean cob

Table 2. Monthly agrometeorological data during the sweet corn growing season, *kharif* 2025 (August-December), IFS Research Field, CAU Imphal

Month	T_{max} (°C)	T_{min} (°C)	AM RH (%)	PM RH (%)	Rainfall (mm)
August	29.3	22.4	92.5	69.6	239.6
September	30.2	22.2	91.9	66.5	237.1
October	29.9	19.9	91.3	62.9	143.4
November	26.7	13.7	90.7	54.4	16.3
December	23.6	7.2	93.0	48.5	0.0
Mean / Total	27.94	17.08	91.88	60.38	636.4 (total)

Source: Experimental Agromet Advisory Service, ICAR Research Complex for NEH Region, Manipur Centre, Lamphelpat, Imphal.

weight of 231.77 g, 12.73 rows per cob, and 29.60 grains per row. Crude protein content was 6.14% in the cob and 2.54% in the stover, with a total soluble solids (TSS) content of 14.26 °Brix. Gross return under control conditions was Rs. 4,78,886 ha^{-1} against a cost of cultivation of Rs. 99,575 ha^{-1}, yielding a net return of Rs. 3,79,311 ha^{-1} and a B:C ratio of 3.81.

These figures establish a documented productivity floor. The fresh cob yield of 98.53 q ha^{-1} under no-input conditions is less than half the yield achievable with recommended mineral fertilizer alone (135.44 q ha^{-1}, T2) in the same trial, confirming that nutrient limitation, rather than water availability per sec, is the binding agronomic constraint. The delay of tasseling and silking was 16.33 and 16.00 days, respectively, relative to the most efficient treatment, which may be due to lack of nitrogen, which delays vegetative growth to reproductive development in maize (Uhart and Andrade, 1995). This is also evident in field conditions, as shown by the research conducted by Shrestha *et al*. (2018). Newer field evidence supports this trend, where nitrogen-limited maize shows changes in post-anthesis partitioning of dry matter and nitrogen, which leads to delays in reproductive development (Wu *et al*., 2024). The TSS of 14.26 °Brix, while at the lower boundary of commercial acceptability for fresh sweet corn (≥14 °Brix), fell significantly below the values achievable under balanced nutrient management (up to 16.10 °Brix), indicating that kernel sweetness, the primary commercial differentiator of sweet corn, is depressed under chronic nutrient limitation. A global meta-analysis of 59 biochar field trials reported that improved crop production is invariably witnessed in coarse and fine-textured (clayey) soils (Singh *et al*., 2022). Another meta-analysis carried out with data collected from paired field trials from all over the globe through 1,011 data points reported that biochar application influenced increased crop production in acidic, sandy, or clay soils more than alkaline or loamy soils (Xu *et al*., 2025). The same type of soil is being considered in the current research work, demonstrating the agricultural benefits possible through nutrient management in this case study.

Conclusion

The pre-crop soil of the IFS Research Field, CAU Imphal, is moderately acidic (pH 5.71), clay-textured, and deficient in available nitrogen, which are similar to most rainfed smallholder fields in Manipur's NEH-IV zone. The *kharif* 2025 growing season delivered 636.4 mm of rainfall, heavily front-loaded in August-September, with negligible precipitation in November-December. Under no-input conditions, sweet corn cv. Golden Cob produced only 98.53 q ha^{-1} fresh cob yield, with delayed phenology and below-optimum sweetness (14.26 °Brix). These documented baseline values provide a reproducible productivity reference for future nutrient-management trials, support calibration of extension recommendations, and confirm that nutrient limitation constitutes the binding agronomic constraint in rainfed sweet corn systems of Manipur.

Acknowledgements

The authors acknowledge Central Agricultural University, Imphal, for research infrastructure. Meteorological data were provided by the Experimental Agromet Advisory Service, ICAR Research Complex for NEH Region, Manipur Centre. The authors thank the reviewers for their constructive comments.

Conflict of interest

The authors declare no conflict of interest.

Data availability

All supporting data are presented in the tables. Additional data are available from the corresponding author upon reasonable request.

Funding

No specific funding was received for this study.

AI tool usage

Language editing and grammar checking were performed using Grammarly and Quillbot. No AI tool was used for content generation or data analysis. The authors take full responsibility for all scientific content.

References

Ansari, M. A., Babu, S., Choudhary, J., Ravisankar, N. & Panwar, A. S. (2022). Soil quality restoration and yield stabilization in acidic soils of northeastern Himalayas: Five years impact of green manuring and crop residue management. *Frontiers in Environmental Science*, **10**: 940349. https://doi.org/10.3389/fenvs.2022.940349

Bouyoucos, G. J. (1962). Hydrometer method improved for making particle size analyses of soils. *Agronomy Journal*, **54**(5): 464-465. https://doi.org/10.2134/agronj1962.00021962005400050028x

Jackson, M. L. (1973). Soil chemical analysis. Prentice-Hall Inc., Englewood Cliffs, NJ, 498 p.

Kapoor, K. K. & Paroda, S. (2007). Experimental soil microbiology (1st ed.). CBS Publishers & Distributors. (ISBN: 978-81-2-391,430-5). https://www.cbspd.com/product/experimental-soil-microbiology

Ma, Q., Chen, H., Yang, Y. & Zhou, B. (2025). Unlocking phosphorus resources: Phosphate-solubilizing microorganisms as a green strategy for activating phosphorus in acidic red soils and promoting crop growth. *Frontiers in Microbiology*, **16**: 1630650.

Martin, J. P. (1950). Use of acid, rose bengal, and streptomycin in the plate method for estimating soil fungi. *Soil Science*, **69**(3): 215-232. https://doi.org/10.1097/00010694-195003000-00006

NER Databank / NEDFi (2024-25). Maize - Manipur (area, production, yield to 2024-25). https://databank.nedfi.com/node/3776

Penn, C. J. & Camberato, J. J. (2019). A critical review on soil chemical processes that control how soil pH affects phosphorus availability to plants. *Agriculture*, **9**(6): 120. https://doi.org/10.3390/agriculture9060120

Ramesh, T., Balusamy, A., Parisa, D., Hazarika, S., Choudhury, B. U. & Mishra, V. K. (2025). Management of acid soil for sustainable agriculture in hilly ecosystems of eastern Himalaya. *Indian Farming*, **75**(7): 12-15. https://epubs.icar.org.in/index.php/IndFarm/article/view/173995

Rousk, J., Bååth, E., Brookes, P. C., Lauber, C. L., Lozupone, C., Caporaso, J. G., Knight, R. & Fierer, N. (2010). Soil bacterial and fungal communities across a pH gradient in an arable soil. *The ISME Journal*, **4**(10): 1340-1351. https://doi.org/10.1038/ismej.2010.58

Shrestha, J., Yadav, D. N., Amgain, L. P. & Sharma, J. P. (2018). Effects of nitrogen and plant density on maize (Zea mays L.) phenology and grain yield. *Current Agriculture Research Journal*, **6**(2): 175-182. https://doi.org/10.12944/CARJ.6.2.06

Sinclair, J. B. & Dhingra, O. D. (1995). Basic plant pathology methods (2nd ed.). Boca Raton. CRC Press. 448p. https://doi.org/10.1201/9781315138138

Singh, H., Northup, B. K., Rice, C. W. & Prasad, P. V. V. (2022). Biochar applications influence soil physical and chemical properties, microbial diversity, and crop productivity: A meta-analysis. *Biochar*, **4**(1): 8. https://doi.org/10.1007/s42773-022-00138-1

Subbiah, B. V. & Asija, G. L. (1956). A rapid procedure for the estimation of available nitrogen in soils. *Current Science*, **25**(8): 259-260.

Uhart, S. A. & Andrade, F. H. (1995). Nitrogen deficiency in maize: I. Effects on crop growth, development, dry matter partitioning, and kernel set. *Crop Science*, **35**(5): 1376-1383. https://doi.org/10.2135/cropsci1995.0011183X003500050020x

Unified Portal for Agricultural Statistics (2025). Data for the year 2025-26 is of 3rd Advance Estimates, Department of Agriculture and Farmers' Welfare. https://upag.gov.in/dash-reports/allindiaapy

von Uexküll, H. R. & Mutert, E. (1995). Global extent, development and economic impact of acid soils. *Plant and Soil*, **171**(1): 1-15. https://doi.org/10.1007/BF00009558

Walkley, A. & Black, I. A. (1934). An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil Science*, **37**(1): 29-38. https://doi.org/10.1097/00010694-193401000-00003

Williams, S. T. & Cross, T. (1971). Actinomycetes. In J. R. Norris & D. W. Ribbons (Eds.), Methods in microbiology (Vol. 4, pp. 295-334). Academic Press. https://doi.org/10.1016/S0580-9517(09)70016-9

Wu, B., Cui, Z., Zechariah, E., Guo, L., Gao, Y., Yan, B., Liu, H., Wang, Y., Wang, H. & Li, L. (2024). Post-anthesis dry matter and nitrogen accumulation, partitioning, and translocation in maize under different nitrate–ammonium ratios in Northwestern China. *Frontiers in Plant Science*, **15**: 1257882. https://doi.org/10.3389/fpls.2024.1257882

Xu, Z., Zhou, R. & Xu, G. (2025). Global analysis on potential effects of biochar on crop yields and soil quality. *Soil Ecology Letters*, **7**(1): 240267. https://doi.org/10.1007/s42832-024-0267-x