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RESEARCH ARTICLE

Relationship between Internet access to agricultural information and postharvest yield loss: evidence from maize growers in China

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KEYWORDS

Agricultural information, China, food security, maize loss, the Internet

HIGHLIGHTS

- On-farm maize loss and its impacts were evaluated in China.
- Over 19 Mt of maize is lost on-farm annually.
- Mitigating maize loss has considerable economic, resource and environmental effects.
- Internet access to agricultural information is positively related to reduced maize losses.
- Policies encouraging farmers to access agricultural information via the Internet are needed.

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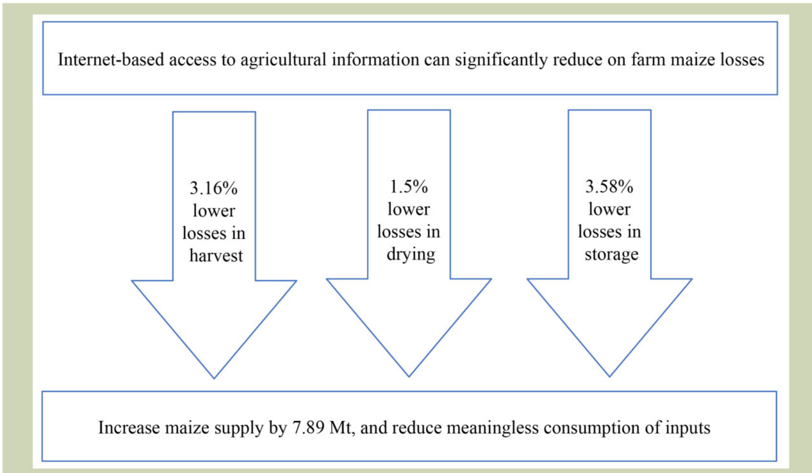
GRAPHICAL ABSTRACT



ABSTRACT

Based on survey data from 832 maize growers of four major maize production regions in China, on-farm maize losses were assessed and the effects of Internet access to agricultural information on the losses were evaluated. The results showed that on average 4.5%, 4.0% and 3.7% of maize was lost in the harvest, drying and storage stages, respectively. This indicated that at the farm level, 19 Mt of maize is lost annually in China, and these losses have considerable economic, resource and environmental impacts. Additionally, Internet-based access to agricultural information was found to be positively related to reduced maize losses. Compared with farmers who do not access agricultural information from the Internet, farmers with Internet-based access to agricultural information experienced 3.2%, 1.5% and 3.6% lower losses in the maize harvest, drying, and storage stages, respectively. Therefore, enhancing farmers access to agricultural information could increase the maize supply by 7.89 Mt and enhance the utilization of 1.02 Mha of farmland. Additionally, 0.39 Mt of fertilizer could be saved, and the carbon emission and water usage could be reduced. It is recommended that the government accelerate the removal of barriers to farmers using the Internet to access agricultural information.

1 Introduction

The combination of continuous population growth and limited earth resources has raised concerns about food insecurity[1]. Also, climate change, COVID-19, war, and trade protectionism have also created major challenges for achieving global food security[2,3]. With such an imbalanced food supply, food loss and waste are disproportionately serious issues[4].

Losses occur in almost every stage of food production, distribution and consumption, resulting in reductions in the quantity, quality and economic value of food[5,6]. The FAO[7] showed that more than one-third of food is lost or wasted worldwide each year. These losses result not only in a decrease in the food supply but also an increase in the waste of water, land, energy and other inputs used for food production[8]. If the annual global greenhouse gas emissions from food losses and waste was compared to emissions from individual countries, it equivalent to the country with the third most emissions[9,10].

Compared to the advanced technology in developed countries, the technologies and facilities in underdeveloped nations are poor and primitive[11]. Hence, on-farm food loss in developing countries, especially least developed countries, is much more severe[12]. The World Bank estimated that the value of food loss reached 4 billion USD in one year in sub-Saharan Africa[13]. The Ministry of Agriculture of China estimated that the on-farm grain loss was 7% to 11% of the total grain output each year[14]. By comparison, grain harvest losses in Japan, the European Union and other developed economies were mostly less than 2%[15].

Generally, both subjective consciousness and objective conditions influence food losses[16]. For example, in the harvest stage, weather conditions, the availability of machinery and crop maturity significantly impact grain harvest loss[17,18]. Some socioeconomic factors, such as household income, risk attitudes and credit constraints, also affect the food losses of rural households[19,20]. Additionally, the literature has shown that mechanical upgrades, information dissemination, education and agricultural training programs are important ways to improve farmer skill and reduce food losses[21].

With economic development and infrastructure construction, farmers in China have gradually become inclined to use the Internet to obtain the required information, which accelerates the flow and dissemination of information[22]. Through the Internet, farmers can directly access not only information on reducing food losses but also information related to agricultural production, technologies and services, which can help farmers make more rational decisions and achieve optimal resource allocation[23,24].

Currently, governments, social organizations and scholars are interested in the impact of Internet access on agriculture[25–27]. However, despite the useful discussion of the impact of Internet access on agriculture and food loss in the literature, few studies have attempted to reveal the effects of Internet-based agricultural information access on grain loss. Further, a significant proportion of the data used in these studies came from expert speculation or secondhand sources, and the accuracy and representativeness of the studies could be further improved[11].

In this study, based on survey of 832 rural maize-growing households in China, we aimed to assess on-farm maize losses in China and analyze the role of Internet-based agricultural information access in mitigating losses. First, a national survey was conducted to estimate on-farm maize losses, which allowed us to obtain a valid picture of the losses and the impacts on resources and the environment. Second, we focused on the losses of rural households, which are critical participants in food loss reduction. We clearly established the characteristics of food losses at different stages for rural households and assess the economic value of the losses. Third, we used econometric models to evaluate the impacts of Internet-based agricultural information access on maize losses and estimated the effects of loss reduction on resources and the environment to reveal the impacts of modern technological development on agriculture. To our knowledge, this is the first study to use an econometric model to analyze and evaluate the effects of Internet-based agricultural information access on the food losses of rural households.

2 Survey data and on-farm maize losses in China

2.1 National survey

In October 2022, we collaborated with the National Agricultural Cost Survey system of China to conduct a nationwide survey to collect information on household maize losses and other relevant characteristics. It is an official system for collecting data on the cost and benefit of agricultural production in China, and there are dedicated agencies at all levels of government responsible for system operation and data collection. Currently, the survey system covers more than 1600 counties in 31 provincial administrative units, and 20,000 farm households who participate each year.

The sample households for this survey of household maize losses were selected based on a stratified random sampling method. First, we established four survey regions based on maize production and geographic location, namely, north-eastern, north-western, south-western and northern China. Second, we allocated the survey sample sizes to each region based on their portion of maize production in 2021; that is, regions with a high share of maize production had a larger sample size than other regions. Third, we randomly chose at least one major maize-producing county per province in each region. Simultaneously, we prioritized well-developed transportation areas to ensure that the survey could be conveniently conducted. Fourth, we randomly selected 10 to 30 maize growers in each county. Finally, the local staff completed the data collection and checked the data to ensure authenticity.

Family decision makers or heads of household reported the quantities of maize produced, dried, and stored and the loss in each stage in kilograms. In addition, we collected information on farmers, such as whether they use the Internet to access agricultural information, the number of laborers per household and annual household income. Notably, most maize in China is harvested from September to October, and during this survey, the majority of regions had completed the maize harvest. However, some farmers had not completed the maize harvest, and the quantities of maize output, dried, stored and lost were estimated based on the current maize growth and the previous losses. In total, we obtained a sample of 832 households from 18 provincial units (Table 1).

2.2 Descriptive statistics

Table 2 summarizes the other core information obtained from this survey. Thirty-four percent of households use the Internet to search for and obtain agricultural information, which means that despite the high rate of Internet penetration in China, the proportion of farmers using the Internet to access specialized information is still low. Additionally, the average age and education level of family decision makers and heads of household were 56.9 years and 2.21 (classification details are given in Table 2), respectively, which indicates that our sample reflects reality in China, with an aging agricultural population and low human capital.

On average, each household had 2.52 laborers and an annual income of 6.57×10^4 yuan (equivalent to 940 USD in 2022). The households cultivated 11.2 mu (0.75 ha) of maize, and the output per unit of area was 481 kg. Twenty-five percent of the farmers reported that there was a postharvest service agency in their village, and 91% of the farmers reported that their maize was mature at harvest. Thirty-five percent of households used machinery in all stages of harvest, and the other farmers used machinery in part of the harvest stage or completely relied on manpower at the harvest stage. Thirty-seven percent of the farmers reported that they experienced bad weather, such as rainfall and hail, during harvest.

On average, each household dried 4.29 t of maize, which means that a portion of the maize was sold directly after harvesting, and 95% of the total households chose sunshine rather than machinery for drying. Also, each household stored an average of 3.64 t of maize after drying. The use of silos to store maize was low, at 25%, and the severity of rodent damage was 1.85%, suggesting that some farmers experienced rodent damage during storage. Overall, the total maize yield for sample

Table 1 Sample distribution

Survey region	Province, city and autonomous region	Sample size
North China	Anhui, Hebei, Henan, Jiangsu, Shandong, Shanxi	435
Southwest China	Chongqing, Guizhou, Sichuan, Yunnan	199
Northeast China	Heilongjiang, Inner Mongolia, Jilin, Liaoning	131
Northwest China	Gansu, Ningxia, Shaanxi, Xinjiang	67

Table 2 Summary statistics

Variables	Obs.	Mean	Standard deviation	Min	Max
Whether agricultural information was acquired from the Internet (yes = 1)	832	0.34	0.47	0	1
Harvest losses: losses/output (%)	832	4.49	8.57	0	80
Drying losses: losses/the amount of drying (%)	459	3.99	7.77	0	50
Storage losses: losses/the amount of storage (%)	343	3.69	5.76	0	50
Characteristics of family and socioeconomic factors					
Age of family decision-maker or head (years)	832	56.9	10.0	26	82
Level of education (primary school and below = 1, junior = 2, senior = 3, bachelor's degree and above = 4)	832	2.21	0.61	1	4
Number of laborers	832	2.52	0.96	1	5
Annual income of the family ($\times 10^4$ yuan)	832	6.57	5.93	0.40	55
Characteristics of maize production					
Area of land for maize (mu[a])	832	11.2	28.0	0.1	499
Yield per unit area ($kg \cdot mu^{-1}$)	832	481	205	50	991
Whether there is a postharvest service agency in the village (yes = 1)	832	0.25	0.43	0	1
Whether the maize was mature at harvest (yes = 1)	832	0.91	0.28	0	1
Harvest method					
Harvest by machines (yes = 1)	832	0.35	0.48	0	1
Whether bad weather occurred (yes = 1)	832	0.37	0.48	0	1
Drying method					
Drying quantity (kg)	459	4290	13,800	5	180,000
Drying by sunshine (yes = 1)	459	0.95	0.22	0	1
Storage method					
Storage quantity (kg)	343	3640	11,900	2	180,000
Rodent damage (none = 1, light = 2, medium = 3, severe = 4)	343	1.85	0.64	1	4
Whether silos were adopted to store maize (yes = 1)	343	0.25	0.44	0	1

Note: [a]1 ha = 15 mu; the same below. The total maize quantity of the sample farmers was 4.49 kt during harvest, which decreased to 1.97 kt in the drying stage and 1.25 kt in the storage stage. The total amount of maize in each stage is the sum of maize owned by all farmers involved in that stage within the sample.

farmers during the harvest stage was 4.49 kt, but the quantity decreased to 1.97 and 1.25 kt in the drying and storage stages, respectively.

3 Methodology

3.1 Conceptual framework

In traditional economic theory, it is assumed that the information available to market agents such as farmers is complete[28]. However, in reality, farmers are unlikely to obtain all the market information when they make decisions because of the wide range of information available, which covers the whole process from production to marketing; notably, such information can change rapidly[29].

With the development of information technology, various types of physical elements can be transformed into information elements[30]. Through the Internet, farmers can easily access information about agriculture and other topics, which helps farmers make rational decisions[31]. Also, the cost for farmers to obtain agricultural information through the Internet is nearly zero, and the Internet is easy to navigate[32]. The literature confirms that connecting farmers to the Internet can effectively increase their probability of adopting technology[33]. Specifically, Internet access enhances farmer access to information, impacting postharvest grain loss in three key ways[34]. First, Internet access reduces search and transaction costs, thereby facilitating the adoption of advanced technologies and equipment in the harvesting and storage stages, which subsequently decreases postharvest loss. Second, it enables farmers to conveniently acquire production management knowledge, improve management practices in postharvest stages and reduce associated losses. Third, Internet access allows farmers to obtain timely weather information, which aids them in taking preventive measures to mitigate weather-induced postharvest losses.

Table 3 shows the maize losses of farmers who used and did not use the Internet to access information, and there were substantial differences between the users and non-users. Households with Internet information access had much smaller losses than non-users in all three stages (harvest, 2.3% vs 5.6%; drying, 2.7% vs 4.6%; and storage, 2.7% vs 4.2%). Hence, for this study, we assumed that Internet-based agricultural information access can reduce maize losses.

3.2 Empirical strategy

To test our hypothesis that Internet-based access to agricultural information can reduce farm maize losses in China, based on abundant survey data, we constructed the following econometric model:

$$\text{Loss}_i = \alpha_0 + \alpha_1 \text{Internet}_i + \alpha_2 \text{Practices}_i + \alpha_3 \text{Family}_i + \alpha_4 \text{SC}_i + \gamma \text{Location}_i \tag{1}$$

where, Loss is the maize loss of household *i* at each stage. Three explanatory variables were included: harvest loss, drying loss, and storage loss. Internet_i is for household access to agricultural information through the Internet, and Family_i and SC_i are for family and socioeconomic characteristics of household *i*, such as farm size, number of laborers and annual income, and Location_i is the vector of the location dummies of household *i* used to control for regional impacts.

These explanatory variables are fractions with values between 0 and 1, and ordinary least squares and other traditional linear estimation methods are not suitable for estimating bounded explanatory variables because of the probability of obtaining biased results[35,36]. To address this situation, Papke and Wooldridge[37] exploited the fractional response method (FRM) to use dependent variables in the form of fractions, which can improve the model fit[38]. Hence, we used the approach of Papke and Wooldridge[37] to establish the model.

Although the FRM can be used to examine whether Internet-based agricultural information access may have an impact on maize losses, it cannot be used to evaluate the effects. Hence, we used propensity score matching (PSM), which is a universal methodology for evaluating policy effectiveness based on non-experimental data (e.g., survey data)[39] and has been widely used in various fields of study[40], to test the robustness of the FRM results and evaluate the effects of Internet-based agricultural information access on maize losses.

The PSM applied consisted of four steps. First, a logit model was used to calculate the propensity scores for using the Internet to obtain agricultural information. Second, three different matching algorithms, that is, nearest neighbor, kernel and radius matching, were used to match users and non-users of the Internet in terms of accessing agricultural information. Third, the average effects of the treatment on the treated (ATT) were calculated. Fourth, a sensitivity analysis and a series of covariate balancing tests were conducted to assess the robustness of the results[41].

4 Results

4.1 On-farm maize losses in China

The results of the survey showed that on average, 4.49% of the total maize produced was lost during the harvest stage, encompassing losses during harvesting, cleaning, threshing, and transporting (from the field to the farm) processes. Additionally, 4.0% of the total maize dried was lost in the drying stage, and farmers reported that biological factors, such as insects and birds, were the main sources of drying loss. Further, 3.7% of the total maize stored was lost during storage,

Table 3 Maize losses of users and non-users of the Internet to access agricultural information

Variable	Users			Non-users			*t*-test
	Obs.	Mean	Std. error	Obs.	Mean	Std. error	Difference
Harvest loss	281	2.38	0.12	551	5.56	0.44	3.18***
Drying loss	143	2.73	0.27	316	4.57	0.51	1.84**
Storage loss	106	2.66	0.29	237	4.15	0.43	1.49***

Note: ** $p < 0.05$ and *** $p < 0.01$

and the main reasons for storage losses were insects, rats and mildew.

Based on the portion of households that reported drying and storage among all samples in the survey and the ratios of maize dried and stored to the total harvest quantity, we found that 6.9% of the total maize produced was lost at the farm gate in China[1], a value higher than that (3% to 5%) reported in developed regions[42]. In 2022, the quantity of maize production was 277 Mt in China, ranking second in the world after the USA (349 Mt). This means that at the farm level, 19.2 Mt of maize were lost in 2022 in China, and these losses were equal to 51.69 billion yuan (equivalent to 7.68 billion USD in 2022), 2.48 Mha of farmland, 0.94 Mt of fertilizer, a carbon footprint of 12.7 Mt, or 20.1 billion m^3 of water usage (Fig. 1).

4.2 Fractional response method estimates

In first three columns of Table 4, we show the estimated effects of Internet-based access to agricultural information on maize harvest, drying and storage losses. For each stage, Internet access to agricultural information was significantly correlated with reduced losses. This indicates that the use of the Internet can overcome agricultural information barriers, allowing for effective loss reduction techniques. Further, the magnitude of the coefficients indicates that Internet-based agricultural information access has a greater impact on maize harvest loss and a smaller impact on loss in the drying and storage stages. This may be due to the relatively high losses in the harvest stage, which means that this stage has more loss reduction potential. In addition, the Chinese Government has given more attention to harvest loss control than to loss in other stages, and activities such as harvester operator training programs, and targeted mechanical and skill upgrades are offered to farmers; thus, there is more information available on the Internet about these methods for loss reduction during harvesting than in other stages.

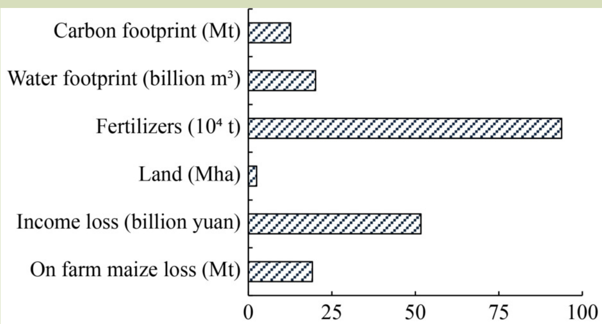


Fig. 1 Economic, resource, and environmental impacts of on-farm maize losses in China.

The results also show that for the harvest stage, more laborers and a higher yield were correlated with lower losses, and bad weather was correlated with greater losses. During the drying period, sunny weather contributed to lower losses, and farmers who used drying machinery experienced greater losses in comparison. The storage quantity and maize storage in silos were significantly negatively correlated with maize storage losses, and rodent damage was significantly positively correlated with maize storage losses. These findings are consistent with the findings reported in the literature. For example, bad weather directly causes maize lodging, making harvesting more difficult and increasing moisture levels, leading to serious losses[43,44]. Also, compared to traditional storage facilities, such as cabinets, silos are well sealed, providing better protection from rodents and reducing losses[45].

4.3 Effects of Internet-based access to agricultural information on maize losses

The FRM estimates indicate that Internet-based agricultural information access can reduce maize harvesting, drying and storage losses. Following the previously mentioned steps of the PSM method, we tested the robustness of the empirical results and further evaluated the effects of Internet-based access to agricultural information on maize losses.

First, the logit model revealed that the gender and education of family decision makers or heads, annual income, percentage of leased land to the total land area and presence of a postharvest service agency in the village were correlated with Internet-based agricultural information access[2].

Second, we matched households with and without access to agricultural information from the Internet and used a series of

[1] Farm maize loss rate = harvest loss rate + (storage loss rate × portion of stored samples to total samples × percentage of stored product to harvest quantity) + (drying loss rate×portion of dried samples to total samples × percentage of dried product to harvest quantity). Also, the drying loss rate and storage loss rate refer to the loss caused by factors other than water loss.

[2] We evaluated the effects of Internet-based agricultural information on maize loss in different stages separately and significant factors that occurred in more than two stages are shown in the text.

Table 4 The impact of Internet access to agricultural information on maize loss

Variable	Coefficient	Z value	Coefficient	Z value	Coefficient	Z value
Whether agricultural information was retrieved from the Internet (yes = 1)	−0.65***	−6.01	−0.39**	−1.98	−0.38***	−2.22
Characteristics of family and socioeconomic						
Age of family decision-maker (years)	−0.004	−0.78	0.002	0.19	−0.02**	−2.28
Level of education (primary school and below = 1, junior = 2, senior = 3, bachelor's degree and above = 4)	−0.03	−0.37	−0.16	−1.12	−0.15	−1.17
Number of laborers	−0.13**	−2.41	0.06	0.69	−0.15*	−1.68
Annual income of the family	0.07	0.77	0.05	0.30	0.12	0.89
Characteristics of maize production						
Area of land for maize (mu)	0.002	1.23	−0.005	−0.87	−0.0007	−0.12
Yield per unit area ($kg \cdot mu^{-1}$)	−0.0008***	−3.11	0.0003	0.47	0.0006	1.41
Whether there is a postharvest service agency in the village (yes = 1)	−0.03	−0.27	0.09	0.47	−0.14	−0.66
Whether the maize was mature at harvest (yes = 1)	0.25	1.42	−0.46	−1.49	0.29	1.08
Harvest method						
Harvest by machines (yes = 1)	0.04	0.31				
Whether there was bad weather during the harvest (yes = 1)	0.87***	8.15				
Drying method						
Drying quantity (kg) (logarithm)			0.12	1.31		
Drying by sunshine (yes = 1)			−0.65*	−1.69		
Storage method						
Storage quantity (kg) (logarithm)					−0.10*	−1.86
Rodent damage (none = 1, light = 2, medium = 3, severe = 4)					0.72***	5.92
Whether to adopt silos to store maize (yes = 1)					−0.45**	−2.53
Regional dummy						
Northeastern (yes = 1)	0.40*	1.92	0.60	1.31	0.37	0.81
Northwestern (yes = 1)	0.73***	3.13	0.68*	1.80	0.34	0.77
Northern (yes = 1)	0.23	1.34	0.46	1.56	0.68*	1.75
Southwestern (yes = 1)	−0.03	−0.16	0.62**	2.11	−0.003	−0.01
_cons	−2.71***	−5.74	−2.89***	−4.03	−2.95***	−3.70
Obs.	832		459		343	

Note: Coefficients with small values are shown with three or four decimal places. * $p < 0.1$, ** $p < 0.05$ and *** $p < 0.01$

tests, such as statistical tests, propensity score tests, visual inspection, and a sensitivity analysis, to test the matching results. All of the tests, especially the sensitivity analysis, showed that even if the gamma value increased by 1.5 times, the results were still significant in terms of the treatment effect on all outcome variables, indicating that the matching results were reliable.

Third, we calculated the ATT to show the effects of Internet-based agricultural information access on maize losses after matching (Table 5). The results showed that compared with farmers who lacked access to agricultural information through the Internet, farmers who acquired agricultural information from the Internet reduced maize harvest, drying, and storage losses by at least 3.2%, 1.5% and 3.6%, respectively.

Based on the assessment of the economic, resource, and environmental impacts of farm maize losses in China, the effects of promoting maize grower access to agricultural information through the Internet are significant. If the drying and storage losses of the average maize harvest decreased to the levels of farmers who used the Internet to access agricultural information (harvest, 4.5% vs 2.3%; drying, 4.0 vs 2.7%; and

Table 5 Effects of Internet-based access to agricultural information on maize loss

Outcome variable	Matching algorithm	Treated	Controls	ATT	SE	*t*-stat
Harvest loss (%)	Radius matching	2.38	5.98	–3.60	0.77	–4.69
	Caliper matching	2.38	5.54	–3.15	0.62	–5.09
	Kernel matching	2.38	5.59	–3.21	0.63	–5.10
Drying loss (%)	Radius matching	2.73	4.23	–1.50	0.84	–1.79
	Caliper matching	2.72	4.31	–1.59	0.81	–1.97
	Kernel matching	2.72	4.30	–1.58	0.82	–1.93
Storage loss (%)	Radius matching	2.66	6.24	–3.58	0.97	–3.69
	Caliper matching	2.66	6.37	–3.71	0.77	–4.85
	Kernel matching	2.66	6.35	–3.69	0.77	–4.77

storage 3.7% vs 2.7%), this would result in an increase in the maize supply of 7.89 Mt and an increase of 21.3 billion yuan (equivalent to 3.16 billion USD in 2022) in farmer incomes. This amount is equivalent to saving 1.02 Mha of farmland and 0.39 Mt of fertilizer or reducing the carbon footprint by 5.21 Mt and water usage by 8.29 billion m^3 (Fig. 2).

5 Conclusions

Currently, reducing food losses has been recognized as an important strategy for countries to ensure food security. Also, with improvements in information infrastructure and technology, the Internet can make an important contribution to the enhancement of practical skills of smallholders with limited education[46]. Based on large-scale survey data for 832 maize growers from major maize production regions in China, we assessed the on-farm maize harvest, drying and storage losses and used empirical models to analyze and evaluate the impact of access to Internet-based agricultural information on these losses.

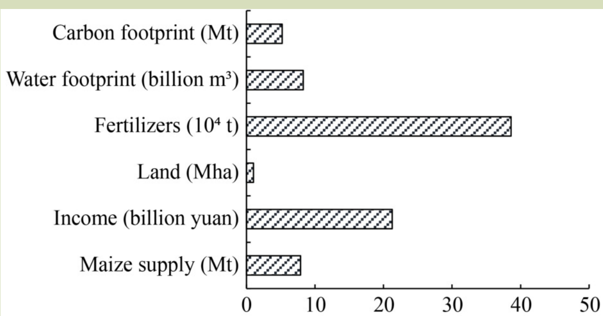


Fig. 2 Loss reduction effects of promoting household access to agricultural information through the Internet.

The results showed that maize farmers in China experienced 4.5% loss during harvest, 4.0% loss during drying and 3.7% loss during storage, which is more serious than that in developed economies and implies great potential for loss reduction. According to the annual maize production in China, this loss means that 19.2 Mt of maize are lost at the farm gate, which was valued at 51.7 billion yuan (equivalent to 7.68 billion USD in 2022), which was equal to 2.48 Mha of farmland, 0.94 Mt of fertilizer, a carbon footprint of 12.65 Mt or 20.1 billion m^3 of water use.

Additionally, the empirical analysis revealed that Internet-based agricultural information access was correlated with reduced maize losses. The application of the PSM showed that Internet-based agricultural information access can reduce maize harvest, drying and storage losses by at least 3.2%, 1.5% and 3.6%, respectively. If the average maize harvest, drying and storage losses decreased to the levels of farmers who use the Internet to access agricultural information, this would result in an increase in the maize supply of 7.89 Mt and an increase of 21.3 billion yuan (equivalent to 3.16 billion USD in 2022) in farmer income. Further, this is equivalent to saving 1.02 Mha of farmland or 0.39 Mt of fertilizer and reducing the carbon footprint by 5.21 Mt or water usage by 8.29 billion m^3. Hence, the Chinese Government should encourage farmers to use the Internet to acquire agricultural information by upgrading the rural information infrastructure, distributing free or discount smartphones (to provide Internet access), and providing tutorials or training programs, especially for older, less educated and low-income households.

Nonetheless, this study has some limitations, primarily in the measurement of loss rates. The analysis relies data self-reported by farmers, which may not fully represent actual losses and could introduce additional errors to the overall estimates. In addition, our study explored only whether farmer access to agricultural information via the Internet affects postharvest losses. Due to data limitations and the lack of data for relevant variables, we were unable to conduct a mechanism analysis. Future research could refine this variable by distinguishing between different types of information, such as technology, equipment, production or weather-related information, and incorporate these pathways into the model for empirical testing in order to better analyze the mechanisms through which Internet access helps reduce postharvest losses.

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Compliance with ethics guidelines

Yi Luo, Xue Qu, Kunyang Zhang, Yonghao Hu, Fangfang Cao, Laping Wu, and Junfeng Zhu declare that they have no conflicts of interest or financial conflicts to disclose. This article does not contain any studies with human or animal subjects performed by any of the authors.

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