Methodology of Study on Farm Operation System

By HIROSHI IKEDA

Upland Farming Division, Central Agricultural Experiment Station

A number of studies have been made in recent years to systematize production technology which utilizes medium or large farm machinery. Socioeconomic background of Japanese agriculture requires this kind of research. Although these studies are recognized to be important and even socially inevitable, research results have been regarded merely as a case study, specific to a given condition. Principles obtained by these studies have not been properly utilized by farmers, and the feedback of problems raised in the process of an integration of individual components into a system of technology to different disciplines of research have also not been done well. Main reason for that can be found in the fact that the assessment of research results have not been properly made or left to be ambiguous. In this sense, it can be said that the research on systems of production technology has not yet established the scientific methodology.

The purpose of this paper is to define scope and content of the study on farm operation system, as being oriented between related research disciplines on one hand and the actual farm management on the other hand, with an attempt of establishing scientific methodology for this kind of research.

Farm operation system studies

The term "farm operation system" signifies a whole system of labor-oriented production technology in which inter-related individual farm operations (refer to components) are integrated to complete crop production—in other words, a structural unity of systematized production inputs applied in the whole process of farm operations.

Studies on farm operation system are usually carried out by repeating a series of three steps, i.e., (1) designing of a system, (2) checking and verification of the system, and (3) development of improved system, by the trial-and-error method. To obtain fruitful results with high efficiency, information obtained at each step of the research has to be integrated or analyzed properly and rationally. For this purpose, it is necessary to adopt the system engineering methodology for the integration and assessment of information, particularly at the step of designing and in technical assessment.

Works to be done are described below:

1) Data and information are collected from research results obtained in related research fields, and by integrating these information new designs of the system are developed.

2) Some of the farm operations which are considered to be important from the technical point of view are examined by conducting verifying field experiments.

3) Based on the results of these experiments, optimum farm operation plans are worked out. These plans are assessed as the possible components of the whole system. As a result, problems to be solved in developing the system are made clear, giving concrete targets for research.

For designing and assessment, the linear programming method, one of the methods of so-called operations research (OR), was applied. Regarding the premises for application of the linear programming method, the linearity, independency, additivity and divisibility of the objects were examined. As a result it was found that these premises were practically satisfied by using number of 0.3 ha field unit as the variable.

Farm operation system for Italian ryegrass—lowland rice cultivation

From 1964 to 1968, a group of research workers, including the author, carried out the study on the Italian ryegrass—lowland rice cultivation on double cropping paddy field by the use of medium and large size farm machines. By utilizing the result of this study, the author developed the method to calculate the various coefficients to be used for the application of linear programming method for the system integration and assessment.

Since study on cultivation itself of Italian ryegrass and following lowland rice as a second crop was so scarce so far that cultivation experiments were carried out in parallel to the system study. As a result, it was found that dry matter yields of Italian ryegrass at the first cutting can be estimated by knowing the accumulated effective temperature, and the yields of subsequent cuttings can be estimated by daily mean temperature (Figs. 1 and 2). The estimated figures were found to be fairly consistent with the actual harvests obtained in the system study. The latest limit of sowing time, allowable in scheduling farm operation, was also determined.

As the growth of lowland rice cropped after Italian ryegrass is liable to be very unstable, the following factors were examined: rate of fertilizer applied to Italian ryegrass, duration of cropless period and methods of land preparation before transplanting of rice, rice variety to be used, planting density, water management in rice growing period, PCP application for controlling growth, etc. The result indicated that lowland rice cultivation after Italian ryegrass has to be divided into two groups, which must be treated differently: rice after

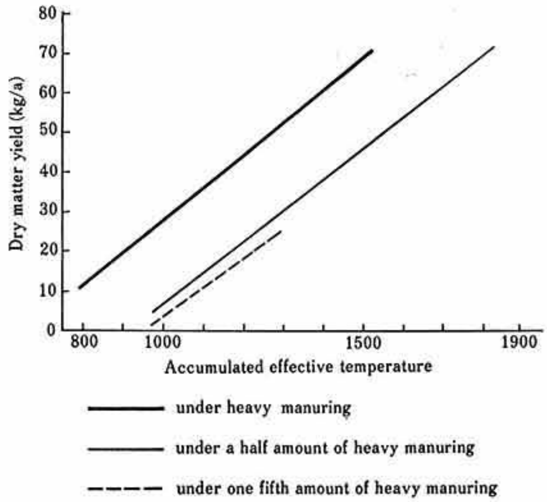

Fig. 1. Relationship between yields of Italian ryegrass at the first cutting and the accumulated effective temperature

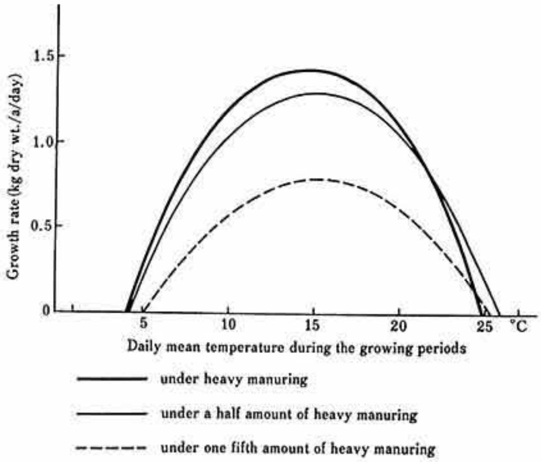

Fig. 2. Relationship between the growth of Italian ryegrass and the daily mean temperature

Italian ryegrass which received heavy fertilization *vs* light fertilization. Difference was found in the effect of grass root residues on growth of rice plants and ways to control it. For each case, agronomic significance, interrelationship and possible alternatives of these factors were studied to design cultural management of rice. The latest limit of sowing time of rice was also determined.

To apply the linear programming method, concrete working schedule was planned on weekly basis, and number of 0.3 ha field units was used as the variable.

1) A whole system of farm operation was divided into components (working process) and each working process was expressed by a symbol.

2) Using the results of above-mentioned experiments, a range of time allowable for each working process was determined.

3) By combining working processes in different arrangements within a range of allowable time for each process determined as above, different types of combination (farm operation system) were designed.

4) Technical coefficients or actual working hour/unit parcel of 0.3 ha were calculated.

5) Total hours/week available for the use of tractor or combine-harvester were determined by taking into consideration the weather statistics and the soil condition which permits the use of big machines.

6) Calculation of Cj-value was made for each of the following cases:

1. Maximum acreage to be managed by the system
2. Maximum yield (production) to be obtained by the system
3. Maximum profit to be gained by the system

The Cj-value represents the target, and is expressed on the basis of cultivation on one unit of 0.3 ha field parcel.

7) After completing all these procedures, the simplex tableaux were produced and they were processed by computer.

In calculating all these coefficient, results of studies on farm operation system and its components available so far were utilized.

Assessment of farm operation system

Assessment of the system was made by calculations in which the followings were taken as parameter: way of diving the system into components and rearrangement of the components into the system, period for each working process, yields of rice, price of product of Italian ryegrass, weather, etc.

1) As to the assessment of the components, it was found that the farm operations during a period between the harvest of Italian ryegrass and planting of rice offer the most important technical problem (Table 1). In case when rice is grown by direct-seeding culture, it was found that the use of plowing for land preparation gives high accuracy of sowing operation which causes stabilized high yields of rice, but is of low efficiency. The system using a 15 PS tractor can cover only 4 ha of field by this method. On the other hand, if the rotarying is applied, an efficiency is increased so that 6 ha of field can be covered with the same 15 PS tractor, but sowing accuracy is decreased, giving adverse effects on yields. This is same with the system using 35 PS tractor. Therefore, it can be concluded that the partial rotarying (with 10 cm of width only of the seeding row) is recommendable.

In case of transplanting culture, it was made clear that the system using 15 PS tractor can cover 10 ha and that of 35 PS can cover 16 ha at the most.

2) Assessment of the whole system of Italian ryegrass—lowland rice was made on the system which adopted partial rotarying, by calculating the optimum working program by using the linear programming method. Under climatic condition of the normal year, the system using 35 PS can cover about 9 ha, but by considering yearly fluctuations of weather it was assessed to be safe to cover 6.4 ha in 8 years out of 10 years.

3) Economic assessment predicted that Italian ryegrass may not be grown by farmers as a winter crop unless rice yield (brown rice) is as low as 3.5 ton/ha and the price of harvested Italian ryegrass is kept as high as 60 Yen/kg of dry matter. If the production cost of Italian ryegrass is reduced by using cattle urine as a substitute for chemical fertilizer which occupies a major portion of the cost, Italian ryegrass can be grown with profit under the combinations of 3.5 ton of rice yield and more than 40 Yen/kg of

Table 1. Assessments of acreage which can be managed by systems using a tractor in spring (two cropping paddy field)

Trial's No. (year)	Power of tractor (PS)	Type of rice culti-vation	1) Acreage under manage-ment of each system (ha)	2) Farm operation limiting the acreage	3) Methods of tilling & seeding or trans-planting for rice	4) Efficiency (hr/ha)	5) Brown rice yield (ton/ha)	6) Dry matter yield of Italian rye-grass (ton)
1 (1964)	15	direct seeding	4. 0	Ti & S for rice	Pl–R–S	53. 3	4. 0	17. 6
2 (1964)	15	trans-planting	6. 6	——	R–Pu–Tr	26. 0	3. 1	38. 1
3 (1965)	15	direct seeding	5. 7	Ti & S for rice	R–S	29. 0	2. 9	18. 7
4 (1965)	15	trans-planting	10. 0	H of Italian ryegrass	R–Tr	10. 3	3. 9	50. 0
5 (1966)	35	〃	16. 0	Ti & Tr for rice	Pu (with rotary harrow)–Tr	16. 7	2. 4	39. 8
6 (1968)	35	direct seeding	5. 9	Ti & S for rice	R–S	24. 3	4. 9	26. 6
7 (1968)	35	〃	8. 7	H of rice	partial R–S	11. 7	5. 2	45. 2
8 (1968)	35	〃	8. 6	H of rice	no tilling–S	4. 3	5. 6	51. 5

Note. Symbol of farm operations ; Ti : tilling, S : seeding, Tr : transplanting, Pl : plowing, R : rotarying, Pu, puddling, H : harvesting.

Italian ryegrass or 4.3–5.0 ton of rice yield and more than 60 Yen/kg of Italian ryegrass. Reduction of cost has to be further studied as a future target of technical improvement.

The present study proved that the application of linear programming method is extremely useful to the study of farm operation system, not only in designing the optimum system, but also for the assessment of the system and its components.