A NAVIGATION SYSTEM FOR APPROPRIATE PESTICIDE USE AND FOOD SAFETY

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ABSTRACT

To prevent the occurrence of pesticide misapplication, it is necessary to establish support systems for appropriate pesticide use by applying information technology (IT) based on prior risk management. This paper introduces the concept of the Navigation System for Appropriate Pesticide Use (Nouyaku-navi), the state of development of the system, functions of the latest system and the results of the demonstration experiment. The latest Nouyaku-navi comprises various functions, as follows: support functions for creating guidelines on pest control, support functions for creating pesticide use plans, judgment functions for the pesticide use plans, on-site warning functions for pesticide application and functions for on-site registration of pesticide application records. Users of the system can create pesticide use plans by means of a personal computer and easily judge their propriety using the Nouyaku-navi judgment server. Also, users can easily use a cellular phone to determine the propriety of pesticide application from farming fields or agrochemical storage lockers just before the application. If the plan has no problem, data on the pesticide application can be simultaneously registered on the system as a pesticide application record. Also discussed are issues on the Nouyaku-navi and its relationship with good agricultural practice (GAP) and traceability systems.

Key words: pesticide use, navigation system, on-site warning system, GAP

INTRODUCTION

In recent years, the practical use of traceability systems has been promoted in the fields of agricultural production and distribution (Ikeda, Sugiyama and Hara 2003; Yamamoto 2003; Food Safety and Consumer Affairs Bureau of the Ministry of Agriculture, Forestry and Fishery 2005). This trend has developed along with an increase of public interest in food safety and security generated by the BSE (bovine spongiform encephalopathy) issue, problems of pesticide residue and misapplication, the deliberate food mislabeling scandal, among other things. In the agricultural production process, campaigns for agrochemicals application records have been mounted and procedures have begun to determine whether a pesticide application was appropriate after the application. With traceability systems, such operations are inevitable and therefore the systems should be promoted. However, if a misapplication of agrochemicals is discovered after the application, problems of disposal of the agricultural products concerned and a violation of the obligation of appropriate pesticide use will occur and such problems will destroy public trust in distributors as well as producers and production centers, possibly becoming an issue of critical importance.

Standards for pesticide use have been revised a number of times in line with expansion of their application, thus becoming more detailed and complicated. In addition, because of the use of unregistered agrochemicals, the Agricultural Chemicals Regulation Law was revised in respect of user obligation to comply with standards and of penalties for failure to do so. Whoever commits an offense against the law shall receive punishment of incarceration of no more than three years, a fine of no more than one million yen, or both (Tazou, 2003). In agricultural production, mislabeling of pesticide containers or written errors in guidelines on pest control created by prefectural governments have been discovered. As a result, situations have occurred in which
prefectural governments are being held responsible for losses. Moreover, in particular for farmers intending a growing system with reduced pesticide use, pesticide use plans must be constantly revised according to outbreaks of diseases or pest insects during the busy farming season. In consequence, there are limits and concerns in respect of manually creating pesticide use plans that accurately meet all the standards for pesticide application. To prevent these issues in advance, it is necessary to establish support systems for appropriate pesticide use by applying information technology (IT) based upon prior risk management. Here we describe the concept of the "Navigation System for Appropriate Pesticide Use" (Nouyaku-navi), on which we have promoted research and development, and the current state of the latest system. Also, the future challenges for the Nouyaku-navi and the relationship with GAP and traceability systems are discussed. The details of the system are described in Nanseki et al. (2005).

CONCEPT OF NAVIGATION SYSTEM FOR APPROPRIATE PESTICIDE USE

The Nouyaku-navi is a system aimed at actively guiding and supporting farmers’ correct use of pesticides in agricultural production in order to prevent in advance their misapplication. The research concerned was launched in 2003, and the R & D activities for the systems have been performed since 2004 under the budget of the “Research project for utilizing advanced technologies in agriculture, forestry and fisheries” by the Ministry of Agriculture, Forestry and Fisheries. The Nouyaku-navi judgment server was first developed as a core system, and an operational test and an open demonstration test of it have already been performed.

In the Nouyaku-navi, the goal is to enable farmers to prevent pesticide misapplication due to carelessness and to automatically register the application records by automatic recognition of the agrochemicals using bar-codes (Japanese Article Number codes) and/or RFID (Radio Frequency Identification: Wireless IC) tags attached to the agrochemical containers (Nanseki, Sugahara and Watanabe, 2004, Fig. 1, http://nouyaku-navi.info/). It is expected that using the Nouyaku-navi will achieve effects such as prevention of pesticide misapplication and of promotion of effective pesticide use and reduced pesticide farming. In addition, the Nouyaku-navi will accomplish the automatic and labor-saving collection and accumulation of objective data which supports pesticide application records. Outlines of major systems assumed in the Nouyaku-navi project are as follows:

Development of support systems for judgment on appropriate pesticide use

A judgment server system has been developed (hereinafter referred to as the Nouyaku-navi judgment server) which determines in advance the propriety of pesticide use, together with a system for preparing appropriate plans or guidelines on pesticide application and pest control which can easily and precisely create such plans.

Development of Systems for automatic recognition of pesticide application and for on-site warning

An on-site warning system has been developed which uses barcodes or RFID to give farmers warning information and real-time judgments on the propriety of pesticides planned to be used, and an automatic recognition system of pesticide application which can accomplish a labor-saving and objective understanding of the state of pesticide application in farming fields.

Development of a risk assessment system for cases of pest infestation

A system for risk assessment in individual cases of pest infestation/pesticide application corresponding to actual situations in production fields has been developed by accumulating information on pesticide application using mobile terminals and a pesticide automatic recognition system, and by using information on pest infestation collected by micro climate monitoring in the field and by automatic insect counters and others. Also, a system for assessing the risks of a pest infestation in terms of effective pesticide use or introduction of alternative materials has been developed by applying a data mining method
Database on the pesticide registration information disclosed (e.g., Agricultural Chemicals Inspection Station, prefectural institutes)

Existing disclosure systems for production records (e.g., SEICA of the National Food Research Institute)

Support Systems for Appropriate Propriety Use

Support system for creation of recommendation on pest control (e.g., prefectural institutes and agricultural cooperatives)

Judgment Server System for Appropriate Pesticide Use

Check at the time of purchasing pesticides

Support system for creation of pesticide use plans (e.g., producer groups and JAs)

Information for pesticide propriety use

Cellular phone (with camera), mobile

Pesticide application records, states of pesticide use

Appropriate pesticide use plans

Field monitoring system

Information on pest

Database on the cases of pest infestation and pesticide application

Risk assessment system based on the cases of pest infestation

Risk assessment system for pest infestation

Barcode reader or RFID reader (various forms)

Pesticide automatic recognition system using RFID

On site warning system using RFID

Pesticide use automatic recognition and on-site warning system

Fig. 1. Overall view of the Nouyaku-navi system.
on individual cases of pest infestation and pesticide application, as well as on a climate database.

**Risk management system for pesticide application using the Nouyaku-navi**

To put to practical use the results of research on the Nouyaku-navi, a commercial system for JAs or advanced producer groups must be developed, based on traceability systems and collaboration with GAP. We suggested “feasibility study experiments for risk management systems of pesticide application using the Nouyaku-navi” for inclusion in the “2005 Ubiquitous Food Safety and Security System Development Activities” sponsored by the Ministry of Agriculture, Forestry and Fisheries (http://www.maff.go.jp/www/press/cont2/20050701press_3.html), and our suggestion was adopted in July 2005. The characteristics of the system intended to be developed are summarized as follows: (1) function for multi-step and prior judgment on the propriety of pesticide use and for on-site warnings which meet various different standards among local communities, producers, and production systems (e.g., contract farming), (2) function for automatic registration of appropriate pesticide application information (5W1H) at the time of prior judgment on the propriety of its use, and (3) function for real-time analyses of actual states of pest infestation or agrochemicals application and displaying advice on effective application of the pesticides concerned.

**NEW FUNCTIONS IN THE NAVIGATION SYSTEM FOR APPROPRIATE PESTICIDE USE**

We have already suggested a two-step procedure for appropriate pesticide application: first, the creation of pesticide use plans and judgment on their propriety, and second, registration of the application records integrated into the judgment just before the actual application. According to this procedure, the Nouyaku-navi provides functions as follows (Nanseki et al., 2005); (1) A “support function for creation of guidelines on pest control” which searches and extracts data on pesticide registration information to generate the guidelines and recommendations for pest control. (2) A “support function for creation of pesticide use plans” which supports generation of pesticide use plans and spray calendars. (3) A “judgment function for pesticide correct use” which judges the propriety of pesticides to be used, based on the guidelines on pest control and on the pesticide use plans. (4) A “function for on-site warning and application records” which immediately prior to application judges the propriety of pesticides to be used and registers the application records using mobile terminals such as cellular phones, portable computers and others.

Users of the system can, via personal computer, obtain data on the latest pesticide registration information (recommendations for pest control) required for creation of pest control guidelines and application plans from the Nouyaku-navi judgment server. A pesticide use plan prepared by a personal computer can be easily assessed for propriety using the Nouyaku-navi judgment server (Fig. 2). Immediately prior to application, users in farming fields or at pesticide storage lockers can, via cellular phone, easily judge the propriety of the pesticides planned for use. When an application plan is determined to be appropriate, the data can be immediately registered as a pesticide use record. For the on-site warning function, two types of judgment system have been prepared, taking consideration of past records or future plans of application. In the following section, an outline of the main functions is described.

**System-development environment**

Table 1 shows a system-development environment. A Linux OS (operating system) machine was used for the server system and PHP was used as the programming language. For the DataBase Management system (DBMS), MySQL, characterized by a high-speed processing capacity, was used because the volume of data on pesticide registration was relatively small (approximately 50 MB). The PC system was developed using Microsoft Visual Basic (MS-VB) which allows easy prototyping under the assumption of widely-used MS-Windows machines. The application for cellular phones was developed using JAVA (i-Appli), targeting NTT DoCoMo FOMA (900, 901) and MOVA (505, 506).
Fig. 2. Image of the use of the Nouyaku-navi judgment server

1. A pesticide use plan is prepared.

2. A judgment for the plan is requested.

3. Results of judgment are obtained.

The Nouyaku-navi judgment server

Total frequency of use of the active ingredient MEP will exceed the total frequency prescribed in the law.
### Table 1. System-development environment

<table>
<thead>
<tr>
<th>1) Nouyaku-navi judgment server</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Server machine</strong></td>
<td>Dell PowerEdge650 Pentium 4 2.40 GHz, Memory: 256 MB, HDD: 80 GB</td>
</tr>
<tr>
<td><strong>OS/Web Server software</strong></td>
<td>FedoraCore1(Linux)Kernel 2.4.22-1.2115.nptl Apache 2.0.47 (Fedora)</td>
</tr>
<tr>
<td><strong>Database</strong></td>
<td>MySQL 3.23.58, Master file: approximately 50 MB</td>
</tr>
<tr>
<td><strong>Programming language</strong></td>
<td>PHP4.3.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2) Support system for creation of pesticide use (operating environment)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OS/PC/Browser</strong></td>
<td>Windows XP Professional/ Windows XP Home Edition/ Windows 2000 Professional Internet Explorer Version 6.0 or higher Memory: 128 MB or higher Screen resolution: 1024 x 768 pixels or greater recommended Hard disk with 10 MB free disk space is needed</td>
</tr>
<tr>
<td><strong>Programming environment/language</strong></td>
<td>Visual Basic Ver 6.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3) i-Appli equipped with a barcode reader for the JAN codes (operating environment)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cellular phone model</strong></td>
<td>NTT DoCoMo FOMA900, 901, MOVA505, 506</td>
</tr>
<tr>
<td><strong>Programming environment/language</strong></td>
<td>JAVA(i-Appli), iápli Development Kit for DoJa DoJa3.0 for MOVA, DoJa3.5 for FOMA <a href="http://www.nttdocomo.co.jp/p_s/imode/java/">http://www.nttdocomo.co.jp/p_s/imode/java/</a></td>
</tr>
</tbody>
</table>

### Creation of pesticide use plans

In the support functions for creation of pesticide use plans, an application system for PCs is provided that enables easy creation and judgment of pesticide use plans and spray calendars. When the "gJudgment" button is clicked after a pesticide use plan is prepared, the plan is sent to the Nouyaku-navi judgment server via the Internet. After the plan’s propriety is judged by the Nouyaku-navi server, the judgment is automatically displayed (Fig. 3).

### Characteristics of the Nouyaku-navi judgment server

The judgment function for pesticide use plans in the Navigation System for Appropriate Pesticide Use is implemented on the Nouyaku-navi judgment server (Nanseki, Sugahara and Kikuchi, 2003). The Nouyaku-navi judgment server ([http://nouyaku-navi.info/](http://nouyaku-navi.info/)) is designed so that users can intuitively understand the main points of complicated results regarding the propriety of pesticide application by means of judgment systems which enable users to understand the reasons for the judgment/warning and by contriving the user interface accordingly. The applicable conditions for pesticides are wide-ranging, such as applicable crop, applicable pest and weed, purpose of use, frequency of use, total frequency of use of active ingredient, time of use, instructions for use, applicable region, applicable site, applicable soil, dilution, quantity of use, quantity sprayed, fumigation time, fumigation temperature, and so on. In the latest version, judgments are performed on applicable crop, applicable pest and weed, frequency of use, total frequency of use of active ingredient, pre-harvest interval, dilution, and quantity of use.
The judgment system displays the reason why a planned pesticide application was regarded as inappropriate. To make an intuitively-recognizable display of the results, high-priority judgment items are singled out by investigating the needs of farms. The user interface is similarly devised. For example, signals using red (suspected to be illegal) and yellow (caution needed), similar to traffic lights, are employed in the warning description in order of importance.

**Structure of the Nouyaku-navi judgment server**

The Nouyaku-navi judgment server consists of a database of pesticide registration information, a judgment module and an interface (Fig. 4). The interface is used to input the data on application plans and application records used for judgment to the judgment module, and to pre-treat the data. It is also used to display the consequences of the judgment to users. The judgment module checks the data on the plans against the database to determine whether the plans meet applicable conditions.

When the database of pesticide registration information is created, the pesticide registration information of the Incorporated Administrative Agency Agricultural Chemicals Inspection Station is analyzed. Based on the results, we devise a system by which the information is automatically converted into a form suitable for use in automatic judgment by the judgment server, thus enabling reconstruction of the pesticide registration information database. Among the pesticide registration information, sometimes fine print or footnotes describe the applicable conditions such as frequency of use, total frequency of use of active ingredient, pre-harvest interval, applicable crop and applicable crop.
pest and weed. For this reason, there was the problem that compiling only the pesticide registration information into the database was not enough for automatic judgment via computer. However, compiling and/or updating the interpreted applicable conditions manually whenever the pesticide registration information is updated requires a great amount of manpower and may entail human error.

To solve this problem, a conversion system was devised which analyzes all the applicable conditions in the currently available pesticide registration information and automatically converts it into a form suitable for judgment by the computer (Sugahara, Nanseki and Endo, 2005). This system enables construction of a pesticide database for the Nouyaku-navi judgment server. The devised data conversion system has the advantage that it can provide labor savings and prevent human error from occurring because the data is converted according to rules set in advance. However, the present system cannot convert all the data.

**NEW FUNCTIONS IN THE NOUYAKU-NAVI JUDGMENT SERVER**

Functional enhancements and improvements based on the results of the demonstration experiment in 2004 are as follows:

**New function 1: Judgment function by crop name**

The old version of the Nouyaku-navi judgment server had the problem that it could not judge by crop name because it needed to specify crop codes in pesticide use plans. Therefore, the new version is designed to enable users to assign their own “crop name” by choosing all targeted crop codes on the server prior to judgment (Fig. 5). Thus, in creating a pesticide use plan, when the user designates a “crop name” set beforehand, judgment by the server can be made by the use of all the corresponding crop codes.
Various displays (detailed, brief, color, and monochrome) are available by the XML output.

Monochrome display suitable for printout

Specifying a crop name enables a judgment from all crop codes provided by the server.

Easy-to-see color display

Fig. 5. Screen sample displaying the results of the judgment

<table>
<thead>
<tr>
<th>Crop</th>
<th>Registration Number</th>
<th>Date</th>
<th>Dilution Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>12345</td>
<td>May 1</td>
<td>1:10</td>
</tr>
<tr>
<td>B</td>
<td>67890</td>
<td>June 2</td>
<td>1:50</td>
</tr>
<tr>
<td>C</td>
<td>11111</td>
<td>July 3</td>
<td>1:200</td>
</tr>
<tr>
<td>D</td>
<td>22222</td>
<td>Aug 4</td>
<td>1:1000</td>
</tr>
<tr>
<td>E</td>
<td>33333</td>
<td>Sept 5</td>
<td>1:10</td>
</tr>
</tbody>
</table>

Not applicable pest or weed

Beyond the dilution ratio prescribed

Under the dilution ratio recommended (too low)

Applicable information of the pesticide named the same product name because the pesticide in question is designated as a cancelled pesticide

Applicable information is displayed by clicking pesticide registration numbers.
New function 2: Judgment by pesticide product name

The old version had the problem of being unable to judge by the pesticide common names usually used by farmers and agricultural extension advisers because judgment required specification of pesticide registration numbers. To solve this problem, the new version is designed to make a judgment by automatically searching all the pesticide registration numbers corresponding to the pesticide common name specified by a user.

New function 3: Judgment by name of insect or weed

The old version had the problem of being unable to judge by name of pest or weed because judgment required specification of the name codes of pest or weed. Therefore, the new version is designed to make a judgment by automatically searching the name codes of pest or weed corresponding to the name specified by the users.

New function 4: Various forms and styles for displaying the consequences of the judgment

The old version was designed to output judgment results in HyperText Markup Language (HTML) form. It was difficult to change the output style or form in response to the needs of individual users. Therefore, in the new version, a new system which enables judgment results to be output in Extensible Markup Language (XML) form is adopted. With this output system it becomes possible to display the results in various styles or forms such as detailed or brief display, easy-to-see color display, and monochrome display which is suitable for printout (Fig. 5).

PRIOR JUDGMENT AND REGISTRATION OF PESTICIDE APPLICATION RECORDS AT THE TIME OF THE ACTUAL APPLICATION

Using this function enables users to integrally perform prior judgment at the time of the actual application and registration of the application records (Fig. 6). As a result, users can perform a judgment on the propriety of the application, and if it is determined as appropriate, they can immediately register the record of the application on the system. In addition, users can easily check the registration information of pesticides intended for use in pest control while they are working in the fields or at the pesticide storage lockers.

This function is accomplished by a system consisting of the judgment server and cellular phones. When users access the URL for the cellular phone version of the Nouyaku-navi via cellular phones and input a pesticide registration number or a Japanese Article Number (JAN) code, they can browse the pesticide registration information. In addition, pesticide use plans judged by the server in advance (the results can be displayed by crop or field) are displayed. When the users select “Planning of the field work schedule”, a list of pesticides planned for use before and after the date of working is displayed with the date on which a pesticide was/is to be used (number of days to be displayed can be changed). A pesticide of which the registration number, name, abbreviation, and type matches is simultaneously displayed. Users can judge the propriety of use by selecting the pesticides intended to be applied from the pesticide list displayed. In addition, when users want to apply new pesticides which have not been registered in the plans, the pesticides are added to the existing plans by clicking the “New entry” button.

When users select pesticides, two judgment results, “judgment up to the present date” or “judgment from tomorrow” are displayed. In the former, a judgment is performed on the pesticide use plans, the actual use records up to the date of judgment, and the pesticides planned to be used this time. In the latter, a judgment is performed on all the plans and records including the pesticide use plans from tomorrow. If users select pesticides planned to be used tomorrow, the date of use is changed to the present day and the pesticides are excluded from the target of judgment, for example. In the cellular phone version, the items for judgment are applicable crop, frequency of use, total frequency of use of active ingredient, pre-harvest interval and others. When a plan does not meet these conditions, a warning is displayed with a red signal. Moreover, for a pesticide whose
A common cellular phone with camera can read bar-codes using a bar-code reader. A dedicated i-Appli can accomplish an easier judgment procedure.

Fig. 6. Prior judgment and registration of the application records at the time of the actual application.

Pesticides available are searched from the application plans and the results are displayed. A pesticide applicable can be chosen. New entry of pesticides is also available.

To apply the pesticide and register the application record or to judge propriety of use alone can be selected.

A display of judgment results. Attention is attracted by a warning signal. Two types of judgment can be displayed: judgment based on the application record and the application plan and judgment based on the application record, the application plan, and future plans for application.
frequency of use has reached that prescribed in the standards for pest control and cannot be used for the next application, the system calls attention to this with a yellow signal.

When the Nouyaku-navi judgment server is used via a PC, user authentication is performed by inputting a login ID and a password. However, authentication procedure is more complicated when the system is used via cellular phone from farming fields. To solve this problem, users can in advance register individual identifying information (for example, serial number) of the cellular phone to the Nouyaku-navi judgment server. This information is sent to the server from the cellular phone and checked against the registered information to identify the user. Thus, keyed entry at the time of login to the server is unnecessary under this system.

PROBLEMS IN THE DEMONSTRATION EXPERIMENT AND THE SOLUTIONS IN THE NEW SYSTEM

In the open demonstration experiment performed for about one month from September 17 to October 18, 2004, approximately 450 individuals (people involved in the development of the system were excluded) were registered as users. The experiment demonstrated strong needs from farming fields. The occupations of the registered users showed component ratios higher in farmers and workers of agricultural companies (21%), agricultural extension advisers (the present extension instructors, 17%) and prefectural officials (16%). Persons involved in agriculture accounted for 70% when workers for the Japan Agricultural Cooperatives (JA) (8%) and researchers in agricultural experiment stations (8%) were added (Fig. 7). The ratios of distributors/mass merchandisers (5%), consumers (3%) and co-op workers (2%) were small. However, judgment of pesticide use plans was most frequently performed by the co-op workers, revealing a strong interest in the Nouyaku-navi system among this group. Others included pesticide manufacturers, food manufacturers, software makers, other companies, officials from the Ministry of Agriculture, Forestry and Fishery, and various organizations.

An open demonstration experiment on the improved version of the Nouyaku-navi presented in this paper has been in progress since February 15, 2005. The number of registered users had reached approximately 850 as of July 19, suggesting a strong social interest.

The challenges revealed in the 2004 demonstration experiment were as follows: (1) Improvement of judgment accuracy (on crop codes) and expansion of judgment functions (judgment by pesticide product name and others); (2) Link-up with the systems for farming records and pesticide application records; (3) Development of a version for cellular phones and an on-site warning system before the actual control practice; (4) Development of support functions for creating guidelines on pest control, spray calendars, and pesticide use plans, according to the communities or JAs concerned; (5) Security measures for the systems; and (6) Data preparation and pilot operation for commercialization of the systems (Table 2).

In the new version introduced in this paper, judgments by crop name, pesticide product name, or name of insect or weed, can be performed. Other new functions accomplished are as follows: Integration of prior judgment of application plans and registration of application records, support for cellular phone users, on-site warning system using bar-codes without keyed entry, and functions for providing data on the recommendation for pest control. Furthermore, security measures are being promoted, such as a user authentication system using the serial number of a cellular phone, and encrypted data communication, and a test installation has already started. Thus, many of the problems clarified in 2004 have already been solved. The remaining problems for commercialization of the Nouyaku-navi system include cooperation with the existing farming records and pesticide application records, establishment of the method for using the support systems for creating guidelines on pest control and spray calendars, preparation of pesticide-products’ JAN code data, and others.

CONCLUSION

In Good Agriculture Practice (GAP), it is necessary to understand various risks in agricultural production, to regularize concrete
Fig. 7. Composition of users registered in the demonstration experiment of 2004.

Table 2. Challenges clarified in the 2004 demonstration experiment and the current state of the systems

<table>
<thead>
<tr>
<th>Challenges clarified in the 2004 demonstration experiment</th>
<th>Details of the challenges and the state of the new system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improvement of judgment accuracy (on crop codes) and expansion of judgment functions (e.g., judgment by pesticide product name)</td>
<td>C:Judgment by crop name  C:Judgment by pesticide product name  C:Judgment by name of pest and weed</td>
</tr>
<tr>
<td>Integration with the systems for farming records and pesticide application records</td>
<td>N:Integration of functions of pesticide use plan, judgment and application records  P:Cooperation with the existing systems for farming records and pesticide application records</td>
</tr>
<tr>
<td>Development of a cellular phone-enabled system and an on-site warning system prior to the application</td>
<td>C:Cellular phone-enabled judgment system  C:On-site warning system without keyed entry using pesticide barcodes</td>
</tr>
<tr>
<td>Development of support functions for creation of recommendations on pest control, spray calendars, and pesticide use plans according to the state of the communities or JAs concerned</td>
<td>C:Data acquisition function for recommendation on pest control  P:Establishment of technologies for applying the judgment system remains a problem</td>
</tr>
<tr>
<td>Security measures for the system</td>
<td>C:User authentication through identification numbers of cellular phones  C:Encryption of the data (by use of https and others)</td>
</tr>
<tr>
<td>Data preparation and test installation for commercialization of the system</td>
<td>C:Start of test installation for actual operation  P:Preparation of the JAN code data</td>
</tr>
</tbody>
</table>

Notes: C: completed, N: nearly completed, P: partly completed
countermeasures, and to practice them in farming activities (e.g., Tagami, 2005). For pesticide use, GAP is performed according to the following procedure:

1. Recognize risks of pesticide use (safety of agricultural products, environmental pollution, welfare and safety of workers, etc.),
2. Clarify application procedures for pesticides,
3. Clarify the risks of pesticide use in each application procedure,
4. Devise measures to avoid the risks of pesticide application,
5. Institutionalize risk management of pesticide use and countermeasures,
6. Record the contents of the actual implementation, including the pesticide application records.

In this way, the risks of pesticide use in GAP include a wide range of items from health damage in pesticide applicators to environmental pollution by disposal of pesticide waste. Among these, the target of the Nouyaku-navi is the pesticide misapplication risk which is directly associated with the safety and security of agricultural products. In other words, the Nouyaku-navi is a system aimed at minimizing the risks of pesticide use by performing a prior judgment on the propriety of pesticide application to meet the standards for use set out in the law or contracts and preventing misapplication by users, as well as by supporting objective records of pesticide application. From this viewpoint, the Nouyaku-navi is one of the systems supporting a practical implementation of GAP from the aspect of risk management on pesticide application.

Recently, various traceability systems for agricultural products have been suggested and their commercialization has been promoted to deal with consumers’ interest in the safety and security of agricultural products. Although these systems often include functions for ex-post checking of pesticide application records, there are many remaining problems from the viewpoint of risk management of pesticide misapplication. To solve these problems, it is necessary to develop systems with different concepts from those of the conventional traceability systems. In other words, the process required for risk management of pesticide misapplication is not a flow of disclosure of the information on distribution pathways, but the following:

- disclosure of the information on pesticide application records
- registration of pesticide application records
- ex-post check on pesticide application records, but a flow of judgment on the propriety of pesticide use
- automatic registration of pesticide application records
- disclosure of the information on pesticide application records.

The former is a process based on the concept of the conventional traceability systems, and the latter is the concept of the Nouyaku-navi system.

However, the two systems must obviously be integrated. When pesticide application records created by the automatic process from “Judgment on the propriety of pesticide use” to “Automatic registration of pesticide application records” under the Nouyaku-navi system are incorporated into the existing traceability systems, a seamless integration of these systems will be accomplished. Thus, it is expected that the safety of agricultural products will be further improved and enhance the security of consumers by collaboration between the Nouyaku-navi and the existing traceability systems.

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