Rice Objective Yield Survey in Japan

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ABSTRACT

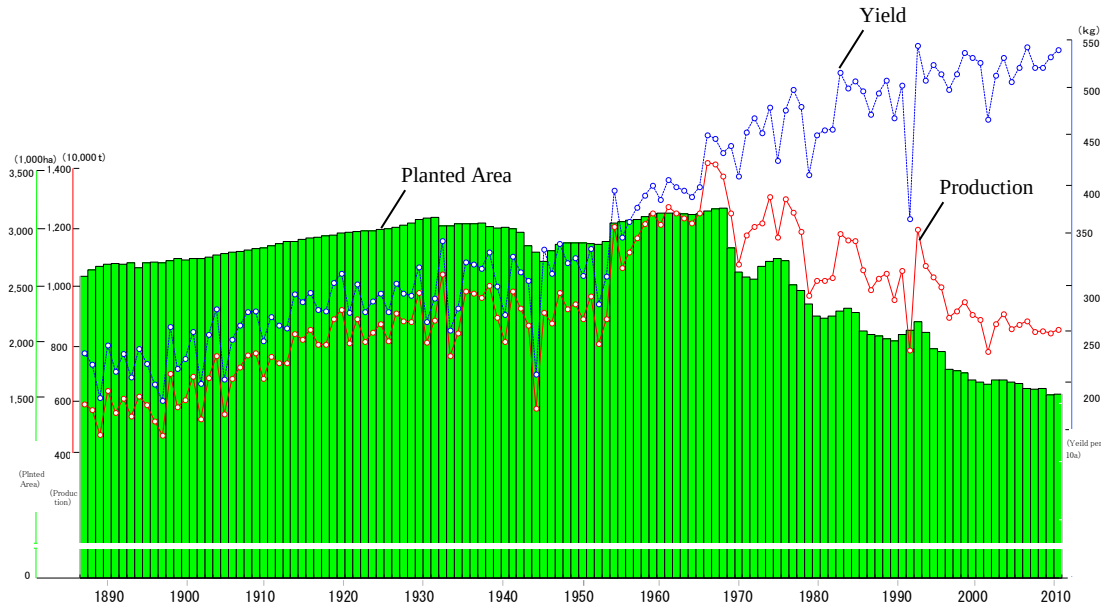
Rice production is estimated by results of objective yield survey in Japan. The number of sample field is around 10,000 and those are selected by random sampling. Before harvest season, yield is forecasted by number of stocks, number of ears, number of grains and weight of 1,000 grains. When those items can be measured, measured value is used for estimation. If not, items are forecasted by prediction formula. After experimental harvest is conducted, yield is estimated by weight of sample. Current method is established as a result of several revisions but we need to seek more efficient method.

Key Terminology Objective Yield Survey, Random Sampling, Regression Formula

1. Background:

Rice is a staple food in Japan. Although diversification of dietary life is making rice consumption and production decrease, it is still main agricultural product and production of rice is 8.6 million ton and consumption of it is 7.2 million ton in 2012. Result of rice objective yield survey is one of the most important agricultural index and widely utilized for preparing agricultural policy by politicians and the ministry or deciding farming plan by producers, thus the survey result must be released accurately and quickly. The ministry of agriculture, forestry and fisheries is conducting the objective survey by using of random sampling method more than 60 years.

Chart 1 Change in Rice Production in Japan



2. Methodology Used

(1) Purpose and System of the Survey

The rice objective yield survey is conducted to prepare necessary documents for administrative measures in the fields of agriculture, forestry and fisheries, such as the estimation of supply and demand for rice and planning measures for the rice production.

The surveys are conducted 5 times a year (July, August, September, October and Harvest Season). The survey is conducted by Statistics Department, Ministry of Agriculture, Forestry and Fisheries Japan (hereinafter referred to as "MAFF"). Survey in the field is carried out by governmental official of Area Centres that are set in each prefecture and the result is reported to Regional Agricultural Administration Offices and HQ of MAFF to estimate regional and national value.

Chart 2 Organization of MAFF

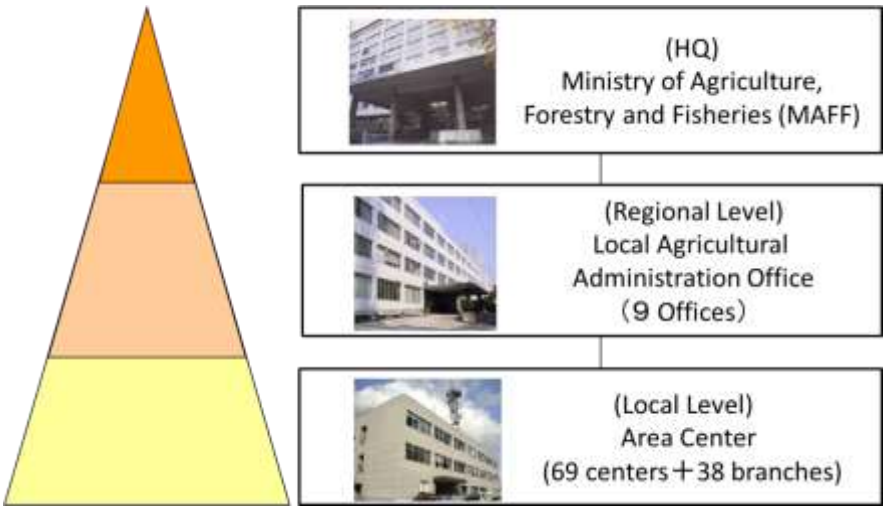
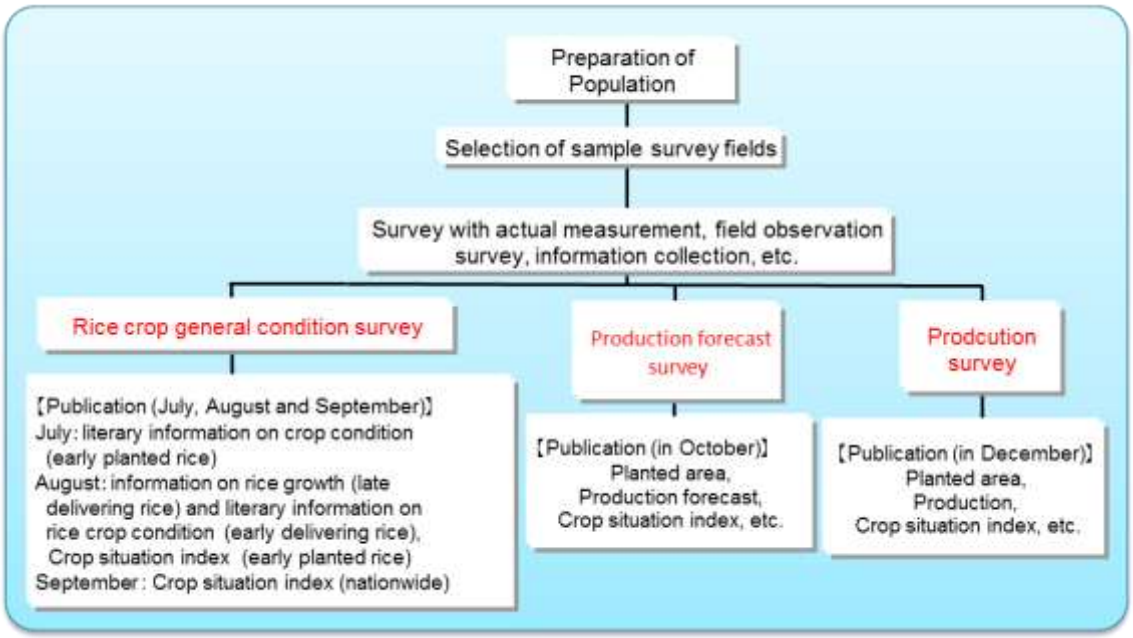


Chart 3 Survey System



(2) Survey Items

Rice is grown once a year and cultivation period is from May to October in Japan generally. Depending on the developing stage of rice, the items of each survey are decided and the yield is forecasted based on the survey results we get at the time, before experimental harvest survey.

Chart 4 Growing Stage of Rice

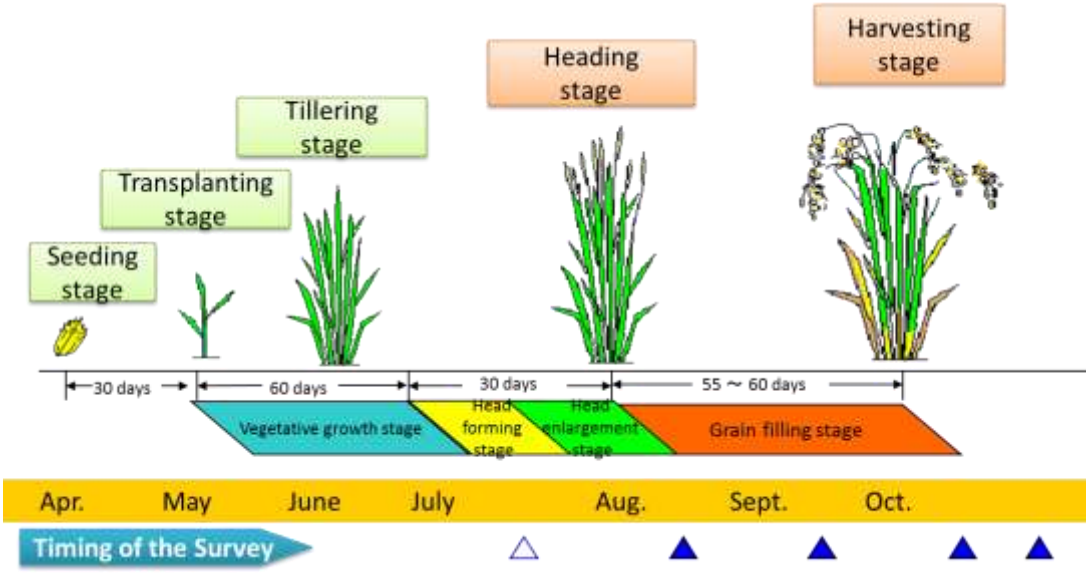


Chart 5 Survey Items by Survey Period

Survey period \ Survey items		Seeding situation	Nursery plant conditions	Planting situation	Rooting situation	Plant height	Number of stocks/ number of stems	Heading/flowering situation	Number of panicles	Number of grains per a panicle	Ripening conditions	Grain growth conditions	Damage situation	Rice cultivation technology, etc.						Yield constitutional component
														Seeding method	Transplanting method	Changes in variety	Fertilizer application situation	Pest control situation	Harvesting method	
Rice crop general condition	July	★	★	★	★	★	★	★	★	★			★	★	★		★	★		
	August	★	★	★	★	★	★	★	★	★			★	★	★	★	★	★		
	September							★	★	★	★	★	★				★	★		
Production forecast (October)									★	★	★	★	★				★	★	★	
Production (harvest season)												★	★						★	★

Note: Only main survey items are mentioned, due to different stages of rice development in different locations.

(3) Survey Method

A. Sample Allocation

a) Number of sample of each prefecture is calculated in HQ MAFF based on aimed precision and informed of Area Centres through Regional Agricultural Administration Offices. Average of aimed precision of prefecture is approximately 1%. Average number of sample is around 220 fields in each prefecture and total is around 10,000 fields.

b) In Area Centres, they stratify area where they are in charge, based on geography, cultivated variety and trend of cultivation etc. then they allocate samples to each stratum depending on product of "Planting Area of Previous Year x Population SD of Yield per 10are (a, 1a=10meter x 10meter) ".

B. Selection of Sample Field

a) The total area of Japan is divided into a grid of 200m x 200m square (a 400m grid square for Hokkaido), which is defined as a "land unit" in this survey. Of all grids, those containing paddy fields are defined as survey population.

b) Of the population, approx. 10,000 land units are randomly selected as sample land units.

c) In each selected sample land unit, a parcel of paddy field is randomly selected as "sample survey field (farmland to be surveyed)" out of paddy field planted paddy rice.

d) In each sample survey field, 3 points are randomly selected as points to be surveyed diagonally in farmland by the table of random numbers.

C. Measured Item at sample field

a) Length of Rows and Length of Stocks

We measure length of 11rows and length of 11 stocks at 3 survey points in a sample field and calculate average of 3 points. Then we calculate number of stocks per $1m^2$. The result is used to convert result of experimental harvest to yield per 10a

b) Height of Plant

We measure height of plant of 5 stocks at 3 survey points (total 15 stocks) in a sample field to understand growing condition.

We multiply the results of c) and d) by number of stocks per $1m^2$ to calculate number of stems per $1m^2$ and number of panicles per $1m^2$.

c) Number of Stems

We count number of stems of 10 stocks at 3 survey points (total 30 stocks) in a sample field to understand growing condition.

d) Number of Panicles

We count number of all panicles and number of sterile panicles of 10 stocks at 3 survey points (total 30 stocks) in a sample field. Then we deduct number of sterile panicles from number of all panicle to calculate number of fertile panicle. The result is used for forecasting yield.

e) Number of Grains

We count number of grains of total 10 stocks at 3 survey points (1st point : 3 stocks, 2nd point : 4 stocks, 3rd point : 3 stocks) At each survey point, number of grains of highest panicle and 2nd lowest panicle of the stock are counted and average number of grains per a panicle is calculated. Then number of grains per $1m^2$ is calculated by multiplying number of grains per a panicle by number of fertile panicles per $1m^2$. The result is used for forecasting yield.

f) Experimental Harvesting Survey

Rice grains are cultivated in area equal to $1m^2$ in each of the 3 survey points (an equivalent of $3m^2$ in total), and the cultivated rice grains are threshed, dried and hulled. Brown rice that is considered fit for the table is selected (i.e. brown rice ranked as third grade or higher as defined by the Agricultural Products Inspection Act and retained on a mesh sieve with openings of 1.70mm and over) Finally yield per 10a is estimated based on the weight of brown rice considering combine loss etc.

(4) Method to Estimate Yield per 10a

3 different methods are adopted depending on the timing of estimation. At first, normal yield is estimated before planting. Normal yield is estimated on the basis of the trend of past production, taking into consideration the improvement in cultivation method and the recent trend in production, on the assumption that weather condition and crop damage are equal to those of normal years. Normal yield is used for calculating percent change from the normal year (hereinafter referred to as “Crop Situation Index”, please see (5) for detail explanation). Then, after planting, yield is forecasted by regression formula utilizing surveyed value. Lastly,

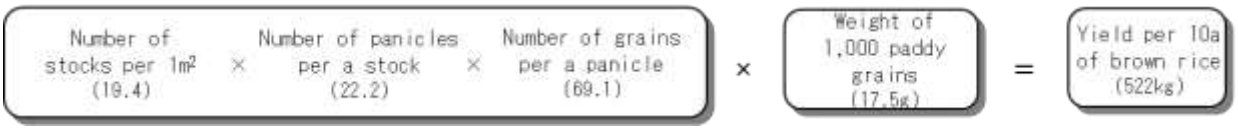
after harvest season, the result of experimental harvesting survey is used to estimate yield as explained in 2 (3).

A. Forecast before Harvesting

a) Element of Yield

It is very difficult to forecast yield per 10a directly with high accuracy because yield is affected by a lot of factors. Therefore yield is broken down following elements and each element are surveyed or forecasted.

Chart 6 Element of Yield



※The values shown are only examples

When you calculate yield by above mentioned formula, the surveyed value is used for elements that can be measured in the time of forecast. On the other hand, Elements that cannot be measured at the time is forecasted by prediction formula based on historical meteorological data and surveyed data.

b) Prediction Formula

Multiple regression equation is adopted as a prediction formula basically. Historical Meteorological data and surveyed value are used for variables of the equation. Among elements of yield, weight of 1,000 grains cannot be measured before conducting experimental harvest survey so it is vital to forecast weight of 1,000 grains as accurately as possible. Therefore we use surveyed value as soon as we get and meteorological data which is selected by knowledge of crop science for variables to forecast weight of 1,000 grains. One example is shown below (Variables are different from prefectures.).

Chart 7 Example of Multiple Regression Formula

$$Y=5.470+0.205(x1)-0.023(x2)-0.003(x3)$$

$R^2=0.958$

Y : Weight of 1,000 grains
X1: Rate of Insemination
X2: Total number of unripened rice per 1m²
X3: Accumulated 20 days of low temperature after heading of panicle

c) Change in Yield by Survey Period

When we see change in yield per 10a by survey period last 10 years, it is little changed from October to final data. From September to final data, it decreased 5kg average in the year

when serious damage is occurred by typhoon. When we compare Crop Situation Index, it is little changed from September to final data.

Chart 8 Changes in Yield per 10a by Survey Period

Unit : kg

Year	Sept.	Oct.	Final Data	Reason of Change
2004	528	514	514	Injury of Ripening by typhoon and long period rainfall
2005	536	532	532	Injury of Ripening by high temperature and insects
2006	515	508	507	Salty wind damage
2007	523	522	522	
2008	542	543	543	
2009	521	522	522	
2010	526	522	522	Injury of Ripening by high temperature
2011	535	533	533	
2012	539	540	540	
2013	543	539	539	Typhoon, insects and disease

Chart 9 Changes in Crop Situation Index by Survey Period

Year	Sept.	Oct.	Final Data	Reason of Change
2004	101	98	98	Injury of Ripening by typhoon and long period rainfall
2005	102	101	101	Injury of Ripening by high temperature and insects
2006	97	96	96	Salty wind damage
2007	99	99	99	
2008	102	102	102	
2009	98	98	98	
2010	98	98	98	
2011	101	101	101	
2012	102	102	102	
2013	102	102	102	

B. Calculating Normal Yield per 10a

When we estimate normal yield, we consider that elements of yield variation is consist of moderate annual variation caused by change of production situation such as composition of variety and meteorological variation. Then moderate annual variation is shown by spline function and meteorological variation is shown by multiple regression equation.

At first, historical data of yield per 10a since 1979 is prepared and element of meteorological variation that affect yield is removed from historical yield data to estimate correction value of yield. Then trend value is estimated by spline function using correction

value. Finally we estimate normal yield based on correction value taking into consideration of the latest production situation.

Chart 10 Estimation of Normal Yield

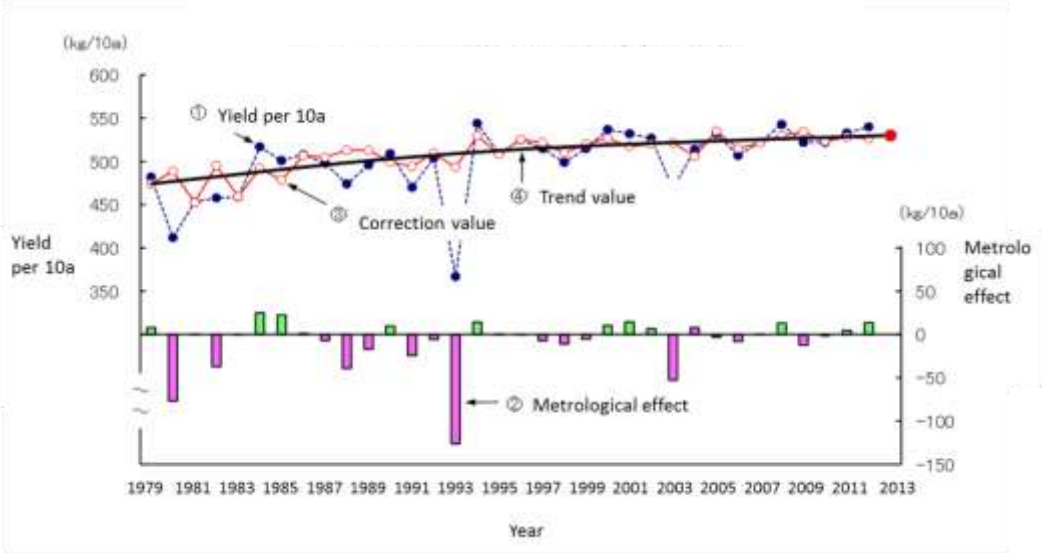
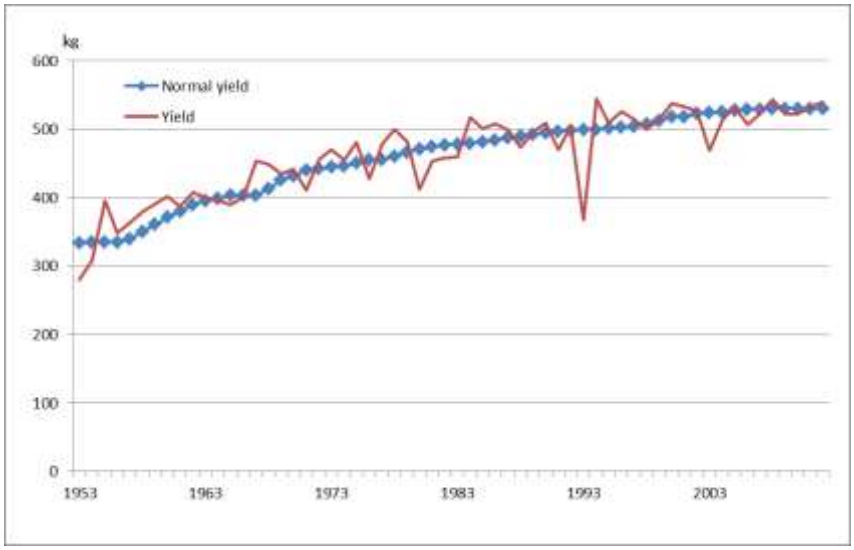


Chart 11 Changes in Yield and Normal Yield



(5) Crop Situation Index

Crop Situation Index is the one to measure rice production situation of the year and is defined as a ratio of “forecasted yield per 10a” to “normal yield per 10a”. This index is published August, September, October and December and is very popular in Japan because it shows rice production situation straight.

Chart 12 Crop Situation Index

$$\text{Crop Situation Index} = \frac{\text{Yield per 10a}}{\text{Normal Yield per 10a}} \times 100$$

3. Conclusions

The result of survey estimated above mentioned method has a quite high accuracy and Standard Error Ratio is 0.13% in national total in 2012. The result is utilized for several agricultural policies such as forecasting supply and demand of rice.

Although our current survey system is well established, we have made a lot of efforts to reach current system for more than 60 years conducting survey every year and revised method many times to make the survey more accurate and efficient, taking into account of user needs, progress of cultivation method, budget and number of staff of the organization.

For example, number of sample field is reduced from approx. 34,000 in 1965 to approx. 10,000 in 2012 and area of survey points of a sample field is also reduced from 9.9m^2 (3.3m^2 x 3 points) to 3m^2 (1m^{2}x3 points). Regarding the method of forecasting yield, yield was tried to directly forecast before but currently we adopt method to resolve yield into its composition elements and survey or forecast each elements as I explained before. Furthermore normal yield was average of past years originally and the estimation method was revised to use regression formula and now it is estimated by using spline formula to reflect recent trend more adequately.

Of course we still have challenges to be overcome. As just described, current system is with great accuracy but we need to streamline the method more keeping accuracy of survey. Because a lot of officials are necessary to conduct the current survey system, especially for field survey and unfortunately the number of staff is expected to be decreasing in future. Although we do not have specific idea now, we might consider reduction of sample, change of survey method and introduction of new technology etc.. We hope to find some hints in presentations of the expert meeting for our future consideration.