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AGRIBUSINESS

Labour Costs on the Vegetables: A Research on the location effect on salaries in Jiangsu Province, China

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ABSTRACT: *In this study, the labour requirement and labour cost of common vegetable cultivation were investigated to help agricultural enterprises and family farms establishing reasonable "working hour" management systems in Jiangsu Province. The labour requirement of each step of three type of producers, agriculture enterprises, family farms, and private vegetable growers, in three regions in Jiangsu Province, named north, middle and south Jiangsu, was investigated by on-site observation or questionnaire survey during 2018 and 2019. The labour cost of each step and each vegetable was counted according to the labour requirement and the salary level. The results indicated that "residue cleaning", "soil preparation and bedding", "plant regulation", "auxin treatment of tomato flowers" and "hand pollination" accounted for higher proportions of labour cost amongst the entire vegetable culture process. No significant differences in the labour requirements of the investigated vegetables were reported amongst three regions in Jiangsu Province. However, the order of labour cost is south Jiangsu > north Jiangsu > middle Jiangsu, due to the salary difference amongst three regions. Watermelon, broccoli and chive are more suitable for growing by agricultural enterprises since they have relatively low unit labour and high prices. We established a method to calculate and analyze labour requirement and cost of vegetable production in Jiangsu Province, which also may be instructive for other regions. In addition, our results provided useful data for various vegetable producers to improve their labour management.*
Key words: *vegetable producer, Labor requirement, Salary, Jiangsu Province.*

Custos trabalhistas nas hortaliças: uma pesquisa sobre o efeito da localização nos salários na província de Jiangsu, China

RESUMO: *Neste estudo, a necessidade de trabalho e o custo do cultivo comum de vegetais foram investigados para ajudar as empresas agrícolas e fazendas familiares a estabelecer sistemas de gestão de "horas de trabalho" razoáveis na província de Jiangsu. A necessidade de trabalho de cada etapa de três tipos de produtores, empresas agrícolas, fazendas familiares e horticultores privados, em três regiões da província de Jiangsu, denominadas norte, centro e sul de Jiangsu, foi investigada por observação no local ou pesquisa por questionário durante 2018 e 2019. O custo da mão de obra de cada etapa e de cada hortaliça foi contabilizado de acordo com a necessidade de mão de obra e o nível salarial. Os resultados indicaram que "limpeza de resíduos", "preparo de solo e cama", "regulação de plantas", "tratamento com auxina de flores de tomate" e "polinização manual" foram responsáveis por maiores proporções de custo de mão de obra em todo o processo de cultivo de vegetais. Nenhuma diferença significativa nas necessidades de trabalho dos vegetais investigados foi encontrada entre as três regiões da província de Jiangsu. No entanto, a ordem do custo da mão-de-obra é sul de Jiangsu> norte de Jiangsu> meio de Jiangsu, devido à diferença salarial entre as três regiões. Melancia, brócolis e cebolinha são mais adequados para o cultivo por empresas agrícolas, uma vez que têm uma unidade de trabalho relativamente baixa e preços altos. Estabelecemos um método para calcular e analisar a necessidade de mão de obra e o custo da produção de vegetais na província de Jiangsu, que também pode ser empregado para outras regiões. Além disso, nossos resultados forneceram dados úteis para vários produtores de vegetais melhorarem sua gestão de mão de obra.*
Palavras-chave: *produtor de vegetais, Necessidade de mão de obra, Salário, Província de Jiangsu.*

INTRODUCTION

The pattern of vegetable growers growing and marketing vegetables by themselves has gradually broken in recent years with the acceleration of urbanization process and the implementation of the "vegetable basket" project by government departments at all levels in China (XU, 2020). The vegetable industry in Jiangsu province, one of the most developed regions in China, is also evolving towards large-scale and intensive management. New business entities, such as leading vegetable production enterprises, cooperatives, and family farms, are constantly emerging in recent years. Basically, these

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vegetable producers should hire a certain number of workers long-termly or short-termly to satisfy their demands of vegetable production. However, due to the multiformity of operation in vegetable production, too many factors that affect the efficiency of these agricultural practices, the varying quality of agricultural employees, and the low management level, little agricultural enterprises mentioned above have formed a perfect "working hour" regulation and an effective management system. Most vegetable production enterprises still use the traditional "growth leader" management model, which often results in low work efficiency and the inability to complete tasks on time, and ultimately affects the formulation of the production plan and labour cost budget of the enterprise. Therefore, it is imperative to research the scientific and reasonable "working hours" management system for vegetable production (YANG et al., 2018; YANG et al., 2019; ZHU & HOU, 2020).

Up to date, there are only a few studies focusing on the labour requirement of vegetable production-related operations. HUONG et al. (2013) investigated the average labour amount of open-field vegetable production in the Red River region of Vietnam and reported that the labour amount requirement of different vegetables varied from 3 to 9 workers per hectare per day. MANZANO-AGUGLIARO & GARCIA-CRUZ (2009) spent three years investigating 23 processes and 50 workers in the production of greenhouse tomatoes in Spain, and results showed that every hectare of greenhouse tomato production required 2 full-time workers. During the peak period of production, an additional worker who worked a half day was required for approximately 3 weeks. KESKIN et al. (2010) reported that the working efficiency of tomato production in different provinces in Turkey was quite different, which may be related to the crop rotation systems and disease occurrence. YIANNISet al. (2012) invented an electronic weighing device that was connected with the harvesting container and monitored the harvesting efficiency of workers in real time. Because there are so many kinds of vegetables, cultivation methods vary widely around the world, and research results from one region are often less instructive to another region.

Jiangsu Province is traditionally divided into three regions, named north Jiangsu, middle Jiangsu, and south Jiangsu according to both natural and social conditions. Typical agricultural enterprises, family farms, and vegetable growers were selected to investigate the labour amount involved in various agricultural operations during vegetable cultivation. Based on the wage levels of three regions, the composition of the labour costs of vegetable production in various regions were analyzed to provide basic data for establishing labour management systems of various vegetable production entities.

MATERIALS AND METHODS

Sample source

As shown in figure 1, the basic information about climate and soil characters of north Jiangsu, middle Jiangsu, and south Jiangsu are shown in figure 1. Top three districts or counties of the vegetable cultivation area in were selected in each region. In north Jiangsu, they were Yan du District in Yancheng City, Haizhou District in Lianyungang City and Qingpu District in Huaian City. In middle Jiangsu, they were Yizheng in Yangzhou City, Jiangdu District in Yangzhou and Rugao in Nantong City. And in south Jiangsu, they were Jintan in Changzhou City, Zhangjiagang in Suzhou City and Taicang in Suzhou City. At each sampling point, 10 agricultural enterprises, 10 family farms, and 10 vegetable growers were selected randomly from the list provided by the local government. Generally, the total amounts of three type of vegetable producers of each sampling point ranged from 50 to 100. Therefore, thirty agribusinesses, family farms and vegetable growers were surveyed in each region. For all selected producers, vegetable production was is main source of their income. Local farmers were main resource of the workforce of investigated producers.

Survey method

The entire process of vegetable production in Jiangsu Province was broken up according to common operation steps (Figure 2). The working hours in each operation step and the wage level of the workers were investigated. Due to large differences in the labour consumption per unit weight of various vegetable harvest, this step of studied vegetables was investigated separately. Amongst 9 selected regions, an on-site observation and recording method was adopted to collect the working hour data in the vegetable entities of Yizheng City. Specifically, we direct observed and recorded the amount of labour for 4 hours (half of a day) at the agricultural operation site of the certain vegetable production entities. In remaining sampling sites, we used a questionnaire survey method.

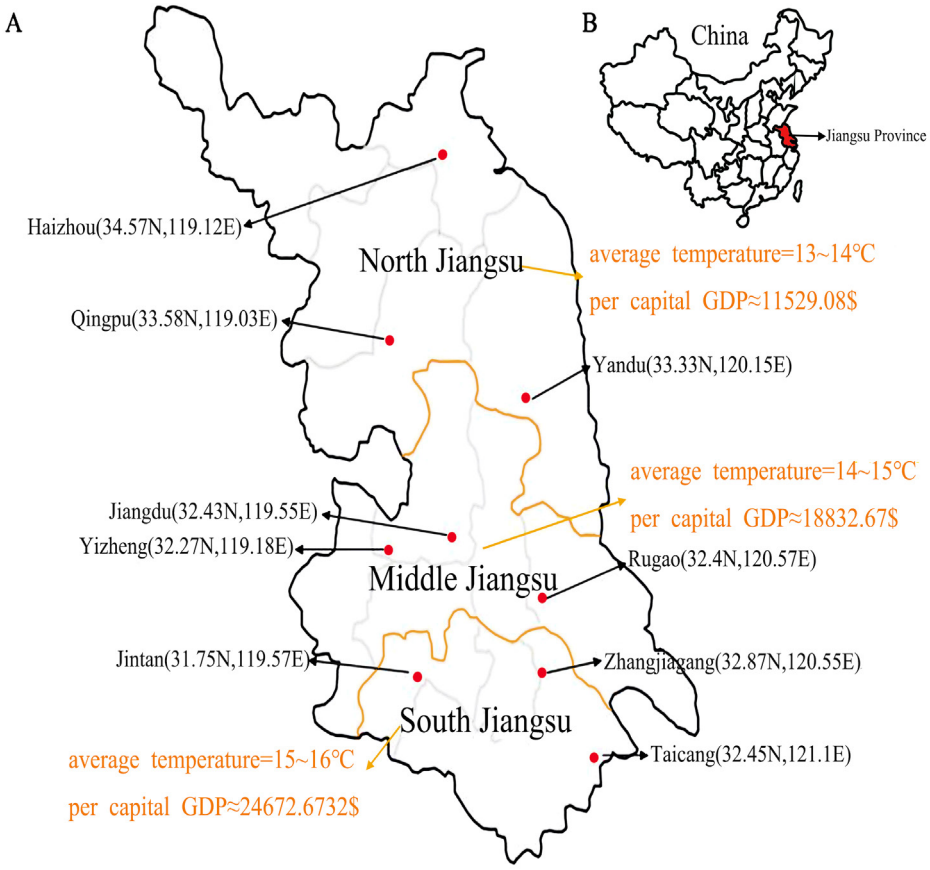

Figure 1 - The locations of vegetable production entities selected in this study. (A) Jiangsu Province map, (B) map of China.

Calculation of labour cost for main vegetable production

The total working hours per unit area of the vegetable was obtained by summing the working hours required for each operation in the production process of a certain vegetable and combining the number of cultivated plants per unit area. The typical 8-meter plastic shed in Jiangsu Province was used as a cultivation unit for working hour statistics. The length of each shed was approximately 84 meters (the effective use length is 83 meters). For the convenience of calculation, the cultivation methods of various vegetables were uniformly specified as shown in table 1.

Statistics

The data of each operation step were the average of 30 observations (3 observations per of various seasons, weathers and soil cultivation conditions in 2018 and 2019. SPSS version 15.0 (SPSS, Inc., Chicago, IL, USA) was used for one-way ANOVA of all data. Differences between treated samples were evaluated at 0.05 and 0.01 probability levels using the Duncan's test.

RESULT AND ANALYSIS

Salary levels of employees in vegetable industry

Figure 3 shows significant differences in the wages of vegetable production personnel amongst north, middle and south Jiangsu, with the south Jiangsu being the highest, while the middle region the lowest. In the same area, the employee wage level of family farms was basically higher than that of agricultural enterprises.

As shown in figure 2, Amongst three type of employees, there were no significant difference

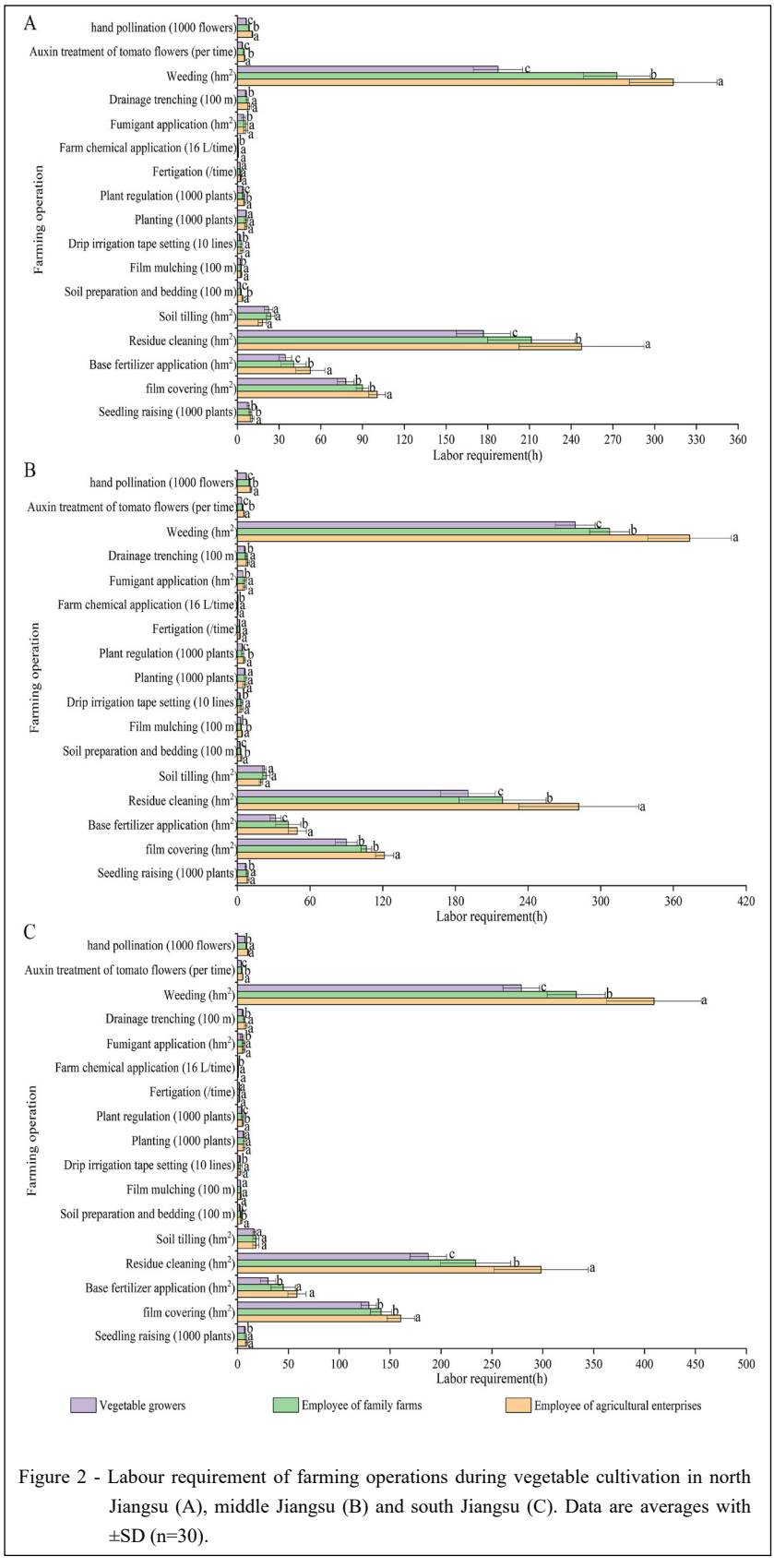

Figure 2 - Labour requirement of farming operations during vegetable cultivation in north Jiangsu (A), middle Jiangsu (B) and south Jiangsu (C). Data are averages with ±SD (n=30).

Table 1 - Culture parameters of common vegetables in Jiangsu Province.

Vegetables	Planting distance(cm)	Number of rows per tunnel	Number of bed/ tunnel	Plants (groups)/hm^2	Number of shoots/h m^2	Expected yield (kg/hm^2)	Times of plant regulation	Times of Fertigation	Times of farm chemical application	Times of fumigant application	Times of weeding	Times of hand pollination
Tomato	30	12	6	49775	49775	74663	3	3	10	4	1	—
Cucumber	30	12	6	49775	49775	62219	2	3	12	4	1	—
Eggplant	50	16	4	39730		29985		4	16	6	1	—
Chili	35	12	6	42579		22489	1	4	16	6	1	—
Gourd	50	4	4	9895	39580	37481	3	2	8	3	1	—
Cowpea	25	12	6	59670	119340	22489	—	2	12	3	1	—
Watermelon	50	3	3	7346	22039	47976	4	3	6	2	1	1470
Cauliflower	50	16	4	39730		29985	—	2	6	—	1	—
Cabbage	40	16	4	49775		67466	—	2	4	—	1	—
Pakchoi	20	30	4	186657		13493	—	1	6	—	—	—
Radish	25	16	4	79460		74963	1	2	4	—	2	—
Chives	15	40	4	331829		179910	—	6	10	4	6	—

Note: Farm chemicals are applied 16 L per time. "—" means this kind of farming operation is not required during the cultivation of certain vegetable.

in the labor requirement for some agricultural operations, such as "soil tillage", "planting" and "plant regulation". Other operations differed greatly amongst three type of employees, such as "residue cleaning", "soil preparation and bedding", "plant regulation", "weeding", "auxin treatment of tomato flowers" and "hand pollination". Most operation steps had no significant difference in labor consumption amongst three regions, but the work hour of a few steps were significantly different. For instance, the labour amount for "seedling raising" in north Jiangsu was greater than in middle and south Jiangsu, "film covering" in south Jiangsu was larger than in middle Jiangsu, "residue cleaning" in south Jiangsu was larger than in middle and north Jiangsu, and "drainage trenching" in south and middle Jiangsu was larger than in north Jiangsu, etc.

In different agricultural operations amongst three investigated regions, the order of working time required for certain agricultural operations amongst different vegetable industry employees is: agricultural enterprises employees > family farm Employees > vegetable growers (Figure 4). In other words, the work efficiency is: agricultural enterprise employees < family farm employees < vegetable growers, since vegetable growers were self-employed. However, since the wage level of employees employed on family farms was generally higher than that of agricultural enterprises, the labor costs of some operations were higher of family farms than that of agricultural enterprises (Figure 5).

The labor costs of harvest (per 100 kg or per hm^2) of common vegetables in Jiangsu Province were shown in figure 6. Although, there was significant difference in wage levels amongst three regions, no significant correlation was reported between the wage level and the work efficiency. For example, the wages in south Jiangsu were higher, but the average work efficiency was not higher than that of other two regions (Figure 6). As mentioned above, the amount of manpower used in certain operations was even greater than that of middle and north Jiangsu.

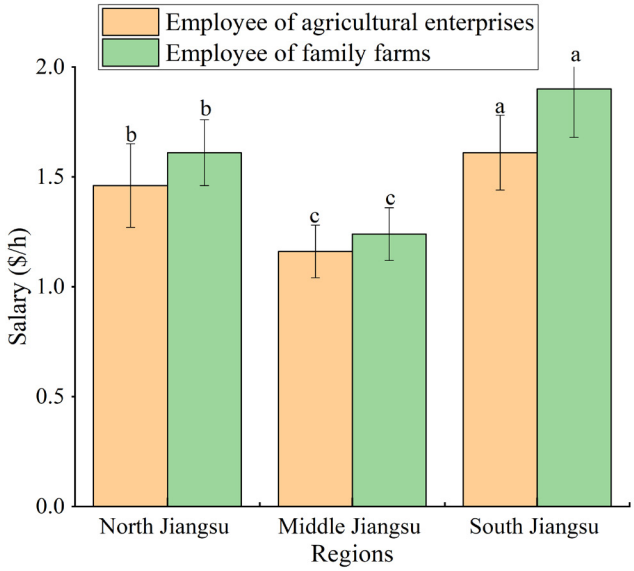

Figure 3 - Salaries of employees of the vegetable production enterprises and family farms in Jiangsu Province. Data are averages with ±SD (n=30). According to current exchange rate, 1 US Dollar ($)=6.4735 China Yuan.

There was a great difference of the labor amount amongst different vegetable cultivation. In one growth season, vegetables required a large amount of labour include chives, tomato and cucumber, while cauliflower, cabbage, radish and pakchoi need less labour. Amongst fruit vegetables, the labour requirement for tomato and cucumber production was relatively large, while for gourd, cowpea, and watermelon was relatively small. The difference in the labour consumption of various vegetables amongst three regions was not significant, but due to the difference in the wage levels of these regions, the cost of cultivation labour in south Jiangsu was greater than that of north Jiangsu (Figure 7).

Due to the large difference in yield per unit area of various vegetables, the comparability and reference value of labour per unit area may be biased. Therefore, we further calculated the labour cost per unit yield of various vegetables. When calculated according to yield, the types of vegetables with higher labour costs included peppers, cowpea, and pakchoi, and crops with lower labour costs were Chinese cabbage, radish, watermelon, and broccoli. The labour cost of cucurbits was generally lower than solanaceous vegetables. Although, the labour cost per unit area of tomato was higher than cowpea, the labour cost per unit yield was lower of tomato than of cowpea due to the higher yield per unit area of tomato. (Figure 8).

As shown in the figure 9, regardless of vegetable types, “harvesting” account for the largest proportion of labour consumption in the whole vegetable cultivation process. In most vegetables, the working time for harvesting is more than 50% of the total labour requirement. Only two vegetables, cabbage and cauliflower reveal less harvesting labour consumption (less than 50% of the total cultivation labour). The highest proportion of harvested labour was chives, which accounted for 86.7% of the total labour hours. In addition to the harvesting process, the labour requirement of “planting” and “residue cleaning” of eggplant and cucurbits were relatively large. For tomato and watermelon, the labour for “auxin treatment of tomato flowers” and “hand pollination” was relatively large. For cabbage and cauliflower, the proportion of “planting” was high.

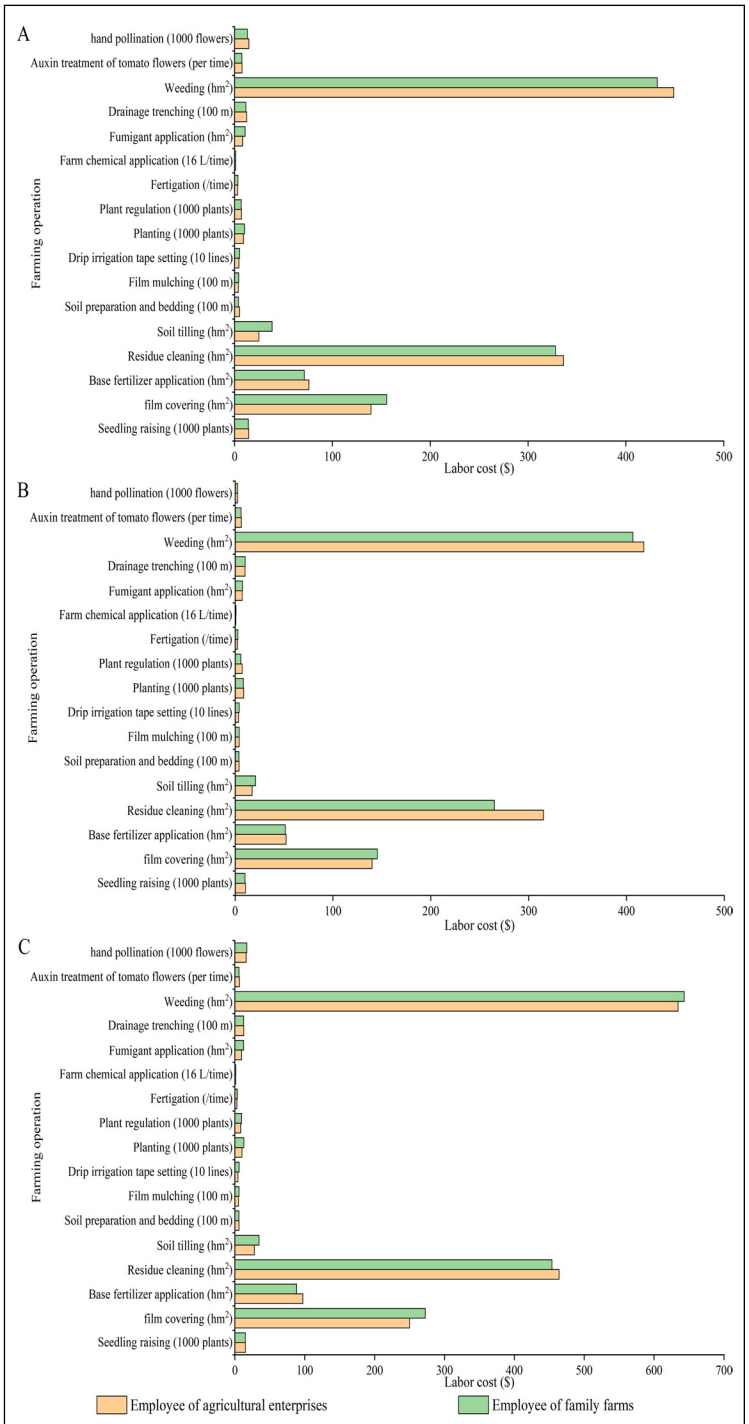

Figure 4 - Labour cost of farming operation during vegetable cultivation in north Jiangsu (A), middle Jiangsu (B) and south Jiangsu (C).

Notes: 1) The "seedling raising" was carried out suing in 72-hole trays. 2) The plant regulation of tomato and the artificial pollination of watermelon were used for working hour calculation. 3) The remaining agricultural operations are the basic practices in the vegetable cultivation, which are similar amongst different vegetables.

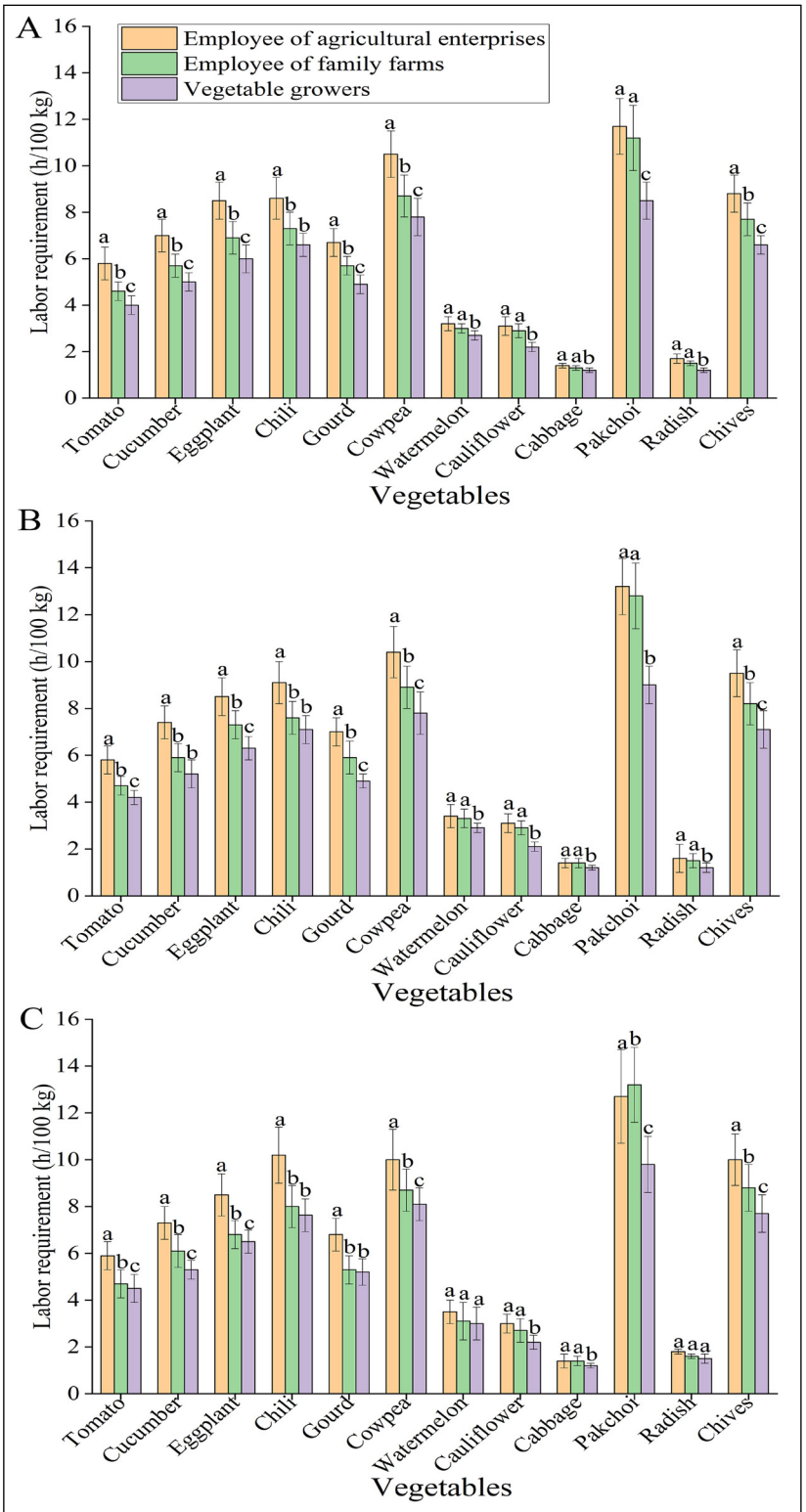

Figure 5 - Labor requirement of the "harvesting" of common vegetables in north Jiangsu (A), middle Jiangsu (B) and south Jiangsu (C). Data are averages with ±SD (n=30).

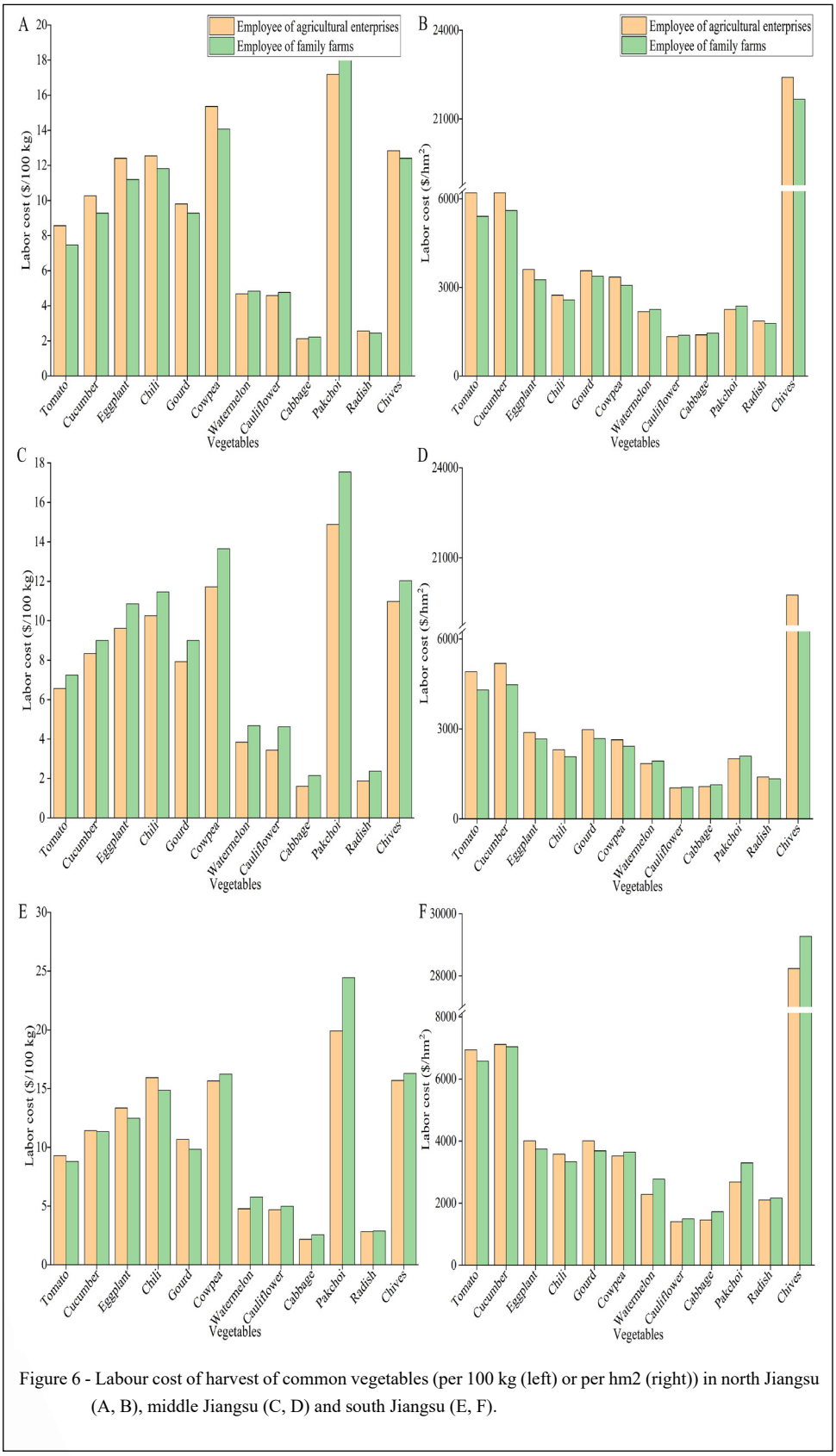

Figure 6 - Labour cost of harvest of common vegetables (per 100 kg (left) or per hm2 (right)) in north Jiangsu (A, B), middle Jiangsu (C, D) and south Jiangsu (E, F).

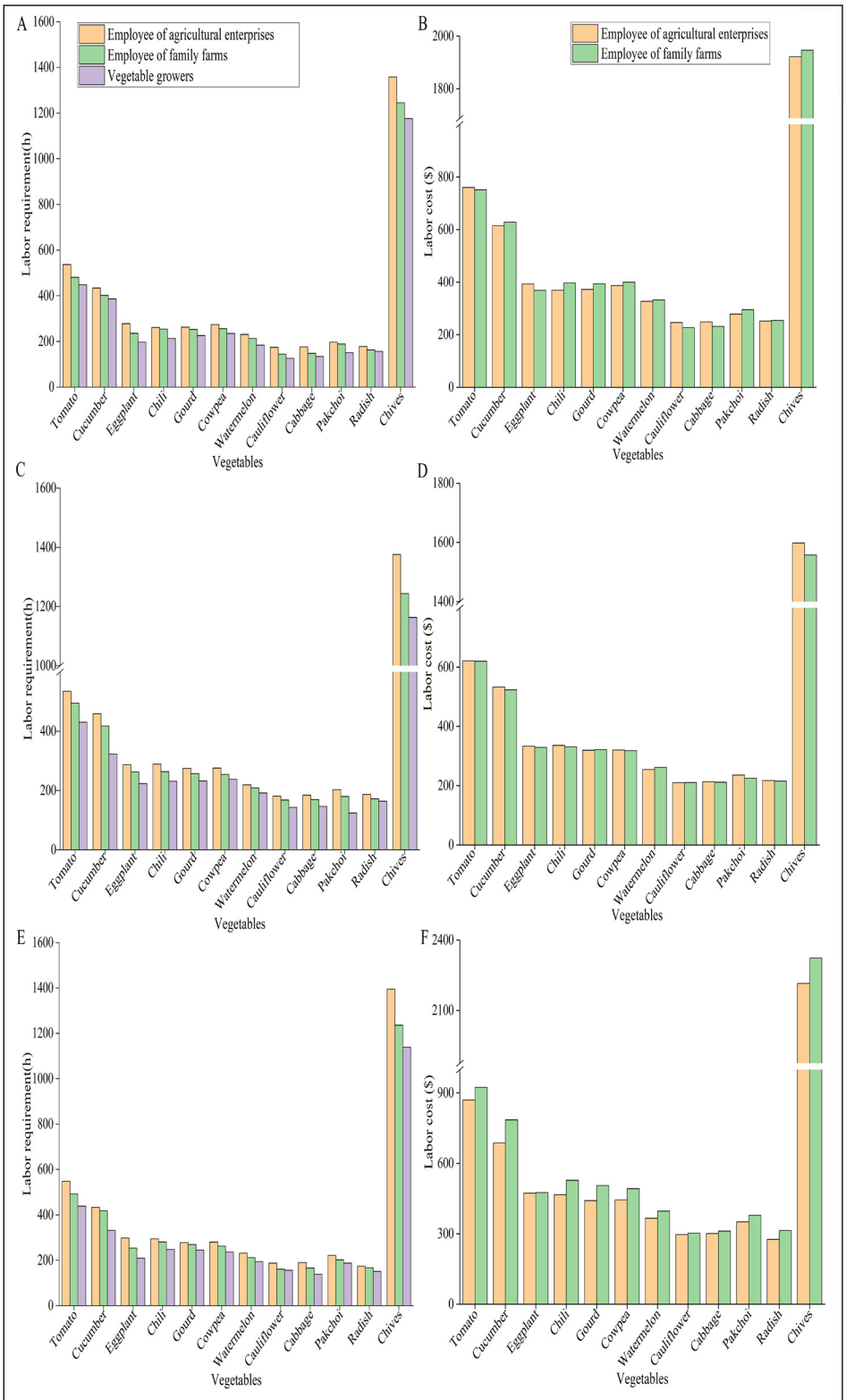

Figure 7 - Labor requirement (left) and labor cost (right) of common vegetable production in north Jiangsu (A, B), middle Jiangsu (C, D) and south Jiangsu (E, F). as figure 1.

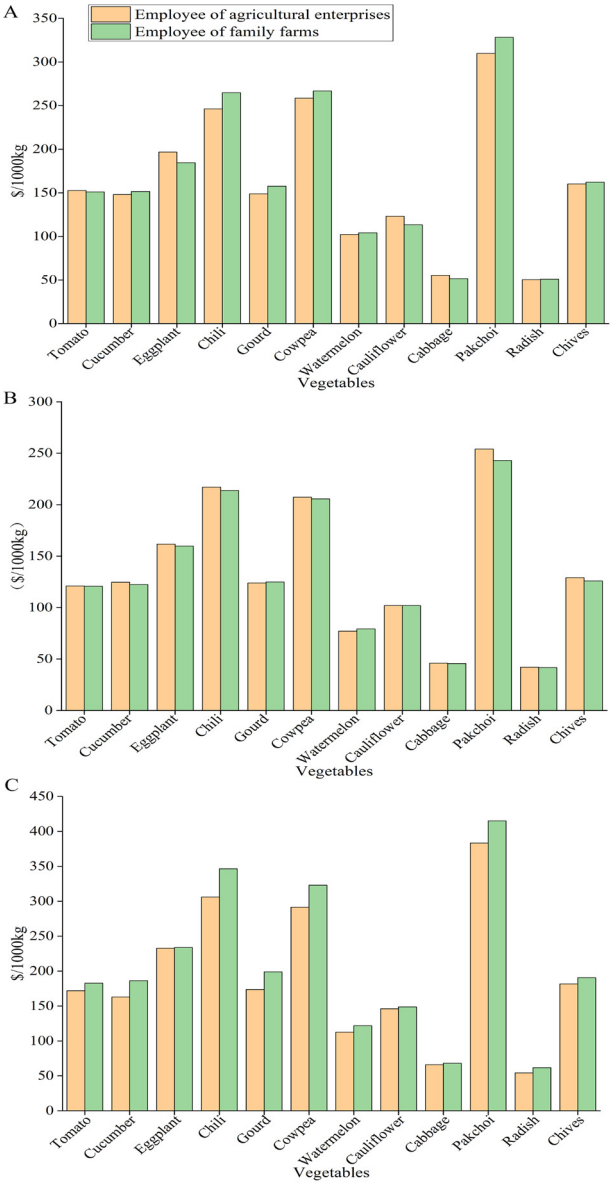

Figure 8 - Labor cost per 1000 kg yield of farming operation during common vegetables cultivation as figure 1.

DISCUSSION

The present study reported significant differences in the wage levels of vegetable production workers amongst north, middle, and south Jiangsu regions. Due to the more developed economy in the south Jiangsu, the living standard is higher, and the wage level is correspondingly higher than that of other two regions. We performed further investigations about the lower wage level in middle Jiangsu compared with that in north Jiangsu and reported that there were more industrial enterprises in the vegetable production area in middle Jiangsu than in north Jiangsu, which recruited more young

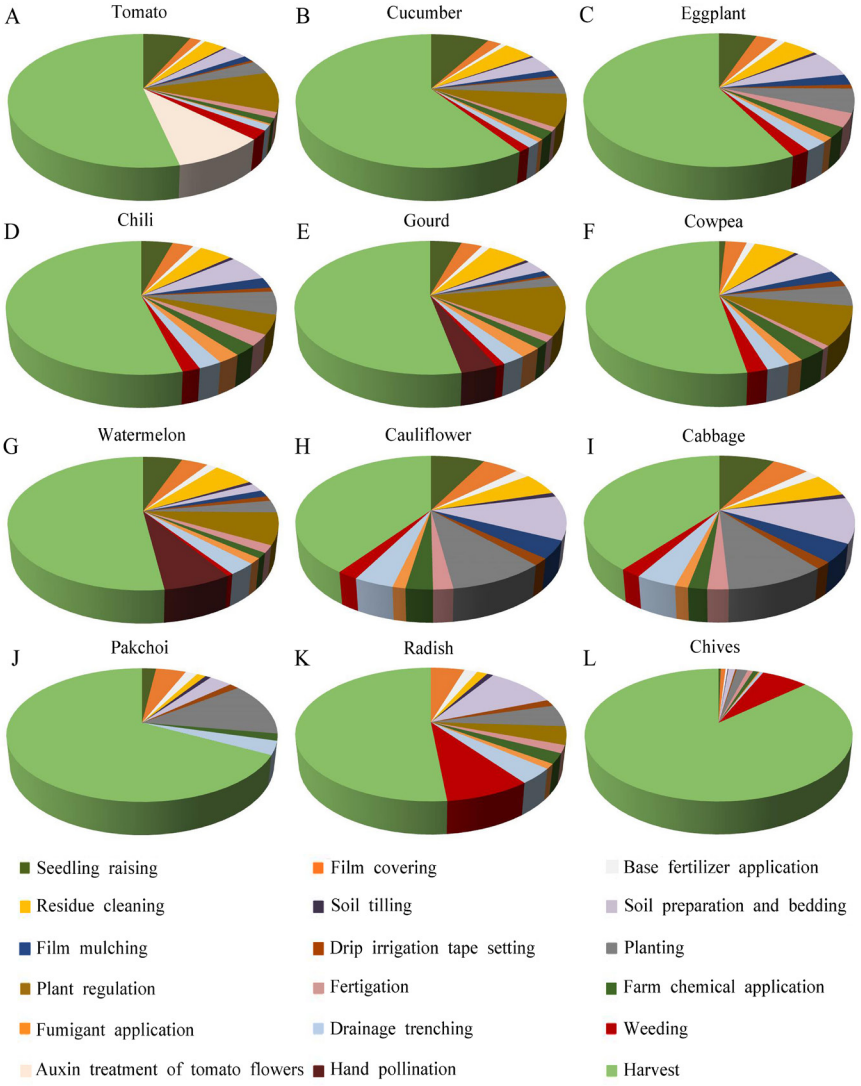

Figure 9 - The proportion of different farming operations amongst whole process of vegetable production. (A: tomato, B: cucumber, C: eggplant, D: chili, E: gourd, F: cowpea, G: watermelon, H: cauliflower, I: cabbage, J: pakchoi, K: radish, L: chives). As for figure 1.

workers and raised the labour cost (GUAN et al., 2014). As a result, the aging of vegetable workers is more serious in middle Jiangsu than in north Jiangsu. On the contrary, there are relatively few industrial enterprises in the north Jiangsu, and the age of vegetable employees was relatively younger than that in middle Jiangsu (ZHANG et al., 2006). This difference may be an important reason for the higher salary of vegetable employees in north Jiangsu. DEMIRCAN et al. (2019) suggested that in the 15-49 age group worked more than other age groups. However, results of our investigation showed that the age advantage of the vegetable practitioners in north Jiangsu was not reflected in their work efficiency, which led to higher vegetable production costs than in middle Jiangsu. It shows that there is still a great potential to improve the management for agricultural enterprises and family farms in the north Jiangsu.

The labour requirement of some operations was different amongst three regions. For example, for "seeding raising" operation, the labour force in north Jiangsu was larger than in middle and south Jiangsu. Investigations showed that simple plug tray were popularly l used for seedling raising in north Jiangsu . In some areas, the sprinkling equipment for seedbed was lack. However, The average level of seedbed equipment was better in south and middle Jiangsu than in north Jiangsu, which may be the reason for the differences in "seedling raising" labour need amongst regions (GU et al., 2013). The data also showed that the labour force for the "film covering" was greater in south Jiangsu than in middle Jiangsu, which may be due to the relatively high-standardized greenhouses in the south Jiangsu (often including skirt film and tension rope). Besides, the double-film covering greenhouse accounted for a large proportion in this area, which further increased the labour requirement of "film covering" operation. On the contrary, most greenhouses in the middle and north Jiangsu regions did not equipped skirt membranes, the spacing between the tension ropes was large, and double-film covering plastic tunnels were rare. The labour consumption of the two operations, "residue cleaning" and "drainage trenching" of south Jiangsu was also larger than that of middle and north Jiangsu. Further investigation showed that this difference may be due to south Jiangsu had higher requirements for the cleanliness of the greenhouse. In addition, the groundwater table was generally high, and the drainage ditch must be dug deeply in the south Jiangsu comparing with middle and north Jiangsu. The amount of labour required for the harvesting of a few vegetables, such as pepper and pakchoi, was less in north Jiangsu than that in middle and south Jiangsu, which may be caused by the different requirements for product uniformity and cleanliness in different region. Similar effects of industrialization and facilities on the labour requirement were also found in other researches. KESKIN et al. (2010) reported that the labour requirement of tomato production was highest in a province where greenhouse was widely used and lowest in another area where the industrial tomato production was popular.

Amongst the various vegetable production operations, some steps had smaller differences in the amount of labour amongst different business entities, while others had larger differences. These steps with large differences included "residue cleaning", "soil preparation and bedding", "plant regulation", "weeding", "auxin treatment of tomato flowers", and "hand pollination". These operations were usually performed more efficiently by vegetable growers than by agricultural enterprises or family farms, which indicate that agricultural enterprises or family farms have a great potential for improving work efficiency at these steps. It is suggested that managers of agricultural enterprises and family farms can formulate management or incentive regulations to improve workers enthusiasm for these works. Furthermore, operations that accounted for a relatively large amount of total labour request, such as harvesting, were also the critical steps which were well worth greatest attention of agricultural enterprise managers. If a method for improving work efficiency is reported in these operations, it will be greatly help to improve the overall work efficiency.

In the same area, the amount of labour required varied greatly depending on the type of vegetables planted. For example, the amount of labour required for growing tomato was three times more than that of cauliflower. These information provide important basis for labour cost budget making of agricultural enterprises. Therefore, when the agricultural enterprises and family farms develop the labour cost budget, they should consider both the production scale and the types of vegetables they want to plant.

The present study also suggested the types of vegetables that are suitable for agricultural enterprises from the perspective of labour costs. Some vegetable types with relatively low unit labour and relatively high prices, such as watermelon and broccoli, are more suitable for agricultural enterprises. Amongst the leafy vegetables, the labour cost of chive was significantly lower than pakchoi. Therefore, chives are more suitable for production in these enterprises. Although, pakchoi is in great demand in most Chinese cities, the labour cost per unit of production was very high. If agricultural enterprises plan to plant it, they must work hard to control the harvest cost.

In summary, we reported that the operations with large differences in labour requirement amongst three business entities were often those steps that occupied a relatively large proportion of labour in the entire cultivation process, such as "residue cleaning", "soil preparation and bedding", "plant regulation", "auxin treatment of tomato flowers", "hand pollination", and "harvest". In future vegetable cultivation processes, agricultural enterprises may reduce artificial labour by improving the cultivation mode and increasing the degree of mechanization of agricultural operations, such as the use of crop residue cover cultivation and water-dry rotation,

which should reduce the labour for residues cleaning and accelerate the decay of crop straws and increase soil fertility and drought resistance, and then reduce the labour for watering and fertilization (FENG et al., 2017). “Auxin treatment of tomato flowers” and “hand pollination” should be replaced by using bumblebee pollination and electric pollinators to greatly reduce the work time and labour costs. In the harvesting process, some countries, such as Germany, the United States and Japan, have achieved the mechanized harvesting of cabbage (DASGAN et al., 2004; FEN et al., 2009; WANG et al., 2014). In China, the mechanized harvesting of cabbage was also initially successful in several regions and has greatly reduced the amount of labour required to harvest cabbage (CHEN et al., 2012; ZHAO et al., 2019). Conversely, agricultural enterprises must also perform in-depth research to make reasonable management and incentive mechanisms, and focus on improving work efficiency to reduce the labour cost of vegetable production.

CONCLUSION

During 2018 to 2019, in Jiangsu Province, China, the wage level of vegetable production personnels in different regions was: south Jiangsu > north Jiangsu > middle Jiangsu. In the same area, the employee wage level of different type of producers was: family farms > agricultural enterprises. For operations including “residue cleaning”, “soil preparation and bedding”, “plant regulation”, “weeding”, “auxin treatment of tomato flowers” and “hand pollination”, the work efficiency amongst different producers was: agricultural enterprise employees < family farm employees < vegetable growers. In addition, regardless of vegetable types, “harvesting” accounted for the largest proportion of labour consumption in the whole vegetable cultivation process. These results indicated that agricultural enterprises and family farms should take effort to improve work efficiency at these steps. Finally, some vegetables with lower labour costs including Chinese cabbage, radish, watermelon, and broccoli were recommended as candidates for agricultural enterprise production.

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DECLARATION OF CONFLICT OF INTEREST

We have no conflict of interest to declare.

AUTHORS’ CONTRIBUTIONS

All authors contributed equally for the conception and writing of the manuscript. All authors critically revised the manuscript and approved of the final version.

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