# The Application of Decision Support System to Forecast the Yield of Agricultural Products in Taiwan

Lee, Tzong-Ru
Associate Professor
Department of Agricultural Marketing
National Chung-Hsing University
Taiwan, R.O.C.

Abstract

To make agricultural marketing policies be carried out more easily, this research establishes a decision support system by using the rice field of one farmer in Changhwa area, Taiwan as the example and explains how this decision support system works. Actually, this research has three purposes: 1.To study how key production factors affect the yield of rice variety No.67. 2.To establish a decision support system to forecast the yield of rice variety No.67. 3.To use Visual Basic to write computer programs which can simulate how yield changes if key production factors change.

There are four sections in this paper: literature review, the establishment of decision support system, example and conclusion.

## 1. Literature Review

This section is divided into two parts: situation of agricultural status data and introduction of decision support system.

### 1.1 Situation of agricultural status data

Currently, the main information source for the collection of agricultural status data is from field investigating staffs. Taiwan Government started to establish field investigating staffs in 1986 and in 1997 there were 2441 of them. The content of their work mainly predict the yield or production of fish, livestock and other agricultural products. When the disaster comes, they also need to report or evaluate the damage degree of Agriculture. Hsiao(1997) pointed out that the accuracy and timing of the forecast made by field investigating staffs needed to improve. Hence, this study tries to use the decision support system to improve the accuracy and timing of forecast. The pre-requisite is to determine who should be the knowledge provider of this system because the degree of profession can affect the accuracy of forecast of the decision support system.

Our research's cooperating rice farmer has being in rice farming over 20 years and knows local temperate condition, local environment and land management very well. He has an agricultural degree, owns an agricultural chemicals store and often attends seminars to learn knowledge about rice farming. Also, this farmer is over 55 years old with a mild temper and can control mood and stress maturally. Hence, the selected farmer is a professional with high credibility. From years of experience, rice farming farmers know how rice yield changes when any of the key production factors changes such as the strength of local wind and soil condition. More important is that they also know how key production factors affect each other. Thus, the yield of rice forecasted by these farmers can reach a reasonable accuracy.

This study uses the concepts of decision support system to extract knowledge from this farmer and apply it to forecast the yield of rice to increase forecasting accuracy.

1.2 Introduction of decision support system

Little(1970) defined decision support system as a data processing and distinguishing process based on models, aiming to increase the quality of decisions made by decision makers.

In other words, decision support system is the combination of tools, data and techniques which is designed to help managers to make ad hoc decisions. Ad hoc means that due to the change of situation some necessary information can't be forecasted during the decision marking process. In the real world, problems can be divided into three types: structured problems (routing work, such as secretarial typing), semi-structured problems (happen more than one time in one's life but the number of times is low, such as buying a house or a car) and unstructured problems (happen less than or equal to one time in one's life, such as selecting the cover of an advertisement). Different type of problems need different supporting techniques to get acceptable and feasible solutions. Table 1 shows the suitable techniques for each type of decision. The general purposes for establishing a decision support system are:

1. improving the efficiency and effectiveness of decision makers.
2. acting as a decision support tool for semi-structured and unstructured problems.
3. helping decision makers to manage knowledge.
4. smoothing the problem solving process.

Because the weather condition is different every year, we can say that to forecast the rice yield belongs to the semi-structured problem.

Table 1. Decision types and their corresponding suitable techniques

| Decision Type | Suitable Tools |
|---|---|
| Structured problem | Management information system<br>Managerial science model |
| Semi-structured problem | Decision support system |
| Unstructured problem | Manager's intuition |

2. The establishment of decision support system

Due to natural and man-made factors, the yield of rice can't be forecasted accurately in easy ways. Furthemore, water deficit crisis happened periodically in Taiwan made the forecast of rice yield a semi-structured problem. Thus, this study tries to establish a decision support system to solve yield forecast problems. The constructing steps of this decision support system are as follows:

1. To collect related literature: it contains (1).data of rice production factors (2)related theories of and research on the forecast of rice yield in Taiwan (3)theories and applications of decision support system
2. To build a decision support system which is composed of two parts.
   Part 1: Interface.
   We use graphs, icons, figures or tables to make the system user-friendly.
   Part 2: Modulization.
   Modulization concept is used in this research to develop, test and justify the system.

3. Example

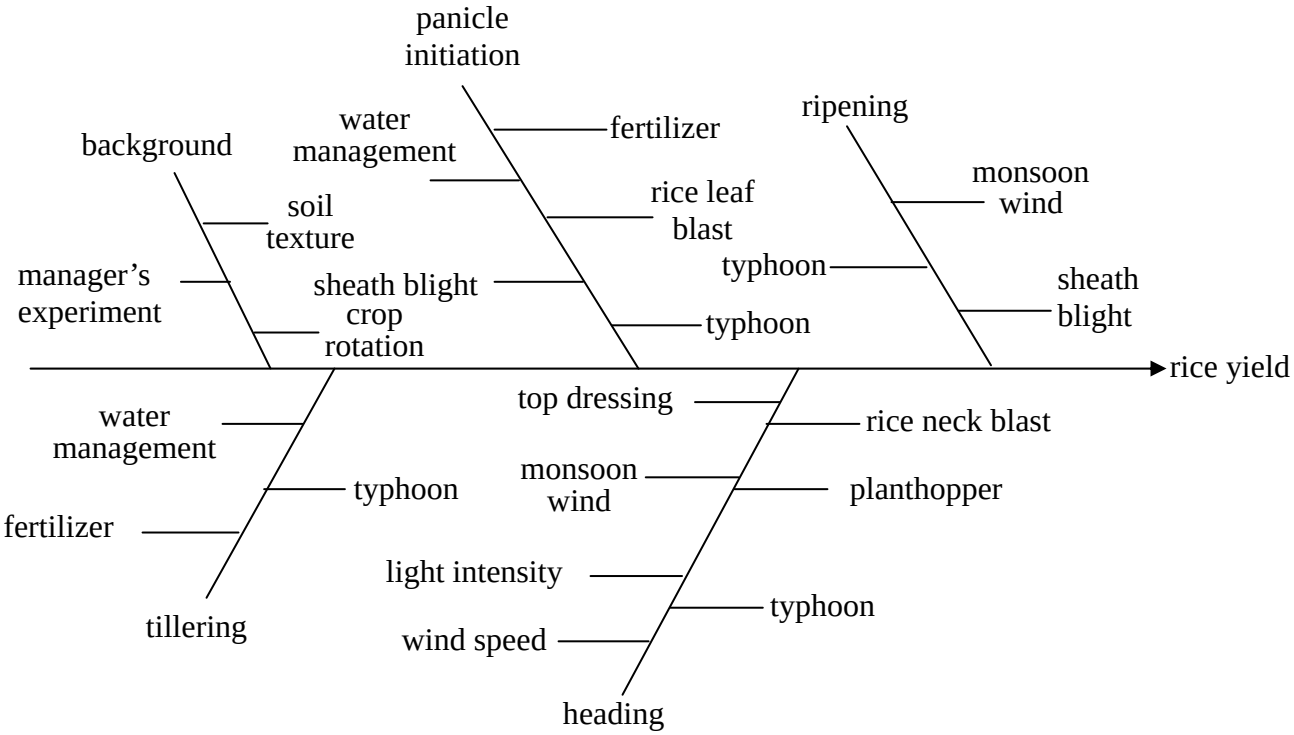


Figure 1 The key production factors of yield of rice variety No.67

Our research companion is a farmer with more than 20 years experience in planting rice. Therefore, he is so familiar with the environment around his farm. Based on this senior farmer's knowledge, we divide the whole growing process into five periods (background, tillering, panicle initiation, heading and ripening) and try to find out how each key production factor influences the production. It's not an easy job because each factor is not independent. That is, the change in one single factor may influence the values of more than one other factor simultaneously. Based upon the farmer's experience his average rice yield is 17,650 kilograms per hectare. Figure 1 is the fishbone of factors which will influence the yield of rice variety No.67. Figure 2 is the man-machine interface design based on Figure 1. Table 2 shows the steps to develop a decision support system and their corresponding activities in this research.

Based on Figure 1 and conversations between researchers and this senior farmers, we classify all possible knowledge into 26 rules (as shown in Table 3) which can represent the interaction between each factor.

Some terminology in some rules of Table 3 is not well-defined because it is defined by farmer's sloan. For example, the definition water usage can be shown below. (1).Overuse: when you step into the rice farm with bare feet, the heel of your feet will be in water completely. (2).Adequate: when you step into the rice farm with bare feet, you can see your footprint. But your heel is not in water completely. (3).Inadequate: when you step into the rice farm with bare feet, you can see your footprints clearly.

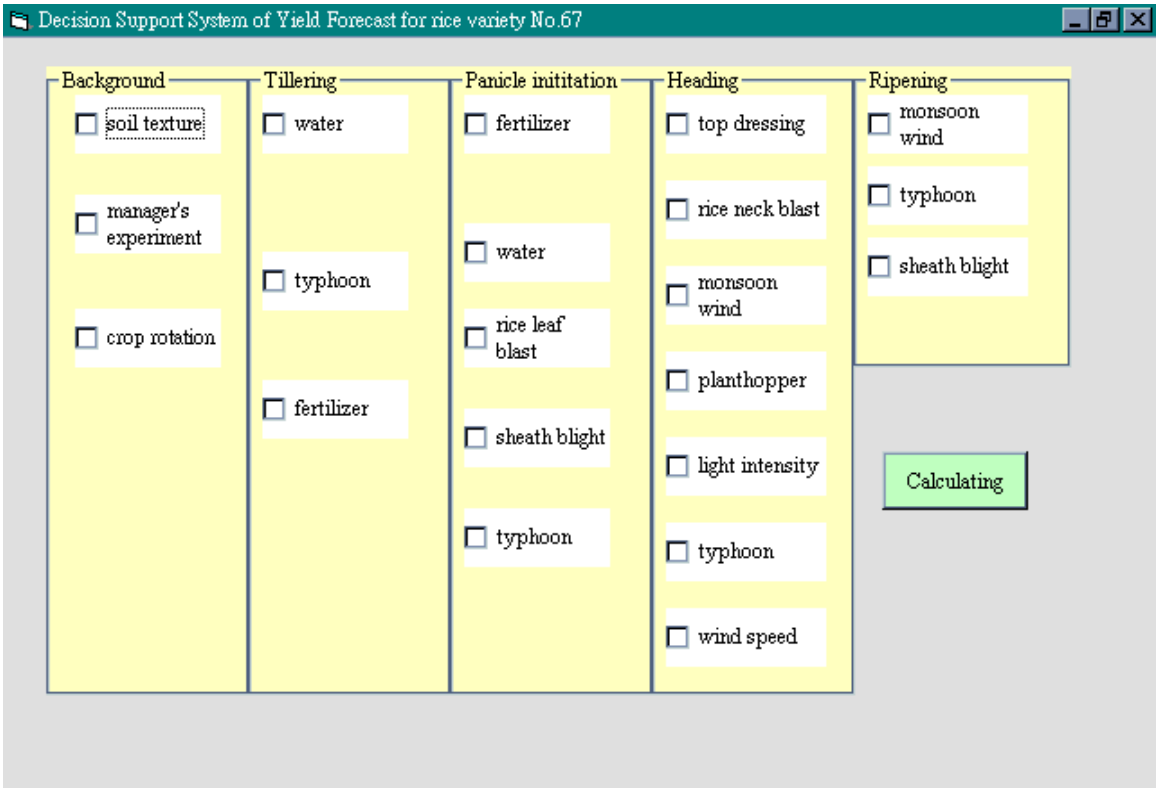


Figure 2. The man-machine interface of the decision support system

Table 2. The steps to develop a DSS and their corresponding activities in our research

| Steps to develop a DSS* | Corresponding activities in our research |
|---|---|
| Problem Definition | To forecast the rice yield of a particular land |
| Feasibility Analysis | To know the DSS is a tool to forecast the rice yield after interviewing the senior farmer |
| System Analysis | (1)To divide rice growing processes into 5 periods (2)To list the key production factors in each period and (3)To build the relationship between each key production factor. |
| Design | Using "if-then" structure to represent knowledge |
| Programming | To write computer programs by using Visual Basic language. |
| Testing | To test the performance of the DSS by using real case. |

Note: DSS means “decision support system”

The knowledge in the knowledge base of the decision support system is mainly from the senior farmer. It's better to define rules in the decision support system based on farmer's terminology. Take rule 19 and 22 as example, if farmers do not use pesticide but planthopper comes in heading period, then the rice yield will decrease 50%. If there is a typhoon in tillering, panicle initiation, heading or ripening period, then we can ignore the influence of water to the rich yield. That is, we can ignore what rule 4 says.

Table 3. Rules for forecasting yield for rice variety No.67

| | |
|---|---|
| rule1 | IF (background. soil texture = sandy soil)<br>THEN yield- 13% |
| rule2 | IF (background. crop rotation = yes)<br>THEN yield + 20% |
| rule3 | IF (background. manager =with experience)<br>THEN yield + 15% |
| rule4 | IF (tillering. water =overuse)<br>OR (tillering. water =inadequate)<br>OR (panicle initiation. water = overuse)<br>OR (panicle initiation. water = inadequate)<br>THEN yield- 10% |
| rule5 | IF (tillering. fertilizer =overuse10%)<br>AND (panicle initiation. fertilizer =continue to use)<br>THEN yield - 15% |
| rule6 | IF (tillering. fertilizer =overuse10%)<br>AND (panicle initiation. fertilizer =stop to use)<br>THEN yield - 10% |
| rule7 | IF (tillering. fertilizer =overuse20%)<br>AND (panicle initiation. fertilizer =continue to use)<br>THEN yield - 35% |
| rule8 | IF( tillering. fertilizer =overuse20%)<br>AND (panicle initiation. fertilizer =stop to use)<br>THEN yield - 35% |
| rule9 | IF (tillering. fertilizer = inadequate)<br>THEN yield - 10% |
| rule10 | IF (panicle initiation. pesticide =used)<br>AND (panicle initiation .rice leaf blast =happened)<br>THEN yield - 10% |
| rule11 | IF (panicle initiation. pesticide =unused)<br>AND (panicle initiation. rice leaf blast =happened)<br>THEN yield - 45% |
| rule12 | IF (panicle initiation. pesticide =used)<br>AND (panicle initiation. sheath blight =happened)<br>THEN yield - 5% |
| rule13 | IF (panicle initiation. pesticide =unused)<br>AND (panicle initiation. sheath blight =happened)<br>THEN yield - 20% |
| rule14 | IF (heading. top dressing =overuse)<br>THEN yield - 20% |
| rule15 | IF (heading. monsoon wind =happened)<br>THEN yield - 20% |
| rule16 | IF (heading. rice neck blast =happened)<br>THEN yield - 35% |
| rule17 | IF (heading. light intensity = inadequate)<br>THEN yield - 5% |
| rule18 | IF (heading. wind speed =strong)<br>THEN yield - 10% |
| rule19 | IF (heading. pesticide =unused)<br>AND (heading. planthopper =happened)<br>THEN yield - 50% |
| rule20 | IF (ripening. monsoon wind =happened)<br>THEN yield - 10% |
| rule21 | IF (ripening. sheath blight =happened)<br>THEN yield - 20% |
| rule22 | IF (tillering. typhoon =happened)<br>OR (panicle initiation. typhoon =happened)<br>OR (heading. typhoon =happened)<br>OR (ripening. typhoon =happened)<br>THEN ignore rule 4 |
| rule23 | IF (ripening. typhoon =happened)<br>THEN (yield - 30% AND Stop) |
| rule24 | IF (heading. typhoon =happened)<br>THEN (yield - 40% AND Stop) |
| rule25 | IF (panicle initiation. typhoon =happened)<br>THEN (yield - 25% AND Stop) |
| rule26 | IF (tillering. typhoon =happened)<br>THEN (yield - 20% AND Stop) |

In this paper, we use the "if- then" structure of the Visual Basic computer language in PC to write the decision support system for forecasting the rice yield. The flowchart of the computer programs of decision support system is shown in figure 3.

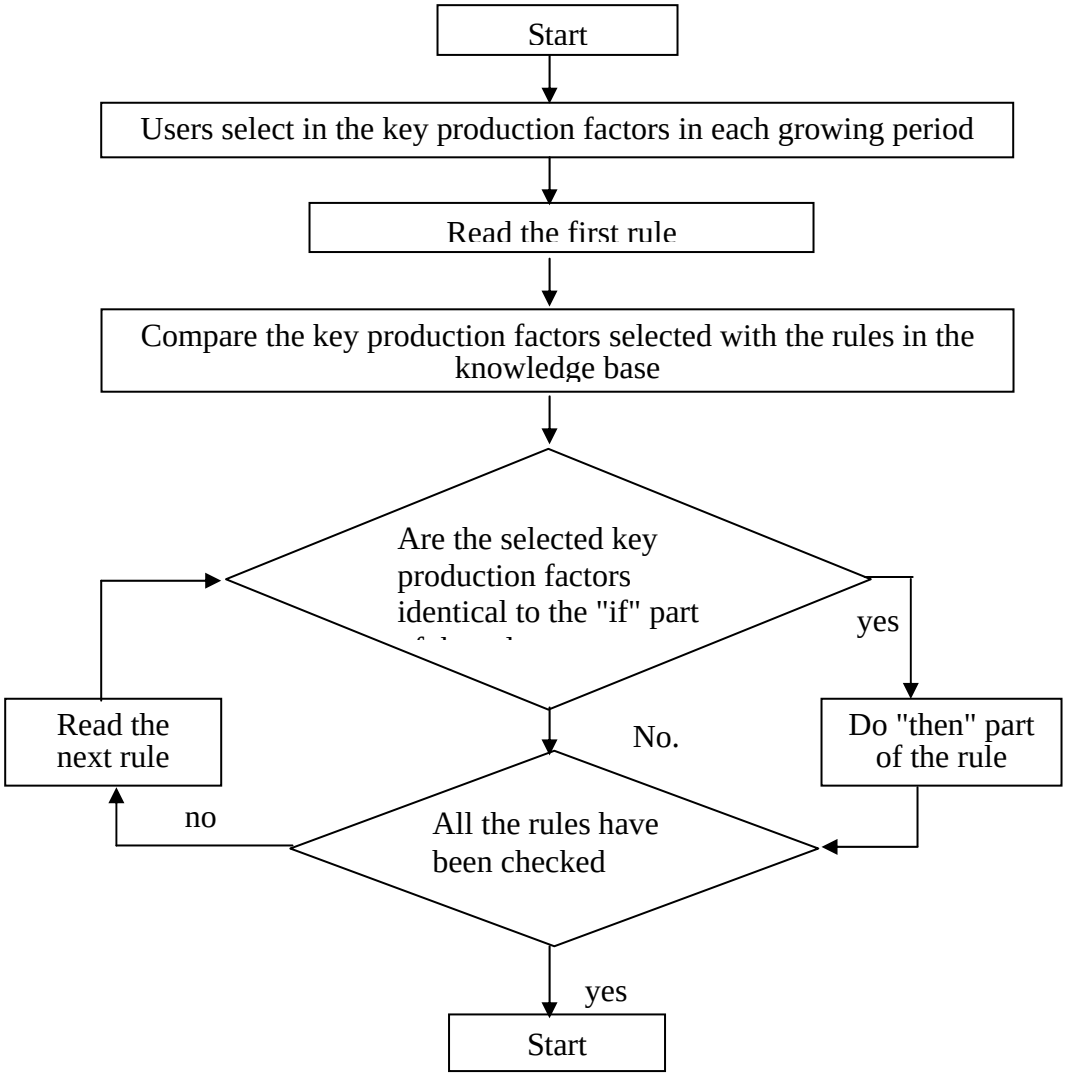


Figure 3 the flowchart of the decision support system

The senior farmer told us that the rice yield of his land (0.1 hectare) in 1996 is 1,417 kilogram because he overused 20 % of fertilizers in tillering period, he continued to use fertilizers in panicle initiation period, water usage is not enough in tillering period, he uses crop rotation and he is full of experience. The claculation of Figure 4 and 5（urge rules 2, 3, 4 and 7）shows the rice yield of the senior farmer's land is 1,425 kilograms. The difference between the real rice yield and the rice yield forecast is acceptable.

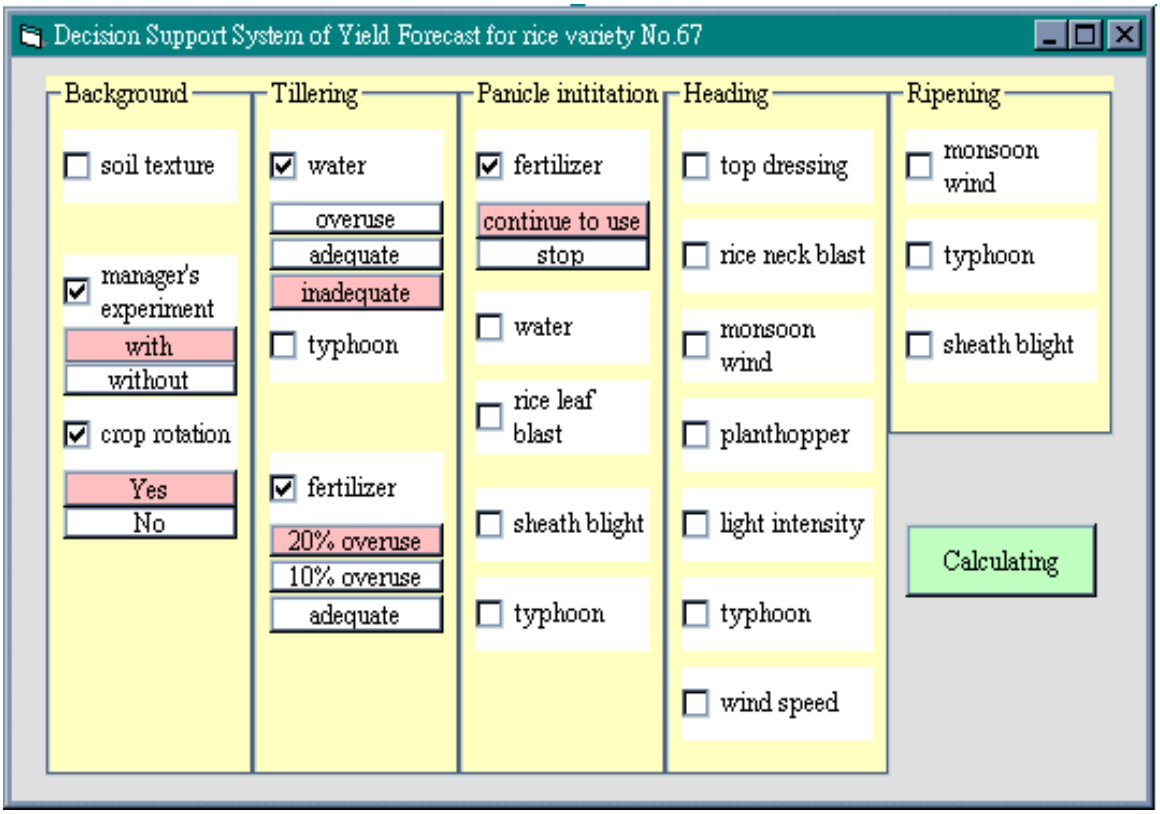

Figure 4. Key production factors selected in the example

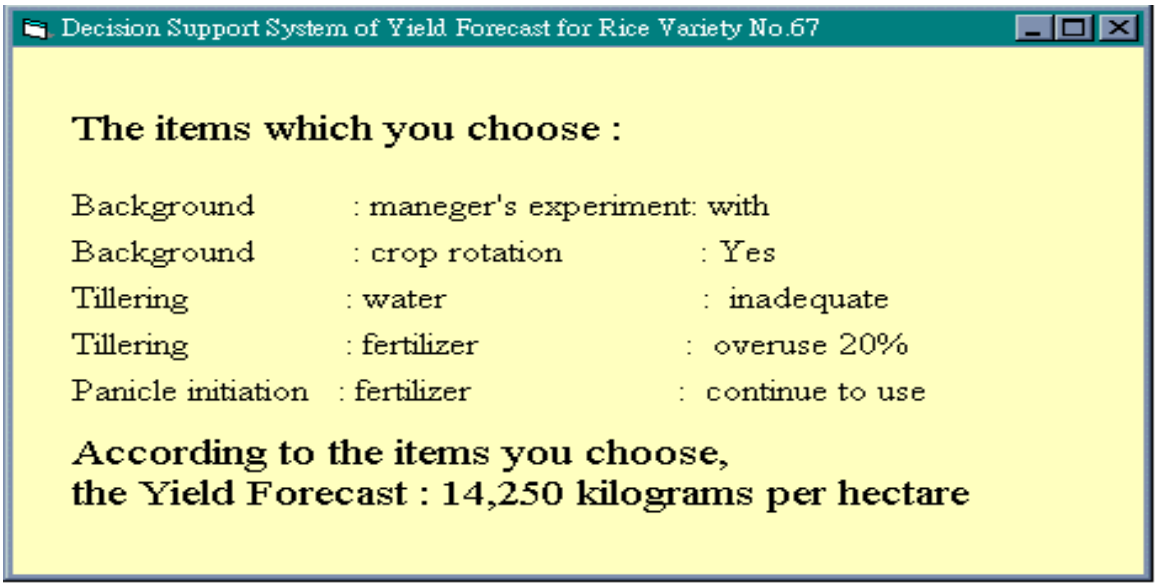

Figure 5. The forecast result of the decision support system

## 4. Conclusion

The purpose of this research is to forecast the rice yield of a particular land in Taiwan by developing the decision support system. The advantages of this decision support system are (1).we can predict the rice yield before the harvest and(2) the impact of the disaster can be known in advance when the disaster happens. The performance of the

decision support system developed in this paper is acceptable because the forecast rice yield is very close to the real world.

As we know, the soil texture, climate, land management style is quite different in each area in Taiwan. Therefore, we need to consider the difference in areas when we use the decision support system to predict the rice yield in broader regions.

References


1. Holsapple, Clyde W. and Andrew B. Whinston, 1996, *Decision Support Systems: A Knowledge-Based Approach*, West Publishing Company.
2. Hsiao, Hsiu-Chin, 1997, *The changes and future development of vegetable yield forecast task in Taiwan*, conference of forecasting vegetable production, National Chung-Hsing University.
3. Little, J. D. C., 1970. “Models and Managers: The Concept of a Decision Calculus.”, *Management Science*, Vol. 16, No.8.
4. Su, Mao-Hsiang, Hao-Chieh Wang, 1997, *Introduction to Agricultural Status Report*, conference of forecasting vegetable production, National Chung-Hsing University.