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A Data and Code Availability

A.1 Code

The code for prompting and training is available at https://github.com/open-sciencelab/Crop.

A.2 Data

The CROP dataset is available at https://drive.google.com/drive/folders/11be8-Gd3h_VntRhmiIdhwopiAS8fh5Y7?usp=sharing.

The CROP benchmark is available at https://drive.google.com/drive/folders/11be8-Gd3h_VntRhmiIdhwopiAS8fh5Y7?usp=sharing.

A.3 Result

The test results of API models (GPT-3.5, GPT-4, Claude-3-Opus, Qwen-max) are available at https://github.com/open-sciencelab/Crop.

B Dataset Documentation

We adhere to the established dataset schemas as delineated in [28], with the objective of furnishing comprehensive information about our dataset to the prospective dataset consumers.

B.1 Motivation

For what purpose was the dataset created? The impetus for the development of the dataset is to augment the proficiency of Large Language Models in knowledge-intensive application scenarios, specifically within the realm of crop science. Existing datasets exhibit limitations in adequately encapsulating these knowledge-intensive areas or may not present the information in a manner that is readily interpretable by LLMs. By curating this novel dataset, we can facilitate the training of LLMs to comprehend and respond more effectively to queries in these areas. This could culminate in more precise and informative responses, thereby enhancing decision-making processes in crop science. Moreover, the dataset can serve as an invaluable resource for researchers and practitioners in the field, offering a rich repository of information and insights. It also holds the potential to propel the advancement of AI applications in agriculture, fostering more sustainable and efficient crop farming practices.

Who created the dataset (for example, which team, research group) and on behalf of which entity (for example, company, institution, organization)? Researchers in the Shanghai AI Laboratory created the dataset.

Who funded the creation of the dataset? Shanghai AI Laboratory, Yazhouwan National Laboratory, China Agricultural University.

B.2 Composition

What do the instances that comprise the dataset represent (for example, documents, photos, people, countries)? Each instance is the question-answer pair.

How many instances are there in total (of each type, if appropriate)? See Table 4 and Table 5.

Does the dataset contain all possible instances or is it a sample (not necessarily random) of instances from a larger set? Our dataset is composed of question-answer pairs about rice and corn. This contains a subset of crops. We have applied manual filtering to find related content.

What data does each instance consist of? Each question-answer pair in our dataset consists of a question and an answer, where reference material is provided for open-book questions.

Is there a label or target associated with each instance? We group each instance into a specific task.

Is any information missing from individual instances? N/A.

Are relationships between individual instances made explicit (for example, users' movie ratings, social network links)? The relationship between individual instances can be determined by the defined task.

Are there recommended data splits (for example, training, development/validation, testing)? In this paper, we propose a dataset as well as a benchmark, thus there is no need to fix a recommended data split.

Are there any errors, sources of noise, or redundancies in the dataset? Yes, there are. See Table 4.

Is the dataset self-contained, or does it link to or otherwise rely on external resources (for example, websites, tweets, other datasets)? The dataset is self-contained for the tasks described in the paper.

Does the dataset contain data that might be considered confidential (for example, data that is protected by legal privilege or by doctor–patient confidentiality, data that includes the content of individuals' non-public communications)? No.

Does the dataset contain data that, if viewed directly, might be offensive, insulting, threatening, or might otherwise cause anxiety? No.

Does the dataset identify any subpopulations (for example, by age, gender)? No.

Is it possible to identify individuals (that is, one or more natural persons), either directly or indirectly (that is, in combination with other data) from the dataset? No.

Does the dataset contain data that might be considered sensitive in any way (for example, data that reveals race or ethnic origins, sexual orientations, religious beliefs, political opinions or union memberships, or locations; financial or health data; biometric or genetic data; forms of government identification, such as social security numbers; criminal history)? See Appendix C.

B.3 Collection Process

How was the data associated with each instance acquired? Was the data directly observable (for example, raw text, movie ratings), reported by subjects (for example, survey responses), or indirectly inferred/ derived from other data (for example, part-of-speech tags, model-based guesses for age or language)? See Section 3.2.

What mechanisms or procedures were used to collect the data (for example, hardware appara tuses or sensors, manual human curation, software programs, software APIs)? See Section 2 and 4.

If the dataset is a sample from a larger set, what was the sampling strategy (for example, deterministic, probabilistic with specific sampling probabilities)? N/A.

Who was involved in the data collection process (for example, students, crowdworkers, con tractors) and how were they compensated (for example, how much were crowdworkers paid)? The authors and their institutes were involved in the data collection process.

Over what timeframe was the data collected? The data collection was conducted from January 2024 to May 2024.

Were any ethical review processes conducted (for example, by an institutional review board)? N/A.

Did you collect the data from the individuals in question directly, or obtain it via third parties or other sources (for example, websites)? See Section 3.2.

Were the individuals in question notified about the data collection? N/A.

Did the individuals in question consent to the collection and use of their data? N/A.

If consent was obtained, were the consenting individuals provided with a mechanism to revoke their consent in the future or for certain uses? N/A.

Has an analysis of the potential impact of the dataset and its use on data subjects (for example, a data protection impact analysis) been conducted? See Appendix C.

B.4 Preprocessing/Cleaning/Labeling

Was any preprocessing/cleaning/labeling of the data done (for example, discretization or bucketing, tokenization, part-of-speech tagging, SIFT feature extraction, removal of instances, processing of missing values)? Yes. See Section 2.3 and Section 2.4.

Was the "raw" data saved in addition to the preprocessed/cleaned/ labeled data (for example, to support unanticipated future uses)? Yes.

Is the software that was used to preprocess/clean/label the data available? Not yet available.

B.5 Uses

Has the dataset been used for any tasks already? No.

Is there a repository that links to any or all papers or systems that use the dataset? See Appendix A.

What (other) tasks could the dataset be used for? The dataset can also be used to pre-train an LLM for professional knowledge acquisition or fine-tune a multi-modal model for instruction following.

Is there anything about the composition of the dataset or the way it was collected and preprocessed/cleaned/labeled that might impact future uses? No.

Are there tasks for which the dataset should not be used? See Appendix C.

B.6 Distribution

Will the dataset be distributed to third parties outside of the entity (for example, company, institution, organization) on behalf of which the dataset was created? Yes.

How will the dataset be distributed (for example, tarball on website, API, GitHub)? See Appendix A.

When will the dataset be distributed? The dataset is already available at `https://drive.google.com/drive/folders/11be8-Gd3h_VntRhmiIdhwopiAS8fh5Y7?usp=sharing`.

Will the dataset be distributed under a copyright or other intellectual property (IP) license, and/or under applicable terms of use (ToU)? See Appendix A. Except for third-party works, the extent to which they are attributed to the authors is distributed under a specific license that can be found under the dataset repository.

Have any third parties imposed IP-based or other restrictions on the data associated with the instances? The third-party data is not for commercial use and is otherwise subject to the terms and conditions of the organization.

Do any export controls or other regulatory restrictions apply to the dataset or to individual instances? No.

B.7 Maintenance

Who will be supporting/hosting/maintaining the dataset? The authors will be.

How can the owner/curator/manager of the dataset be contacted (for example, email address)? By email address.

Is there an erratum? No.

Will the dataset be updated (for example, to correct labeling errors, add new instances, delete instances)? It is conceivable that modifications could be made to the dataset within the codebase, either for the rectification of inaccuracies or for the addition or removal of instances, contingent upon specific requests.

If the dataset relates to people, are there applicable limits on the retention of the data associated with the instances (for example, were the individuals in question told that their data would be retained for a fixed period of time and then deleted)? N/A.

Will older versions of the dataset continue to be supported/hosted/maintained? It depends on the nature of the dataset update. We may notify the dataset consumers via a website or codebase.

If others want to extend/augment/build on/contribute to the dataset, is there a mechanism for them to do so? Yes. One can use the proposed pipeline to generate new data. But any additional work should be considered as a distinct contribution, independent of our original work.

C Ethics Statement

In alignment with the NeurIPS Code of Ethics [5], we offer the following statement on the data-related concerns and potential societal impacts of our research.

C.1 Data-related Concerns

Privacy. Our dataset comprises text from research articles, professional books, crop enterprise reports, and structural data. Since enterprise reports may contain sensitive information, we clean the original data before generating Q&A pairs to ensure privacy.

Consent. Our dataset includes information such as corporate disclosures, and we recognize that the information is intended to be publicly available.

Deprecated Datasets. Not applicable. We do not use any deprecated datasets.

Copyright and Fair Use. Because the dataset in this paper is original, the authors bear all responsibility in case of violation of rights and confirm that our dataset is open-sourced under the CC BY NC 4.0 license.

[5] https://neurips.cc/public/EthicsGuidelines

Representative Evaluation Practice. Our dataset primarily considers two types of crops: rice and corn. In Appendix G, Table 4 and 5 list the main types and tasks included. Consequently, we have successfully constructed comprehensive domain-focused and general question-answer pairs for rice and corn. However, we must acknowledge that our dataset faces several limitations. Users should be aware of the content discussed in D.

Labor Compensation. Regarding the ethical concern about fair compensation for domain experts and laborers, we would like to clarify that these individuals volunteered to contribute to the project. Their motivation stems from a desire to support the open-source community and raise awareness about the crop science domain. As such, there is no specific price for single-turn or multi-turn dialogues. We created the first version of the CROP suite, and view this as a starting point. We aim to engage the academic community in future iterations of CROP and are grateful for the efforts of involved domain experts and laborers who have contributed thus far.

C.2 Potential Social Impacts

Safety. Our technology cannot be used to harm individuals.

Security. The starting point of our dataset is to provide guidance for current crop science techniques. However, some of the knowledge is derived from historical experience. To avoid security problems such as blindly referencing this information and potentially impacting agricultural production, users of our dataset should consider it comprehensively.

Discrimination. Not applicable. Our dataset is targeted at crop science.

Surveillance. Not applicable. Our dataset is targeted at crops rather than individuals.

Deception & Harassment. We believe there is a low likelihood that this dataset could be used to facilitate deceptive interactions.

Environment. As a dataset intended for application in agricultural production, our starting point is to utilize limited land resources to increase food yield and address hunger issues. Despite our careful efforts in creating the dataset, such as extensive manual screening of the data, there may still be misleading information present. This misleading information could impact crop science, such as inappropriate levels of pesticide use, thereby causing environmental burdens. We sincerely hope that our dataset will have a predominantly positive impact, which requires researchers to consider it thoroughly when using this dataset.

Human Rights. Not applicable. Our dataset is targeted at crops.

Bias and fairness. We performed extensive manual screening during the creation of our dataset, therefore the likelihood of biases related to specific races, genders, *etc*., is very low.

D Limitations

D.1 Raw Data

The comprehensiveness of the raw data is somewhat limited, given that the discussion is confined to a select number of crop species. Corn and rice are considered representative examples, notwithstanding the existence of other prevalent crop families such as wheat, tuber crops, and beans, which were rarely incorporated in the raw data collection. Even within the context of corn and rice, the raw data may exhibit a bias towards specific varieties or geographical regions. For instance, research papers in Chinese predominantly focus on varieties of corn or rice cultivated in mainland China.

In terms of the format of the source data, text was the sole modality considered during the collection of raw data, with no inclusion of images, audio, or videos. One of the primary motivations for this approach was to ensure compatibility with the GPT-4 API in the dataset generation pipeline. However,

images or charts omitted from research papers could potentially provide additional context for the formulation of Question-Answer pairs if included.

Crop science is a dynamically evolving field, and as such, we do not intend for this initial collection of raw data to remain aligned with the most current information. While the most recent research study within the raw data was published in 2022, new findings can be integrated to augment the dataset, with the entire data generation pipeline readily available.

D.2 Dataset Construction Pipeline

We acknowledge that the origin of errors can be traced back to the selected extraction tools, prompting substantial efforts towards enhancing the quality of the dataset. As one of the meticulously chosen information extraction tools, despite being effective in recognizing texts within documents, [46] demonstrated sub-optimal performance when dealing with all forms of charts. Other presented extraction tools also exhibited varying degrees of information loss.

With a reference context given, an LLM could manifest certain biases when generating Q&A pairs. The model might interpret the context in a biased manner based on its training data, namely the generation bias. For instance, if the model has been trained on data that frequently associates certain practices with specific crop varieties, it might overgeneralize these associations in the generated Q&A pairs. In some cases, the LLM may not fully consider the provided context when generating Q&A pairs, leading to answers that might be inconsistent with the context.

Tasks are defined with guidance from researchers and domain experts. This can lead to a bias towards certain types of tasks that involve individuals deemed important. Due to our task design settings, we also do not expect an LLM fine-tuned using the proposed dataset to perform significantly better in any task regarding scopes other than Information Access.

D.3 Benchmark and Evaluation

Recent advancements in the field of LLMs predominantly feature models with around 70 billion or 110 billion parameters. The selection of these specific parameter sizes represents a strategic equilibrium between enhancing model performance and efficiently allocating computational resources. Further empirical investigations are necessitated to ascertain the efficacy of the suggested dataset in the fine-tuning of LLMs with these parameter dimensions.

E Related Work

E.1 AI for Agriculture

The integration of Artificial Intelligence (AI) into various sectors has led to transformative advancements in recent years, with agriculture being no exception [9]. As a labor-intensive field, agriculture must adapt to the growing population and the escalating demands for crop production, making automation an essential advancement [33]. AI stands to contribute by alleviating the burden of labor-intensive tasks and enhancing both the yield and quality of agricultural products, thereby ensuring a stable global food supply [54, 63].

On the one hand, the advanced robotic technologies incorporated with AI, are playing a vital role in tackling the labor-intensive issue while ensuring the crop-producing process [44, 22]. Robotics, such as wheeled vehicles [41] equipped with RGB cameras and laser sensors, by utilizing AI-Vision algorithms, are adept at land preparation before planting [4, 35], sowing [31, 56], plant treatment [52, 27], and crop harvesting [13]. In addition, the implementation of Unmanned Aerial Vehicles (UAVs) [19, 61] and Internet of Things (IoTs) [51] can build a three-dimensional monitoring system for crop cultivation, thus promising significant reduction in cost and increase in the yield [60].

On the other hand, advanced AI can enhance crop cultivation in a data-driven approach, achieving the goals of precision agriculture [53, 39]. The combination of sensor data from equipment, along with remote sensing technologies like satellites and drones, soil and weather data, and other available data sources, can generate a dataset abundant in contextual information [47]. Consequently, processes such as irrigation, fertilization, and pest control in crop cultivation can be refined through the timely predictions provided by sophisticated AI methods [14, 62].

The introduction of LLMs has provided crop science researchers and agricultural practitioners with new opportunities to enhance production [50, 37]. The robust ability of LLMs to generate and acquire domain-specific knowledge has been a significant factor in this potential [17]. While researchers have explored the use of LLMs in answering agriculture-related exams [55], their performance in certain crop cultivation scenarios, such as pest management, has been less than satisfactory [66]. Moreover, there remains a considerable gap between the ability to answer exam questions and the application of this knowledge in real-world situations. To bridge the gap and thoroughly assess LLMs in supporting the crop science field, we introduce CROP. CROP comprises an instruction tuning dataset that equips LLMs with the necessary skills to aid tasks in crop production, along with a carefully designed benchmark to evaluate the extent to which LLMs fulfill the demands of real-world agricultural applications. We anticipate that CROP will serve the research community and also provide practical benefits to industry practitioners.

E.2 LLM-based Multi-turn Dialogue Generation

In recent research, several LLM-based approaches have emerged for constructing multi-turn dialogues. [21] tried to prompt LLMs to generate full multi-turn dialogues based on the 'ChatSEED', which were sampled from the very first utterances of real-world human dialogues. [57] first trained a question-asking model and then collected multi-turn conversations by utilizing it to iteratively chat with ChatGPT. [45] also used a two-stage approach, where instructional strategies were first extracted from real human-machine dialogues and then applied to produce new instructions. While these approaches collectively contribute to advancing LLM-based multi-turn dialogue systems, they are either restricted in terms of context dependency or less likely to be transformed into an end-to-end system.

F Dataset Collection Detail

We provide more details of the experts' evaluation. The evaluation work of human experts on single-turn and multi-turn dialogues is based on the same metrics designed for the LLM grader. A total of 115 participants were involved, including 14 domestic rice breeding experts, 49 graduate students in breeding-related fields, and 52 undergraduate students (junior year and above). For single-turn dialogues, experts focus on correctness, professionalism, and richness, while for multi-turn dialogues, experts focus on coherence, consistency, and specificity. After the first stage of filtering work, the generated contents include around 220k single-turn dialogues and 2k multi-turn dialogues. Our human experts clean the generated contents based on the mentioned rules, deleting around 5% low-quality samples of single-turn dialogues and 7% low-quality samples of multi-turn dialogues. After the filtering by human experts, we have 210,038 samples of single-turn dialogues and 1871 samples of multi-turn dialogues.

G Dataset Analysis Detail

G.1 Basic Statistics

Table 4 and 5 show the composition of single-turn dialogues and multi-turn dialogues, respectively.

G.2 Diversity

Data source. Figure 6 and 7 show the data source distribution of rice and corn, respectively.

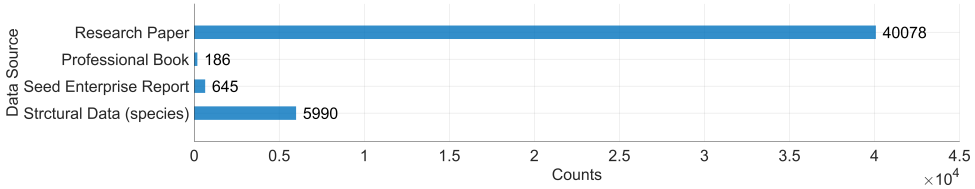


Figure 6: Distribution of rice-related data source. Counts include both Chinese and English.

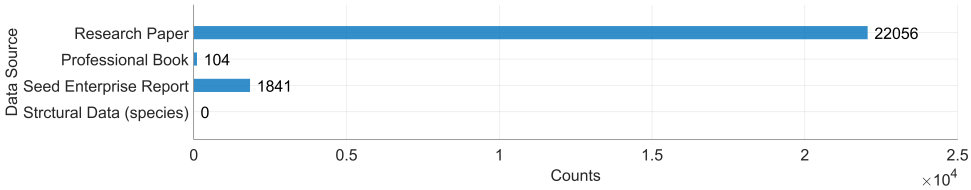


Figure 7: Distribution of corn-related data source. Counts include both Chinese and English.

Table 4: Composition of single-turn dialogues. Please note that despite our data-cleaning efforts, the final CROP dataset inevitably contains a small amount of data (<0.5%) from other grains like wheat. As this portion does not dominantly influence the fine-tuning results, it is included in the final CROP dataset. We have listed it explicitly in the table to avoid any misleading counts.

Cereal	Type	Task	Abbr.	English Q&A	Chinese Q&A	Total
Rice	Domain	Closed-book Q&A	CQA	42,951	83,396	126,347
		Open-book Q&A	OQA	2,430	2,037	4,467
	General	Event Extraction	EE	1,891	1,030	9,742
		Named Entity Recognition	NER	2,003	1,604	
		Summary	Summary	1,586	1,628	
Corn	Domain	Closed-book Q&A	CQA	25,259	27,667	52,926
		Open-book Q&A	OQA	3,202	3,047	6,249
	General	Event Extraction	EE	2,245	1,322	10,307
		Named Entity Recognition	NER	2,008	1,316	
		Summary	Summary	1,559	1,857	
Others*			—			<1000
Overall		—		85,134	124,904	**210,038**

Table 5: Composition of multi-turn dialogues. Blue denotes counts of 3-turn dialogues, green denotes counts of 4-turn dialogues, and yellow denotes counts of 5-turn dialogues.

Cereal	Scenario	Task	English Q&A	Chinese Q&A	Total
Rice	Problem Solving	Pest Control	14+71	8+37	130
		Nutrient Supplementation	19+93	2+ 90+ 1	205
		Disease Containment	19+ 60	4+ 39	122
	Personalized Recommendation	Crop Variety Selection	12+ 53	9+ 9	83
		Resource Management	4+ 110+ 1	5+ 50	170
	Knowledge Interpretation	Research Interpretation	3+ 125+ 1	8+ 85	222
Corn	Problem Solving	Pest Control	20+ 84	7+ 77	188
		Nutrient Supplementation	24+ 56	8+ 30	118
		Disease Containment	21+ 64	2+ 19+ 1	107
	Personalized Recommendation	Crop Variety Selection	19+ 75	46+ 47	187
		Resource Management	8+ 94	1+ 69	172
	Knowledge Interpretation	Research Interpretation	5+ 94+1	6+ 61	167
Overall	—		1,150	721	**1,871**

Geographic Diversity. Table 6 and 7 show the geographic diversity of rice and corn data, respectively.

Table 6: Geographic diversity of rice dataset. Note that we only include countries with more than 5 occurrences in all samples.

Continent	Country
Asia	Bangladesh, China, India, Indonesia, Japan, Laos, Nepal, North Korea, Philippines, South Korea, Thailand, Vietnam
Europe	France, Germany, Hungary, Italy, Russia, Spain
North America	Cuba, Guatemala, Mexico, United States
South America	Argentina, Brazil, Colombia, Guyana
Africa	Egypt, Guinea, Kenya, Madagascar, Mali, Tanzania
Oceania	Australia

Table 7: Geographic diversity of corn dataset. Note that we only include countries with more than 5 occurrences in all samples.

Continent	Country
Asia	Bangladesh, China, India, Indonesia, Japan, Laos, Nepal, Philippines, South Korea, Thailand
Europe	France, Germany, Greece, Hungary, Italy, Malta, Poland, Romania, Russia, Serbia, Spain, United Kingdom
North America	Canada, Cuba, Guatemala, Mexico, United States
South America	Argentina, Brazil, Colombia, Guyana, Peru
Africa	Congo, Egypt, Guinea, Kenya, Madagascar, South Africa, Tanzania, Zambia, Zimbabwe
Oceania	Australia, New Zealand

Content Length. Table 8 shows the statistics of content length measured by token counts of single-turn dialogue datasets. We use the official GPT-4 tokenizer provided by OpenAI. Figure 8 shows the statistics of the number of rounds in multi-turn dialogues.

Content Distribution. Figure 9 and 10 show the information cartography of the Chinese and English Q&A instructions, respectively.

H Template for Structural Data

Inspired by [67], we use the template technique to transform structured data into a dialogue format suitable for fine-tuning LLMs. There are 5 templates in different styles provided for two properties, presented in Table 9 and 10. We translate the original Chinese template into English as we are provided with the structured data in Chinese for a better illustration. By inserting the name of a rice variety into "[Rice Species]" and providing answers in simple declarative sentences, complete Q&A pairs can be obtained.

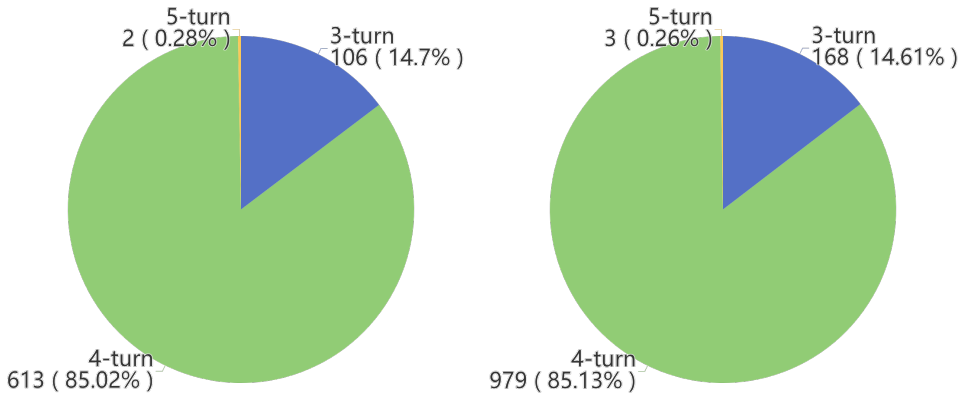
I Benchmark Analysis Detail

I.1 Topic Distribution

Figure 11 shows the topic distribution of the CROP benchmark.

Table 8: Statistics of token counts of single-turn dialogues.

Cereal	Language	Task	Max Q token	Max A token	Avg Q token	Avg A token
Rice	EN	CQA	45	179	18.79	62.11
		OQA	262	114	89.54	44.47
		EE	586	148	98.57	46.22
		NER	386	106	108.97	21.99
		Summary	1480	194	203.06	99.20
	ZH	CQA	191	1779	27.38	123.55
		OQA	1100	425	235.89	105.36
		EE	770	192	209.33	80.08
		NER	1135	215	277.74	57.00
		Summary	2059	713	384.01	175.40
Corn	EN	CQA	56	203	22.36	86.68
		OQA	377	203	91.76	43.94
		EE	785	123	105.42	48.88
		NER	329	184	108.26	22.01
		Summary	2183	189	213.53	96.62
	ZH	CQA	138	500	31.47	139.91
		OQA	1213	443	255.94	103.23
		EE	921	170	206.33	74.94
		NER	3194	570	362.09	53.94
		Summary	3188	314	440.65	172.26



(a) Chinese Q&A.

(b) English Q&A.

Figure 8: Statistics on the number of rounds in multi-turn dialogues. Both for Chinese Q&A and English Q&A, the majority is 4-turn dialogues.

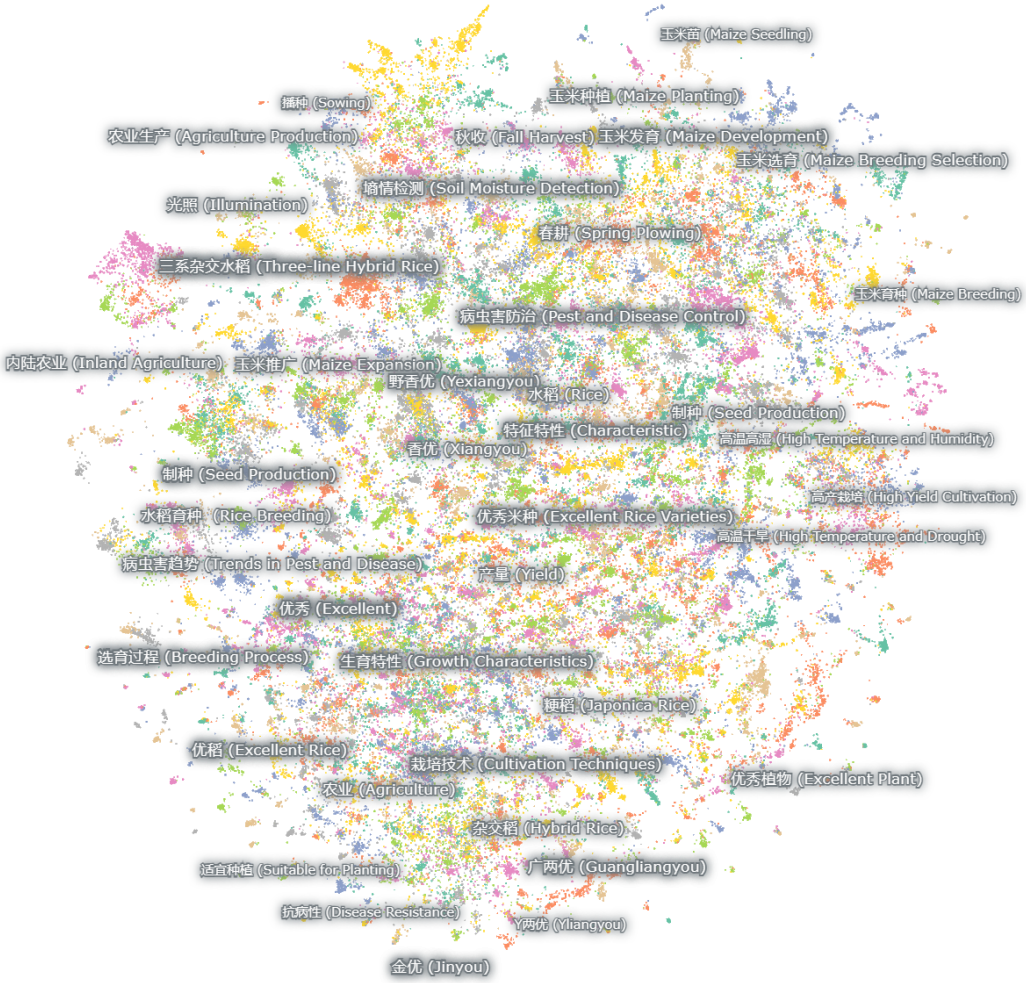


Figure 9: Chinese Q&A Instructions Cartography. We use the Chinese Q&A including the closed-book domain Q&A and open-book domain Q&A for generating the information cartography, where multiple diverse topics are revealed. Chinese topics and corresponding translations are presented and the map was generated using Nomic Atlas.

Table 9: 5 Templates in different styles for the rice property "Rice Blast Grade". We translate the original Chinese template into English.

Style	Template
Simple Inquiry	"What is the Rice Blast Grade for [Rice Species]?"
Detailed Request	"Could you please provide the Rice Blast Grade for [Rice Species], including any relevant details on lesion coverage and severity?"
Expert Opinion	"As an expert, what Rice Blast Grade would you give to [Rice Species] based on the severity and spread of the lesions?"
Historical Data	"Based on historical agricultural data, which Rice Blast Grade was assessed on [Rice Species]?"
Comprehensive Evaluation	"Based on the current conditions and symptoms observed, what would be the appropriate Rice Blast Grade for [Rice Species]?"

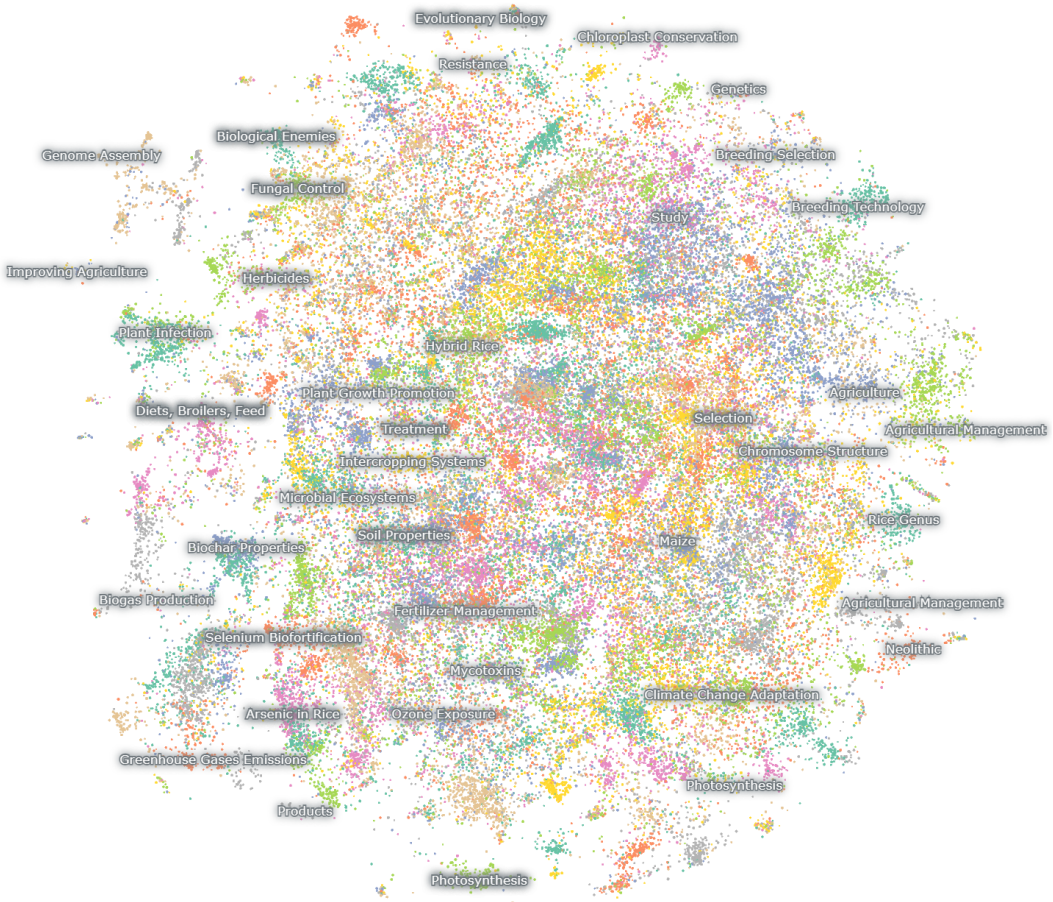


Figure 10: English Q&A Instructions Cartography. We use the English Q&A including the closed-book domain Q&A and open-book domain Q&A for generating the information cartography, where multiple diverse topics are revealed. The map was generated using Nomic Atlas.

Table 10: 5 Templates in different styles for the rice property "Suitable Cultivation Area". We translate the original Chinese template into English.

Style	Template
Simple Inquiry	"Which area is suitable for [Rice Species]'s cultivation?"
Detailed Request	"Could you provide detailed information on the regions that are most suitable for planting [Rice Species], considering soil quality and climate conditions?"
Expert Opinion	"As an agricultural expert, which areas would you recommend for planting [Rice Species]?"
Historical Data	"Based on historical agricultural data, which areas have consistently proven to be suitable for [Rice Species]'s cultivation?"
Comprehensive Evaluation	"Please provide a comprehensive evaluation of the best areas for planting [Rice Species], considering factors such as soil, climate, and water resources."

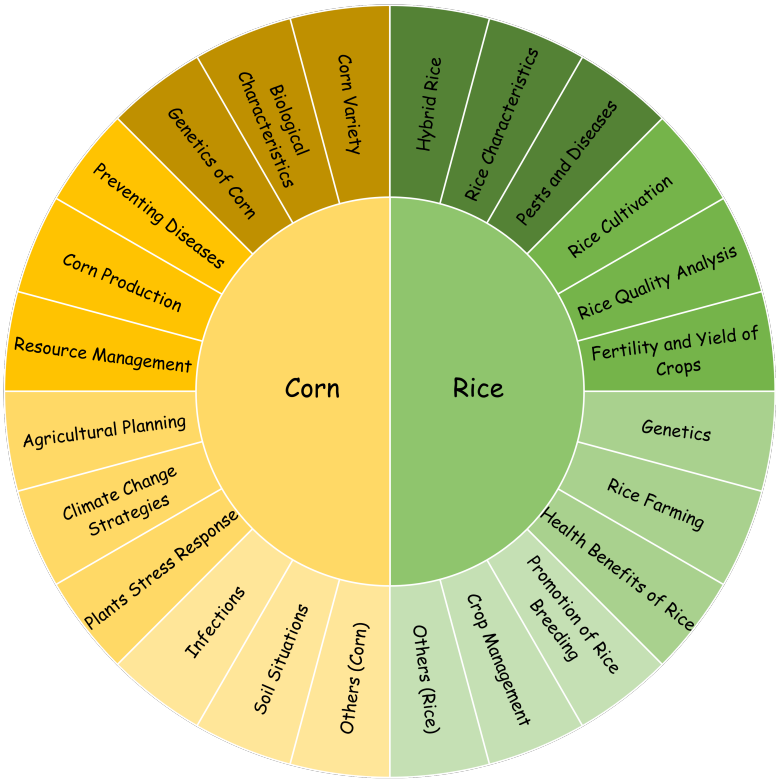


Figure 11: Topic distribution of benchmark. We list the keywords in the CROP benchmark for a deeper insight. Darker colors indicate a higher frequency of occurrence, while lighter colors indicate a lower frequency of occurrence.

I.2 Benchmark Comparison

Table 11: Geographic diversity of benchmark. Note that we only record countries with more than 3 occurrences in benchmark samples.

Continent	Country
Asia	Bangladesh, China, India, Indonesia, Japan, Nepal, North Korea, South Korea, Thailand, Vietnam
Europe	Germany, Italy, Russia, Spain
North America	Cuba, Mexico, United States
South America	Brazil
Africa	Madagascar, Mali, South Africa
Oceania	Australia

Table 11 shows the geographic diversity of the CROP benchmark. The statistical rules we adopted are the same as those applied to the CROP dataset (See 3.2), except the occurrence threshold was adjusted more than 3 times. There are 22 countries across six continents included in the CROP benchmark.

Table 12 compares the CROP benchmark against other agriculture-related question databases across four dimensions: language, format, dataset size, and region. CROP benchmark includes questions in two major world languages, English and Chinese, unlike other benchmarks limited to a single language. In terms of volume and geographic coverage, CROP benchmark significantly outperforms the other three benchmarks, offering roughly triple the number of questions found in AgriExams and

Table 12: Benchmark Comparison. CROP benchmark surpasses existing datasets in terms of quantity and locality.

Dataset	Language	Format	Size	Region
Certified Crop Advisor (CCA) Exam[1]	English	MCQs	312	United States
EMBRAPA[2]	Portuguese	Test-based Inquires	1,000	Brazil
AgriExams[3]	English	MCQs	1,723	India
CROP (Ours)	English & Chinese	MCQs	5,045	22 Countries

[1] `https://www.certifiedcropadviser.org/become-certified/certifications/`.
[2] `https://mais500p500r.sct.embrapa.br/view/index.php`. For EMBRAPA, we count the number of test-based inquiries related to rice and corn.
[3] `https://www.agriexam.com/agriculture-previous-year-question-paper`.

spanning 22 countries. Clearly, CROP benchmark is equipped to provide a more extensive evaluation of LLMs.

J Tasks and Prompts

J.1 Dual-guided Task Design

We propose a prior-based, dual guidance enhanced framework that integrates insights from both researchers and domain experts into the task design workflow. Ultrachat [20] proposed three scopes of dialogue data: Information Access, Information Creation, and Information Transformation, to model human-AI interactions. While the scope dimension poses a certain level of restriction on the task design, additional variables are required to define a complete task partitioning criterion.

We consider domain D and raw data R as two dimensions which, together with scope S, help determine a task sample space. The prior is thus defined as follows:

$$K_{prior} = (d, s, r), \quad d \in D, s \in S, r \in R, \tag{7}$$

where we consider d being the crop science domain, s being either the Information Access scope or the Information Transformation scope, and r being the data source.

For single-turn dialogues, we delineated two categories of tasks under the guidance of researchers and domain experts. Question-answer pairs in the domain-focused category belong to what is generally called "knowledge Q&A". An LLM fine-tuned using this portion of the single-turn dialogues is expected to provide highly specialized and well-formatted responses to domain knowledge queries. The general category aims to adapt general language modeling tasks to the crop science domain. Each task within this category is domain-adapted, thereby further enhancing the capabilities of an equipped LLM.

A task and its setting are determined separately. Within the task sample space defined by a prior triplet (d, s, r), subdivided tasks T of a category are determined based on researcher guidance G_R and expert guidance G_E:

$$T \sim P^{ST}(t|G_R, G_E, K_{prior}) \tag{8}$$

A specific setting τ, is chosen from a set of possible settings τ_t for a given task t, which is influenced by additional expert guidance G'_E:

$$\tau_t \sim P^{ST}(\tau|t, G'_E) \tag{9}$$

Consider NER as a task t within the open-book category, additional expert guidance G'_E specifies entity categories to be geographic location, disease, pest, and crop variety as a task setting τ. We intend to enhance the capability of an LLM in recognizing selected entity types in crop science.

As discussed, tasks for multi-turn dialogues are also defined in a two-step manner, with recommended scenarios first and tasks afterward. The work of determining concrete tasks is assigned to an LLM with contextual prompts from raw data.

Within the task sample space defined by a prior triplet (d, s, r), the set of scenarios S is determined based on only expert guidance G_R:

$$S \sim P^{MT}(s|G_E, K_{prior}) \tag{10}$$

Tasks T_s of a chosen scenario s is generated using an LLM L:

$$T_s \sim P_L^{MT}(t|s) \tag{11}$$

Consider pest control as a task t within the problem-solving scenario s. The LLM recognizes it as one of what should be included in a multi-turn setting as it is frequently discussed in the raw data.

The proposed framework is designed with high adaptability. The triplet of the three prior variables can be adjusted to cater to specific use cases, providing a flexible and customizable approach to task design.

J.2 Single-turn Q&A

The single-turn Q&A includes five tasks:

Closed-book Q&A. The content of closed-book Q&A is professional knowledge, where there are no external reference materials provided in the question. Our Q&A pairs cover the following aspects: stress resistance, pests and diseases, cultivation techniques, breeding, characteristics, suitable planting areas, *etc*.

Open-book Q&A. The content of open-book Q&A is also professional knowledge, where there are external reference materials provided in the question. The considering aspects of the open-book Q&A are the same as closed-book Q&A.

Summary Q&A. Give a professional summary for a portion of the provided article.

Named Entity Recognition. Understand and extract specific entity information from the provided article. The entity information is emphasized on the geographic location, diseases and pests, and crop variety.

Event Extraction. Identify the event triggers and extract relevant arguments associated with these events from the provided article. The event categories restricted by the task are (1) no event, (2) pest impact, (3) new variety release or breeding, (4) climate or weather event, (5) planting or production trial, (6) policy release, (7) yield record, and (8) variety mutation.

We formulate the task-oriented prompts to query the LLM for the Q&A pairs and present several examples of produced Q&A pairs in this section, where the corresponding arrangements are shown in Table 13. We divided our prompt into four parts: role description, reference text, guidelines, and example dialogue.

Table 13: The arrangement of templates and examples for single-turn Q&A.

EN		ZH	
Task	Location	Task	Location
Closed-book Q&A	Figure 12	Closed-book Q&A	Figure 13
Summary Q&A	Figure 14	Summary Q&A	Figure 15
Named Entity Recognition	Figure 16	Named Entity Recognition	Figure 17
Event Extraction	Figure 18	Event Extraction	Figure 19
Open-book Q&A	Figure 20	Open-book Q&A	Figure 21

Closed-book Q&A (EN)

Topic Description:
Instruct the model to return professional knowledge Q&A. There are no external reference materials provided in the produced question.

System:
You are an expert in the field of study relevant to the academic paper enclosed within the <doc></doc> tags. Please generate a set of question-answer pairs that reflect the key findings and discussions in the paper.

Role Description

<doc>
In the recent past, population explosion has augmented urbanization……
</doc>

Reference Text

For each question-answer pair, please adhere to the following guidelines:
1. The number of question-answer pairs should be determined by the depth and breadth of the paper, with a minimum of *N_min* and a maximum of *N_max*.
2. The questions should cover various aspects of the paper, avoid focusing solely on numerical data, and refrain from asking yes/no questions or questions with obvious answers.
3. If the paper provides relevant information, ensure that the question-answer pairs cover the following aspects: Stress Resistance, Pests and Diseases, Cultivation Techniques, Breeding, Characteristics, Suitable Planting Area, etc.
4. Ensure that the answers follow a logical sequence and are supported by the information in the paper.
5. You may refer to the example provided within the <example></example> tags for designing the question-answer pairs, but ensure that the output strictly follows the format of this example.

Guidelines

<example>
Question: How to achieve a high yield in the cultivation of Y302 through fertilizer management?
Answer: In the cultivation of Y302, high yield is achieved through the scientific ratio and timely application of base fertilizer, topdressing, ear fertilizer, and grain fertilizer. Considering the longer growth time and high yield potential of Y302, organic fertilizer needs to be added.
</example>

Example Dialogue

User:
Please generate a set of question-answer pairs based on the given academic paper.

Example:
Question 1: What was the primary objective of the field research conducted on fourteen early genotypes of maize?
Answer 1: The primary objective of the field research was to explore the roles of chlorophyll content and its relation with other yield attributing traits in maize.
Question 2: What were the specific findings regarding aflatoxin levels in maize using different drying methods?
Answer 2: The research found significant differences in aflatoxin levels among the three drying methods tested. Kitchen drying resulted in the lowest aflatoxin contamination (1.4 ppb), followed by sun drying (1.6 ppb) and dry shelter drying (2.2 ppb). These findings indicate that kitchen drying is more effective at reducing aflatoxin levels in maize compared to the other methods.
Question 3: ……
Answer 3: ……

Figure 12: Prompt and few examples for English Closed-book Q&A.

Closed-book Q&A (ZH)

Topic Description:
Instruct the model to return professional knowledge Q&A. There are no external reference materials provided in the produced question.

System:
你是一名育种专家，同时是一位农业科学和生物科学的教授，请基于在<doc></doc>标记之间的这篇学术论文，生成若干问答对。

Role Description

<doc>
玉米营养诊断是在玉米生育进程中的某些时期检测植株的营养状况是否符合……
</doc>

Reference Text

对于每一个问答对，你需要注意以下几点：
1. 请根据论文长度决定生成问答对的具体数量，问题数量最小为*N_min*，最大为*N_max*。
2. 这些问题应当从不同的角度出发，不应当着重关注于数字部分，避免提出是/否的问题或有明显答案的问题。
3. 如果论文中有相关信息，请确保问答中包含涉及选育过程；特征特性；栽培技术要点；适宜种植区域；抗逆性；病虫害防治等方面的内容。
4. 请确保回答遵循合适的逻辑关系。
5. 你可以参照<example></example>标记之间的示例设计问答，但请确保完全遵循该示例的格式输出回复。

Guidelines

<example>
问题：需要AI Agent推荐一个水稻品种，适合在西藏等高海拔地区种植。
回答：中国高海拔地区通常是指海拔在500-4000米之间的地区，主要包括云南、贵州、四川、西藏等地。按照全国稻区划分，这些地区大多属于西南高原单双季稻稻作区，水稻面积占全国的8%左右。高海拔造成这些区域年积温低和极端低温，光照和紫外线强烈。同时，海拔决定水稻的垂直分布。云南省海拔1750 m以下的为籼稻，海拔1750～2000 m的为籼粳混交带，海拔2000 m以上的为粳稻。2023年西藏自治区农科院农研所选育的水稻新品系“2021LS－68”在海拔3177米实现亩产1112.32斤。此外，其他品种赣73优8601、赣宁粳1号等经过多年测试，能够适应高海拔种植。高海拔地区的气候条件差异可能会很大。因此，选择适宜种植品种，需要根据具体地区的平均光照温度报告或数据进行决策。
</example>

Example Dialogue

User:
请基于给定学术论文，生成若干问答对。

Example:
问题1：莱农糯10号玉米品种的主要特点是什么？
回答1：莱农糯10号玉米品种具有较短的生育期（75天），较高的抗病性，以及较高的支链淀粉含量（99.27%），适合在黄淮海夏玉米区种植。
问题2：桂糯518玉米品种的主要优势是什么？
回答2：桂糯518玉米品种具有较高的保绿度（88.9%），较低的倒伏率（2.5%），以及较高的产量表现，特别适合在广西种植。
问题3: ……
回答3: ……

Figure 13: Prompt and few examples for Chinese Closed-book Q&A.

Summary (EN)

Topic Description:
Instruct the model to return a professional summary for a portion of the provided article.

System:
You are an expert in the field of study relevant to the academic paper enclosed within the <doc></doc> tags. Please generate a set of question-answer pairs that summarize the key findings and discussions in the paper.

Role Description

<doc>
In the recent past, population explosion has augmented urbanization……
</doc>

Reference Text

For each question-answer pair, please adhere to the following guidelines:
1. The task specified for the question-answer pair is Summary.
2. Please extract a portion of the paper (at least 200 words) as the reference text for the task.
3. Please ensure that the answer follows the appropriate logical relationship.
4. You may refer to the example provided within the <example></example> tags for designing the question-answer pairs, but ensure that the output strictly follows the format of this example.
5. Please replace the part within '()' in the example question with the extracted reference text, and ensure not to change other parts of the question.

Guidelines

<example>
Question: (Folates, also known as vitamin B9, are one of the essential micronutrients for the human body. Due to the inability of the human body to synthesize on its own, it can only rely on food for intake. Adults need to consume at least 400 per day μ Folic acid is used to meet the needs of life activities, increasing to 600 during pregnancy μ G. But in many parts of the world, the daily intake of folic acid is around 400 μ As a result, folate deficiency has become a global health problem. Folate deficiency is more likely to worsen in pregnant and breastfeeding women. As the world's main cultivated crop and the largest grain crop in China, corn has an average folate content of 40-60% in dry seeds μ (g/100g) Only one tenth of the daily dietary requirement for folate in humans.) Please read and understand the given text, and summarize it.
Answer: This paragraph points out the importance of folic acid in human health and the problem of insufficient folic acid intake worldwide. Special emphasis was placed on the health issues that may arise from folic acid deficiency during pregnancy and lactation. At the same time, it was mentioned that the folate content of corn, the main crop, is generally low, which is different from the daily needs of the human body.
</example>

Example Dialogue

User:
Please generate *N* question-answer pairs based on the given academic paper.

Example:
Question 1: (The water availability is calculated based on the amount of rainfall that occurs during the year. The rainfall per year suitable for corn cultivation is between 300 mm to 400 mm and 900 mm to 1200 mm. Based on the analysis of rainfall data from 2018 to 2022, the average This happens because of a monsoonal rainfall pattern in this study area. Hence, it is classified as not suitable (N) for the corn, as shown in Figure 4. The Dadahup irrigation area has low land elevation, so high rainfall may make the inundated land. Inundated land can inhibit the growth of corn. Based on the previous study in Kaliwungu Village, corn productivity with inundated land was 10.17 tons/ha. In comparison, corn production with regularly irrigated land was 12.10 tons/ha.) Read and understand the given text, and summarize it.
Answer 1: The passage discusses water availability for corn cultivation in the Dadahup irrigation area, emphasizing that the ideal annual rainfall for corn ranges from 300 mm to 1200 mm. However, due to the monsoonal rainfall pattern, the area experiences higher than ideal rainfall, leading to classification as unsuitable for corn cultivation. The low elevation of the land contributes to inundation, which further inhibits corn growth, as evidenced by lower productivity in inundated conditions compared to well-irrigated land.
Question 2: ……
Answer 2: ……

Figure 14: Prompt and few examples for English Summary Q&A.

Summary (ZH)

Topic Description:
Instruct the model to return a professional summary for a portion of the provided article.

System:
你是一名育种专家，同时是一位农业科学和生物科学的教授，请基于在<doc></doc>标记之间的这篇学术论文，生成概括总结。

Role Description

<doc>
玉米营养诊断是在玉米生育进程中的某些时期检测植株的营养状况是否符合……
</doc>

Reference Text

对于每一个问答对，你需要注意以下几点：
1. 问答对的任务类型是概括总结。
2. 请提取文章的一部分（至少200字）作为问答对任务中的参考文本。
3. 请确保回答遵循合适的逻辑关系。
4. 你可以参照<example></example>标记之间的示例设计问答，但请确保完全遵循该示例的格式输出回复。
5.请将示例问题中‘（）’内的部分替换为提取的参考文本，并确保不会更改问题的其他部分。

Guidelines

<example>
问题：(玉米生产过程中会出现各种病虫草害的问题，严重影响玉米的生产。通过合理的植保技术手段，可以减少病虫草害的影响，常规的地下害虫和苗期病害以及丝黑穗病都可以用种衣剂解决。玉米苗期低温冷害的问题由于气候多变，春季低温冷害时有发生，严重影响玉米种子正常发芽和出苗，对芽势弱的种子影响更大。解决方案包括适当晚播，选用含精甲霜灵和咯菌腈成份的种衣剂进行种子包衣处理，以及使用“亨达608”对种子进行包衣处理，可直接包衣，农民也可以对已包衣种衣剂的种子进行二次包衣处理。)阅读并理解给定文本，对该文本进行概括总结。
回答：这段文本讨论了玉米生产中遇到的病虫草害问题及其解决方案。强调了通过使用种衣剂和合理的植保技术可以有效减少这些问题的影响。特别提到了春季低温冷害对玉米种子发芽和出苗的不利影响，以及通过晚播和种衣剂处理（包括使用“亨达608”）来提高种子的抗逆性和生长势。
</example>

Example Dialogue

User:
请基于给定学术论文，生成*N*个问答对。

Example:
问题1：（玉米防病防虫抗倒伏问题。玉米大小斑病、锈病和虫害是玉米中后期的主要病虫害，发生严重时会造成明显减产。玉米倒伏问题近年来也频繁发生，特别是2020年东北三省遭遇特大台风，造成大面积倒伏，造成机收困难，农民损失很大。解决方案包括国家玉米产业体系研究玉米病虫害防治前移技术，在玉米6-11叶期间喷施的玉米矮化防病增产套餐产品：具体是用“佳节”（30%胺鲜酯·乙烯利）+“享尔”（40%丁香·戊唑醇）+“亨达福”（0.01%芸苔素内酯）+杀虫剂，具有防病、防虫、抗倒伏和增产作用。）阅读并理解给定文本，对该文本进行概括总结。
回答1：这段文本描述了玉米生产中的防病防虫和抗倒伏问题，特别是在遭遇极端天气如台风时的倒伏问题。文中提供了一种解决方案，即使用国家玉米产业体系研究的前移技术，通过在特定生长期喷施一套特定的化学品组合，这些化学品包括胺鲜酯、丁香、戊唑醇和芸苔素内酯，以及杀虫剂，以达到防病、防虫、抗倒伏和增产的效果。
问题2：……
回答2：……

Figure 15: Prompt and few examples for Chinese Summary Q&A.

Named Entity Recognition (EN)

Topic Description:
Instruct the model to understand and extract specific entity information from the provided article.

System:
You are an expert in the field of study relevant to the academic paper enclosed within the <doc></doc> tags. Please generate a set of question-answer pairs that reflect the key findings and discussions in the paper.

Role Description

<doc>
In the recent past, population explosion has augmented urbanization……
</doc>

Reference Text

For each question-answer pair, please adhere to the following guidelines:
1. The task specified for the question-answer pair is Named Entity Recognition (NER).
2. Please extract a portion of the paper as the reference text for the task.
3. The entity categories restricted by the task are: Geographic Location, Disease, Pest, Crop Variety.
4. Ensure that the extracted part covers as many entity categories as possible.
5. You may refer to the example provided within the <example></example> tags for designing the question-answer pairs, but ensure that the output strictly follows the format of this example.
6. Please replace the part within '()' in the example question with the extracted reference text, and ensure not to change other parts of the question.

Guidelines

<example>
Question: (The \"Golden Dragon 1\" variety has shown resistance to \"rice blast\", a common disease in rice crops. \"Golden Dragon 1\" is suitable for planting in Jiangsu Province. Farmers have reported an increase in the number of rice water weevil in their rice fields.) Read and understand the given text, identify the entities in it and classify them into the following categories: Crop Variety, Geographic Location, and Disease. The reply should be given in dictionary format, where the key is the entity category and the value is a list containing entities belonging to that category.
Answer: {\"Crop Variety\": [\"Golden Dragon 1\"], \"Disease\": [\"rice blast\"], \"Geographic Location\": [\"Jiangsu Province\"]}, \"Pest\": [\"rice water weevil\"]}.
</example>

Example Dialogue

User:
Please generate *N* question-answer pairs based on the given academic paper.

Example:
Question 1: (The four maize inbred lines: Agaiti-85 (P1), Golden (P2), Soneri (P3), and Sultan (P4) from F population (99.25% purity) under high temperature (>45°C) and drought stress conditions were selected during 2009-2010 in the University of Agriculture, Faisalabad, Pakistan (31°26'N, 73°06'E).) Read and understand the given text, identify the entities in it and classify them into the following categories: Crop Variety, Geographic Location. The reply should be given in dictionary format, where the key is the entity category and the value is a list containing entities belonging to that category.
Answer 1: {“Crop Variety”: [“Agaiti-85”, “Golden”, “Soneri”, “Sultan”], “Geographic Location”: [“Faisalabad, Pakistan”]}.
Question 2: (The intensities of crop damage caused by thrips, armyworm, fruit fly, bacterial wilt (Ralstonia solanacearum), and gemini virus (pepper yellow leaf curl virus) infections were then determined.) Read and understand the given text, identify the entities in it and classify them into the following categories: Disease, Pest. The reply should be given in dictionary format, where the key is the entity category and the value is a list containing entities belonging to that category.
Answer 2: {"Disease": ["bacterial wilt", "gemini virus"], "Pest": ["thrips", "armyworm", "fruit fly"]}.
Question 3: ……
Answer 3: ……

Figure 16: Prompt and few examples for English Named Entity Recognition Q&A.

Named Entity Recognition (ZH)

Topic Description:
Instruct the model to understand and extract specific entity information from the provided article.

System:
你是一名育种专家，同时是一位农业科学和生物科学的教授，请基于在<doc></doc>标记之间的这篇学术论文，生成命名实体识别问答对。

Role Description

<doc>
玉米营养诊断是在玉米生育进程中的某些时期检测植株的营养状况是否符合……
</doc>

Reference Text

对于每一个问答对，你需要注意以下几点：
1.问答所指定的任务为命名实体识别（NER）。
2.请截取论文的一部分作为任务的参考文本。
3.任务限制的实体类别为：地理位置，病虫害，作物品种。
4.请确保所截取部分涵盖尽可能多的实体类别。
5.你可以参照<example></example>标记之间的示例设计问答，但请确保完全遵循该示例的格式输出回复。
6.请将示例问题部分中'（）'之间的部分替换为所截取的参考文本，确保不要更改问题的其他部分。

Guidelines

<example>
问题：（“金龙1号”品种已经显示出对“稻瘟病”的抗性，这是水稻作物中的一种常见疾病。“金龙1号”适合在江苏南部种植。然而，农民们报告说，在他们的稻田里，一种害虫“稻象甲”的数量有所增加。）阅读并理解给定文本，识别其中的实体并将其分类为以下类别：作物品种、地理位置和疾病。回复应该以字典格式给出，其中键为实体类别，值为含有所属该类别实体的列表。
回答：{"作物品种": [“金龙1号”], "疾病": [“稻瘟病”], "地理位置": [“江苏南部”]}
</example>

Example Dialogue

User:
请基于给定学术论文，生成*N*个问答对。

Example:
问题1：（“2023年河北省农科院植保所郭宁等统计在2018-2020年黄淮海区427个玉米国审品种中，南方锈病的抗性以高感和感病为主，未发现高抗品种，抗性品种和中抗品种的数量也较少。对2020年黄淮海主栽品种也进行了抗性分析。”）阅读并理解给定文本，识别其中的实体并将其分类为以下类别：作物品种、地理位置和疾病。回复应该以字典格式给出，其中键为实体类别，值为含有所属该类别实体的列表。
回答1：{“作物品种”: [“玉米”], “病虫害”: [“南方锈病”], “地理位置”: [“河北省”, “黄淮海区”]}。
问题2：（美国转基因玉米面积约占全国玉米面积的93%，主要以抗虫和抗除草剂叠加性状为主。由于转基因玉米品种的推广，大幅减少了虫害（玉米螟、黏虫、根虫等）对产量的影响，相当于增产10~15%。而我国玉米基本都是常规玉米（除近年来一些地区非法种植了小部分转基因玉米外），生产上虫害频发（玉米螟、黏虫、棉铃虫、桃蛀螟、草地贪夜蛾等），给玉米的产量造成了很大损失，同时也严重影响了玉米的商品品质。）阅读并理解给定文本，识别其中的实体并将其分类为以下类别：作物品种、地理位置和疾病。回复应该以字典格式给出，其中键为实体类别，值为含有所属该类别实体的列表。
回答2：{“作物品种”: [“转基因玉米”, “常规玉米”], “病虫害”: [“玉米螟”, “黏虫”, “根虫”, “棉铃虫”, “桃蛀螟”, “草地贪夜蛾”]}。
问题3：……
回答3：……

Figure 17: Prompt and few examples for Chinese Named Entity Recognition Q&A.

Event Extraction (EN)

Topic Description:
Instruct the model to identify the event triggers and extract relevant arguments associated with those events from the provided article.

System:
You are an expert in the field of study relevant to the academic paper enclosed within the <doc></doc> tags. Please generate a set of question-answer pairs that reflect the key findings and discussions in the paper.

Role Description

<doc>
In the recent past, population explosion has augmented urbanization……
</doc>

Reference Text

For each question-answer pair, please adhere to the following guidelines:
1. The task specified for the question-answer pair is Event Extraction.
2. Please extract a portion of the paper as the reference text for the task.
3. The event categories restricted by the task are: No Event, Pest Impact, New Variety Release or Breeding, Climate or Weather Event, Planting or Production Trial, Policy Release, Yield Record, Variety Mutation.
4. Ensure that the extracted part belongs to only one event category and highly matches that event category.
5. You may refer to the example provided within the <example></example> tags for designing the question-answer pairs, but ensure that the output strictly follows the format of this example.
6. Please replace the part within '()' in the example question with the extracted reference text, and ensure not to change other parts of the question.

Guidelines

<example>
Question: (Last week, the \"Golden Dragon 1\" variety was officially released in the Philippines. This variety was developed by the International Rice Research Institute (IRRI) and was biofortified to combat Vitamin A deficiency. Farmers, scientists, and government officials attended the release event. It was announced at the event that the \"Golden Dragon 1\" seeds will be distributed to local farmers in the next planting season.) Identify the main event type and provide a summary of the event from the given text. The result should be presented in a dictionary format where the key is the event type and the value is a summary of the event.
Answer: {\"New Variety Release or Breeding\":[\"The 'Golden Dragon 1' variety, developed by the International Rice Research Institute (IRRI) to combat Vitamin A deficiency, was officially released in the Philippines. The seeds will be distributed to local farmers in the next planting season.\"]}
</example>

Example Dialogue

User:
Please generate *N* question-answer pairs based on the given academic paper.

Example:
Question 1: (The seedlings were grown for two weeks in a glasshouse under a maximum natural daylight irradiance of 1200-1600µmol m² s, 21/27-13/16°C day/night temperature, 14/10 h light/dark cycle, and relative humidity between 65 and 70 % in pots filled with a mixture of vermiculite and Trio-hum tray substrate, being irrigated with Hoagland nutrient solution.) Identify the main event type and provide a summary of the event from the given text. The result should be presented in a dictionary format where the key is the event type and the value is a summary of the event.
Answer 1: {"Planting or Production Trial":["Wheat and maize seedlings were cultivated in a glasshouse with controlled environmental conditions including light, temperature, and humidity for two weeks to ensure optimal growth before undergoing chilling stress trials."]}
Question 2: ……
Answer 2: ……

Figure 18: Prompt and few examples for English Event Extraction.

Event Extraction (ZH)

Topic Description:
Instruct the model to identify the event triggers and extract relevant arguments associated with those events from the provided article.

System:
你是一名育种专家，同时是一位农业科学和生物科学的教授，请基于在<doc></doc>标记之间的这篇学术论文，生成事件提取问答对。

Role Description

<doc>
玉米营养诊断是在玉米生育进程中的某些时期检测植株的营养状况是否符合……
</doc>

Reference Text

对于每一个问答对，你需要注意以下几点：
1.问答所指定的任务为事件提取（Event Extraction）。
2.请截取论文的一部分作为任务的参考文本。
3.任务限制的事件类别为：无事件，病虫害影响，新品种发布或选育，气候或天气事件，种植或生产试验，政策发布，产量新纪录，品种变异。
4.请确保所截取部分仅属于一个事件类别，且与该事件类别高度匹配。
5.你可以参照<example></example>标记之间的示例设计问答，但请确保完全遵循该示例的格式输出回复。
6.请将示例问题部分中'（）'之间的部分替换为所截取的参考文本，确保不要更改问题的其他部分。

Guidelines

<example>
问题：（上周，“金龙1号”品种在菲律宾正式发布。该品种是由国际水稻研究所（IRRI）开发的，经过生物强化以对抗维生素A缺乏症。农民、科学家和政府官员参加了此次发布活动。活动中宣布，“金龙1号”种子将在下一个种植季节分发给当地农民。） 阅读并理解给定文本，识别其中的事件并将其分类。回复应该以字典格式给出，其中键为事件类别，值为含有事件高度概括的列表。
回答：{"新品种发布或选育":["国际水稻研究所（IRRI）为对抗维生素A缺乏症而开发的“黄金大米”品种在菲律宾正式发布。种子将在下一个种植季节分发给当地农民。"]}
</example>

Example Dialogue

User:
请基于给定学术论文，生成*N*个问答对。

Example:
问题1：（玉米杂交种丹农玉788是丹东农业科学院2017年以F5866 为母本、外引系沈1554为父本杂交选育而成。2017 年参加品种比较试验，2018-2019年参加联合比较试验，试验名称为丹3202，2020-2021 年参加中科玉科企联合体中晚熟组区域试验，2021年参加中科玉科企联合体中熟组生产试验。2022 年通过国家品种审定委员会审定(审定编号：国审玉20220202)，定名为丹农玉788。）阅读并理解给定文本，识别其中的事件并将其分类。回复应该以字典格式给出，其中键为事件类别，值为含有事件高度概括的列表。
回答1：{"新品种发布或选育":["丹东农业科学院选育的玉米杂交种丹农玉788，经过多年的试验和审定，最终在2022年被正式命名并发布。"]}
问题2：……
回答2：……

Figure 19: Prompt and few examples for Chinese Event Extraction.

Open-book Q&A (EN)

Topic Description:
Instruct the model to return professional knowledge Q&A. There are external reference materials provided in the produced question.

System:
You are an expert in the field of study relevant to the academic paper enclosed within the <doc></doc> tags. Please generate a set of question-answer pairs that reflect the key findings and discussions in the paper.

Role Description

<doc>
In the recent past, population explosion has augmented urbanization……
</doc>

Reference Text

For each question-answer pair, please adhere to the following guidelines:
1. The task specified for the question-answer pair is Direct Question Answering.
2. Please extract a portion of the paper (at least 300 words) as the reference text for the task.
3. The question part of the question-answer pair should include the reference text and the generated question, and the answer part is the matching answer.
4. If the paper provides relevant information, ensure to include the following aspects: Stress Resistance, Pests and Diseases, Cultivation Techniques, Breeding, Characteristics, Suitable Planting Area, etc.
5. You can design the question-answer pair according to the example within the <example></example> tags, but ensure the output strictly follows the format of the example.
6. Please replace the part within '()' in the example question with the extracted reference text, and the part within '[]' with the generated question.

Guidelines

<example>
Question: (\"Golden Dragon 1\" is a type of rice produced through genetic engineering to biosynthesize beta-carotene, a precursor of vitamin A, in the edible parts of rice. It is intended to produce a fortified food to be grown and consumed in areas with a shortage of dietary vitamin A.) [What is the main purpose of developing Golden Rice?]
Answer: The main purpose of developing \"Golden Dragon 1\" is to produce a fortified food to be grown and consumed in areas with dietary Vitamin A deficiency.
</example>

Example Dialogue

User:
Please generate *N* question-answer pairs based on the given academic paper.

Example:
Question 1: ("The diseases detected in the experiment were southern rust, maize bushy stunt, corn stunt and corn smut. Southern rust was the prevailing disease, with the highest incidence (76.94%). Caused by the fungus Puccinia polysora Undrew, this disease is currently one of the most important diseases of maize in Brazil and is considered the most aggressive rusts that occur on this crop.") [What was the most prevalent disease found in the maize crops during the study?]
Answer 1: The most prevalent disease found in the maize crops during the study was southern rust, caused by the fungus Puccinia polysora Undrew.
Question 2: ("The highest prevalence and severity of southern rust in maize was found in crops using the high technology system tested. Statistical analyses detected that rust severity increased along with the technology level used for maize cropping.") [How did the technology level used in maize cropping affect the severity of southern rust?]
Answer 2: The severity of southern rust increased with the technology level used in maize cropping, with the highest prevalence and severity found in crops using the high technology system.
Question 3: ……
Answer 3: ……

Figure 20: Prompt and few examples for English Open-book Q&A.

Open-book Q&A (ZH)

Topic Description:
Instruct the model to return professional knowledge Q&A. There are external reference materials provided in the produced question.

System:
你是一名育种专家，同时是一位农业科学和生物科学的教授，请基于在<doc></doc>标记之间的这篇学术论文，生成问答对。

Role Description

<doc>
玉米营养诊断是在玉米生育进程中的某些时期检测植株的营养状况是否符合……
</doc>

Reference Text

对于每一个问答对，你需要注意以下几点：
1.问答所指定的任务为直接问答（Direct Question Answering）。
2.请截取论文的一部分（至少200字）作为任务的参考文本。
3.问答对的问题部分包括参考文本和生成的问题，回答部分为匹配的回答。
4.如果论文中有相关信息，请包含涉及选育过程；特征特性；栽培技术要点；适宜种植区域；病虫害防治；抗逆性等方面的问题。
5.你可以参照<example></example>标记之间的示例设计问答，但请确保完全遵循该示例的格式输出回复。
6.请将示例问题部分中'（）'之间的部分替换为所截取的参考文本，'[]'之间的部分替换为生成的问题。

Guidelines

<example>
问题：（“金龙1号”是一种水稻，通过基因工程在大米的可食用部分生物合成维生素a的前体β-胡萝卜素。它旨在生产一种强化食品，在膳食维生素a短缺的地区种植和食用。）[开发黄金大米的主要目的是什么？]
回答：开发“金龙1号”的主要目的是生产一种强化食品，在膳食维生素a短缺的地区种植和食用。
</example>

Example Dialogue

User:
请基于给定学术论文，生成*N*个问答对。

Example:
问题1：（玉米种子质量和成本是良种推广的重要因素，也体现品种价值。长期以来，玉米育种家在制定玉米育种目标时，多重视杂种一代的配合力，特别是杂种一代的产量、质量和抗性，轻视玉米制种产量、质量及其技术，从而影响了品种的推广。）[在玉米育种中，为什么制种产量和质量同样重要？]
回答1：在玉米育种中，制种产量和质量同样重要，因为它们是良种推广的重要因素，体现了品种的价值。如果忽视这些方面，将影响品种的推广。
问题2：（甘肃、新疆、宁夏由于地处我国内陆，光照充足，昼夜温差大，气候干燥，病虫害轻，是我国乃至世界最佳制种基地。针对上述存在问题，通过多年实践，探索创新了一些制种技术。）[为什么甘肃、新疆、宁夏被认为是最佳的玉米制种基地？]
回答2：甘肃、新疆、宁夏被认为是最佳的玉米制种基地，因为这些地区地处内陆，具有充足的光照、大的昼夜温差和干燥的气候，同时病虫害较轻，这些条件都非常适合玉米制种。
问题3：……
回答3：……

Figure 21: Prompt and few examples for Chinese Open-book Q&A.

J.3 Multi-turn Q&A

We design a multi-agent setting for the generation of multi-turn Q&As, where an assistant agent and a user agent are defined with different roles. Meanwhile, for each type of crop, we define six tasks under three scenarios (problem-solving, personalized recommendation, and knowledge interpretation). Thus, prompts are determined by the role of the agent and specific tasks. Since our proposed multi-turn Q&A prompts are task-dependent, we only present the prompt of the pest control task as an example, illustrated in Figure 22 and 23, with both an English version and a Chinese version.

Problem Solving—Pest Control. The dialogue involves identifying and providing solutions for pest problems in crops based on the farmer's descriptions and queries. The following aspects of the pest infestation scenarios are considered: infestation identification, infestation control, post-infestation recovery, *etc*. The example is shown in Figure 24.

Problem Solving—Nutrient Supplementation. The dialogue involves identifying and providing solutions for nutrient deficiency problems in crops based on the farmer's descriptions and queries. The following aspects of the nutrient deficiency scenarios are considered: deficiency analysis, soil testing, nutrient balancing, *etc*. The example is shown in Figure 25.

Problem Solving—Disease Containment. The dialogue involves identifying and providing solutions for disease problems in crops based on the farmer's descriptions and queries. The following aspects of the disease outbreak scenarios are considered: disease identification, emergency treatment, post-outbreak recovery, *etc*. The example is shown in Figure 26.

Personalized Recommendation—Crop Variety Selection. The dialogue involves recommending crop varieties that are best suited to the farmer's specific conditions (such as soil types, climate, and disease resistance needs) and goals (such as yield, and quality). The following aspects of the crop variety selection scenarios are considered: pest and disease resistance, tolerance to abiotic stresses, nutrient requirement analysis, *etc*. The example is shown in Figure 27.

Personalized Recommendation—Resource Management. The dialogue offers tailored advice on efficient resource management, which might include the optimal use of water, fertilizers, and labor, to maximize crop yield and profitability while minimizing environmental impact. The following aspects of the resource management scenarios are considered: precision agriculture, sustainable practices, climate-resilient practices, *etc*. The example is shown in Figure 28.

Knowledge Interpretation—Research Interpretation. The dialogue should offer a clear interpretation of the specific research findings to help the farmer stay updated with discoveries in the crop science domain, regardless of when the research was conducted. The following research interpretation scenarios are considered: understanding the research methods, interpreting the results, discussing the implications, *etc*. The example is shown in Figure 29.

J.4 Benchmark

Multiple-choice Q&As are extracted from the data source using prompts shown in Figure 30 and 31, with both English and Chinese versions.

K Training Details

Our fine-tuning work was performed based on the LLaMA-Factory framework [70]. To mitigate the risk of overfitting during the tuning process[65, 15], we augmented our training data with the COIG-CQIA dataset[5]. We used the LoRA[32] method to train all three models, with rank set to 8, alpha set to 16, and learning rate set to 5e-5. Additionally, we deployed Deepspeed ZeRO-2[49, 48] to improve memory efficiency and set the total train batch size to 320, and epoch to 4.

All fine-tuning was performed with 16 NVIDIA A100-40G GPUs. During inference, we set a maximum input length to 4096 tokens, and an output length to 1024 tokens for weights-access models. For API-access models, we set the temperature to 0, and the top p to 1.

Multi-turn Q&A (EN)

Assistant System Prompt:
You are a crop pestologist (assistant). I am a farmer (user), who approaches you with concerns about my crop. Your role is to engage in a dialogue with me, ask insightful questions, and provide information to help identify the problem and suggest potential solutions based on your expertise.

<doc>
RAG contents……
</doc>

Please adhere to the following guidelines:
1. As a Crop Pestologist, you have access to a broad range of professional domain knowledge. Use this knowledge to inform your responses and provide accurate, helpful advice.
2. For each round, you have access to a reference text that is highly relevant to the conversation content. Use this context to inform your responses where relevant. The reference text for this round is enclosed within the <doc></doc> tags.
3. Ensure that you only consider the following knowledge-intensive problem-solving scenario: Pest Infestation. The dialogue involves identifying and providing solutions for pest problems in crops based on the farmer's descriptions and queries.
4. You must maintain your role as the crop pestologist (assistant) throughout the conversation. Never flip roles.
5. You must provide your responses one at a time, ensuring they are non-empty.
6. Ensure to terminate the conversation timely when I conclude the conversation with 'Thank you, I got the information I needed' by responding with 'You are welcome'.
7. Ensure that your output strictly follows the format of the example enclosed within the <example></example> tags, and replace the content enclosed within the [] tags with your response.

<example>
Crop Pestologist (Assistant): []
</example>

User System Prompt:
You are a farmer (user) who is concerned about the health of your crops. You approach me, a crop pestologist (assistant) with your concerns. Your role is to engage in a dialogue with me, describe the symptoms you observed, ask questions, and seek advice.

<doc>
RAG context……
</doc>

Please adhere to the following guidelines:
1. As a farmer, you have hands-on experience with your crops. Use this knowledge to provide detailed descriptions or queries.
2. For each round, you have access to a reference text that is highly relevant to the conversation. Use this context to inform your descriptions and queries where relevant. The reference text for this round is closed within the <doc></doc> tags.
3. You are only part of the following knowledge-intensive problem-solving scenario: Pest Infestation. The dialogue involves describing your crop symptoms and asking for solutions to potential pest problems.
4. You must maintain your role as the farmer (user) throughout the conversation. Never flip roles.
5. You must provide your descriptions or queries one at a time, ensuring they are non-empty.
6. Ensure to terminate the conversation timely when you have obtained the information you need by saying 'Thank you, I got the information I needed'.
7. Ensure that your output strictly follows the format of the example enclosed within the <example></example> tags, and replace the content enclosed within the [] tags with your response.

</example>
Farmer (User): []
</example>

Figure 22: English Prompt for multi-turn Q&A. We take the pest control task as an example to show our multi-agent system prompts.

Multi-turn Q&A (ZH)

Assistant System Prompt:
你是一位作物病虫害专家（助理）。我是一位农民（用户），我因对作物健康状况感到担忧而向你寻求帮助。你的任务是与我进行对话，根据你的专业知识提供信息，帮助识别问题并提出可能的解决方案。

<doc>
RAG contents……
</doc>

请遵循以下准则：
1. 你可以获取广泛的专业领域知识。使用这些知识来完善你的回答从而提供准确、有用的建议。
2. 对于每一轮对话，你都可以访问一段与对话内容高度相关的参考文本。请使用此上下文来补充你的回复。本轮的参考文本包含在<doc></doc>标记之间。
3. 请确保你只考虑以下知识密集型问题解决场景：农作物害虫侵害。这种场景中的对话涉及根据农民的描述和询问，识别农作物害虫问题并提供适配的解决方案。
4. 你必须在整个对话中保持你作为作物病虫害专家（助理）的角色。不要切换为其他角色。
5. 你必须一次仅提供一个回复，且该回复应当非空。
6. 当我以“谢谢，我得到了我需要的信息”请求结束对话时，确保及时通过回复“不客气”来终止对话。
7. 请确保完全遵循<example></example>标记之间示例的格式输出回复，将【】标记之间的内容替换为你的回复。

<example>
作物病虫害专家（助理）：【】
</example>

User System Prompt:
你是一位农民（用户），你对作物的健康状况感到担忧。我是一位作物病虫害专家（助理），你向我寻求帮助。你的任务是与我进行对话，描述你观察到的症状，提出问题，并根据我的专业知识寻求可能的解决方案。

<doc>
RAG context……
</doc>

请遵循以下准则：
1. 你拥有自己作物的第一手经验。请利用这些知识给出详细的描述或查询。
2. 对于每一轮对话，你都可以访问一段与对话内容高度相关的参考文本。请使用此上下文来补充你的描述或查询。本轮的参考文本包含在<doc></doc>标记之间。
3. 你仅参与以下知识密集型问题解决场景：农作物害虫侵害。这种场景中的对话涉及描述作物的症状并寻求潜在害虫问题的解决方案。
4. 你必须在整个对话中保持你作为农民（用户）的角色。不要切换为其他角色。
5. 你必须一次仅提供一个描述或查询，且该描述或查询应当非空。
6. 当你已经获得所需的信息时，确保通过回复“谢谢，我得到了我需要的信息”来及时终止对话。
7. 请确保完全遵循<example></example>标记之间示例的格式输出回复，将【】标记之间的内容替换为你的回复。

</example>
农民（用户）：【】
</example>

Figure 23: Chinese Prompt for multi-turn Q&A. We take the pest control task as an example to show our multi-agent system prompts.

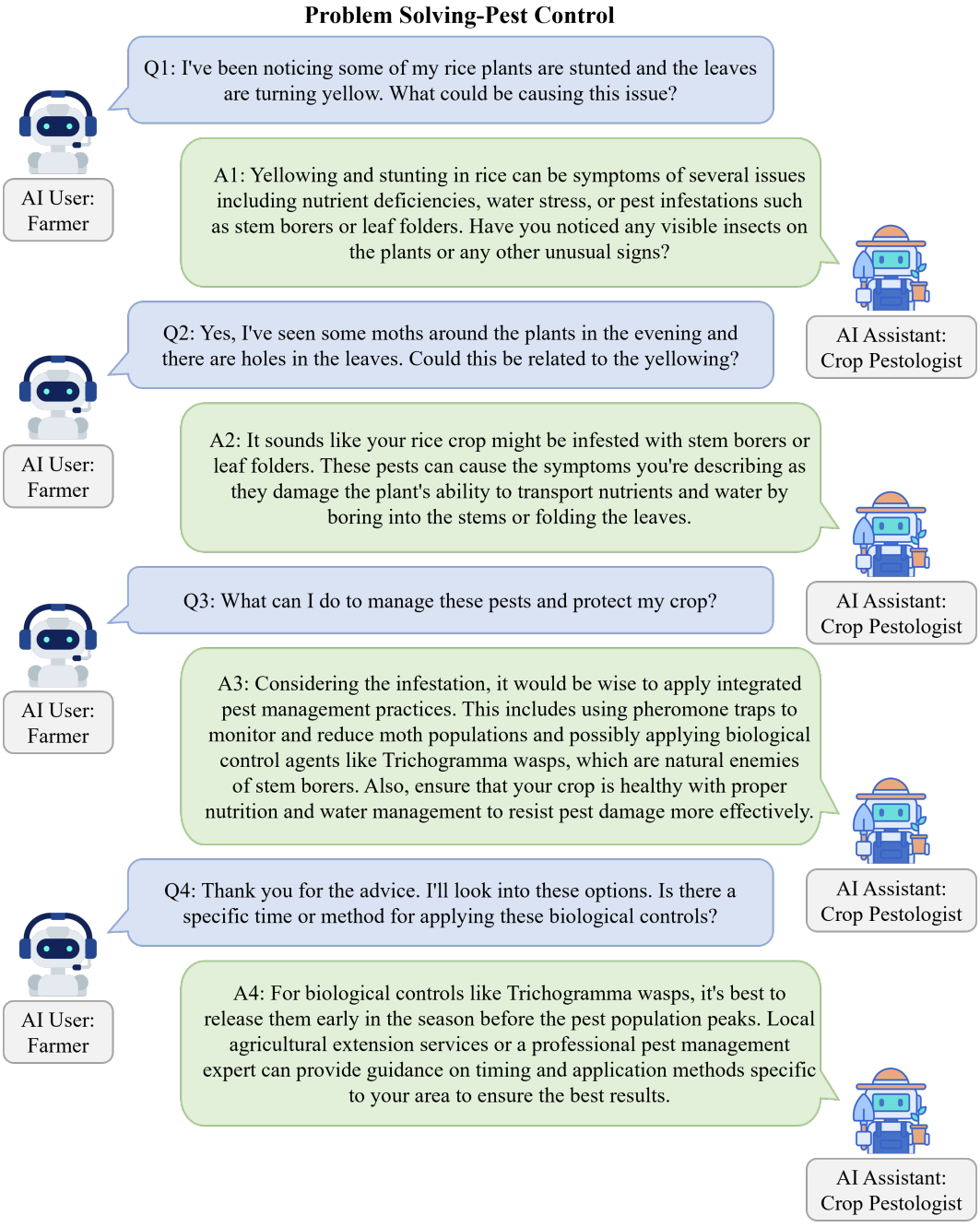


Figure 24: The example for the pest control task of problem-solving scenario.

Figure 25: The example for the nutrient supplementation task of problem-solving scenario.

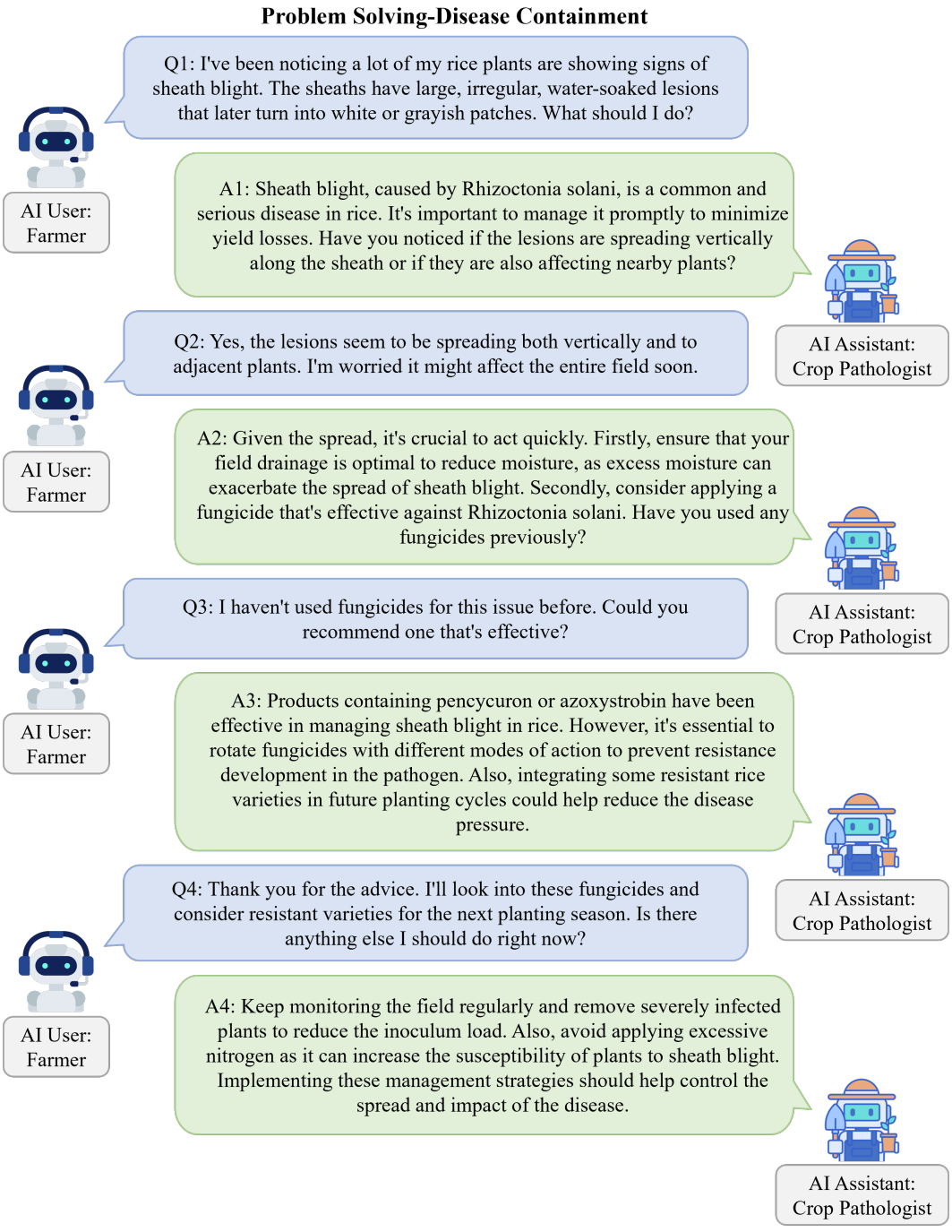


Figure 26: The example for the disease containment task of problem-solving scenario.

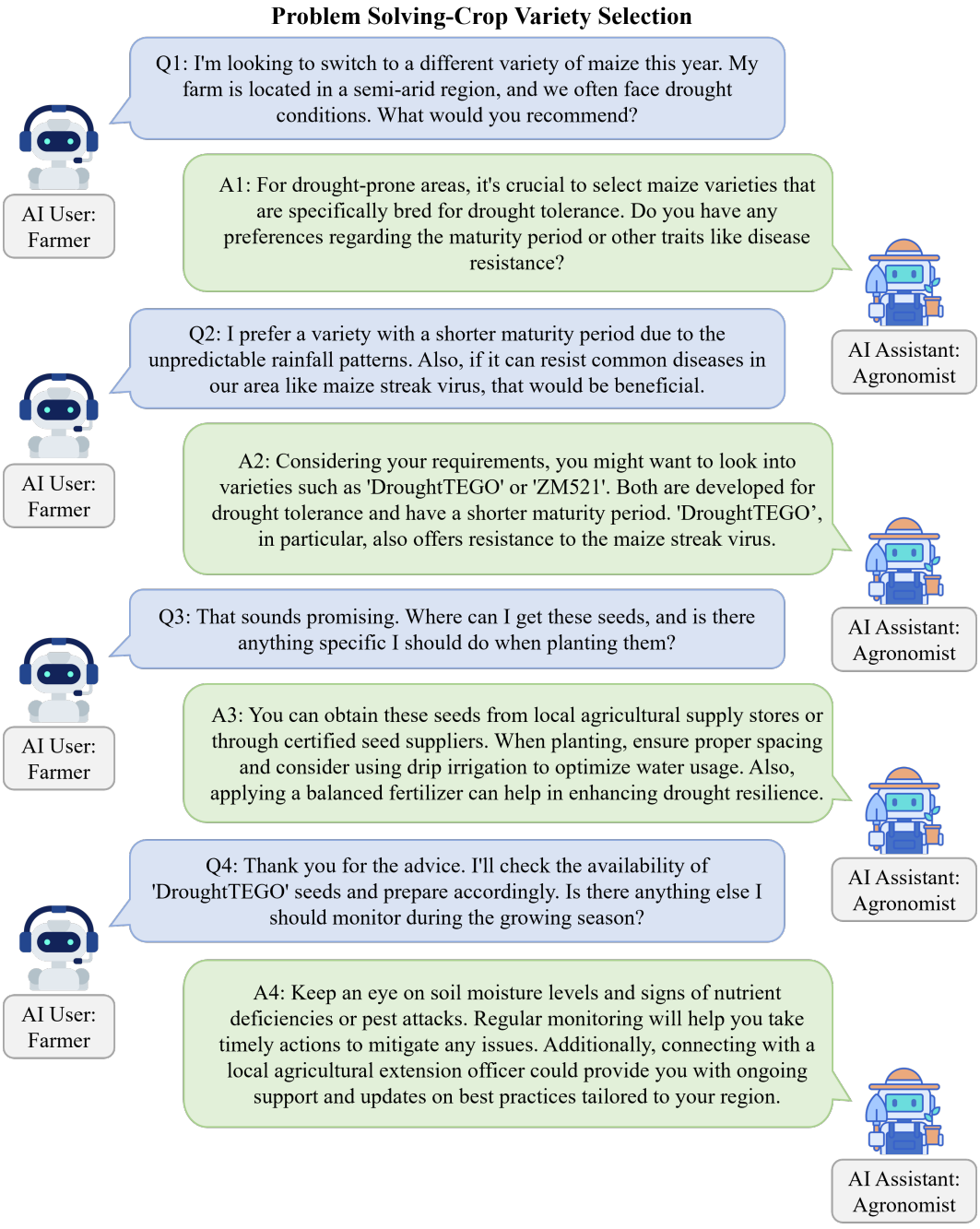


Figure 27: The example for the crop variety selection task of personalized recommendation scenario.

Figure 28: The example for the resource management task of personalized scenario.

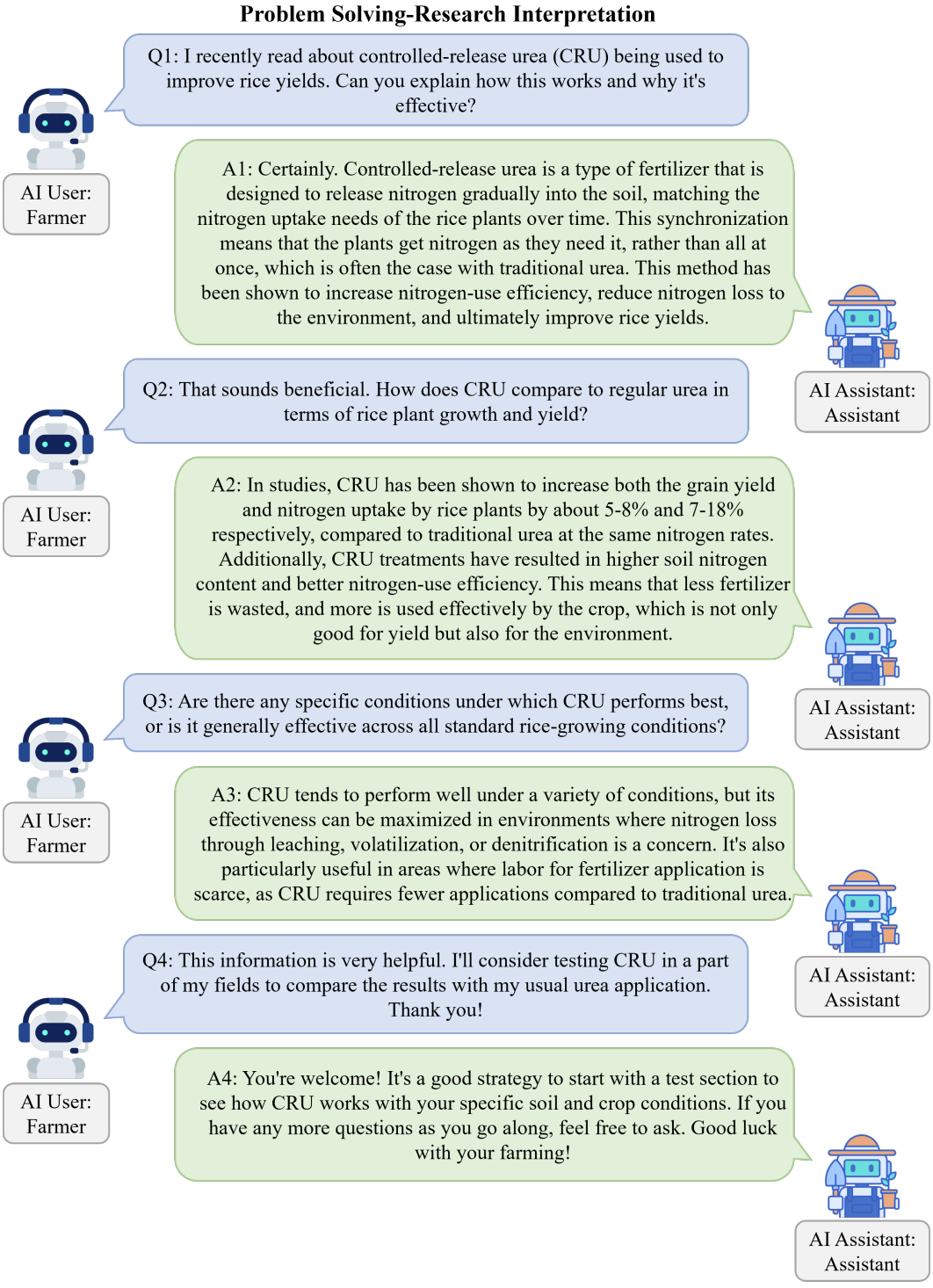


Figure 29: The example for the research interpretation task of knowledge interpretation scenario.

Multiple-Choice (EN)

Topic Description:
Instruct the model to return multiple-choice from the provided article. There are no external reference materials provided in the produced question.

System:
You are a breeding expert, as well as a professor of agricultural science and biology. Please generate a set of question-answer pairs for this academic paper between the <doc></doc> tags.

Role Description

<doc>
In the recent past, population explosion has augmented urbanization……
</doc>

Reference Text

For each QA pair, you need to consider the following:
1.The task specified for the question-answer pair is Multiple-Choice.
2.The question part of the question-answer pair should include the generated question. The answer part consists of 4 options and the correct answer.
3.Please ensure that each option has significant differences but similar lengths.
4.Please ensure that the production of questions and answers is related to the knowledge of crop cultivation or the properties of crops.
5.You can refer to the example between the <example></example> tags for the design of QA, but please ensure to strictly follow the format of that example.
6.Replace the part within '[]' in the example answer with 4 options, and the part within '{}' with the correct answer.

Guidelines

<example>
Question: What was the experimental design used to study the decomposition of Bt and non-Bt rice residues?
Answer: [Options: A. The experimental design was a completely randomized design with two types of rice residues, KMD (Bt) and Xiushui 11 (non-Bt), cultivated in six plots over two successive years using conventional intensive rice cropping methods.
B. The experimental design was a stratified random design with two types of rice residues, KMD (Bt) and Xiushui 11 (non-Bt), cultivated in four plots over three successive years using conventional intensive rice cropping methods.
C. The experimental design was a block design with three types of rice residues, including KMD (Bt) and Xiushui 11 (non-Bt), cultivated in eight plots over two successive years using organic rice cropping methods.
D. The experimental design was a factorial design with two types of rice residues, KMD (Bt) and Xiushui 11 (non-Bt), cultivated in ten plots over one year using conventional intensive rice cropping methods.]
{Correct answer: A.}
</example>

Example Dialogue

User:
Please generate *N* question-answer pairs based on the given academic paper.

Example:
Question 1: How was the herbicide resistance gene introduced into the restorer line Bar68-1?
Answer 1: [Options: A. By crossbreeding Bar68-1 with naturally resistant wild rice strains.
B. Through traditional selective breeding techniques focusing on natural mutations.
C. By particle bombardment using gold particles coated with plasmid DNA containing the bar gene.
D. By chemical induction of mutations in the Bar68-1 line followed by selective breeding.]
{Correct answer: C.}
Question 2：……
Answer 2：……

Figure 30: Prompt and few examples for English Multi-Choice Q&A.

Multiple-Choice (ZH)

Topic Description:
Instruct the model to return multiple-choice from the provided article. There are no external reference materials provided in the produced question.

System:
你是一名育种专家，同时是一位农业科学和生物科学的教授，请基于在<doc></doc>标记之间的这篇学术论文，生成问答对。

Role Description

<doc>
玉米营养诊断是在玉米生育进程中的某些时期检测植株的营养状况是否符合……
</doc>

Reference Text

对于每一个问答对，你需要注意以下几点：
1.问答所指定的任务为多项选择题（Multiple-Choice）。
2.问答对的问题部分为生成的问题，回答部分为4个选项和正确答案。
3.请确保每个选项的内容差异化很大，但是长度相近。
4.请确保生产的问题和答案与农作物种植知识或农作物性质相关。
5.你可以参照<example></example>标记之间的示例设计问答，但请确保完全遵循该示例的格式输出回复。
6.请将示例回答部分中'[]'之间的部分替换为4个选项，'{}'之间的部分替换为正确答案。

Guidelines

<example>
问题："白梗一号"水稻的主要农艺特性有哪些？
回答：[选项：A、"白梗一号"水稻的主要农艺特性包括中早熟品种，生育期131天，需活动积温2650℃，平均株高100cm，茎秆坚韧抗倒伏，分力强，株型紧凑，平均穴穗数27.2穗，平均穗粒数116.3粒，结实率90%以上，千粒重24.4g，谷粒长形，长宽比为2.2，无芒，颖壳黄色。
B、"白梗一号"水稻是晚熟品种，生育期150天，需活动积温3000℃，平均株高120cm，茎秆脆弱易倒伏，分力弱，株型松散，平均穴穗数20穗，平均穗粒数90粒，结实率80%，千粒重30g，谷粒短圆形，长宽比为1.5，有芒，颖壳绿色。
C、"白梗一号"水稻是中晚熟品种，生育期140天，需活动积温2800℃，平均株高110cm，茎秆坚韧抗倒伏，分力中等，株型紧凑，平均穴穗数25穗，平均穗粒数100粒，结实率85%，千粒重26g，谷粒长形，长宽比为2.0，无芒，颖壳红色。
D、"白梗一号"水稻是早熟品种，生育期120天，需活动积温2500℃，平均株高90cm，茎秆脆弱易倒伏，分力强，株型松散，平均穴穗数30穗，平均穗粒数130粒，结实率95%，千粒重22g，谷粒短圆形，长宽比为1.8，有芒，颖壳白色。]
{正确答案：A。}
</example>

Example Dialogue

User:
请基于给定学术论文，生成*N*个问答对。

Example:
问题1："甬优17"水稻的米质特性如何？
回答1：[选项：A、整精米率71.3%，长宽比2.3，垩白粒率14.0%，垩白度2.0%，透明度2级，胶稠度70mm，直链淀粉含量14.4%，蛋白质含量8.2%。
B、整精米率65.0%，长宽比2.0，垩白粒率20.0%，垩白度3.0%，透明度1级，胶稠度60mm，直链淀粉含量12.0%，蛋白质含量7.0%。
C、整精米率75.0%，长宽比2.5，垩白粒率10.0%，垩白度1.5%，透明度3级，胶稠度80mm，直链淀粉含量16.0%，蛋白质含量9.0%。
D、整精米率68.0%，长宽比2.1，垩白粒率18.0%，垩白度2.5%，透明度2级，胶稠度65mm，直链淀粉含量13.0%，蛋白质含量7.5%。]
{正确答案：A。}
问题2：……
回答2：……

Figure 31: Prompt and few examples for Chinese Multi-Choice Q&A.

Table 14: Performance of LLMs trained under different epochs. The highest value for each model on different tasks is **bolded**. Variation denotes the accuracy difference between Chinese and English.

Model	Epoch	Size	Overall ↑	Difficulty		
				Easy ↑	Moderate ↑	Difficult ↑
LLaMA3-Base	N/A	8B	0.348	0.443	0.341	0.161
+CROP	1	8B	0.745	0.847	0.771	0.375
+CROP	2	8B	0.741	0.852	0.760	0.380
+CROP	4	8B	0.752	0.866	0.772	**0.378**
+CQIA+CROP	1	8B	0.738	0.903	0.758	0.292
+CQIA+CROP	2	8B	0.742	0.902	0.772	0.271
+CQIA+CROP	4	8B	**0.754**	**0.918**	**0.779**	0.295
Qwen1.5-Base	N/A	7B	0.646	0.799	0.646	**0.302**
+CROP	1	7B	**0.710**	0.898	**0.724**	0.197
+CROP	2	7B	0.636	0.804	0.645	0.189
+CROP	4	7B	0.676	0.849	0.688	0.202
+CQIA+CROP	1	7B	0.702	**0.910**	0.717	0.183
+CQIA+CROP	2	7B	0.670	0.875	0.677	0.181
+CQIA+CROP	4	7B	0.709	**0.910**	0.704	0.227
InternLM2-Base	N/A	7B	0.368	0.445	0.381	0.148
+CROP	1	7B	0.666	0.841	0.651	0.294
+CROP	2	7B	0.622	0.818	0.600	0.230
+CROP	4	7B	0.748	0.945	0.761	0.212
+CQIA+CROP	1	7B	0.764	**0.942**	0.787	0.276
+CQIA+CROP	2	7B	**0.809**	0.909	**0.855**	**0.414**
+CQIA+CROP	4	7B	0.768	0.939	0.794	0.285

L More Experiments

To explore how much improvement is credited to CROP, we conduct additional experiments on Table 3, shown in Table 14. We show the performance trend of the model with the increase in the number of iterations when trained on our CROP dataset. It can be observed that in most cases, CROP dominates the performance. However, exceptions occur in some epochs, where the reasons are analyzed:

- Continual Pretraining Phase: All base versions of open-source models in the experiments are only fine-tuned using CROP and CQIA without undergoing continual pretraining. Yet continual pretraining is crucial for language models to effectively learn and retain domain-specific knowledge. Instruction fine-tuning primarily focuses on improving the model's ability to follow instructions rather than acquiring new knowledge.
- Benchmark Specificity: While the CROP dataset is designed for the crop science domain, the CROP benchmark might not fully capture the nuanced improvements brought by the CROP dataset given the significant gap in the amount of raw data. The improvements might be more pronounced in real-world applications or other evaluation metrics to be included in future versions of the benchmark.