Current state and prospects of vegetable production in Primorsky Krai, Russia

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Abstract. This article briefly describes the current state and prospects of vegetable production in Primorsky Krai, Russian Federation. Over the past 20 years, the production of vegetables (cabbage, tomatoes, and onion) has increased by 30% in the region. The analysis of the technical operations of cultivation has shown that there are still high labor costs (up to 45% of all manual work) related to planting seedlings in open ground. Therefore, the development of technologies that will allow automating these processes will increase the level of mechanization by 15 – 30%. Moreover, this article aims to provide recent data on vegetable production and prospects, which could be beneficial for scientists, analytical experts, and business entrepreneurs.

1. Introduction

Recently, Primorsky Krai (PK) has become an interesting region with its economy since Vladivostok city (the capital city of PK) has become the administrative center of the Far Eastern Federal District (FEFD). Consequently, the PK is becoming a more economically effective region due to the expansion of overseas agriculture in the region, and its geographical location close to neighboring countries, which is owing to the export and import of indispensable goods [1]. Moreover, the agro-industrial complex of PK plays one of the most important economic roles in the regional development because of a favorable position for mutual agriculture agreements between neighboring countries, for instance China and Japan.

As a result of the overseas cooperation, there are several Chinese entrepreneurs and investors involved in crop production in PK [1, 2]. Moreover, the Ministry of Agriculture, Forestry and Fisheries (MAFF) Japan has been interested in the development of the Russian Far East agriculture by the promoted objectives of Global Food Value Chain Strategy (GFVCS) [3].

PK is located in the south of the Far East, in the southeastern part of Russia. It borders with Khabarovsk Krai in the north, China in the west part, and North Korea in the southwest of the region, and lies on the western coast of the Sea of Japan. It has the main twenty-two districts with a number of major cities, including rural and urban-type localities. Figure 1 shows the geographical location of PK with the main districts.

The total land area of PK is 16,467.3 thousand hectares. Also, the soil and climatic conditions of the region are not entirely favorable for the intensive development of agriculture, therefore, only 10% of the area is cultivated for agricultural purposes (approximately 1,647 thousand hectares) [4, 5].
The climate condition of PK can be characterized as a moderate monsoon climate. The Winters are dry and cold with thin and unstable snow cover and deep soil freezing. The Spring is long (3-4 months), with frequent temperature fluctuations with the average value from -6 to +13 degrees Celsius. Summers are warm and humid, with maximum rainfall in the summer months. Moreover, there are quite frequent Typhoons forthcoming during the summertime, which usually causes enormous damage to infrastructure and agriculture. The Autumn is warm, dry, and sunny, with the average temperature from +20 to -17 degrees Celsius, through September to November.

Over the past 20 years, vegetables, such as cabbage, tomatoes, and onion, have increased by 30% in the region. The analysis of the technical operations of cultivation has shown that there are still high labor costs (up to 45% of all manual work) related to planting seedlings in the open ground [4]. Therefore, the development of technologies that enhance the favorable conditions for potential land use and agricultural development will require technical knowledge toward increasing mechanization and labor-saving costs.

This study aims to introduce the issues and clarify the current state and vegetable production perspectives in PK, Russian Federation. Moreover, the purpose is to highlight the potential development in the current vegetable production technologies by increasing the mechanization level to minimize production costs.

2. Materials and methods
According to the PK statistic center, the total land area was 16,467.3 thousand hectares by January 1, 2019. The total agricultural land area is approximately 1,647 thousand hectares, where 755.1 (46%) thousand hectares is used for arable land, and 807.7 (49%) is used for farmland and hayfields. Also, there is 86.8 (5%) thousand hectares of fallow lands include perennial planting. Furthermore, over the past 20 years, the production of vegetables has increased by approximately 30% in the main crop districts of PK [4]. Subsequently, the leading place in the production of vegetables has been occupied by cabbage, tomatoes, and onions. However, the brief analysis of the current state was based on a six year period (2014-2019) in order to undertake the current dynamics of vegetable production.

This study relied upon qualitative methods, including observation on-site within PK, primary research, and secondary research [6]. The primary data was carried out from a local statistics database center included annual and mid-term reports [4]. The collected numerical data allowed us to analyze the
gross vegetable harvest with the dynamic of the used cultivated area and the volume of manual labor in planting.

3. Results and discussion
The average growing season in PK lasts from 120-130 days. The abundance of moisture in summer contributes to the development of steady vegetable growing. Therefore, as was mentioned above, recently, vegetable production has been increased owing to local vegetable consumption and suitable growing conditions. Cabbage, tomatoes, and onions occupy one of the leading places in vegetable production, as the most demanded in the market. The current dynamics of the gross harvest of three species in open ground are shown in figure 2.

![Figure 2. Gross harvest of vegetables in open ground in PK: note – grown from a seedling [4, 7].](image)

However, there is a slight decline in production that occurs due to the decrease of used cultivated areas and yield. Figure 3 illustrates the dynamics of the used cultivated area with a vegetable yield of all vegetables produced in all farms of PK districts.

![Figure 3. Cultivated area and yield of vegetables in PK [4, 7].](image)

Currently, there are several methods of vegetable cultivation used in PK. The first method includes the vegetable growing in open ground from seeds or seedlings to mature production. The second method involves vegetables growing in greenhouses and hotbeds. Moreover, the year-round production of vegetables in greenhouses is currently under active development in the region. However, manual labor is still prevalent in both cultivation methods, which entails an increase in the final product cost. Additionally, the human factor is also likely, which could finally affect the product and cultivation
processes [8]. Thus, automation of the production process might directly affect both the final product cost by excluding the human factor and the ultimate profitability of production.

One of the most labor costs operations in vegetable production is planting seedlings. This operation currently combines the use of mechanized equipment with a manual method. The analysis of the technological operations (maps) [9] shows that the labor operations remain of 21.2% for cabbage, 9.3% for tomatoes, 25.3% for onions in the total labor costs, as well as 29.7%, 10%, and 25.8% in the volume of manual labor respectively (figure 4).

One of the main issues of automating planting seedlings is associated with its cultivation technology, specifically, with the lack of precise positioning of plants in trays. Therefore, manual work is still needed to control the proper position of plants during the planting operation. Consequently, one of the solutions to the automation of this issue in planting seedlings is the use of adapted trays to work with a planting machine equipped with an automatic transplanting mechanism. This technological complex will allow, (excluding the operation of) the “Selection of seedling by manual work” from the technological operation cycle, reducing labor costs in case of growing cabbage by 10.9%, tomato 0.2%, onion 3.7% in the total volume labor costs (figure 5).

Moreover, solving the problem of replacing manual labor with an automatic seedling distribution system from the tray to the planting receiving device will improve the total level of current mechanization by an expected 60.6% for cabbage, 16.2% for tomato, and 31% for onion. Figure 6 shows graphically the current mechanization level in cooperation with expected estimations (projected).
Furthermore, it is always important to focus on increasing mechanization levels not only by improving the existing technologies and equipment but also by the development of new machinery with the application of relatively new technologies [10]. Moreover, the cooperation in the food production industry between state (public) and private sectors (farmers), as an example of GFVCS by MAFF, will promote useful feedback in the application of scientific results to improve the production chain and introduce better products to consumers.

Additionally, it should be noted that local statistic centers present statistical reports (annual and mid-term reports) with a lack of frequency and all necessary data, which is essential for the evaluation of the current production state. The reports do not specify certain details, such as the production volume by small, middle, and large agricultural producers, their particular cultivated area with various vegetable varieties, yield with mechanization levels, and many other details. However, the statistical reports do provide general official information regarding agricultural production.

4. Conclusion
This study briefly described the current state and prospects of vegetable production in PK, Russia. The overview of the cultivated area, yield, and gross harvest of vegetables has been presented. It was found that there is still a limited mechanization level, which results in a high manual work consumption of approximately 45% to the total cultivation input. Consequently, the development of automated technologies, especially in planting seedlings, will increase the level of mechanization and decrease the total labor costs by 21.2% for cabbage, 9.3% for tomatoes, and 25.3% for onions, as well as the volume of manual labor by 29.7%, 10%, and 25.8%, respectively. Thus, replacing manual labor with automatic methods will improve the total mechanization level by approximately 15 – 30%. However, practical mechanization development and field experiments are needed to validate the proposed methods.

Furthermore, it is crucial to consider open discussion and cooperation with the business sectors with direct production contact and practical feedback through practical field testing. This cooperation is necessary to introduce and apply scientific results to a business.

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