Development of Komatsuna Production Management System in Small Size of Farming

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Abstract. The Japanese agriculture industry faces price competition from world free trade, and food safety and environmental conservation requirements. Although industrial engineering is effective in solving these problems, it has not been introduced in small-scale farming. This study aims to list the agricultural problems from an industrial engineering viewpoint and approach them. Moreover, this study aims to analyze "komatsuna" (Japanese mustard spinach) production of the target farm and develop a production management system that comprises a seeding plan, harvest management, cultivation history, and market analysis. This system can automatically derive the planed seeding date and predict the harvest date from the planned harvest date and executed seeding date. In addition, it can visualize these dates by drawing the Gantt chart and decide these dates by considering the seasonal variation coefficient of the month. This system, support decision making for the production and sale of komatsuna.

Keywords: agriculture, production management system, industrial engineering, Gantt-chart

1. INTRODUCTION

Japan has participated in the General Agreement on Tariffs and Trade (GATT) and World Trade Organization (WTO). As a result, the elimination or reduction of tariffs has been carried out for some agricultural products, and Japan now imports cheap agricultural products produced in foreign countries (Ministry of Agriculture, Forestry and Fisheries, 2015). Japan is progressing in free trade, as exemplified by the Trans-Pacific Partnership agreement and the Economic Partnership Agreement with Australia. According to these agreements, the elimination or reduction of tariffs for farm products is required in the future. In addition, environmental conservation and food safety are also emphasized, and farms are required to manage themselves appropriately in alignment with unified rules, as exemplified by the foundation of the

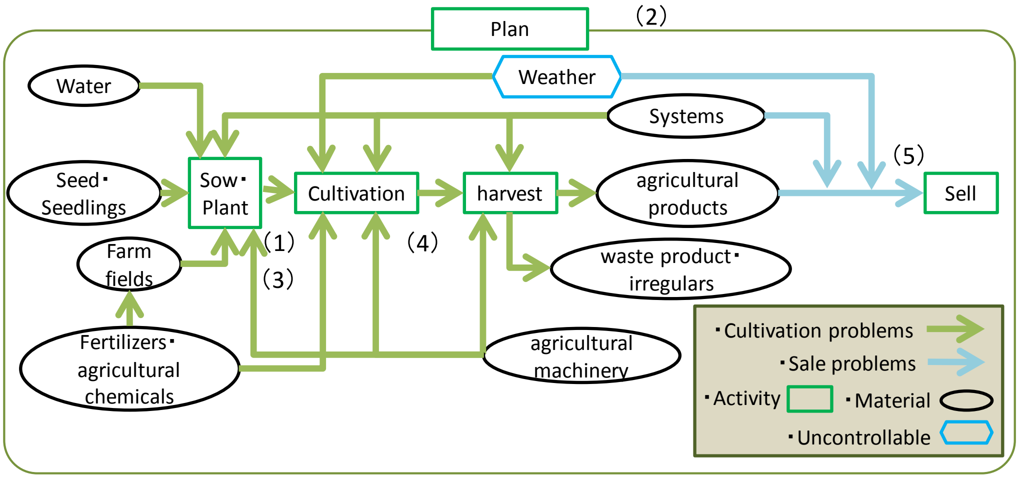

Figure 1: Overall picture of the general flow of agriculture.

Japan Good Agricultural Practice Association. Some non-agricultural companies enter the agriculture in Japan, usually starting in small areas (Ministry of Agriculture, Forestry and Fisheries, 2007). Therefore, a mechanism to earn profit in small-scale farming with sustainable management is necessary. In addition, there is currently a movement to improve quality and productivity in Japanese agriculture (Fujii, 2015). Furthermore, knowledge of kaizen activities developed mainly in the manufacturing industry, is also being applied to agriculture. Industrial engineering, which is the basis of kaizen, is a field that efficiently utilizes people, goods, money and information efficiently. The application of industrial engineering to small-scale farming helps to develop sustainable agriculture.

The following support systems has been deployed to agricultural production management in Japan. They are the farming work planning and management system "PMS" developed by the National Agriculture and Food Research Organization (Yoshida et al, 2009), "GeoMation Farm" developed by Hitachi Solutions, Ltd. (Nishiguchi and Yamagata, 2009), the Agriculture Cloud Platform "Akisai" developed by Fujitsu Ltd. (Fujitsu Ltd., 2012) However, these systems have not been developed enough to create a production plan by taking the market demand and climate into account.

Therefore, this study aims to list the agricultural problems from viewpoint of an industrial engineering and approach them. This study also aims to analyze for "komatsuna" (Japanese mustard spinach) production of the target farm and develop komatsuna production management system that comprises seeding plan, harvest management, cultivation history, and market analysis. This system will automatically derive the planned seeding date and predicted harvest date from the executed seeding date and planed harvest date. In addition, it will visualize these dates by drawing a Gantt chart and decide these dates by considering the seasonal variation coefficient of the month. This system will enable the support of decision making on the production and sale of komatsuna.

2. TARGET COMPANY AND PROBLEMS FROM AN INDUSTRIAL ENGINEERING VIEWPOINT.

2.1 Target company

This study selected NANKAI Farm, Inc. as the target company. The company produces many kinds of agricultural products and sells them in directly and by order to its customers.

2.2 Extracting problems from an industrial engineering viewpoint

Figure 1 shows an overall picture of the general flow of agriculture, which is explained in this section. First, seeds are sown and seedlings are planted in the farm fields. Fertilizers help the growth of agricultural products. Using agricultural chemicals stops the growth of weeds and stops the appearance of pests. After seeding and planting, the farmer irrigates and uses additional fertilizer and agricultural chemicals as needed. The cultivation process is followed by harvesting, at which time agricultural products that can be sold to customers are produced and waste products and irregulars are generated Through the sale, agricultural products are sold to customers. With the progress in computer technology, several systems that manage the seeding, cultivation, harvesting, and sale of the agricultural products exist. Moreover, there is agricultural machinery that can perform planting, seeding, applying fertilizers and agricultural chemicals, and harvesting.

The next section lists problems in small-scale farming on the basis of Figure 1, and explains problems and approaches to solve them from an industrial engineering viewpoint.

(1) Accessing small, disperse farm fields

In small-scale farming, it is difficult to introduce large machinery and access many good farm fields. Therefore, there exists a problem of longer transport time for many small, disperse farm fields. This problem can be approached as the “traveling salesman” problem in the operations research field.

(2) Complicated planning to manage various of agricultural products and farm fields

In a small-scale farming, to profit and not just break even with the fixed cost of small farm fields, “labor-intensive farming” can be employed rather than “land-extensive farming.” The main products of labor-intensive farming are vegetable. However, vegetables can possibly be damaged by continuous cropping. Therefore, for the efficient use of small fields and avoidance of this problem, small farms employ crop rotation. A farm needs to cultivate many types of agricultural products and their types can be pre classified. The success of farm depends on the intuition and the experience of the farmer and his knowledge about matching seasons, farm fields, and types of agricultural products. This problem can be solved by using a production management system and scheduling.

(3) Much hard works

As mentioned in (2), there are many “labor-intensive farming” in a small-scale farming. Thereby, many parts of farm works are performed without agriculture machineries. Their works can change to easier works by using Ergonomics, Motion and Time Study.

(4) Delayed environment and systems about quality

Most of small size farming delay introduction of traceable systems, and they may do not have uniform manual for sorting agricultural products in shipment. However, a part of them set quality standards. In a small-scale farming, "local production for local consumption" is recommended. The strength of them is safety of the food. Thus, this problem can approach as Quality Control to ensure the quality.

(5) Inadequate demand forecasting and marketing

In a small-scale farming, there is a possibility of selling directly to consumers, such as through a farmer’s market. Therefore, it is necessary for farmers to decide on the selling price themselves; yet it cannot be said that farmers adequately analyze of historical market prices and demand forecasting. Small-scale farming has been recommended for sixth-sector industrialization because there is a limit on the amount that can be harvested. Therefore, a small farm needs product development. This problem can be approached as one of value engineering and sales management so as to effectively invest in product development and allow farmers to determine the appropriate selling price.

3. DESIGN OF KOMATSUNA PRODUCTION MANAGEMENT SYSTEM

This study focuses on “(2) Complicated planning to manage various of agricultural products and farm fields” in section 2.2. Komatsuna is one of the main products in the target company and difficult to manage the production, then selected for the target product in this study. The komatsuna production management system comprises a seeding planning system, harvest management system, cultivation history system and market analysis system.

3.1 Contents of a seeding planning system

A seeding planning system decides when the farmer should seed the farm with komatsuna. The system needs this harvest date to decide the sale date for komatsuna. Therefore, this system decides its timing from the information on the komatsuna itself, historical criminate data, komatsuna seed, and harvest date. Information on the komatsuna means how accumulated daily mean temperature from seeding dates of some komatsuna days to the date that grown komatsuna complies with standards. Historical climatic data uses the daily mean temperature from climatic normal in Odawara City area. The daily mean temperature from climatic normal was repeated three times 9-day simple moving average for each data, which is the average of the daily mean temperature from 1981 to 2010.

Here, we describe the flow of the derivation of the seeding date. The farmer inputs a komatsuna seed type of and selects the necessary accumulated daily mean temperature complying with standards from the information on komatsuna. Next, the system accumulates the daily mean temperatures from climatic normal based on the entered harvest date. It then derives the seeding date as the date by which the necessary accumulated daily mean temperature has been reached

3.2 Contents of a harvest management system

A harvest management system calculates when farmers can harvest komatsuna. A farmer enters the harvest date in a seeding planning system, and it determines the seeding date. However, komatsuna may not necessarily grow as scheduled. This is because there is a difference in the daily mean temperature between climatic normal and actual measured data. Therefore, by exchanging climatic normal data for actual measured data, the harvest date reflects the current climate. This system uses the actual measured data obtained by the automatic acquisition of data, which is published by the Japan Meteorological Agency.

Here, we describe the flow of the harvest date calculation. The farmer enters type of komatsuna, and selects the appropriate accumulated daily mean temperature complying with standards from the information on komatsuna. Next, the system accumulates the daily mean temperature of actual measured data from the entered seeding date to the published

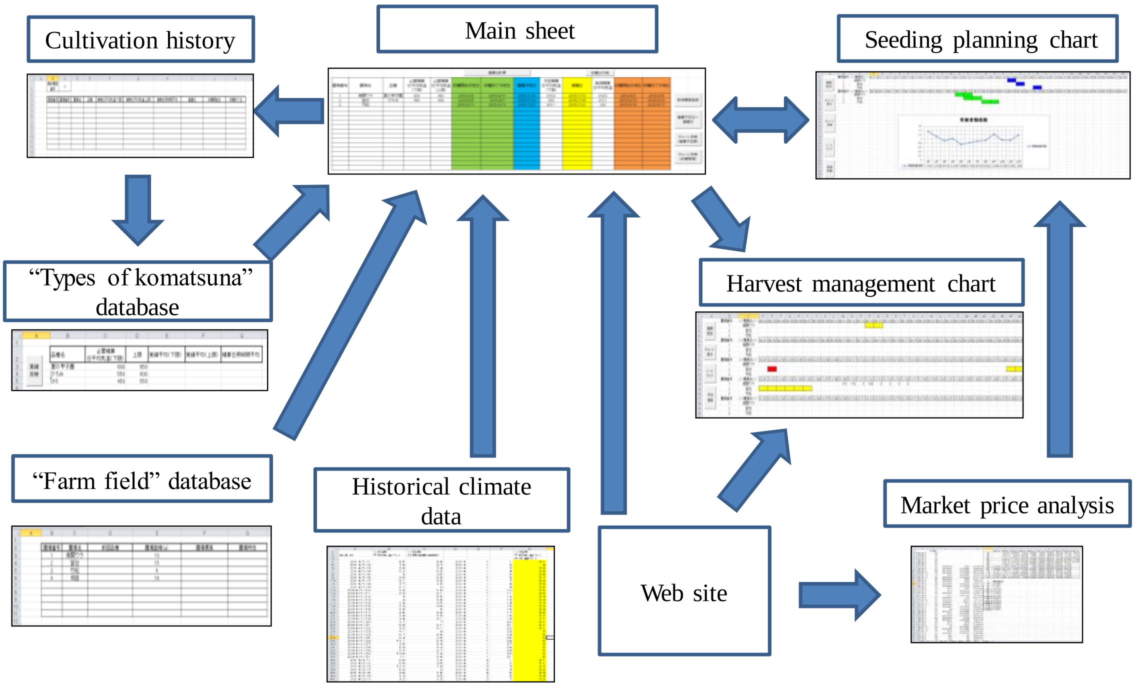

Figure 2: Overall picture of komatsuna production management system.

date of the actual measured data. After the published date, the system accumulates the daily mean temperature of climatic normal. It then calculates the harvest date as the date by which the necessary accumulated daily mean temperature has been reach.

3.3 Contents of a cultivation history system

A cultivation history system records the number of farm fields, name of the farm fields, type of komatsuna, executed seeding date, harvest start date, and harvest completion date as history.

The executed seeding date is the date on which the komatsuna is seeded in the farm. The harvest start date and harvest completion date represent the duration of the komatsuna harvest complying with the standards. In addition, the recorded history can be utilized in the next cultivation.

3.4 Contents of a market analysis system

By analyzing the market price of komatsuna, the market analysis system displays the necessary information for determining the selling price. In the target farm, the farmers do not know the appropriate selling price, which is clearly a problem. The system determines the monthly seasonal variation coefficient using a 12-month moving average of the komatsuna market price, which is published by the Metropolitan Central Wholesale Market. It then displays the necessary information for making a decision on the scheduling of komatsuna operations. Furthermore, it displays the weekly mean price of komatsuna which is published on the web page of the Agriculture & Livestock Industries Corporation. The price list includes 19 markets in 14 cities. The displayed information supports decision making about when and how much komatsuna should be harvested and sold and the duration of the harvest.

4. DEVELOPMENT OF THE KOMATSUNA PRODUCTION MANAGEMENT SYSTEM

4.1 Overall picture of komatsuna production management system

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This section describes the overall picture of the komatsuna production management system. As shown in Figure 2, the komatsuna production management system comprises a main sheet and sheets containing a seeding planning chart, harvest management chart, historical climate data, "farm field" database, "types of komatsuna" database, market price analysis, and cultivation history. "Market price of komatsuna" refers to the website of the Metropolitan Central Wholesale Market. Daily mean temperature refers to the web site of the Japan Meteorological Agency. In this system, the user will usually be a farmer.

4.2 Flow of a seeding planning system

4.2.1 Preparation for seeding planning

In this section, the user enters the seeded farm field and type of komatsuna into the main sheet. First, as shown in

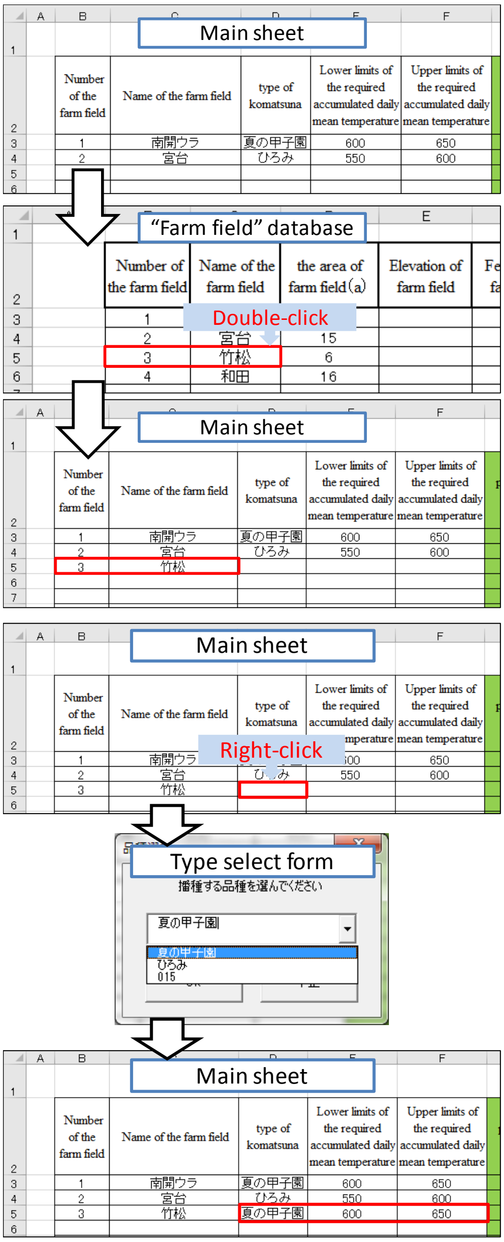

Figure 3: Flow of selecting the farm field and type of komatsuna.

Figure 3, the user double-clicks on the data of the farm field that he wants to seed in the "farm field" database sheet. By doing this, the farm field data is copied onto the main sheet. Second, the user right-clicks on the cell for the type of komatsuna and a form listing the types of komatsuna from the "types of komatsuna" database is displayed. By selecting the type of komatsuna from the form, the upper and lower limits of the required accumulated daily mean temperature are automatically copied onto the main sheet.

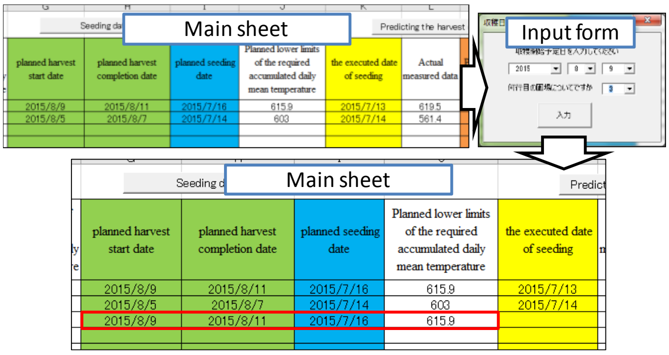

Figure 4: Flow of Seeding plan.

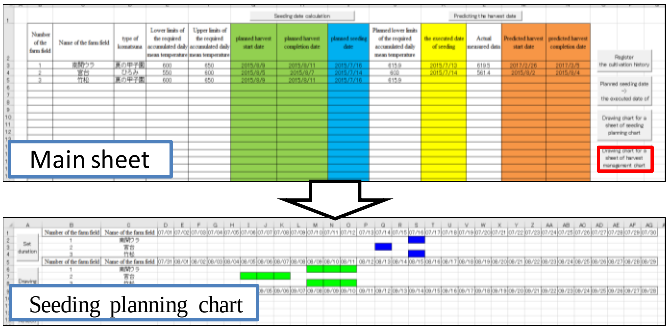

Figure 5: Drawing a Gantt chart in seeding plan.

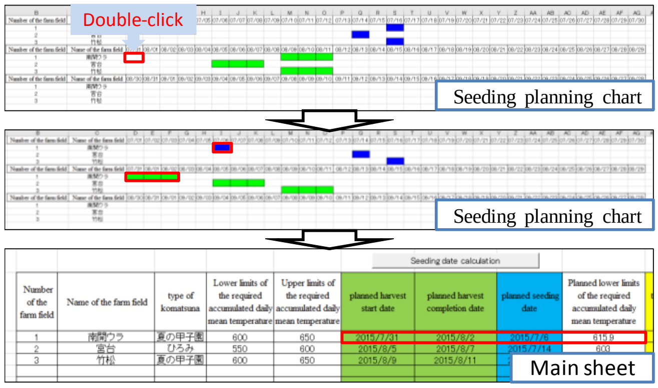

Figure 6: Change plan and reflecting the chart.

4.2.2 Derivation of a planned seeding date

This section describes the information of the planned seeding date. The planned seeding date is derived from "the planned harvest start date". Therefore, as shown in Figure 4, by clicking on a button labeled "Seeding date calculation," a form for entering the planned harvest start date is displayed. The start date is displayed on the main sheet, and this system derives and displays the planned seeding date and planned harvest completion date on a main sheet. In addition, the accumulated daily mean temperature from the planned seeding date to harvest completion date.

Here, the system displays the seeding plan on the seeding planning sheet by drawing a Gantt chart. As shown in Figure 5, when the user clicks on the button labeled "Drawing chart for a sheet of seeding planning chart," the planned seeding date is displayed in blue and the "planned harvest start date" to "the planned harvest completion date" is displayed in green. Moreover, as shown in Figure 6, to change the decided "planned harvest start date," the user simply double-clicks on another date. This system then derives the planned seeding date and the harvest completion date". The new seeding plan is reflected in the main sheet when the user clicks on a button labeled "Reflecting the chart."

By clicking on a button labeled "Seasonal variation" in the sheet containing the seeding planning chart, the system displays a graph that shows the monthly seasonal variation coefficients for the market price of komatsuna. Furthermore, the system automatically adds the new market price to the market price analysis sheet and derives the coefficients again.

4.3 Flow of a harvest management system

4.3.1 Preparation for harvest management

In this section, the user inputs the seeded farm field and type of komatsuna into the main sheet. The operation is the same as described in section 4.2.1. However, this step is not needed when the user has already entered the seeded farm field and type of komatsuna into the type of main sheet.

4.3.2 Determination of predicted harvest date

This section describes the determination of the predicted harvest date. The user enters the executed seeding date. The inputting methods follow two patterns depending on the executed seeding date. First, when the executed seeding date is the same as the planned seeding date, the user clicks on a button labeled "Planned seeding date -> the executed date of seeding." A form is then displayed that allows the user to select a farm field. Therefore, the planned seeding date is copied based on the executed seeding date, and the system predicts and displays the harvest start and completion dates in the main sheet. Second, when the executed seeding date is different from the planned seeding date, the user clicks on a button labeled "Predicting the harvest date," and a form is displayed that allows the user to enter the executed seeding date (see Figure 7). When the user does this, the system predicts and displays the harvest start and completion dates on the main sheet.

Here, the system displays the harvest management data in the harvest management sheet by drawing a Gantt chart. As shown in Figure 8, when the user clicks on a button labeled "Drawing chart for a sheet of harvest management chart," the executed seeding date is displayed in red and the "predicted harvest start date" to the "predicted harvest completion date" are displayed in yellow.

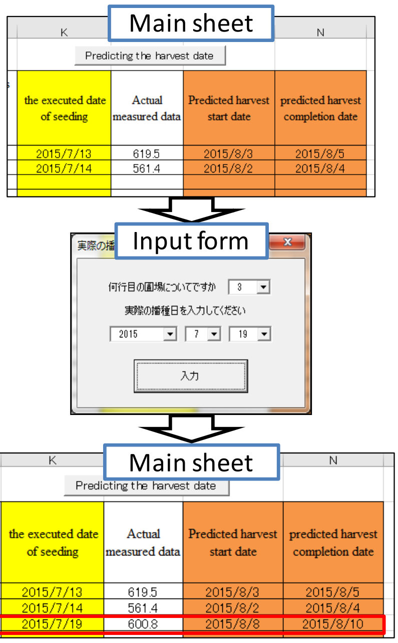

Figure 7: Flow of harvest management.

Figure 8: Drawing a Gantt chart in harvest management.

When the user clicks on a button labeled "Mean price" in the sheet containing the harvest management chart, the weekly mean price of komatsuna will be displayed on the Gantt chart.

4.4 Flow of other functions and user's comments

This section describes some other functions of the system. As shown in Figure 9, when a user clicks on a button labeled "Register the cultivation history," a form is displayed that allows the user to input certain data, including the registered farm field, executed seeding date, harvest start date, and harvest completion date. After the user has entered this data, the system determines the accumulated daily mean temperature from the executed seeding date to the harvest start date and harvest completion date from the actual measured data. The "number of history,"" number of the farm field,"" name of the farm field," "type of komatsuna," "upper limit of the accumulated daily mean temperature," "lower limit of the accumulated daily mean temperature," "executed seeding date," “harvest start date,” and “harvest completion date” are displayed on the cultivation history sheet. “Number of history” mean the numbers of each their data in cultivation history sheet.

There is a button labeled “Sorting out the result.” When the user clicks the button, the average of the accumulated daily mean temperatures in the cultivation history sheet for each type of komatsuna are determined. The average is then displayed on the “type of komatsuna” database sheet. When the user clicks on a button labeled “Reflecting the result,” the form in which the user can select the type of komatsuna is displayed. After the selection, the average data is copied as the required daily mean temperature for the selected type.

A farmer of the target company had used “PMS” i n the above, and compared the system with komatsuna p roduction management system. He gave comments which the latter had better point of using automatically public data of the Japan Meteorological Agency, and easiness t o understand simply.

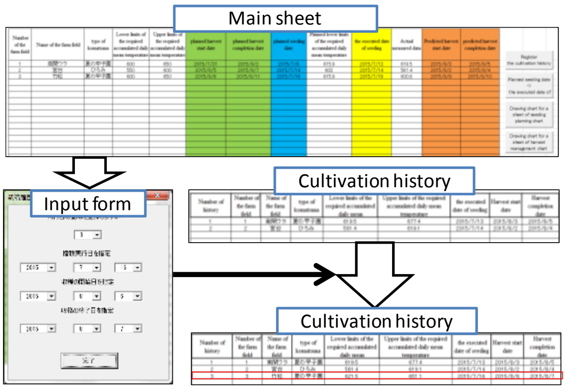

Figure 9: Register the cultivation history.

5. CONCLUSION

This study listed the agricultural problems from industrial engineering and approaches them. Moreover, in this study, we analyzed komatsuna production on a target farm and developed komatsuna production management system that can consider the climate and market analysis. This system enables the support of decision making on the production and sale of komatsuna.

This study targeted only komatsuna; however, it can be extended to all applicable agricultural products. In addition, there are farm fields that have many features of the target farm. Thus, consideration of the features of farm fields enables more advanced support of decision making.

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