Replacing chemical fertilizers with organic fertilizers for fruit, vegetable, and tea – An Evaluation of the Subsidy Policy and its Effects

- The case study of apple cultivation in Gansu Province

Research Summary[1], February 2022

1. Research Background

Excessive use of pesticides and fertilizers has caused soil pollution and degradation, and directly undermined the productivity and restoration of farmland. As a result, the agricultural non-point source pollution has increasingly become a focus of attention in China. The Chinese government has issued a series of related policies on how to accelerate the green development of agriculture and promote the recycling of resources. On February 17, 2015, following the Central Rural Work Conference, Central No. 1 Document and the National Agricultural Work Conference, the Ministry of Agriculture focused on the main line of work of "stabilizing grain, increasing income, adjusting cropping structure, improving agricultural quality and efficiency, and transforming innovative technology". Therefore, the Government formulated the "Action Plan for Zero Growth of Fertilizer Use by 2020" and "By 2020 Action Plan for the Zero Growth of Annual Pesticide Use". In the "13th Five-Year National Agricultural and Rural Informatization Development Plan" adopted by the Ministry of Agriculture in 2016, it was once again emphasized that the new development concept of the Fifth Plenary Session of the 18th Central Committee of the Party must be implemented, vigorously promote the circularity of planting and livestock, and replace chemical fertilizer with organic fertilizer. For green development, the "Action Plan for Carrying out Organic Fertilizer Substitution of Fruit, Vegetable and Tea" (hereinafter referred to as the "Plan") was formulated. In 2017, 100 key counties (cities, districts) in fruit, vegetable and tea production area were selected to carry out demonstrations of organic fertilizers in replacement of chemical fertilizers.

Based on this background, in order to better understand the implementation effect of the Plan and the needs of farmers, this research focused on apple production in Gansu Province and conducted in-depth investigation and analysis of subsidy implementation, subsidy impact, and shortcomings of organic fertilizer substitution for chemical fertilizers in the apple industry by observing the behavior of

[1] This project was conducted in collaboration with a research partner.

apple planting farmers, focusing on soil health and resource utilization efficiency, so as to scientifically and effectively evaluate the subsidy policy. The aim is to put forward reasonable suggestions to improve the efficiency and effectiveness of current subsidy implementation.

2. Development of Apple Industry and Application of Chemical Fertilizer

China is the world largest apple producer, with a total apple planting area of about 2 million hectares. From 2010 to 2015, the total apple planting area in the country has slowly increased year by year. But there was a sharp decline of more than 15% in 2016. Afterwards, the growth has staggered. The apple planting area of each major apple-producing province also has a similar pattern of change. As of 2019, Shaanxi is the province with the largest apple planting area in the country, with this planting area representing 30% of the country. Shandong and Gansu have identical planting areas with more than 240,000 hectares, ranking second and third respectively.

From 1991 to 2017, the overall production cost of apples in China shows an increasing trend, and the net cash income and profit per unit area shows a trend of first increasing and then decreasing. In the composition of apple production costs, input and service costs, labor costs, and land costs per unit area have increased to varying degrees. Labor and land costs have increased significantly, and input and service costs have maintained relatively stable with a small increase.

From the perspective of the proportion of chemical fertilizer costs to total costs, the proportion of chemical fertilizers fluctuated significantly during the 10-year period from 2002 to 2012, and then entered a relatively stable period, which has been hovering around 9% (Figure 1). Expenditure on chemical fertilizers increased significantly from 2005 to 2011, mainly due to the increase in the amount of compound fertilizer used by fruit farmers during this period, the increased price of compound fertilizer, and the sharp increase in the average price of chemical fertilizers. Fertilizers are the means of production that accounts for the largest proportion of material inputs, followed by pesticides and machinery purchase/rental costs. The proportion of fertilizer expenditures in total costs and material service charges was generally stable, with an average proportion of 11.08% and 24.85% respectively. From 1998 to 2017, the prices of nitrogenous fertilizers, phosphate fertilizers, and compound fertilizers all rose, with average annual growth rates of 1.16%, 2.73%, and 3.16%, respectively. Compound fertilizers had the largest increase. The price was the highest in 2008, reaching 7.27 yuan/kg. Potash fertilizer prices fluctuated greatly. They increased from 1998 to 2012, with an average annual growth rate of 7.25%. From 2012 to 2016, they showed a downward trend, with an average annual decrease of 13.96%. In 2017, they resumed growth, an increase of 27.47% over the previous year [2].

[2] Liang Shuo. Analysis of Apple Production Cost and Benefit in Gansu Province[D]. Gansu Agricultural University, 2017.

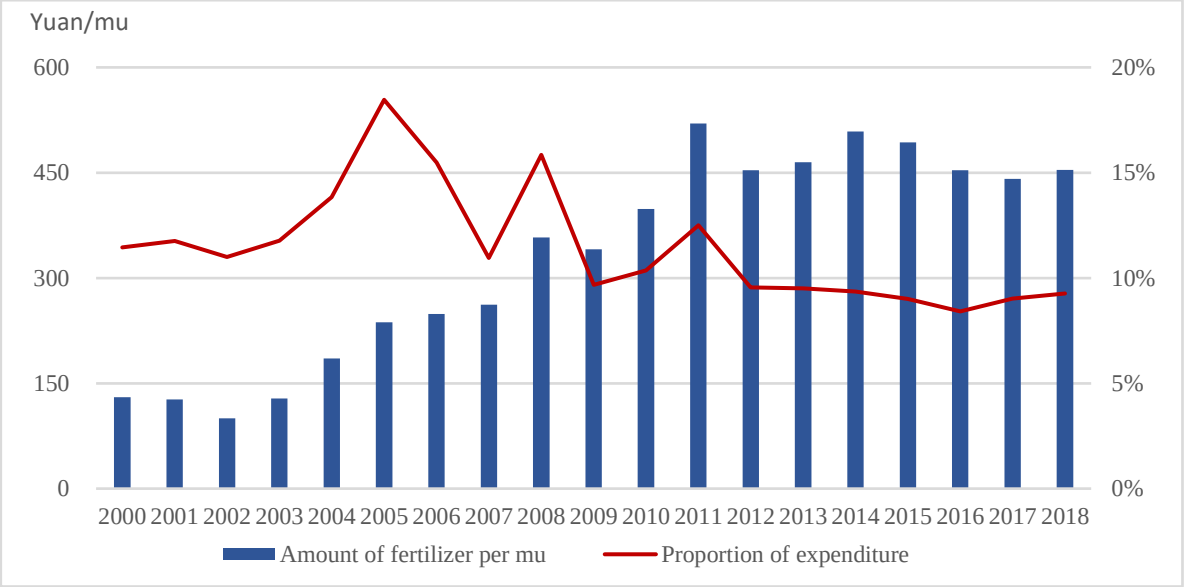

Figure 1 The cost of synthetic fertilizers used in apple farming during 2000-2018

3. Apple Farming in Gansu Province

From 2005 to 2016, the planting area and output of apples in Gansu Province continued increasing but the unit output level was low. The apple planting area increased from 207.4 thousand hectares in 2006 to 294.8 thousand hectares in 2015, with an average annual growth rate of 2.09%, rising to the third place in the country. Apple production increased from 1.254 million tons in 2006 to 3.286 million tons in 2015, with an average annual growth rate of 11.30%, ranking sixth in the country. Gansu Province has now become the famous province for its apple production in the country and is one of the dominant regions in the country. However, in recent years, the yield of apples in Gansu Province has shown a fluctuating upward trend with a small increase. The yield of apples in Gansu is only 1114.7 kg/ha, which is far below the level of Shandong Province and the national average in China [3].

The cost of apple production in Gansu Province has risen very fast and has exceeded the national average. From 2006 to 2015, the total cost of apples per mu in Gansu Province increased from 1474.39 yuan to 7632.74 yuan, which has more than quadrupled in ten years. In 2015, the total cost per mu of apples in Gansu Province is already 1.42 times the national average. The main reason for the substantial increase in total cost is the substantial increase in labor costs and input prices of production factors. The labor cost per mu of apples increased from 1067.30 yuan in 2006 to 5718.51 yuan in 2015, and the average annual growth rate went from high to low. In 2015, the labor cost per mu of Gansu Apple was 1.21 of Shandong Province's times, and 1.78 times the national average. The main factors affecting the total cost per mu of apple planting in Gansu Province and the order of influence are household labor cost > fertilizer cost> tool and material cost> pesticide cost> lease operation cost [4].

[3] Liang Shuo. Analysis of Apple Production Cost and Benefit in Gansu Province[D]. Gansu Agricultural University, 2017.
[4] Liang Shuo. Analysis of Apple Production Cost and Benefit in Gansu Province[D]. Gansu Agricultural University, 2017.

4. The Situation in the Case Area

This study selected Jingning County and Ning County in Gansu Province as the case investigation areas, mainly based on two reasons:

- One is that both counties are traditional agricultural regions, with similar population sizes and development levels, and they are very comparable. According to the "2020 Gansu Development Yearbook" published by the Gansu Bureau of Statistics, the populations of Ning County and Jingning were 414,000 and 428,000 respectively in 2019, the per capita GDP was 13,857 and 16,868, and the per capita income of farmers was 9,636 and 8,331 respectively. The number of rural employees is 265,000 and 225,000 respectively.
- Second, both counties are in high-quality apple production areas on the Loess Plateau. The apple industry is relatively large, but only Ning County was in the “National Organic Fertilizer Substitution Chemical Fertilizer Project” and received the subsidy.

In this study, two counties of Ning County and Jingning County are used as the survey sites. Through the survey of farmers, the production behavior characteristics of project-funded farmers (Ning County) and non-project-funded farmers (Jingning County) were observed, compared, and analyzed. For the region (Jingning County) where farmers spontaneously changed from chemical fertilizers to organic fertilizers, we studied which factors more affected the production behavior of farmers using organic fertilizers, analyzed the impact of government policies and the efficiency of funding, and conducted a comparative analysis of policy support and farmers’ self-induced behaviors. We also discussed the differences in farmer’s behaviors between the two situations in terms of efficiency and benefits and provide theoretical and data support for policy optimization.

4.1 Overview of Apple Industry Development in the Case Area

The Ning County is one of the most suitable areas for apples in the country, and it is also a national green, pollution-free apple production demonstration area. People have a tradition of planting apples, and the development of the apple industry has a unique advantage given the agro-climatic conditions. Since 2014, driven by Shaanxi Haisheng Group, Ning County has developed 70,000 mu of "Haisheng Apple" orchards, which has become the country's largest self-rooted dwarf and densely planted apple base. In 2018, Ning County was listed by the Ministry of Agriculture and Rural Affairs as a national modern agricultural industrial park with key support. Apple became Ning Country's first income-increasing industry. In recent years, Ning County has taken apples as the primary industry for stable income growth of the poor and has gradually formed a modern apple industry chain development system of integrating seedling cultivation, planting, management, sorting, storage, and marketing. At present, the county’s apple area has reached 450,000 mu, of which 110,000 mu of "Ning County Apples" have been built. There are 8 villages and towns with more than 10,000 mu of apples, and 120 specialized villages with 1,000 mu each. More than 13,450 large farm households have planted apples. In 2020, the county’s apple production is expected to reach 500,000 tons with a revenue of 2.5 billion yuan, driving an annual income per capita of 2727 yuan for local farmers.

In the late twentieth century, Jingning has begun to develop the apple industry. Because of its altitude,

climate and other production conditions that are very suitable for apple planting, the industry has developed well in the past 20 years and has a high market recognition. It has gradually developed into a strong county in the country's apple industry. At present, the total area of orchards in the county has reached 1 million mu, accounting for 68.7% of the arable land area, 10.6 mu per household and 2.34 mu per capita. Seven orchard towns including Renda, Lidian, Zhiping, Jiahe, Yuwan, and Shuangxian, and 60 professional fruit villages including Zhiping Leigou and Chengchuan Wumiao have been built, forming 100,000 mu of apples in the Lidian River Basin. In 2017, the total area of fruit orchard is reached 620,000 mu; the output was 780,000 tons; the output amount was 3.2 billion yuan (average yield was 1.25 tons per mu, the average price was 4.1 yuan/kg), and the per capita net income of fruit for farmers was 4,900 yuan; in 2018, the county's fruit orchard The area is 650,000 mu, the output is 760,000 tons, the output amount is 3.55 billion yuan (the average output per mu is 1.16 tons, the average price is 4.7 yuan/kg), and the per capita net income of farmers is 5,500 yuan.

4.2 Fertilizer application in the case area

In 2011 and 2012, the scalar amount of chemical fertilizer application in Ning County reached a peak of 15,541 tons; in 2015, the trend of using fertilizer slowly increased; from 2015 to 2017, the scalar amount of fertilizer application has increased from 14,248 tons to 14,326 tons; since 2010, the scalar amount of fertilizer application in Jingning County has increased, and reached a peak of 28,690 tons in 2016, and declined in 2017, with a scalar amount of 26,176 tons (see Table 1).

Table 1 The amount of chemical fertilizer used in Jingning County and Ning County (tons, converted to pure elements of N, P, K)

Years	Jingning County	Ning County
2009	19788	12618
2010	14948	12923
2011	21735	15541
2012	21735	15541
2013	24257	14211
2014	25458	14256
2015	26128	14248
2016	28690	14306
2017	26176	14326

5. The impact of replacing chemical fertilizers with organic fertilizers- a micro-level analysis

From August 27 to September 8, 2020, the research team, together with the Agricultural Research Center of the Ministry of Agriculture and Beijing Normal University, conducted a 12-day questionnaire survey of apple farmers in Gansu. The survey involved 22 administrative departments in 6 townships

in Ning County and Jingning County. There are 431 apple growers in the village, including 207 growers in Ning County and 224 growers in Jingning County. The surveyed Ning County and Jingning counties belong to the Loess Plateau. The 22 samples of villages are distributed between 1100-1800m above the sea level, and the annual precipitation ranges from 400-800mm. They are mainly drylands with interlaced topography and landforms between highlands. In the last decade, the apple cultivation of Ning County and Jingning has suffered greater losses of several natural disasters, such as frost, hail and drought, the average loss is estimated to 50%, 30%, and 10% respectively.

In summary, the use of animal manure as farmyard manure is mainly based on the following three types of conditions: firstly, local farmers may raise some livestock at the same time and invest some dung of animals as farmyard manure for apple orchards, but the amount is generally insufficient; secondly, there is a huge amount of dung of animals among villages. For livestock farms or large-scale farming operations, apple growers can obtain abundant animal manure regularly, it is uncommon to hold a direct negotiation between the local farmers and the large ranchers. Basically, some or individual local farmers correspond to the surrounding large farmers (factories). The relationship between this kind of purchase is tied relatively strong and stable; thirdly, farmyard manure or processed farmyard manure products transported from a long distance are mainly sheep manure, and it usually purchased from 300 kilometers away. This kind of farm manure application is basically only found in the core production area of Jingning County due to high transportation and labor cost.

5.1 Basic characteristics of organic fertilizer application

Farmers generally lack a higher level of understanding and composition of commercial organic fertilizers. No detail guidance on its application results in the significant difference in application.

The use of farmyard manure is linked to the traditional history of apple cultivation, but it has shown a significant downward trend in recent years. The survey of villages reflects that the usage of annual amount of farmyard manure is rapidly decreasing. The main reasons for the decrease are twofold: one is that the apple cultivation is becoming more and more refined, coupled with the shortage of labor the amount of household livestock keeping is drastically reduced, resulting in insufficient supply of self-produced farmhouse manure. The second is that the general dependence on chemical fertilizers. Through village-level interviews and individual interviews with farmers, it can be observed that farmers have a more comprehensive understanding of the advantages and disadvantages of farmyard manure. The knowledge of longevity and soil improvement is relatively sufficient, but in view of the shortage of labor, poor purchase channels of farmyard manure, high cost, and labor cost, the willingness to use farmyard manure is not proportional to experience and is obviously insufficient.

Farmer perceptions and attitudes towards commercial organic fertilizers are vague. Although growers hope to apply commercial organic fertilizers replacing chemical fertilizers, on the other hand, there are many doubts from growers about the composition, application methods, and effects of commercial organic fertilizers.

The effect of geographical indications and geographical scope have obvious reverse influence, namely, the smaller the geographical scope, the greater the effect of geographical indications. This reflects from one aspect that the sales of apples have a certain geographical indication effect, which is affected by the average quality of apples in the producing areas and their recognition in the market, which will

affect farmers' management of apples in the producing areas to a certain extent. The management includes the application of chemical fertilizers and organic fertilizers.

By observing subsidy-supported farmers and non-supported farmers, the effect of government-driven approach is stronger than the level of publicity. At the same time, because the design and implementation of the policy generally emphasizes the top-down, it ignores the farmers as the final implementation entities of the policy. Also, inadequate attention was given to the positive role of mobilizing farmers' own initiative in implementation. As a result, some policies have not reached its maximum intended effects.

5.2 Farmers' Cognition and Evaluation of Farmyard Manure and Commercial Organic Fertilizer

In comparison, the sample farmers in the two counties have the same perception of the effect of farm manure and organic fertilizer in reducing the use of chemical fertilizers. The majority of farmers believe that the application of farm manure and organic fertilizer can effectively reduce the amount of chemical fertilizer used. Judging from the understanding of the composition of commercial organic fertilizers, only a few farmers can clearly point out the difference in chemical composition of fertilizer. Also, farmers understand very little about the potential hazards or hidden risks of farmyard manure and commercial organic fertilizer in case of inappropriate application. More than 70% of farmers are not aware that farmyard manure and commercial organic fertilizer may contain harmful substances, such as heavy metals. Farmer cognition is mainly derived from experience in traditional agricultural production rather than scientific knowledge under modern agriculture; and the content and methods of understanding are very limited. Nearly half of farmers' understanding of green manure is extremely vague, and even farmers who have some knowledge of green manure have a more conservative assessment of its effect. To close the knowledge gap, the sample farmers expressed a strong willingness to learn, hoping to learn more about fertilizer composition and application aspects to improve the apple quality.

6. Results, Challenges and Policy Recommendation

6.1 Positive effects of policy implementation

First, there is a certain degree of consistency between policy implementation and expected results. The proportion and quantity of farmhouse manure purchased by farmers in Ning County are significantly higher than those in Jingning County. Assuming that the influence of self-produced farmhouse manure consumption is excluded, the purchase ratio and quantity of farmhouse manure by farmers can be regarded as the result of policy intervention, and this result is also consistent with the expected effect of the policy design.

Second, the implementation of the policy has produced a certain demonstration effect. Party members, village cadres or cooperatives managers are becoming more likely to promote and apply commercial organic fertilizer and farmyard manure in apply farming. The main content of policy design has a driving and demonstrative effect on individual farmers in the production and operation activities in the region.

Third, farmers in the project area have a high degree of recognition of the policy of replacing chemical

fertilizers with organic fertilizers, and they have a certain understanding of the substitution effect of organic fertilizers.

6.2 Problems in the implementation of the policy

First, the effect of the policy on replacing chemical fertilizers with organic fertilizers is lower than expected. Farmers have concentrated on the initial changes in their perceptions of replacing chemical fertilizers with farmyard manure. In the actual process, factors such as the convenience and cost of purchasing farmyard manure, the self-production of farmyard manure and the labor input in the application process, affect farmers. The effect of replacing chemical fertilizers with commercial organic fertilizers has not been achieved. On the contrary, since farmers classify commercial organic fertilizers and farmyard manures into one category, the promotion of commercial organic fertilizers is replacing farmyard manures to a certain extent due to higher cost, time, and labor considerations of farmyard manures.

Second, the driving effect of the policy on small-scale farmers is not so obvious. Due to diversified income sources and bargaining power of smallholders, they do not pay enough attention to improve the quality of apples; also, the project support focused mainly on large-scale farmers and cooperatives, and the support for small-scale farmers was relatively limited, and its spillover effect on small-scale farmers has not yet fully manifested.

Third, there is no unified standard for the production and application of commercial organic fertilizers, resulting in a lack of a unified understanding of commercial organic fertilizers by the technical extension departments and farmers. In addition, the market management is not standardized, the good and the bad are mixed, and the overall development is rather chaotic. The technical department also does not have enough experimental data and cannot provide clear guidance to farmers. This has led to confusion about the understanding of commercial organic fertilizers. Under the premise of lack of scientific application norms, the rapid development of commercial organic fertilizers, to a certain extent, has had an effect of not replacing chemical fertilizers but replacing farmyard manure.

Fourth, there is the emergence of new non-point source pollution due to no clear guidance of fertilizer application.

Fifth, some individual farmers are free riders, who benefit from neighboring farmers who adopted organic fertilizers. There are currently no effective measures to curb this type of behavior, which is not conducive to the further promotion and implementation of such policies.

6.3 Policy spillovers

There are a few spillover effects of the subsidy policy implementation:

- Growers recognize the improvement of the soil by the application of farm manure.
- Growers gave positive feedback on improving the quality of apples after adopting the subsidy.
- An increase of farmer income was observed.
- The subsidy fostered the endogenous motivation of farmers. Due to the increase in income, some farmers have shown a keen interest in the rational application of farmhouse manure and the

scientific management of orchards.

Under the conditions of relatively small implementation scale and short implementation time of the policy, the research area has already had a certain promotion effect on apple farmers, and the publicity and implementation effects of the policies are all relatively obvious. However, there are also some problems in the policy implementation process, and there is room for improvement and optimization.

6.4 Suggestions for policy improvement

First, it is important to effectively stimulate the endogenous motivation of farmers, so that farmers' investment can get corresponding economic returns. There is also a need to increase guidance to farmers' production technology, especially farm nutrient management, and widely publicize the production standards of geographical indication products and their public goods attributes and their intrinsic value, so that farmers can deeply realize the consistency of their own interests and the protection of geographical indication brands. This way they will also be more inclined to use more organic fertilizers to replace chemical fertilizers.

The second suggestion is to further scientifically standardize the production standards of geographical indication products and implement them strictly through improved management methods based on market promotion, such as more specifically regulating the geographic scope of "Qingyang Apple", and detailing the standards, such as passing clear regulations. The upper limit of chemical fertilizer application, the production and use of geographical indications in strict accordance with the standards, etc., shall be strengthened.

There is also a need to strengthen market supervision. The authority should strengthen the supervision, specification, and quality requirements of the production of commercial organic fertilizers and biological compound fertilizers to prevent inferior organic fertilizers from harming the interests of farmers; on the other hand, it is to strengthen the supervision of the apple sales market and increase the protection of geographical indication agricultural products. There is also a need to increase the quality inspection of the primary apple market and the final consumer market and strengthen the traceability management of agricultural product sales.

The fourth suggestion is to strengthen the support of agricultural science and technology. Taking the implementation of the current subsidy policy as an example, it is necessary to reasonably set the use ratio and application time of various chemical fertilizers, farm manure/commercial organic fertilizers, biological compound fertilizers, etc. according to factors such as soil, fertility, and tree species in different regions. Technical specifications allow farmers to truly realize the scientific management of orchards and avoid the "double high" phenomenon, in which farmers use large amounts of both farm manure/organic fertilizer and chemical fertilizers.

Lastly, it is needed to further encourage large-scale operation and cooperative operation of farmers. The increased preference of large-scale and cooperative farmers in the application of farm manure is more conducive to the implementation of the policy of replacing chemical fertilizers with organic fertilizers. It is important to promote the combination of planting and livestock in areas where conditions permit, increase the effective supply of farm manure, and save purchase costs, and at the same time reduce the amount of farm manure application labor through mechanical improvements.