

Reporting Summary

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Statistics

For all statistical analyses, confirm that the following items are present in the figure legend, table legend, main text, or Methods section.

n/a	Confirmed
☐	☒ The exact sample size (<i>n</i>) for each experimental group/condition, given as a discrete number and unit of measurement
☐	☒ A statement on whether measurements were taken from distinct samples or whether the same sample was measured repeatedly
☐	☒ The statistical test(s) used AND whether they are one- or two-sided <i>Only common tests should be described solely by name; describe more complex techniques in the Methods section.</i>
☒	☐ A description of all covariates tested
☒	☐ A description of any assumptions or corrections, such as tests of normality and adjustment for multiple comparisons
☒	☐ A full description of the statistical parameters including central tendency (e.g. means) or other basic estimates (e.g. regression coefficient) AND variation (e.g. standard deviation) or associated estimates of uncertainty (e.g. confidence intervals)
☒	☐ For null hypothesis testing, the test statistic (e.g. <i>F</i> , <i>t</i> , <i>r</i>) with confidence intervals, effect sizes, degrees of freedom and <i>P</i> value noted <i>Give P values as exact values whenever suitable.</i>
☒	☐ For Bayesian analysis, information on the choice of priors and Markov chain Monte Carlo settings
☒	☐ For hierarchical and complex designs, identification of the appropriate level for tests and full reporting of outcomes
☒	☐ Estimates of effect sizes (e.g. Cohen's <i>d</i> , Pearson's <i>r</i>), indicating how they were calculated

Our web collection on [statistics for biologists](#) contains articles on many of the points above.

Software and code

Policy information about [availability of computer code](#)

Data collection	Pollination data (seed set) and pollen tube germination ratings reported in this study were collected manually and transcribed into Excel or FieldBook versions 4.5-5.4. Gas concentration measurements were collected using instruments with manual readouts described in the Methods section.
Data analysis	Data analysis was conducted using JMP v17.0 and JMP v18.0.

For manuscripts utilizing custom algorithms or software that are central to the research but not yet described in published literature, software must be made available to editors and reviewers. We strongly encourage code deposition in a community repository (e.g. GitHub). See the Nature Portfolio [guidelines for submitting code & software](#) for further information.

Data

Policy information about [availability of data](#)

All manuscripts must include a [data availability statement](#). This statement should provide the following information, where applicable:

- Accession codes, unique identifiers, or web links for publicly available datasets
- A description of any restrictions on data availability
- For clinical datasets or third party data, please ensure that the statement adheres to our [policy](#)

The authors declare that all data supporting the findings of this study are available within the manuscript.

Research involving human participants, their data, or biological material

Policy information about studies with [human participants or human data](#). See also policy information about [sex, gender \(identity/presentation\), and sexual orientation](#) and [race, ethnicity and racism](#).

Reporting on sex and gender This research did not involve human participants, their data, or biological material.

Reporting on race, ethnicity, or other socially relevant groupings This research did not involve human participants, their data, or biological material.

Population characteristics This research did not involve human participants, their data, or biological material.

Recruitment This research did not involve human participants, their data, or biological material.

Ethics oversight This research did not involve human participants, their data, or biological material.

Note that full information on the approval of the study protocol must also be provided in the manuscript.

Field-specific reporting

Please select the one below that is the best fit for your research. If you are not sure, read the appropriate sections before making your selection.

☒ Life sciences ☐ Behavioural & social sciences ☐ Ecological, evolutionary & environmental sciences

For a reference copy of the document with all sections, see nature.com/documents/nr-reporting-summary-flat.pdf

Life sciences study design

All studies must disclose on these points even when the disclosure is negative.

Sample size Sample size was determined based on the availability of plant materials. The maximum potential sample size for ear data (seed set) was often constrained by the number of plants available in a greenhouse or field trial. For pollen tube germination data, each sample was applied to at least one pollen tube germination plate and a minimum of four separate images were collected from each plate for analysis. For single data point studies such as those on pressurized pollen storage, the sample size and replication was restricted due to limited availability of equipment (only one high pressure vessel).

Data exclusions Maize ear data was excluded if the ear was severely damaged by pest or pathogens between the time of pollination and the time of seed set data collection (typically 12-30 days). Maize ear data was also excluded if the pollination bag (device that excludes pollen in the air from pollinating a corn stigma and ensures all seed set is from the test pollination) was split open or fell off the ear between the time of pollination and seed set data collection. In some instances, maize ear data was excluded if the pollination bag and all relevant labels attached to the plant detached and were lost between the time of pollination and seed set data collection. Sealed storage vessel atmosphere gas composition data was excluded if there were technical issues that impacted the gas composition (leaks, accidental freezing). Criteria for excluding sealed storage vessels from data collection are described in the Methods.

Replication The maize pollen storage protocol that resulted from this research is in regular use at Syngenta global sites as a risk mitigation for pollinations challenges in maize nurseries, breeding, and research plots. The trends and conclusions presented in the manuscript were replicated within Syngenta by disparate teams that included individuals not listed as authors or in the acknowledgments. In general, these replications of the protocol are based on the immediate need of the specific site and do not include the non-pollinated and open pollinated checks that are present in the data sets reported in this manuscript. These routine uses of pollen storage do not involve pollen tube germination testing or gas analysis. Routine use of this protocol tends to involve pollen storage for less than 5 days. Ongoing testing within Syngenta on large-scale pollen collection, storage, and application is not approved for publication at this time. The authors openly disclose that the raw data underlying Supplemental Table 10 is not available. The employee responsible for the data departed Syngenta immediately after the trial. The only remaining record of this data were the box plots and summary statistics listed in Supplemental Table 10 Two of the authors were present for this field trial and attest to the accuracy of the reported average seed set. This experiment was not replicated in full due to the prohibitively high cost of field trials and the low priority of retesting a storage vessel with a proven inferior design.

Randomization Over the course of all the listed experiments, bulk pollen was collected from numerous plants (10s to 10000s) and was mixed together in large vessels. Pollen was then divided into treatments specific to the study in question. Randomization of pollinations within trials was accomplished by randomizing pollination treatments together with non-pollinated negative checks and working through the plants available for pollination sequentially. Open pollinated checks were selected prior to treatment pollinations from random individuals spaced throughout the useful area of a field trial.

Blinding Seed set data collected over the course of the experiment was collected by a combination of the authors and full or part time Syngenta employees listed in the acknowledgments. Maize ears were labeled with a combination of initials and sequential numbers that did not describe the experimental treatment or other relevant information. This labeling strategy avoided bias in reported seed counts or exclusion of poorly pollinated ears. Blinding of gas analysis data collection was not possible due to the limited number of storage vessels per experiment, the high level of technical skill required to collect the data, and the majority of this data being collected during COVID-19 workplace restrictions that limited the number of individuals working the lab.

Reporting for specific materials, systems and methods

We require information from authors about some types of materials, experimental systems and methods used in many studies. Here, indicate whether each material, system or method listed is relevant to your study. If you are not sure if a list item applies to your research, read the appropriate section before selecting a response.

Materials & experimental systems

n/a	Involved in the study
☒	☐ Antibodies
☒	☐ Eukaryotic cell lines
☒	☐ Palaeontology and archaeology
☒	☐ Animals and other organisms
☒	☐ Clinical data
☒	☐ Dual use research of concern
☐	☒ Plants

Methods

n/a	Involved in the study
☒	☐ ChIP-seq
☒	☐ Flow cytometry
☒	☐ MRI-based neuroimaging

Plants

Seed stocks	All maize seed, plants, and pollen used in the course of this research were Syngenta inbred parents or Syngenta hybrids.
Novel plant genotypes	No novel plant genotypes were generated or tested over the duration of this research.
Authentication	Seed stocks used over the course of this research were generated internally by Syngenta. This seed production is subject to line purity testing to ensure accurate genetic identity is maintained. No novel plant genotypes were generated or tested over the duration of this research.