measured together with transcriptomic, metabolomic, proteomic, and isotope-tracing analyses. Existing studies have already shown that integrated omics can identify candidate regulatory nodes such as IbUGP2, IbglgA, miR319-TCP4, and miR172-AP2. The next step is to connect these candidate nodes directly with realistic nitrogen fertilizer treatments.

Breeding objectives should also shift from selecting only for "high yield" toward the simultaneous improvement of high yield, high starch productivity, and high nitrogen-use efficiency. Genome-wide association studies (GWAS), expression quantitative trait locus (eQTL) analysis, and natural allelic variation can be used to identify germplasm that maintains strong storage-root sink activity and starch-forming capacity under relatively low nitrogen supply. On the crop-management side, topdressing timing and rate could be adjusted dynamically by combining critical nitrogen concentration, plant nitrogen nutrition index, soil available nitrogen, and weather conditions. Ultimately, the most useful goal in practice is not simply to reduce nitrogen fertilizer input, but to maintain storage-root yield, starch yield, and marketable quality after nitrogen reduction. This is a more practical objective than pursuing a single maximum-yield value.

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Conflict of Interest Disclosure

The authors affirm that this research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

Reference

Amoah J.N., Keitel C., and Kaiser B.N., 2025, Nitrogen deficiency identifies carbon metabolism pathways and root adaptation in maize, Physiology and Molecular Biology of Plants, 31(7): 1089-1103.
https://doi.org/10.1007/s12298-025-01631-0

Dong H.T., Li Y., Brown P., Akbar D., and Xu C.Y., 2025, Effects of nitrogen application on soluble sugar and starch accumulation during sweet potato storage root formation, Horticulturae, 11(7): 837.
https://doi.org/10.3390/horticulturae11070837

Dong H.T., Li Y., Henderson C., Brown P., and Xu C.Y., 2022, Optimum nitrogen application promotes sweetpotato storage root initiation, Horticulturae, 8(8): 710.
https://doi.org/10.3390/horticulturae8080710

Du X., Xi M., and Kong L., 2019, Split application of reduced nitrogen rate improves nitrogen uptake and use efficiency in sweetpotato, Scientific Reports, 9(1): 14058.
https://doi.org/10.1038/s41598-019-50532-2

Du X., Zhang X., Kong L., and Xi M., 2020, Split application under reduced nitrogen rate favors high yield by altering endogenous hormones and C/N ratio in sweet potato, Agronomy, 10(9): 1243.
https://doi.org/10.3390/agronomy10091243

Duan W., Wang S., Zhang H., Xie B., and Zhang L., 2024, Plant growth and nitrate absorption and assimilation of two sweet potato cultivars with different N tolerances in response to nitrate supply, Scientific Reports, 14(1): 21286.
https://doi.org/10.1038/s41598-024-72422-y

Duan W., Zhang H., Wang Q., Xie B., and Zhang L., 2023, Regulation of root development in nitrogen-susceptible and nitrogen-tolerant sweet potato cultivars under different nitrogen and soil moisture conditions, BMC Plant Biology, 23(1): 454.
https://doi.org/10.1186/s12870-023-04461-y

Duan W., Zhang H., Xie B., Wang B., and Zhang L., 2019, Impacts of nitrogen fertilization rate on the root yield, starch yield and starch physicochemical properties of the sweet potato cultivar Jishu 25, PLoS One, 14(8): e0221351.
https://doi.org/10.1371/journal.pone.0221351

Duan W., Zhang H., Xie B., Wang B., Hou F., Li A.-X., Dong S., Qin Z., Wang Q., and Zhang L., 2021, Nitrogen utilization characteristics and early storage root development in nitrogen-tolerant and nitrogen-susceptible sweet potato, Physiologia Plantarum, 173(3): 1090-1104.
https://doi.org/10.1111/ppl.13504

Fan W.J., Zhang Y.D., Wu Y.L., Zhou W.Z., Yang J., Yuan L., Zhang P., and Wang H.X., 2021, The H^+-pyrophosphatase IbVP1 regulates carbon flux to influence the starch metabolism and yield of sweet potato, Horticulture Research, 8.
https://doi.org/10.1038/s41438-020-00454-2

Fan Y., Xue L., Shang M., Gao S., Zhao N., Zhai H., He S.Z., Zhang H., and Liu Q.C., 2025, Natural allelic variation of NAC transcription factor 22 regulates starch biosynthesis and properties in sweetpotato, Journal of Integrative Plant Biology, 67(7): 1879-1894.
https://doi.org/10.1111/jipb.13916