JARQ 57 (1), 79-87 (2023) https://www.jircas.go.jp

Development of QAgriSupport, a GIS-based Agricultural Production Process Management System, and Foregis, a Mobile Application

Kazushi NISHIMURA*

Division of Dairy Production Research, Hokkaido Agricultural Research Center, National Agriculture and Food Research Organization, Sapporo, Japan

Abstract

In Japan, subsistence feed production has gained momentum in recent years. There has been an increase in the establishment of feed production contractors and efforts by cultivating farmers to grow feed crops, which are then harvested and purchased by contractors and others. These efforts serve a large production scale where the target fields are dispersed over a wide area. Thus, it is challenging to manage the work progress, which is a significant issue in the production field. Multipurpose process management methods and software are available for general manufacturing industries. However, applications for agricultural production, especially those that allow process management while displaying field information on a map, are expensive and lack sufficient functionality. To address these issues, this study developed a free, map-based agricultural production process management system, QAgriSupport, and a mobile application, Foregis, which can be coupled with QAgriSupport for agricultural enterprises that are large-scale and have widely dispersed fields. These applications have been introduced at a farm-type TMR (total mixed ration) center engaged in large-scale double-cropping of corn and a large-scale rice production corporation engaged in rice WCS (whole crop silage) and forage rice production. In addition, these applications have made a significant contribution to agricultural production process management by improving the efficiency of field-to-field movement and reducing the time required for work orders.

Discipline: Information Technology
Additional key words: Android/iOS application, QGIS plug-in, widely dispersed fields

Introduction

Livestock farming in Japan continues to expand in terms of the number of animals raised. At the same time, there is a tendency to rely on purchased feed because the production of self-sufficient feed has not expanded adequately. However, in recent years, as the feed import has become increasingly unstable, the risks of livestock management dependent on imported feed have become more apparent, leading to a momentum on the expansion of domestic feed production. The Ministry of Agriculture, Forestry and Fisheries reported that the number of contractors engaged in harvesting feed crops increased from 317 in 2003 to 826 in 2018. In general, contractors and large-scale feed production organizations make huge investments in machinery and equipment and need to contract large work areas to compensate for their investment costs. The scope of their activities may be extensive, whereas the target harvest is limited to feed crops. A case study of a contractor harvesting corn in a warm climate area reported that about 200 ha of work fields was distributed over 500-600 plots, 11 km × 15 km square (Nishimura 2009).

The number of initiatives where cultivating farmers grow the feed crops and contractors harvest and purchase them has also increased recently. Therefore, it is rare to find prefectures that have centralized management of forage crop fields in the entire region. Thus, the organizations responsible for harvesting are required to manage the progress in fields that are scattered over a wide area. A report on the regional production of rice WCS noted that approximately 190 production fields,

*Corresponding author: kazushin@affrc.go.jp
Received 18 January 2022; accepted 25 April 2022.

totaling 43 ha, were dispersed in a 6 km × 3 km area and the total distance traveled by harvesting machines was 70 km-80 km (Nishimura et al. 2012).

When fields are dispersed over a wide area, as in these cases, it is extremely difficult to manage the work progress, which is a major challenge in agricultural production. Managers need to formulate appropriate work schedule and personnel allocation plans so that the work can be completed within the prescribed period. It is also important to note that these large-scale farms are not only vast in size and scope but also have multiple operators that share and implement the work. The operation manager is required to instruct the operators on the work plan formulated in advance, receive work reports from the operators, and then check and revise the work plan while keeping track of the overall work progress. Communication between management/work supervisors and operators is essential to ensure clear and reliable work instructions and progress reports.

Process management is defined as the series of management actions that aim to complete the required work within a specified time frame by formulating a work schedule, monitoring the progress, and revising the plan. All-purpose process management methods and software are available for general manufacturing industries, whereas the applications for agricultural production, especially those that allow process management while displaying field information on a map, are expensive or insufficient in terms of functionality. To address these issues, this study developed a free, map-based agricultural production process management system, QAgriSupport, and a compatible mobile application, Foregis, for agricultural organizations that are large in scale and have widely dispersed fields.

Agricultural production process management application QAgriSupport

1. Overview

QAgriSupport is a map-based agricultural production process management application that runs as a plug-in to "QGIS" (https://qgis.org/en/site/) (Fig. 1) and was programmed in python (https://www.python.org/) using the QGIS API feature (Sherman 2014, Lawhead 2017, Summerfield 2008). The map screen offers multiple functions, such as visualizing the field information, detecting its precise location among other fields, and providing an interface for data entry. Access to these features in a single application simplifies the operation. In addition, the official "QGIS" plug-in allows using various web maps as background. As for the functions, it can perform consistent process management related to agricultural production, including planning, work instructions, registration of results, monitoring of progress, and revision of work schedule plans. However, it should be noted that QAgriSupport is an application available only in Japanese.

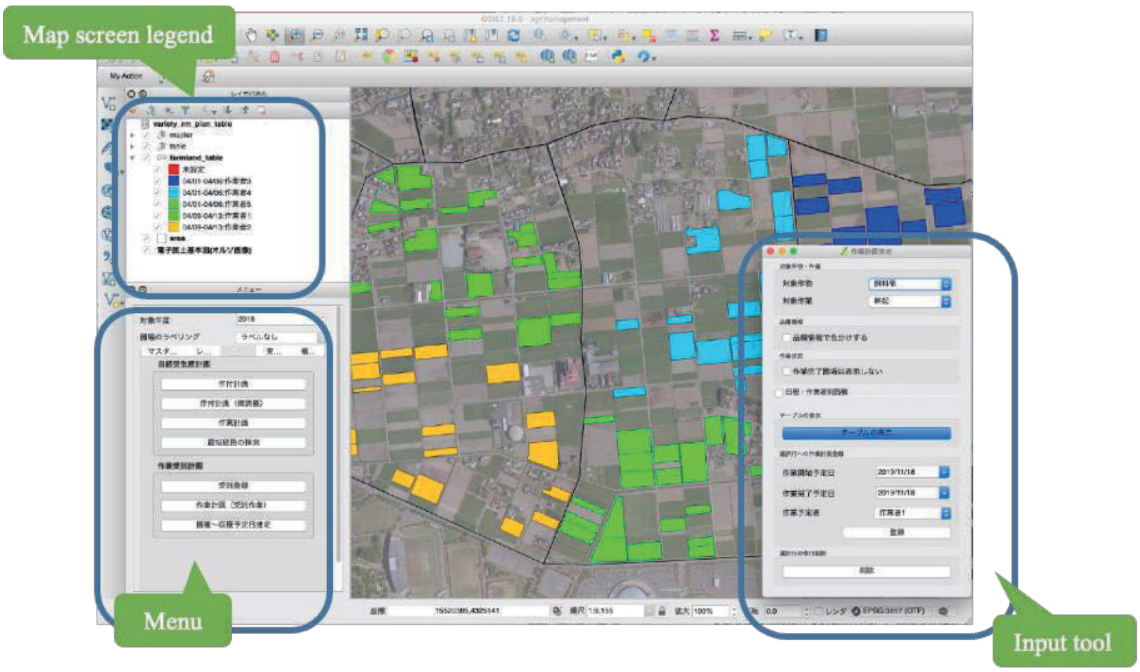

Fig. 1. Operation screen of QAgriSupport

2. Flow of agricultural production process management using QAgriSupport

QAgriSupport provides the following major steps for agricultural production process management.

(1) Crop and Variety Planting Plan

The first step allows the user to register the crops and varieties to be planted in the field set as the management land (Fig. 2). Multiple crops with overlapping growing seasons, such as paddy rice for food and rice for feed, can be displayed on the map simultaneously, and the registration process can be advanced so that the planned planting fields do not overlap.

The “Contracted Work Plan” is a function for organizations such as contractors that perform contracted work. The user can register the plots that are set as contracted land, apart from the managed farmland and from whom the contracted work is being done. The client’s name can be displayed as a label on the registered plots (Fig. 3).

(2) Work Schedule Planning

In the second step, the operator and the scheduled work period can be assigned for the target field for each registered crop or contracted work. The schedule can be modified as necessary, making it possible to start with weekly schedules and defining the details for the most recent week (Fig. 4). A function intended for contractors enables the estimation of the optimum harvesting date based on the sowing date and relative maturity and reflects this in the harvesting schedule. Thus, the optimal harvest date for each client can be estimated in advance based on the variety and sowing date and can be used for schedule adjustment.

(3) Work Instructions for Operators

In this step, work instructions and daily reports can be created for each work schedule plan that has been formulated, with the designated work area on top of the A4 vertical layout and the daily report entry column at the bottom (Fig. 5). Using Foregis, described in the following section, the operator can receive the work instructions and simply enter the results on his/her smartphone.

(4) Registering Work Results

In this step, fields are extracted according to the established work schedule. The required items, such as operator and the implementation date, can be registered (Fig. 6) with a click of the mouse. Optional items, including assistants, machines, and materials used can also be entered. The application supports good agricultural practice (GAP). Using Foregis (see below), work data can be received via e-mail and imported into the performance data in QAgriSupport.

(5) Confirmation of Work Progress

As the work results are registered, the progress against the formulated work schedule plan can be demonstrated. In addition to visualizing the completed

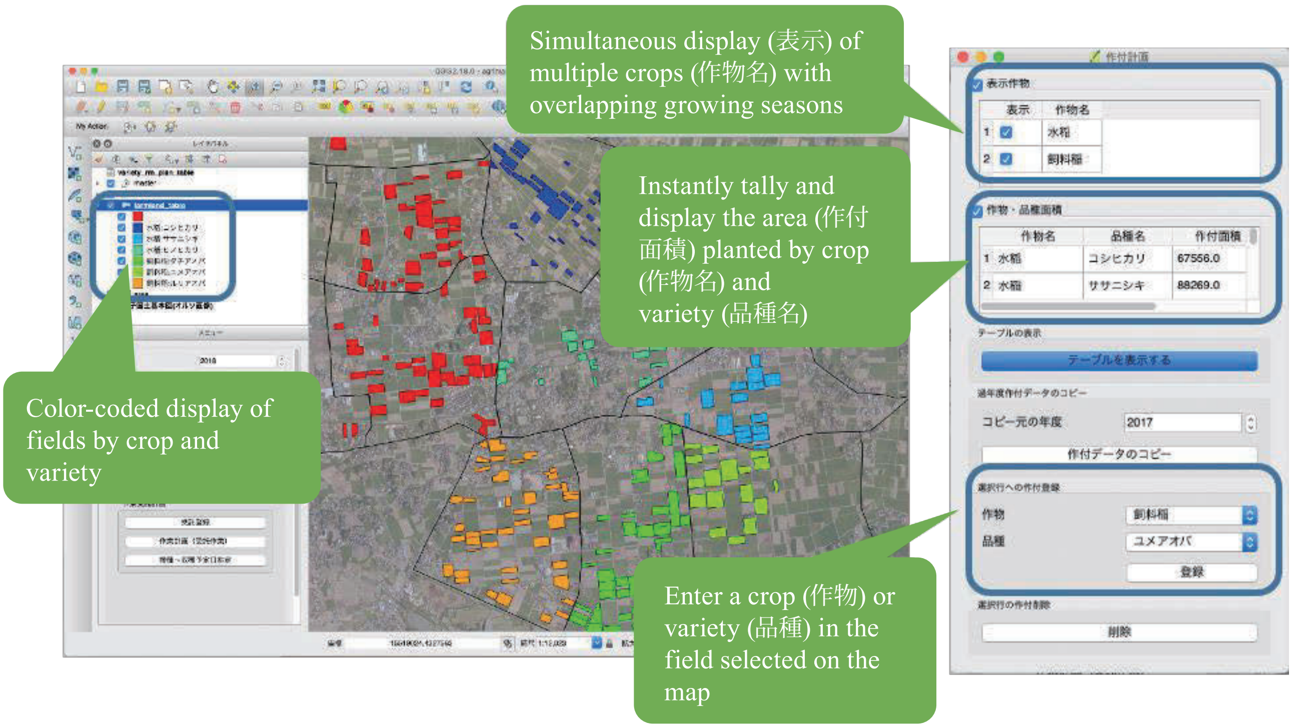

Fig. 2. Example of developing a cropping plan for a crop or variety

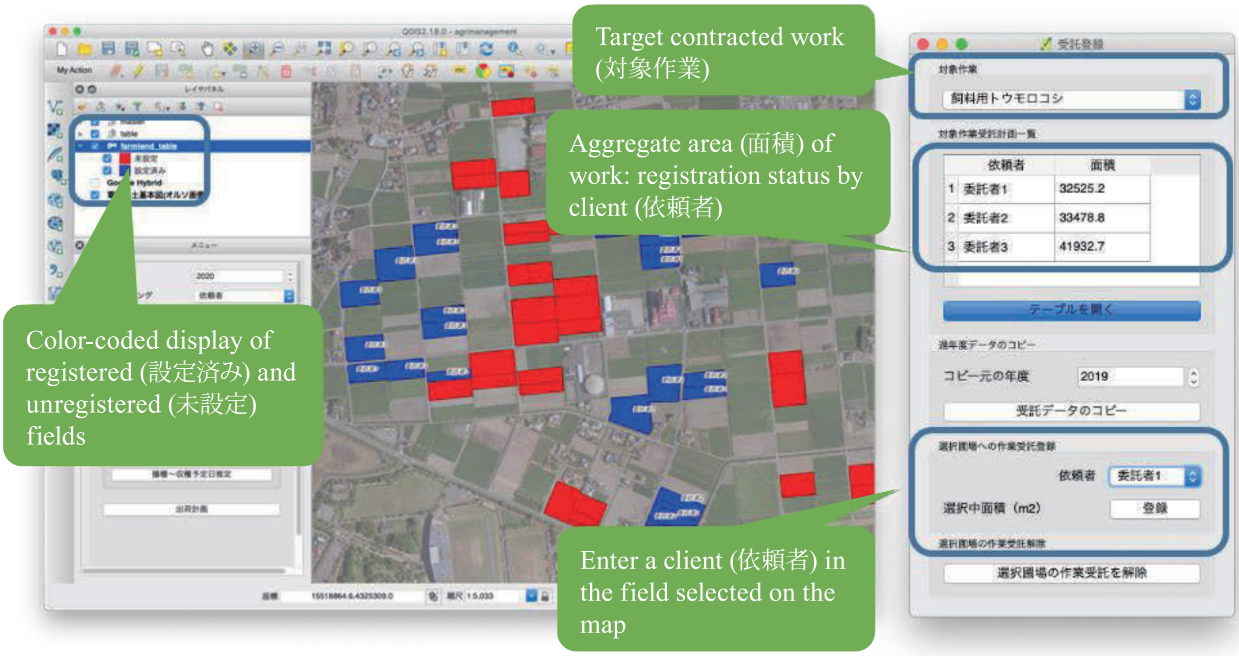

Fig. 3. Example of developing a contracting plan

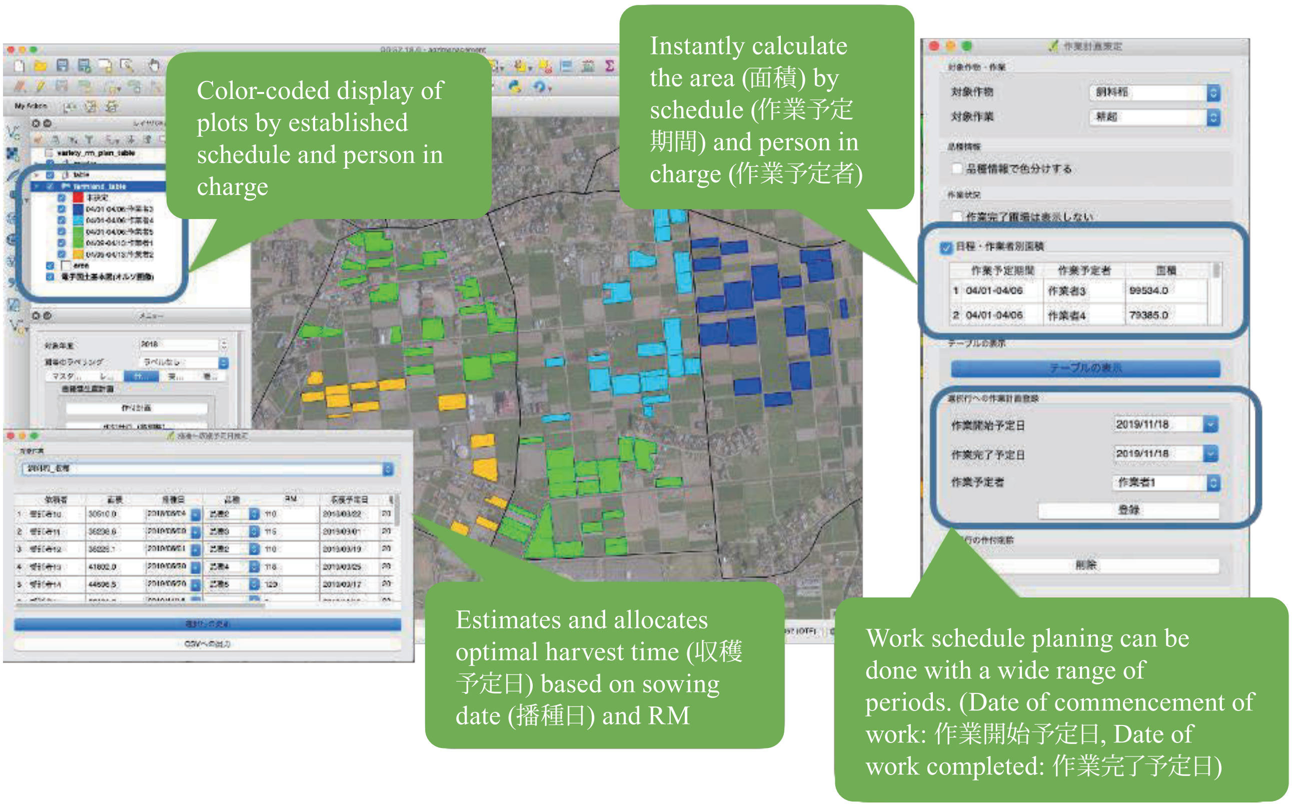

Fig. 4. Example of planning a work schedule

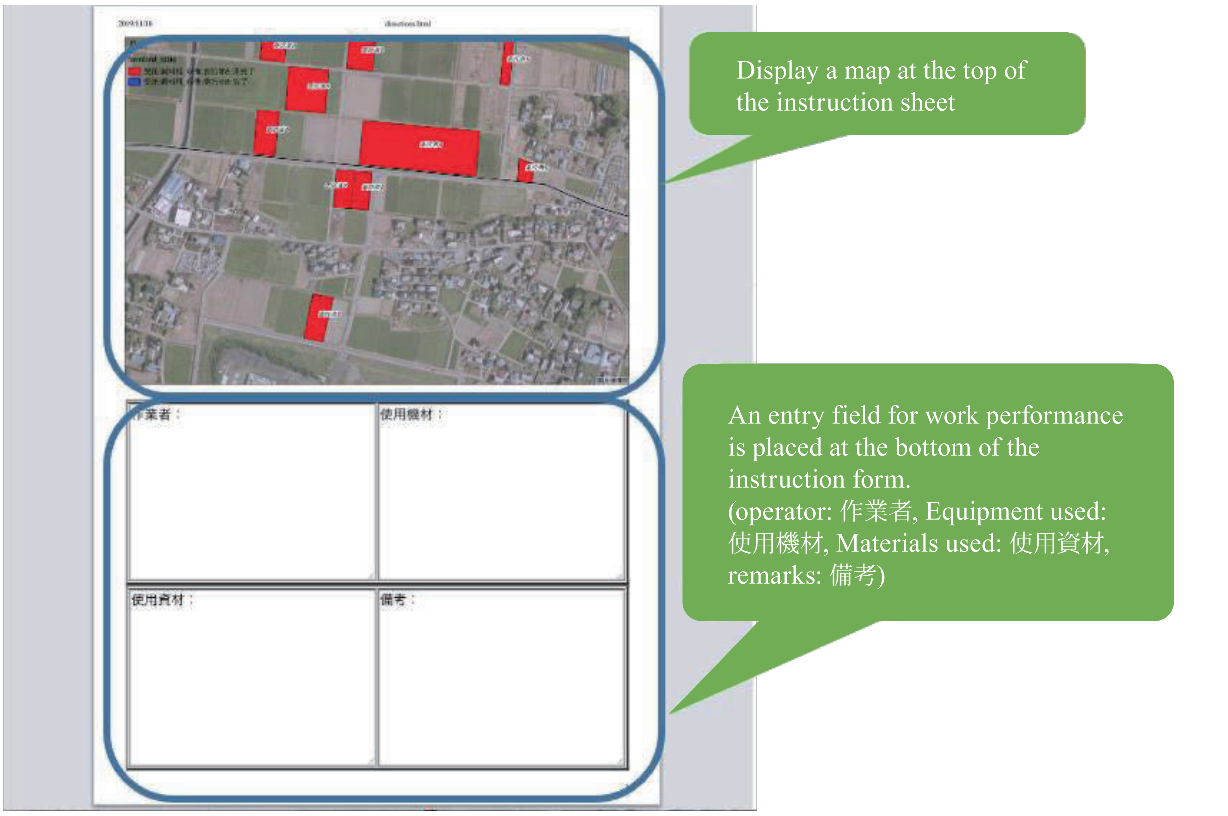

Fig. 5. Example of a work order instruction form and daily report

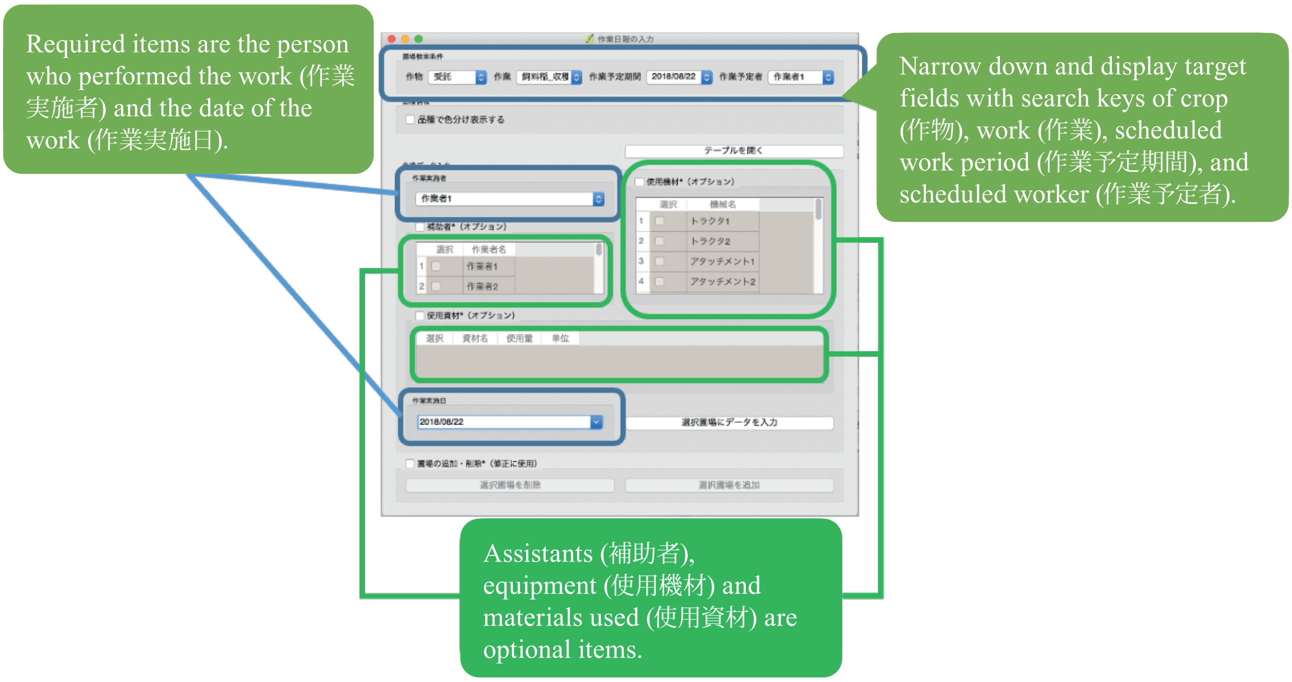

Fig. 6. Example of daily work report registration

and uncompleted plots on the map, the work progress can be presented with the numerical indicators of the schedule completion rate and work progress rate (Fig. 7). This information can be used to revise the work schedule plan, as necessary.

Mobile Application Foregis

Foregis is an application for Android/iOS mobile devices, allowing operators to receive work orders based on the work schedule plan created by QAgriSupport via e-mail on their mobile devices, check the work field, and register the work results (Fig. 8). As the date of work and the person in charge, among others, are specified, the target field is extracted and displayed on Google Maps on the mobile device. Operators can easily check the fields they are in charge of and the contents of their work in the field. They can also register the workers and equipment in use by tapping the field on the map (Fig. 9).

If the target crop is grass roll bale silage, information such as growth stage, number of harvested rolls, average weight of rolls, and moisture content can also be registered (Fig. 10). This forage information can be attached to the rolls as QR (quick response) code labels (which can be created and printed from QAgriSupport) and linked to the harvest field. This allows the end user of the rolls to trace the quality and work history of the feed (Fig. 11).

The attached QR code labels can also be used for shipping and delivery management, allowing to check shipments and deliveries by roll bale against the number of scheduled shipments by destination that were established in advance with QAgriSupport.

Data exchange between QAgriSupport and Foregis is provided via e-mail. Therefore, no cloud server is required to build the system. QAgriSupport and Foregis data are consolidated into a single file of several megabytes (sqlite format), and this file is sent and received via e-mail to keep the data up to date.

It should be noted that, like QAgriSupport, Foregis is an application available only in Japanese.

Case studies

1. Farm-type TMR center

The TMR center manages the farmland of 20 dairy farmers who are members of the center and produce corn by double cropping in a total of 300 ha per year by double-cropping (Fig. 12). For about 10 years, the center had been using a commercial GIS-based management system, i.e., ArcGIS (Nishimura 2018). With the introduction of that system, the ratio of time spent traveling between fields to the machine's harvesting time dropped from 27 to 16%, improving operational efficiency. However, as the GIS base became outdated, the center migrated to QAgriSupport. For process management, the center's administrative staff registers the cropping fields and provides work instructions to the staff in charge of each area. Only harvesting work is outsourced to contractors. Instructions for the target fields and harvest schedules are also prepared in QAgriSupport. Despite minor confusion in the production management in the first year of implementation because of the difference in specifications between the old system and the new system, the new system contributed to the management of large-scale corn production. In addition,

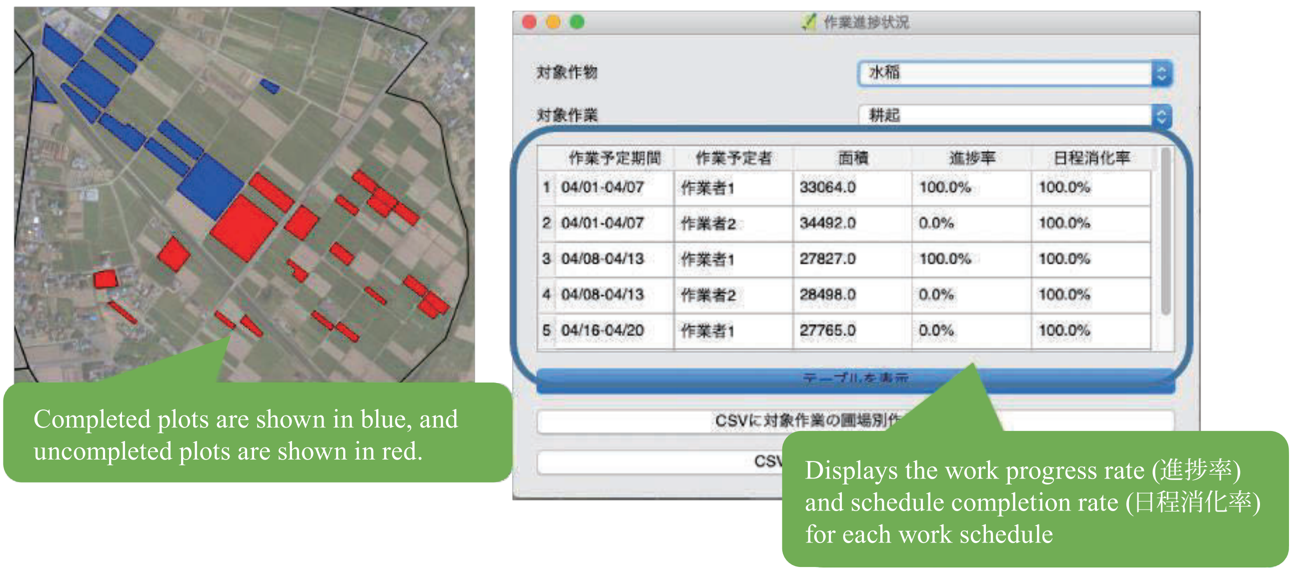

Fig. 7. Visualization of work progress, calculation of work progress rate, and schedule completion rate

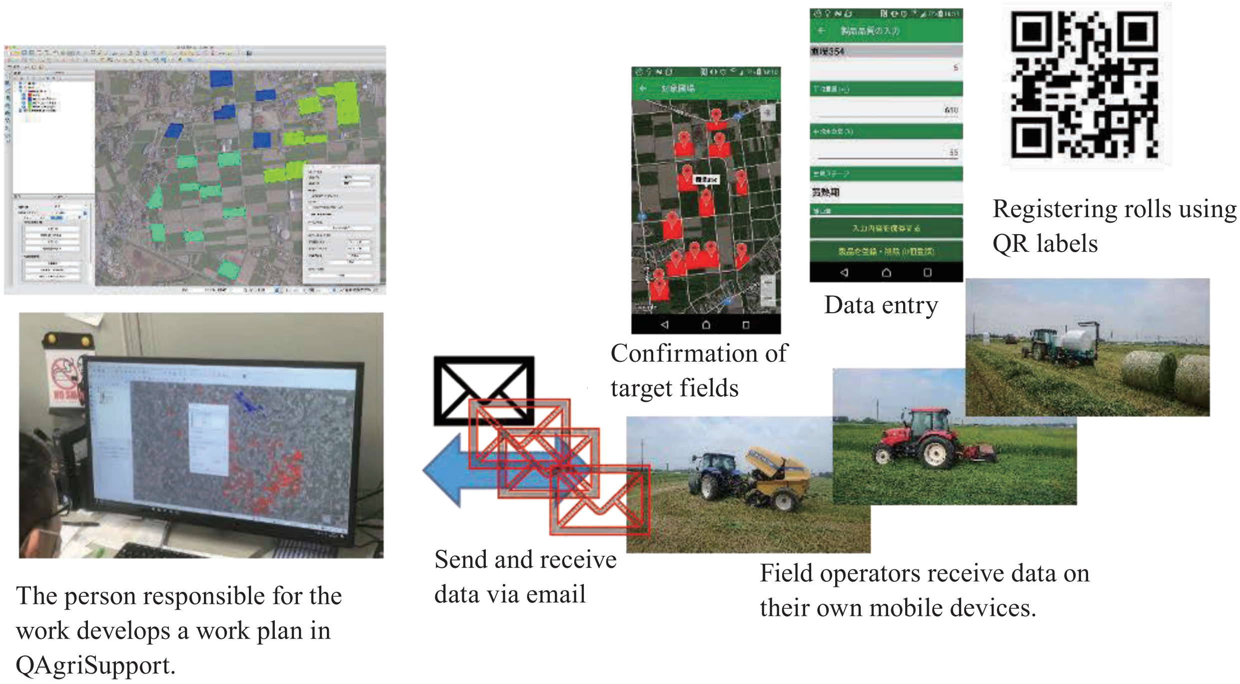

Fig. 8. Linking QAgriSupport and Foregis

Fig. 9. Confirmation of fields on the map screen and registration of results

Fig. 10. Registration screen of forage quality and list of features that can be entered

Fig. 11. Registration, tracking, and confirmation of work history and product quality using QR code labels

they devised their own unique way, such as a tracking application that operates on a smartphone to acquire and record GPS data of the work equipment, which is then displayed on this system to confirm work completion. It should be noted that the center does not use Foregis because they use their own tracking application.

2. A large-scale rice production corporation

This large-scale rice-growing corporation is involved in rice WCS and forage rice production, as well

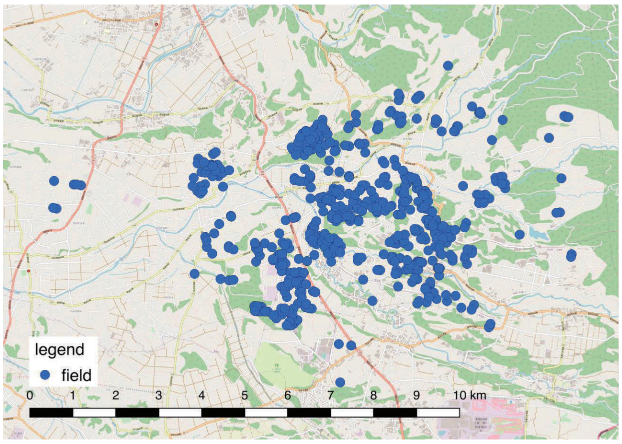

Fig. 12. Case study: farm-type TMR center

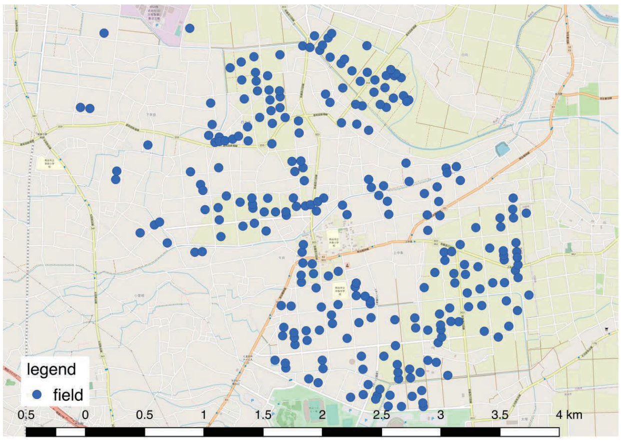

Fig. 13. Case study: large-scale rice production corporation

as double cropping of rice and wheat, and uses QAgriSupport and Foregis for production process management. The total area of cultivated land under management is 105 ha (Fig. 13). In addition to seven fulltime employees, the farm employs several temporary parttime workers. Important field information, such as crops, varieties, and cultivation styles was previously managed using MS Excel. However, the introduction of QAgriSupport and Foregis has facilitated the management of field information and sharing work plans and progress among the members. In particular, operators using Foregis could check their work plots on their mobile devices, considerably reducing the time required for work instructions and confirmation. According to the prefectural report, work order time was reduced by about 50% (Saitama Prefecture 2020). For temporary parttime workers who are not familiar with the Foregis system, information was shared using work order charts that could be printed out using QAgriSupport.

Installation of the system

QAgriSupport operates as a plug-in for “QGIS.” Please refer to the instruction manual at https://github.com/KazushiNishimura/QAgriSupport for the installation and operation of QGIS and QAgriSupport.

Foregis is available in both App Store (iOS) and Google Play (Android). It can also be downloaded from the following links:

iOS version: https://apps.apple.com/jp/app/foregis/id1516220095

Android version: https://play.google.com/store/apps/details?id=com.frog_pod.Foregis

QAgriSupport and Foregis are both available free of charge.

For assistance in building your field database, please contact us at https://www.naro.go.jp/laboratory/harc/inquiry/index.html.

Acknowledgements

This research was supported by grants from the Project of the NARO Bio-oriented Technology Research Advancement Institution (the special scheme project on vitalizing management entities of agriculture, forestry, and fisheries). Foregis is a joint work of Frog Pod Inc. and the National Agriculture and Food Research Organization (NARO).

References

Lawhead, J. (2017) *QGIS Python Programming Cookbook*, Packt Publishing Ltd, Birmingham, UK.

Nishimura, K. (2009) Clarification of field distribution situation and effect of accumulation of warm region corn contractor. *In* Journal of Rural Economics Special Issue 2007, ed. Agricultural Economics Society of Japan (Nosangyoson bunkakyokai) Tokyo, Japan, 158-165.

Nishimura, K. (2018) An Empirical Study on Field Dispersal Problems in External Forage Cropping Organizations. Ph. D. Thesis, Hokkaido University, Sapporo, Japan.

Nishimura, K. et al. (2012) An Influence Analysis of Dispersed Farm Fields on the Traveling Time through Fields. *In* Journal of Rural Economics Special Issue 2012, ed. Agricultural Economics Society of Japan (Nosangyoson bunkakyokai) Tokyo, Japan,100-105.

Saitama Prefecture (2020) Report on the results of dissemination activities 2019. https://www.pref.saitama.lg.jp/a0903/fukyu/h24seika.html. Accessed on 24 March 2022.

Sherman, G. (2014) *The PyQGIS Programmer’s Guide*. Locate Press LLC, Chugiak, AK, USA.

Summerfield, M. (2008) *Rapid GUI Programing with Python and Qt*, Pearson Education, Inc., USA.