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Labor Cost Analysis for Pome Production in Different Cultivation Modes in Hebei Province

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Abstract Taking the traditional fruit pear as the example, this paper analyzes labor cost for pome production in Hebei Province, based on the representative cases and the research of pome production in different cultivation modes. Firstly, it conducts cost analysis for medium-density pome production in Xinji City, focusing on the comparison of the costs for the main production labor in standard thin planting mode and dwarf close planting mode. According to the research results, labor cost has a great influence on the total production cost of pome. The methods to reduce labor cost include: adopting dwarfing rootstock close planting and intensively efficient pome cultivation method; simplifying the pruning method when matching up the shape of tree; improving soil by the methods of natural grasses and addition of organic materials, and increasing mechanized operation.

Key words Labor cost, Pear, Dwarf close planting, Natural grasses

Hebei Province is China's main pear production area where the pear planting area, total output, export quantity and technical level all rank first in the whole country since the founding of new China. Nowadays, pome output in Hebei Province takes 32% of the total output in China, and 1/7 of the total output in the whole world. And both planting area and output rank first in China and the world. The pomes produced in Hebei are not only the best seller in China, but also sold in many foreign countries including USA, Canada as well as Southeast Asia. However, there are some questions on the pome industry in Hebei while achieving good results. Many labors are required in pome industry which will be directly influenced by the quality and cost of labor. The shortage of labor in orchard gets more serious in recent years as the aging of population in our country, the transfer of rural labor to the city and the intensifying of land circulation degree. In particular, it is usually very difficult to hire labors for some small-scaled orchards in key production seasons due to the conflict with other farm work. From micro view, labor costs of orchard tend to increase year by year irreversibly, which results in the yearly rising of pome production cost thus causes the sales price of pome rising, therefore, the price competitiveness of exported pome declines year by year accordingly; while from microcosmic view, the production links of different cultivation modes are similar, but the actual labor amount needed in the process of production has great differences. Therefore, Hebei pome industry has to immediately achieve the historic mission that makes great efforts to explore and develop labor saving cultivation method of pome tree and improve the international competitiveness of pome in Hebei Province; meanwhile, the incomes of orchard should be increased, and various efforts are required to make to realize the systematic project – income increase, in which an important thing is to adopt a more economic and practical

cultivation mode which is capable of reduce the production cost of pome effectively.

1 Current situation of pome production labor needed in Hebei Province

Hebei Province is the largest pome production province in our country, the pome output of which occupies about 1/3 in the whole country, and is also the largest pome exporting province in the country. Xinji City, a county-level city governed by Shijiazhuang, is the largest pome production area in Hebei Province which has a history in pome planting of over 1 000 years. The total fruit growing area in Xinji City is 253 330 000m² of which pear occupies 43.4%, namely 110 000 000 m², and the main varieties of pear include "Huang Pear" and Ya Pear. There are eight fruit exporting enterprises in different scales in Xinji City which export about 20 000 metric tons pomes to many countries and regions including Korea, Japan, Southeast Asia and Europe and America every year.

The pome planting mode in Gaoyang County of Hebei Province is different from the traditional pome cultivation mode in Xinji City, and dwarf close planting mode is generally adopted to develop pome industry in Gaoyang County of Hebei Province. The pome production of Hebei Tianfeng Agricultural Products Co., Ltd. in this county is typical in this mode. The company is an export enterprise engaging in fruit planting, new variety development, fruit and vegetable processing, storage and sales. The company adopts dwarf close planting mode in the area of its 186.67 – hectare planting base to plant pear trees, which means grafting Xueqing pear on dwarfing interstocks then planting the pear trees in meadow orchard by close planting mode. And 4 500 – 4 650 pear trees are planted per hectare, the main planting mode is wide row planting. There are 5 – 6 lines of trees planting in every row and a distance of 3.0 – 3.5 m should be left between each row for operation. And the distance between each tree is 0.7 m. The height of

the tree should remain 3.0m below. The average output per a pear tree is 40 kg, and the output per a hectare is 60 000 kg. The company sets a successful example in dwarf close planting of pome in our country.

This study mainly analyzes the production cost composition of standard medium-density pear orchards in Xinji City of Hebei Province , and the planting density of such orchards is between 825 and 1 650 every hectare. Most respondents and interviewees participating in the research are fruit growers whose fruit production scales are between 6 700 m² and 13 300 m². And their inter-individual differences are small. For pear tree is the perennial woody plant, it takes 5 years to develop a standard medium-density pear orchard from sprigging to stable production period. The initial investment cost of pear orchard will not be considered in the analysis of production cost for the comparability of data. After entering into the stable production period of pear trees, the annual production costs comprises of fertilizer expenditures, pesticides expenditures, herbicide expenditures, raising pouch expenditures, labor costs and other costs (such as utilities expenses, pollen expenses and plant hormone expenditures)^[1], in which water, fertilizer and pesticides expenses are the main part of pear production cost. In the production of standard medium-density pear orchards in Hebei Province, the labor investment cost occupies about 48% of the total production cost (see Fig. 1).

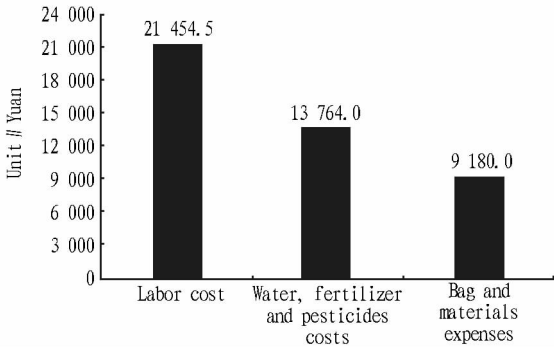


Fig. 1 Pome Production Cost per Hectare in Medium-density Cultivation Mode in Xinji City of Hebei Province in 2010

According to Fig. 1, in the production cost of pome, labor cost occupies about 48.3% of the total cost, water, fertilizer and pesticides costs 31.0%, and pouch and materials expenses 20.0%. And labor cost can have a great influence on the total production cost of pome. Recently, labor cost price rises sharply in the market, which will result in the remarkable increase of the production cost of pome, bring down input-output ratio and cause the decrease of economic efficiency, thus influencing sustainable development of the fruit industry. According to this, it has a practical significance to promote labor saving and efficient cultivating mode of pome, relieve labor intensity and reduce labor input. And from the analysis of interview data, the average labor input of management cycle in all pear orchards in Xinji City is 611.25 man-days per hectare (see Fig. 2).

Labor demands in bagging and harvesting links are the grea-

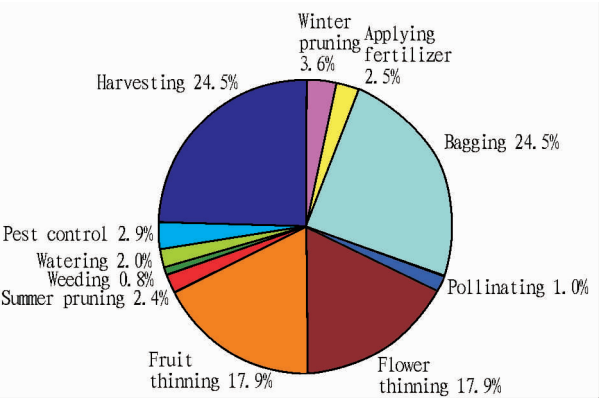


Fig. 2 Employment Situation of Pear Orchard in a Management Cycle under Medium-density Planting Mode in Xinji City in 2010

test. And the labor number per hectare of pear orchard in these two links is 150 man-days which occupies about 24.5% of the total labors in average; and the rest labor situations are as follows in successive: flower thinning and fruit thinning are both 109.5 man-days, occupying 17.9%; winter pruning is 22 man-days, occupying 3.6%, pest control is 17.7 man-days, occupying 2.9%, fertilizer applying is 15 man-days, occupying 2.5%, and weeding is 4.65 man-days, occupying 0.8%. From this, we know bagging, harvesting, flower and fruit thinning, winter pruning and fertilizer and water management are the most important employment link in pear orchard production. Labor inputs are the largest in these links which occupy 92.9% of the total labor inputs. And these links have a remarkable influence on the production cost of pome. The labor input of the rest management work only occupies 7.1% of the total labor input. Though the production links under different planting modes are similar, the specific employment situations have a great difference.

2 Comparison of pome production labor inputs in different cultivating modes

Cultivation modes of pear tree include standard thin planting, medium-density planting and dwarf close planting. Compared with dwarf planting mode of pear tree, more fertilizer and water, larger cultivation space and higher management cost are required and larger difficulties exist in flowering under standard planting mode of pear tree which is a cultivation mode with high consumption and low output. Dwarf close planting mode is the development direction of pome cultivation mode in the world. Under this cultivation mode, the canopy size is just 30% to 70% of that in general cultivating mode. And the pear tree will bear fruit after two years of planting. The output will achieve 37 500 kg per hectare in the third year, and 75 000 to 112 500 kg in the fifth and sixth year. 80% to 90% production links (such as pollinating, flower and fruit thinning, bagging, harvesting, winter and summer pruning and spraying pesticides) are completed under the trees and it is inconvenient to perform all operations against higher tree, so dwarf planting mode can provide convenience to orchard management as

well as agricultural machinery farming and mechanized harvest of fruit, it can also reduce the amount of labor used. And the cost difference between standard planting and dwarf close planting mainly focuses on the production employment link.

2.1 Bagging and harvesting The fruit bearing branch groups formed under standard planting and dwarf close planting are in great differences, thus resulting the labor amount difference between bagging and harvesting. The lead shape of the tree under standard planting mode is open center which has a less number of main branches, with two or three large lateral branches left on each main branch. And vice lateral branches or up-right bearing branch groups can be left on the lateral branches. The space of tree body is large and there are many layers in main branches which mainly have some large – and medium-sized fruit bearing branch groups and small-sized branch groups as supplementary. However, under dwarf planting mode, there are generally 10 to 12 large fruit bearing branches with an interval of 20 cm directly inserting on the center tree trunk, and the branches without obvious layer are arranged when leaving a space between each branch^[2]. No lateral branches can be left on main branches which will have fruit bearing branches directly sprouted. The renewal of main branches of dwarfish tree is quick and the main branches are mainly comprising of small and medium-sized fruit bearing branch groups, so the distribution of branch groups in the canopy should be sparse upward and intensive downward; and the middle part of scaffold branch should be mainly comprising of large fruit bearing branch groups while the inner and outer parts will be arranged with small and medium-sized fruit bearing branch groups. The branch groups include 70% short fruit spur, 15% medium – length fruit spur and 15% long fruit spur. The branch quantity in the pear orchard is controlled between 900 000 and 1 200 000 per hectare, and the output is between 52 500 and 60 000 kg per hectare. And the dwarfish fruit tree is characterized in the only main branch, compact canopy, good ventilation and light-admitting quality, less pruning amount and more growing points. From the difference between the shapes and fruit bearing branches of standard thin planting tree and dwarf close planting tree, we know that the tree body of dwarf close planting tree is short with a large number of short branches, resulting the sharp improvement of the efficiency in bagging and harvesting process. The average bag demand for dwarfish tree is 200/h and for standard tree is only 80 – 100/h, so bagging efficiency for dwarfish tree is one to three times of that for standard tree.

2.2 Training and pruning In order to conduct reasonable training and pruning of the tree body, it is necessary to acquire the growing characters of branch buds by which we can choose suitable pruning method and proper shape of tree. The basic principles of the training and pruning for the pear trees in dwarf close planting orchard are the same to that for the standard rootstock orchard, however, the method has the following characters: the branch pruning of small canopy type is the better selection; the height of tree trunk should be reduced properly and the main center trunk

and extended branches should be controlled to prevent large amount of output of flower and fruit; flower quantity should be controlled reasonably both in orchard and single plant; branch groups should be renewed immediately and the pruning frequency should be increased properly; meanwhile lateral growth of the canopy body should be avoided as possible, namely avoiding canopy crossing. The dwarf close planting orchard can be built fast with a small pruning amount and less wasting. The height of the tree can be determined flexibly by the line spacing and can be slightly higher than the line spacing. And tricycle can pass between the lines for fruit harvest after the formation of the tree. Meanwhile, the excess height of the tree body planted by standard cultivation mode results inconvenient operation, and more labors are needed to conduct high – altitude operation. The area of pruned pear trees per man-day is less than 2 000 m². The shape and pruning method of dwarf planting tree is relatively simple, which can save the labor input greatly and improve the efficiency five times, for details of labor, see Table 1.

Table 1 Survey of labors used for pruning under different modes

Cultivation mode	Shape of tree	Pruning labors man-day/ hm ²
Standard thin planting mode and dwarf close planting mode	Single – layer and high-position open center shape, column shape	22.05 3.75 – 4.95

2.3 Flower and fruit management Firstly, most standard pear orchard generally adopts artificial supplementary pollination method. The pollination methods usually include artificial clicking pollination, pollen bag pollination, pollination method by hanging the potted cuttings, quick clicking pollination with chicken feather and rolling pollination with feather duster. Take anther during initial flowering period; change over to conduct artificial clicking pollination during full-blossom period, namely 25% of flowers are bloomed, then try to complete pollination during two to three days^[3]. The average labor demand for standard pear orchard is generally 75 man-days. Flower picking and pollen processing are required every year.

Bee application in flowering period, an efficient fruit tree pollination method, is adopted in the dwarf closing planting pear orchard of Hebei Tianfeng Development Co., Ltd. Bee is the basic pollinator of the most crops, and pear tree adopts mason bee which has many advantages in early mobilization, low temperature resistance, high reproduction rate, fast pollination speed, great pollination effect and convenient management. This bee can fly out of the nest and conduct pollination even in severe weather conditions such as rainy day. By applying mason bee pollination, the fruit setting rate increases 48% compared with natural pollination. And the amount of labor used is just 3.0 – 4.5 per hectare, the investment amount of mason bees is 225 yuan per hectare. Invest once get benefits for a long time. Secondly, adopting flower and fruit thinning method, which mainly consists of artificial, chemical and mechanical methods, can save the nutrition of the tree effectively

to achieve stable and good quality. As to standard pear orchard, the artificial flower and fruit thinning method is usually used. Though the purpose of flower and fruit thinning can be achieved by this method, some time and labors will be wasted and it is difficult to reach the results if fruit thinning is not in time. For the pear orchard with large area and lack of labor, it is difficult to complete flower and fruit thinning work in time. For example, the area of pear trees is 40 hectares in Dongsheng Fruit Orchard of Xinleitou, Xinji City, and the pear varieties include Emerald, Ya Pear, *etc.* The row spacing includes 6 m × 4 m, 5 m × 5 m, 7 m × 3.5 m and 7 m × 7 m. In spring, when conducting flower thinning work, each person can complete flower thinning work on 7 – 10 trees (Emerald) per day. For fruit thinning, 50 people are required in the whole orchard, and they should work in the orchard for 10 days. If the daily wages are 50 yuan, the labor cost for fruit thinning can reach 25,000 yuan. The efficiency can be increased by 20 times when applying chemical method to perform fruit thinning. And the chemical method also has an effect on sterilization and pest controlling as well as the promotion of flower bud differentiation. At present, the commonly used chemical fruit thinning agents mainly include carbaryl, lime sulphur, naphthylacetic acid, ethephon, *etc.*^[4]. The combination of chemical fruit thinning method and artificial fruit thinning method can be used for flower and fruit thinning of the pear tree. Mechanical flower and fruit thinning method still needs to be tested before promotion.

2.4 Soil, fertilizer and water management The underground management of pear orchard mainly includes soil management, fertilizing, irrigation and water draining, which is aimed to reach sustaining and stable fertilizer and water supply by the soil as well as establish stable conditions for good root activity and functional performance so as to make the pear tree grow and develop normally.

(1) Soil management. There are many methods to improve the soil quality, including soil deep ploughing, adding organic materials, grass cultivation and covering cultivation. Because the shape of tree formed under standard cultivation is large and the space between the trees is narrow and dark, it is difficult for weeds to survive. The traditional method against weeds is to remove them and leave the fruit tree growing only. The traditional tillage method continues to be used in standard cultivation mode at

present, meaning that turn up the tree base deeply in winter and adopt the management method of medium-depth tillage for weeding or spraying herbicide. Under this management method, the labor intensity is large, moisture and fertilizer conservation of the soil is low, the input cost of fertilizer is high and the soil will be exposed in the air in winter and spring so that sandstorm is easy to happen. And under dwarf close planting mode, the shape of the tree formed is small and the space between the pear trees is extended, so the method of natural grasses can be used to suppress the growth of weeds in conjunction. Natural grass means that control the growth of tall worst weeds with large consumption of fertilizer and water by utilizing the existing grasses in the pear orchards, then breed the application grass variety for grass coverage for the fruit orchard after two to three years through the coverage of the cut grasses. Allow the grasses to grow naturally in the fruit orchard during the initial growing period every year, then cut the grasses when the height of grasses reaches 20 to 30 cm. After that, cover the ground with the cut grasses to suppress the growth of them. And the grasses should be cut three to four years every year. The grass lawn has a strong capability to suppress the growth of weeds and artificial weeding is not required in general. In a word, this technique can obviously increase organic matters and inorganic nutrients of the soil as well as improve climatic conditions of the fruit orchard and soil temperature, thus being convenient for all operations and mechanization of fruit orchard^[3]. In Dongsheng fruit orchard of Xinleitou Town, two times of artificial weeding and two times of chemical weeding are required to be conducted every year and the amount of labors used is 82.5 man-days per hectare, while only three times of weeding are required to be conducted in the fruit orchard of Tianfeng company which adopts the natural grass method and the amount of labors used is 11.25 man-days, for details of weeding inputs, see Table 2. According to the data in Table 2, the amount of labors used for soil management in pear orchard of Tianfeng company is reduced by 60 to 75 man-days per hectare per year due to the utilization of natural grass technique instead of artificial weeding and chemical weeding. If the labor cost is assumed to be 70 yuan per man-day, the amount saved from the labor cost for medium-depth tillage and weeding can be 4 200 to 5 250 yuan per hectare per year.

Table 2 The survey of weeding cost in the whole year

Weeding methods	Times	Labor amount times	Herbicide yuan/hm ²	Material consumption			Total cost yuan/ hm ²
				Oil consumption	Rope used to tie the grasses	Machine wear	
Mechanical weeding	3	0.25	0	107.85	75.00	75.00	1 333.65
Artificial weeding	2	2.25	0	0	0	0	3 371.70
Chemical weeding	2	0.50	539.40	22.50	0	22.50	1 888.05

Note: The labor cost is assumed to be 70 yuan per man-day

(2) Fertilizing. In the production of pome, fertilizing and adding fertilizer on fruit trees are one of the links which have large work quantity and labor intensity. Traditionally, fertilizing operation should be conducted three times which include fall manuring, fertilizing after bagging and fertilizing during fruit growing period.

And the amount of labor required for the three fertilizing operations is 5.7 man-days per hectare, 1.8 man-days per hectare and 7.5 man-days per hectare respectively. Tianfeng company has established an organic fertilizer factory with the yearly output of 20 000 metric tons, which can provide many kinds of organic fertilizer.

Due to the source of fertilizer is wide and it is easy for the fertilizer to pile up and rot, the cost is lower and fertilizing method is simple. Therefore, fertilizing operation can only be conducted once every year in the pear orchard, and no other fertilizers should be added. The fertilizer and herbicide are almost at no cost, and the amount of labor used for fertilizing is also reduced to the lowest point as to the pear orchard under traditional cultivation mode. The combination of natural grasses and the fertilizer factory fermenting organic fertilizers forms a great soil management method which can not only improve fertilizer efficiency, reduce pome production cost, relieve the contradiction of shortage of raw materials, but also solve the problems including the decline of soil fertility, fall of fruit quality and environment pollution due to improper application of chemical fertilizer.

(3) Irrigation. The pear orchard should be irrigated 8 to 9 times in the whole year, and the details are as follows: once a month during March to May, once every twenty days during June to August, pay attention to water control in the middle of May to facilitate the differentiation of blossom bud, conduct balanced water control after September and irrigate water used in winter during October and November^[5]. The canopies of the pear trees under standard cultivation mode are intersected, so mechanization method can not be used in the irrigation of these trees. In this condition, the available irrigation methods include furrow irrigation, irrigation by zone, winding irrigation, hole irrigation, etc., which can save the water amount by above 65% compared with the traditional flood irrigation, but some time and labors are still be wasted.

Drip irrigation is an advanced mechanized and automatic irrigation technique developed well in recent years which shows that slowly spray the water drop or fine water flow on the roots of plants. This method can save water and labor used. Tianfeng company adopts the infiltrating irrigation method, meaning that make the irrigation water wet the roots of the crops from bottom to up by

the soil capillary tube with the help of underground pipeline system, which can be also called underground irrigation. The main component of infiltrating irrigation system is underground pipeline system which can reduce the evaporation of surface water and save the water and labor needed by irrigation. With the same amount of water, the irrigating area can be increased by over one time when using infiltrating irrigation method instead of furrow irrigation.

3 Conclusions

As the development of production, the shortage of labor and the increase of labor price, more labor-saving and efficient cultivation mode will be used in the development of pome in the future. However, the production region for pome is large, it is impractical to adopt a single cultivation mode. So it is recommended to promote the wide-row and dwarf close planting mode as the main production mode, vigorously develop fruit growers' collaborative organization and mechanization operation of the fruit orchard and increase the fruit growers' income through simplifying pruning and promoting the methods of natural grasses, scientific fertilizing and water-saving irrigation.

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