Zhi Jingyi
Shijiazhuang Foreign Language School
Shijiazhuang, Hebei, China
China, Factor 6, Sustainable Agriculture

A Glimpse of Sustainable Agriculture in North China

Abstract

According to various definitions of sustainable agriculture, we've got a rough understanding of it, which requires not only feeding huge population on limited croplands, but also not compromising the productivity of the next generation. Nowadays, sustainable agriculture has drawn worldwide attention, in spite of the fact that relevant practices are more in the bud. China, as a historical country with a profound history of agriculture, is attaching great importance to it. Nevertheless, due to the diversification of weather conditions and the deep economic and social gaps between different regions in China, this topic becomes even more complicated. Therefore, this article will mainly focus on sustainable agriculture in North China, based on a comprehensive investigation of a rural village in Hebei Province, China. Current situations along with barriers and dynamics will all be listed below. Among all the factors, apart from agricultural practices including crop rotation and green manure management, the decrease of labor forces and alarms China at an unprecedented level. This paper will deliver you a basic understanding of China's distinct situations, and discuss common challenges and solutions targeting maintaining sustainability.

Introduction

Sustainable agriculture is commonly defined as the kind of agriculture that is capable to meet food demand but does not jeopardize the food security and general welfare of the next generation. (G. Philip Robertson, 2015) Nowadays, agricultural stakeholders have asserted the need for sustainable agriculture, while the intensification has already triggered an array of problems. China is a historical country famous for profound history of agriculture, but currently cannot be called an advanced country in agriculture, making it critical for China to seek practical methods targeting this topic. This paper will analyze those already-existing practices in the regional scale as well as possible initiatives for future development.

Unlike some other countries in the world with unitary conditions, China reveals a more complicated environment caused by China's vast territory, diversity of climates, as well as its complicated physiography and different levels of economic development, thus making it impossible to conclude all the distinct factors. Therefore, this paper selects a typical village, Beiyan Village, Yuanshi County, Shijiazhuang, Hebei, China. This village is a traditional agricultural area, located on the plain in the northeast part of China with temperate monsoon climate. One local family is selected as our case. It includes 6 members, two of them over 65, two working in the city of Shijiazhuang, and two teenagers. The diet of this family is generally balanced, taking in grains (rice and noodles most), meat, vegetables, sugar, oil, etc., despite the fact that they feed on few varieties of vegetables mainly from their own croplands, which in a way represents the current phenomenon of Chinese farmers. There are

usually only three people staying home, while the two middle-aged go out for a higher salary in support of the whole family, taking the 16-year-old girl with them. The old hence shoulder the responsibility of tilling and taking charge of the croplands. The 10-year-old boy goes to school in the village and helps grandparents do farming when available. All members enjoy the health insurance provided by government at a rather low price. Personal clinics are widespread, ranging from individual houses to standardized places.

In the village, croplands are distributed separately, each family owns their isolated areas, ranging from 3 mu to 20 mu. The case family holds totally 5 mu croplands, growing wheat and corn alternatively, representing the circumstance of almost the whole village's agriculture mode. With the development of technology and implementation of high-efficiency machines, farmers are no longer tied tightly to the fields. Along with technical revolution, sustainable practices have long been put into use, including crop rotation, reducing pesticide and fertilizers, etc. Nonetheless, machines are not used by every single family. In fact, there is only one large-scale harvester and two seeding machines in the whole village. As for animals, one interesting phenomenon is that almost every family possesses a pigsty, but pigs rarely exist in the village, because of pig illnesses to a large extent. Instead, chickens, sheep and cows are common there.

Fertilizer and pesticide use

As is universally acknowledged, appropriate fertilizer use contributes to yields but also badly influences sustainability and capability of soil if it exceeds the requirement. According to data released by China's Ministry of Agriculture, more than 40% of total arable lands are degraded because of soil run-off, acidification, impoverishment and salinization. Soil quality is concerning people, with low quality arable land occupying 17.7% of total lands. (Figure 1)
However, local farmers treat fertilizers as imperative, coupled with limitless pesticide use, contributed to the fact that they rely their yields on those external inputs too much. The practices that they are currently employing are mostly based on past experience rather than modern knowledge and experiments, thus triggering overuse. Agricultural Sciences researcher Xu Minggang pointed out that soil internal fertility in China only contributes to 50% of crop yields, 20-30% lower than developed countries. It is so alarming, for this may lead to a vicious circulation where farmers keep increasing the use of fertilizers and pesticides as the result of field depletion and degradation caused by those practices, and thus exacerbates the seriousness of current situation, adding difficulty absorbing water and ingesting needed nutrients for crops. Using pesticides is seemingly beneficial for farmers, as they see less yield loss and less hard work for them. The awareness of pesticide harm to human health has not been raised at a standardized level. Among 20 local families interviewed, the most common reason for using extra chemicals is to prevent risks for commercial crops. Even vegetables and fruit they grow for themselves in a small scale are coupled with overused fertilizers and pesticides. It is to be noticed that some certain farmers inclining to use more pesticides intends to prevent neighbors' animals from eating their crops. What's more, the government provides aid for farmers to purchase agricultural essentials, effectively releasing their economic pressure, and showing considerable yield rewards in comparison to fertilizer and pesticide inputs.

In thus summarizing all these current situations, I don't mean to paint the future dark. On the contrary, things are just being gradually improved, mainly contributed to rotation and green manure management which improve soil quality, capability, and ultimately, sustainability.

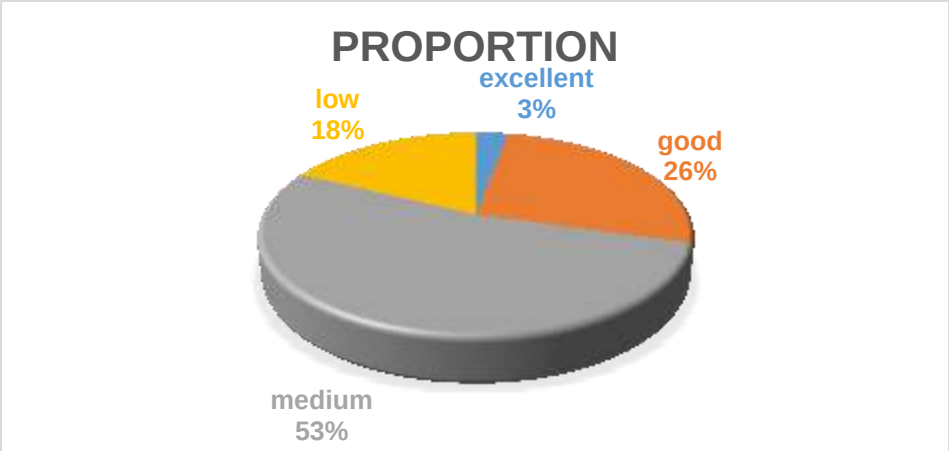

Figure 1(data from Ministry of Land and Resources of the People's Republic of China)

Crop rotation, tillage and straw returning

Crop rotation is the successive cultivation of different crops in a specified order on the same fields, in contrast to a one-crop system or to haphazard crop successions. (the Editors of Encyclopædia Britannica, 2013) The consensus of adapting crop rotation could date from ancient times when ancestors discovered that rotation increased yields and made best use of weather. Actually, the benefits are far more than that. From rotation, the soil can remain fertile, as various crops absorb different nutrients, thus preventing deficiency of certain nutrients and leaving soil enough time to replenish. Legumes can directly supplement Nitrogen in the soil, too. It reduces pests by altering environment that is not favorable for them to thrive. It also contributes to improvement of soil structure by alternating between crops with deep roots and those with shallow roots.

In North China, precipitation is unevenly distributed, concentrated from June to August, leading to drought in the rest of time and flooding during summer, with an average annual precipitation of 525.3mm. (*People Daily*, 2012) Due to the deficiency of water supply, farmers there select wheat as their main crops rather than rice which is widely grown in southern China. Because of temperature and precipitation, farmers there can only harvest twice annually. In Beiyan Village, people tend to plant winter wheat around October 5th, and harvest in June. After 15 days' fallow, farmers will sow summer maize seeds and harvest after four months. There is always green manure left after reaping the crops. Former practices are either burning it or leaving it randomly in the roads or fields. But currently, farmers there have reached a consensus that green manure is beneficial for subsequent crops. With the assistance of agriculture machines, local farmers are now adopting an effective tillage mode, consisting of deep tillage, subsoil tillage and straw returning. Deep tillage and subsoil tillage both decrease soil density, raising its capability of receiving and storing water. They help crops root and absorb deeper nutrients in the soil, too. Straw returning cuts down water evaporation by covering the topsoil, particularly during fallow periods. They operate jointly to reduce soil bulk density, while

improving water efficiency and grain yields. (Table 1-3) There is also a significant interaction between the tillage system and straw returning, especially in water consumption. (Table 4) For example, the interaction of deep tillage increases total water consumption by 3.3%, growing period consumption by 4.2%, but decreases consumption in the fallow period by 7.0%, therefore increasing yields by 18% and water efficiency by 15.9%.

Considering the characteristic of maize straws that is tall and stiff, they use machines to smash straws of maize and in the meantime turn them into soil by deep tillage, which reaches approximately 20-40cm in the soil (average of the North China is15-19cm, 3-7cm shallower than standard of 22cm), decreasing soil bulk density by 7.4% and increasing water efficiency by 2.2% based on the experiments of Zhao, et al. This will additionally provide a fertile topsoil for following wheat with a large share of required nutrients, thus improving yields and decreasing extra fertilizer use.

On the other hand, owing to the genetically modified technology and long-term selection, the wheat they grow is comparatively lower and pliable. Therefore, farmers no longer wipe out those manures and instead directly leave them in the field. When it comes to planting maize, farmers sow seeds in the clearing among manures. This initiative poses benefits for farmers and arable fields. Firstly, green manures act as a natural competitor for weeds, scrambling for sunshine, water, nutrients, and other essentials, hence restricting weeds' thriving, which ensures crop's requisite conditions. Secondly, manures are much less capable for pests to settle and thrive, but more attractive for useful insects and pollinators. (David Chadwick, 2015) This will effectively reduce the use of pesticides and therefore maintain biodiversity and crop quality. Thirdly, those remaining manures root deeper in the soil, and hence promote the process of loosening soil prior to human's interference. This practice also contributes to the transmission of underground water. Fourthly, this initiative has similarity with "cover crop", which is planted intended for covering the soil, maintaining soil quality and prevent soil run-off, depletion and degradation. (Fawce, Jim; Sievers, Josh; Roush, Wayne; and Lang, Brian, 2014) However, local farmers don't have to pay extra money for purchasing cover crop seeds.

All in all, tillage with straw returning is the most appropriate tillage practice in North China.

Table 1: Effects of tillage and straw returning on soil bulk density($g \cdot cm^{-3}$)

Crop	Soil depth (cm)	Treatment	2010-2011				2011-2012			
			CT	DT	ST	Mean	CT	DT	ST	Mean
Winter wheat	0-10	AS	1.24	1.22	1.23	1.23	1.20	1.19	1.21	1.20
		NS	1.25	1.24	1.34	1.24	1.22	1.22	1.23	1.22
	10-20	AS	1.27	1.23	1.24	1.25	1.24	1.21	1.22	1.22
		NS	1.28	1.25	1.25	1.26	1.27	1.24	1.23	1.25
	20-30	AS	1.4	1.37	1.1	1.42	1.47	1.36	1.38	1.40

			7							
		NS	1.48	1.41	1.44	1.44	1.50	1.38	1.40	1.43
	30-40	**AS**	1.49	1.40	1.43	1.44	1.51	1.39	1.42	1.44
		NS	1.52	1.45	1.45	1.47	1.53	1.44	1.44	1.47
Summer maize	**0-10**	**AS**	1.27	1.26	1.26	1.26	1.25	1.23	1.24	1.24
		NS	1.30	1.29	1.30	1.30	1.27	1.25	1.26	1.26
	10-20	**AS**	1.32	1.27	1.29	1.29	1.28	1.23	1.26	1.26
		NS	1.35	1.30	1.31	1.32	1.33	1.29	1.30	1.31
	20-30	**AS**	1.51	1.40	1.43	1.44	1.49	1.38	1.40	1.42
		NS	1.52	1.43	1.46	1.47	1.52	1.40	1.42	1.45
	30-40	**AS**	1.52	1.43	1.45	1.47	1.50	1.42	1.4	1.45
		NS	1.52	1.46	1.49	1.49	1.51	1.45	1.47	1.48

AS: All straw returning, NS: No straw returning, CT: conventional tillage, DT: Deep tillage, ST: Subsoil tillage. The same as below.

Table 2: Effects of tillage and straw returning on water use efficiency(kg·hm^{-2}·mm^{-1})

Crop	**Treatment**	**2010-2011**				**2011-2012**			
		CT	**DT**	**ST**	**Mean**	**CT**	**DT**	**ST**	**Mean**
Winter wheat	**AS**	34.4	35.0	35.9	35.1	32.8	35.4	36.1	34.8
	NS	30.8	34.3	33.7	33.0	30.9	32.4	32.0	31.8
	Mean	32.6	34.7	34.8		31.9	33.9	34.0	
Summer maize	**AS**	11.7	12.7	12.8	12.4	20.6	23.4	22.1	22.0
	NS	11.6	11.7	11.1	11.5	20.2	22.2	20.8	21.1
	Mean	11.6	12.2	12.0		20.4	22.8	21.5	
Whole year	**AS**	22.7	24.8	24.7	24.1	26.7	29.4	29.1	28.4
	NS	21.2	23.7	22.4	22.4	25.6	27.3	26.4	26.4
	Mean	22.0	24.2	23.6		26.4	28.4	27.8	

Table 3: Effects of tillage and straw returning on grain yield of winter wheat and summer maize(t·hm-2)

Crop	**Treatment**	**2010-2011**				**2011-2012**			
		CT	**DT**	**ST**	**Mean**	**CT**	**DT**	**ST**	**Mean**
Winter	**AS**	7.8	8.3	8.6	8.3	11.5	12.5	12.7	12.2

wheat	**NS**	6.8	8.0	7.9	7.6	10.7	11.3	11.1	11.1
	Mean	7.3	8.1	8.3		11.1	11.9	11.9	
Summer maize	**AS**	6.2	7.2	7.1	6.9	6.8	7.8	7.8	7.5
	NS	6.2	6.3	6.4	6.4	6.7	7.4	7.0	7.0
	Mean	6.2	7.0	6.8		6.7	7.6	7.4	
Whole year	**AS**	14.0	15.6	15.8	15.1	18.3	20.3	20.5	19.7
	NS	13.0	14.7	14.3	14.0	17.4	18.8	18.1	18.1
	Mean	13.5	15.1	15.0		17.8	19.5	19.3	

Table 4: Effects of tillage and straw returning on water consumption amount(mm)

Period	**Treatment**	**2010-2011**				**2011-2012**			
		CT	**DT**	**ST**	**Mean**	**CT**	**DT**	**ST**	**Mean**
Growing period	**AS**	758.9	806.2	794.7	786.6	679.5	686.8	685.5	683.9
	NS	755.3	806.2	811.2	790.9	675.8	684.1	700.0	685.5
	Mean	757.1	806.2	802.9		677.7	685.4	692.6	
Fallow period	**AS**	60.7	60.2	58.2	59.7	43.8	43.6	42.3	43.2
	NS	64.4	62.8	63.0	63.4	47.1	45.9	45.9	46.3
	Mean	62.5	61.5	60.6		45.4	44.7	44.1	
Whole year	**AS**	819.6	866.4	852.9	846.3	723.3	729.7	727.8	727.0
	NS	819.7	869.1	875.2	854.3	723.0	730.0	745.6	732.8
	Mean	819.6	867.1	863.5		723.1	729.8	736.7	

Table 1-4 Selected from Zhao Y L, et al. "耕作方式与秸秆还田对冬小麦-夏玉米耗水特性和水分利用效率的影响." *中国农业科学* 47.17 (2014): 3359-3371

Water utility

China has long been suffering from water scarcity, and agriculture in Hebei Province is especially restrained by the deficiency of water. According to the World Bank, China has renewable internal freshwater resources of 2,071 cubic meters per capita, well above the UN definition of water scarcity as 1,000 cubic meters per person. But China's water resources are not distributed equally. According to Choke Point: China, nearly 70 percent of water used in China goes to the agriculture sector, which is concentrated in the north which also happens to be an area of scarce rainfall, receiving only 20 percent of China's total moisture. In northern China, the average water per capita is only around 200 cubic meters.

However, local practices are still flooding, which seriously reduces the storage of underground water and keeps adding challenges for maintaining water supply. The reasons can be divided into two main aspects. On the one hand, water in the case area is free because water plants are not delivering water due to high transport prices and high infrastructure costs. Therefore, water source comes from local wells and fetch water on a regular basis. One the other hand, farmers are economically restrained from upgrading water infrastructures and inwardly restricted from realizing the seriousness of such practices.

In view of this situation, local government attaches great attention to deal with water wastes in agriculture, and is continuously paying for rural water infrastructures. The process of building pipelines for drop irrigation and spray irrigation in Beiyan Village began in early 2016, after the completion of neighbor areas. Till now, the pipelines are almost completed, and will formally be put into use on October 1st. Although conservative practices are gradually employed, the fact that wheat is in great need of water cannot be changed. The government has come up with an array of policies to control the production of wheat in Gaoyi County neighboring Yuanshi County.

Additionally, we find another phenomenon that requires immediate attention. The wells are relatively far from some certain families, driving it impossible to fetch water every day. As a result, they store enough water for 10-15 days at one time, which makes water quality concerning, crude storage reservoir and disinfection exacerbating the problem.

Labor forces

Any practice is based on individuals, and all the endeavor we make is ultimately to improve people's welfare, especially in agriculture-related issues. Due to domestic large population and limited croplands, whether existing agriculture practices are capable to meet people's demand depends more and more on labor productivity. There is already a contradiction between the lack of arable lands and increase amount of idle farm lands.

Nowadays, with speeding trend of urbanization, labor forces are flowing away at an alarming speed. As what is mentioned in the case family, the two middle-aged are seldom at home, except on certain crucial days when seeds are sowed or crops are reaped. Only at that time will they ask for 2-3 days' off, and rush back to the factories they are working for. This leads to the circumstance that permanent labor forces are mostly old people, and their productivity is comparatively low. Even those middle-aged who remain in the village don't entirely devote into agriculture. Instead, they treat agriculture as an insurance, from which they can ensure the basic need for living, or just an avocation. They will also seek outside working opportunities, and it is probable that once they find jobs in the urban areas, they will immediately join in the unity that is called "migration workers" of total 227.47 million people. 26.77% rural labor forces have the experience of working outside, while 40.62% tend to work in the city in future. (China Labor-force Dynamics Survey, 2015) Children and teenagers are rooted in mind with the awareness that only study can change their life, Gaokao is the entrance for a brighter future. Therefore, families attach their sincere hope to children, liberating them from fields, and supporting them finish high school. In view of poor education environment in the village, parents struggle to take their children to advanced cities for a better education opportunity. Once they are admitted by universities, the young adults are not willing to return to croplands, causing the flow away of highly educated labor forces. All these above trigger current rural labor tendency of aging, feminizing, and low educated.

Targeting relevant problems, the government should take more actions to improve the situation.

Firstly, government should enhance the subsidy for local farmers to support their family. The main reason why labor forces are rushing out is that single agriculture is far deficient for a big family

usually consists of 6-8 members, 2-4 of them children, contributed to the traditional sense of boy priority. Moreover, government should attach importance to infrastructure development, providing access to clean and safe water, entertainment places, comprehensive shopping malls and so on to attract residents, and attract people working in the cities back.

Secondly, strengthen propaganda and promote education in the rural area to raise people's awareness of appropriate and environment-friendly tillage, emphasize the importance of cooperating with government, and satisfy education need for rural children. Government is supposed to set rewards and subsidized prices for green practices' purchase, and establish regular free classes and lectures intended for farmers. With the proceeding of Internet revolution, farmers should master basic knowledge of Internet, an access to outside markets, getting timely information of agriculture production and consumption. On the other hand, to maintain education resources and bridge the gap between rural and urban areas, pertinent polices are already playing their role. Teachers who teach in the village get higher salary compared to those working in the county or town. Many national enterprise positions require the experiences of working in rural areas for at least one year. Another long-term policy is that graduates who apply for agriculture, forestry and fishery related majors don't have to pay for tuitions. All of these initiatives are designed to reverse the situation, but there's still a long long way to go.

Rural land system under the household contract responsibility system

Since 1978, China began to implement the household contract responsibility system, which determines the characteristic of farming, separate. This is an innovative approach, strongly stimulating farmers' productivity. Nowadays, this is still playing its role, but faces new challenges exacerbated by resource and labor scarcity. The separate croplands add barriers for large-scale machines to operate efficiently, and cannot reach scale merit, making it essential to change the operation mode. Farmers in the village voluntarily cooperate for a joint larger scale where they grow the same kinds of crops and then distribute harvest according to proportion of inputs set before. Members are expected to share related techniques, machines, labor forces, fundamental resources, information, etc. This proposal will enhance the ability of dealing with underlying risks for individuals, and promote machine operations. It will lead to waste reduction, thus resource conservation. With enterprises entering the cooperation, farmers will have direct access to market, selling to enterprises on the basis of contrast. Government's aid will be more effectively, since a large amount of funds aggregate. Assisted by enterprises, the adoption of new technology and instruments is relatively acceptable.

Up to 2015, China's remaining arable lands is 2.025 billion mu, approaching the redline of 1.8 billion mu. (source from Ministry of Land and Resources of the People's Republic of China) From 2010-2014, arable land shows a decreasing trend because of environmental damage and land transformation. (Figure 2) Therefore, to prevent croplands loss, government should improve supervision system and broaden access of public reflection to prevent croplands from being converted to estate lands or other commercial lands, and control damage of natural disasters.

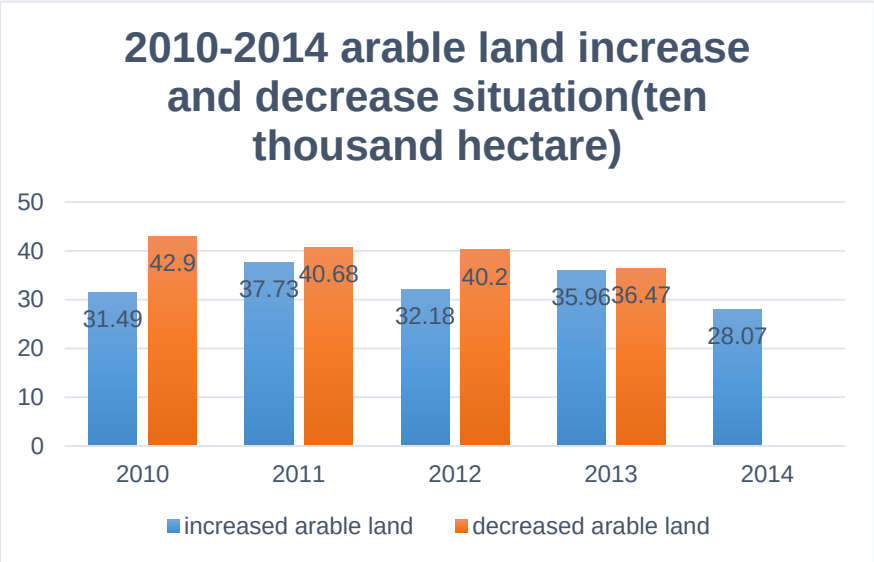

Figure 2(data from Ministry of Land and Resources of the People's Republic of China)

Conclusion

Sustainable agriculture requires comprehensive initiatives and prolonged joint efforts. Chinese government is acknowledged of the urgent situation, and is endeavoring to alter inappropriate practices, and develop an array of practical methods in the meantime. However, as a result of widely distributed rural areas, some practices are just at the beginning, taking Beiyan Village as example. After summarizing and analyzing all these factors above, here are some solutions worth spreading. Keep selecting advantageous crops armed with modern technology like genetically modified technology.

Based on scientific knowledge and traditional experience, implement crop rotation green manure management and conservation agriculture.

Stimulate farmer's enthusiasm and productivity by improving living conditions, welfare, education, equality, etc. and guarantee enough labor forces on the fields. Raise farmers' income consistently. (Average income per capita is RMB 10772, data from Ministry of Agriculture in 2015)
Seek innovative ways to settle problems relevant to separate farmlands and prevent arable land loss.

Although there is still a long way to go, with appropriate methodologies and implementations, I believe sustainable agriculture is within our reach.

References

Fawcett, Jim, et al. "On-Farm Cover Crop Trials." (2014).

Qiu, Jianjun, et al. "Mapping Single-, Double-, and Triple-crop Agriculture in China at 0.5°× 0.5° by Combining County-scale Census Data with a Remote Sensing-derived Land Cover Map." *Geocarto International* 18.2 (2003): 3-13.

Robertson, G. Philip. "A Sustainable Agriculture?" *Daedalus* 144.4 (2015): 76-89.

Yao, Zonglu, et al. "Crop performance as affected by three opening configurations for no-till seeder in annual double cropping regions of northern China." *Soil Research* 47.8 (2010): 839-847.

Zang, Yifei, Xiaorong Wei, and Mingde Hao. "Long-Term Effect of Crop Rotation and Fertilisation on Bioavailability and Fractionation of Copper in Soil on the Loess Plateau in Northwest China." *PloS one* 10.12 (2015): e0145370.

Bai Y F, and Chen A C. "中国现代农业可持续发展的现实途径." *中国人口· 资源环境* 20.4 (2010): 117-122.

Cheng C P, et al. "不同轮作制度下施肥对冬小麦田间杂草群落及小麦生长的影响."*生态环境学报* 22.3 (2013): 370-378.

Li X J, Wang H B, and Sun W S. "河北省农业可持续发展能力指标体系及其评价方法研究." *河北农业大学学报: 农林教育版* 8.2 (2006): 33-36.

Zhao Y L, et al. "耕作方式与秸秆还田对冬小麦-夏玉米耗水特性和水分利用效率的影响." *中国农业科学* 47.17 (2014): 3359-3371