The Optimal Rate of Farm Mechanization at the Village Level**

部落水準에 있어서 農業機械化의 適正水準

李 正 漢* · 李 昇 揆*
Lee, Jeung Han* · Lee, Seung Kyu*

During the past decade, farm labor forces have declined by about 2.5% annually, on the average. The rate of decrease might have been higher for one village while lower for others than indicated above. Most villages in Gyeong-Nam Province now seem to be faced with a serious labor shortage problem at the so-called labor demand peak seasons, particularly in the June season. This fact seems to be supported by the villagers themselves, who say that it is almost impossible for a labor-short farm to get hire since there is no more surplus labor because everyone is busy with one's own business. The consequence often turns out to be failure in the timing of farm operation which is likely to lead to a redution in the potential production rate.

Government has apparently failed in providing a relevant program for farm mechanization, since appropriate machinery, except the power tiller, is not being supplied for the appropriate villages at the approprite time. This study intends to determine the desired rate of farm mechanization, including other adjustments, needed at the village level in facing the labor shortage problem. The kind of machine considered include the power tiller(including attachments), rice transplanter, the reaper, the binder and the combine. All of these are supposed to particularly contribute to curtailing labor demand at the peak seasons. An emphasis is placed on rice and barley production grown on paddy as a second crop because they are predominant enterprises in all respects.

For the first attempt, a village, Jeung-Ja, Geum-Gok, Jin-Yang, Gyeong-Nam, was used for a sample case. This village was a good representative for the farming situation in Gyeong-Nam in terms of paddy ratio, cropping system, man-land ratio, etc., though its average land size per farm is slightly smaller than that of the province, while the two crop ratio on paddy is higher.

A linear programming model was developed for this study. The model took into

* 慶尙大學
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* Professor of Agricultural Economics, Ph.D.
** Assistant Professor of Agricultural Engineering.
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consideration many alternatives in resource uses such as leases of land and labor between large and small farms, capital borrowing, etc. Among others the emphasis was on production technology for rice and barley. That is, the production possibilities as defined for rice include: 1). land can be prepared either traditionally or with a power tiller. 2). prepared paddy can be planted with either the traditional or an improved new variety. 3). any variety can be transplanted either traditionally or with a power transplanter. 4). regardless of the technology used, rice can be harvested either traditionally or with a reaper, a binder, or a combine. All these technologies are separately applied for both one-crop and two-crop paddy since transplanting time is not the same, and harvesting time differs between the varieties planted. For barley grown on paddy, production possibilities include: 1). planting, including land preparation, can be performed either traditionaly or with a power tiller. 2). harvesting can be done with any of the four methods applied to rice. On the other hand, for simplicity, all other upland crops considered are assumed to be produced with traditional technology.

Five categories of land are defined: summer one-crop paddy, summer two-crop paddy, summer upland, winter upland, and winter two-crop paddy, Again, both labor seasons are divided into two: first and last halves based on labor demand by operations of major crops. Thus demand for and supply of labor and farm machinery services are defined according to this classification.

The model assumed that the village was composed of three components: large-farms, small-farms, and farm machinery components. The machinery component buys machines at the going price with annual expenses for depreciation and repair costs, and then provides both farm size components with machinery services on a custom work basis. This component will buy machines as long as there is demand for custom services and it pays. On the other hand, both size farms have the same opportunities in every respect, except labor hiring and land renting, thus both can hire machinery services if it is profitable.

The model is designed such that many relevant policy questions can be examined. However, in this report, only two model inputs are closely examined: machinery price (level of subsidy) and man-land ratio(average land area per man-equivalent labor force). Four levels of man-land ratios are defined:

1). 3.679 tanbo——present situation of Jeung-Ja-Ri,

2). 4.196 tanbo——situation in 1981 if the annual rate of labor decrease is 2.5%,

3). 4.531 tanbo——situation in 1981 if the rate is 4%, and

4). 5.559 tanbo——situation in 1986 if the rate is 4%.

This sensitivity analysis has two purposes: it is intended to infer the desired rate of mechanization not only for Jeung-Ja-Ri(in the present as well as the future), but also for other villages that have a higher man-land ratio at the present time. On the other hand, for each level of man-land ratio, two levels of machinery prices are defined: without price subsidy and with 40% subsidy.

The results derived from the model indicate that there should be three major

adjustments according to decrease in labor forces: crop combination including variety mix, resource mix and mechanization. For the present situation, the optimum level of major adjustments for the village as a whole can be summarized as follows:

1). 23% of the paddy land should be prepared with a power tiller.
2). 86% of the rice should be transplanted with a power transplanter.
3). 100% of the rice planted should be the improved new variety.
4). 65% of the rice should be harvested with a reaper.
5). 6% of the barley on paddy should be planted with a power tiller and 100% of it should be harvested with a reaper.
6). some two-crop paddy be transferred to one-crop paddy which means cutting down barley production, regardless of farm size, and
7). some paddy, either for both rice and barley production or barley alone, should be transferred to small size-farms from large size-farms.

The levels of the last two items are restricted to the going levels in the model, while the large size-farms are allowed to hire labor from the small size without a limit. The results suggest that opportunity cost on this type of restriction is comparatively high, which means it would pay to encourage more of this type of transfer for the village as a whole.

The optimum number of farm machines needed to support the farm mechanization level discussed above are:

1). power tillers·····1.1 per 10 ha,
2). rice transplanters·····1.3 per 10 ha, and
3). reapers ·····2.0 per 10 ha.

In any situation defined in the model, a combine has not appeared to be desirable. In fact, an increase in man-land ratio alone appears not to have much affect on the optimum number of farm machines. According to the model solution, adjustments take place rather in crop and variety mixes: some reduction in barley production on paddy, which is currently observed in Japan and Taiwan: and some increase in the area planted with the traditional rice rariety which requires less labor. This fact implies that food grain production will be decreased as the farm labor force decreases if other conditions remain unchanged.

Farm machinery price subsidy has appeared to have several effects, though all are interrelated. Until man-land ratio becomes 4.196 tanbo, price subsidy has not changed anything except the village income level. When man-land ratio is equal to or greater than 4.531 tanbo, price subsiby appears (1) to encourage the rate of farm mechanization, particularly, the substitution of a reaper with a binder. (2) to promote barley production on paddy, and (3) to increase village income, as compared with it without price subsidy. When man-land ratio is 5.559 tanbo and with price subsidy, the optimum number of farm machines is as follows:

1). power tillers····· 2.7 per 10 ha,
2). rice transplanters·····1.3 per 10 ha,
3). reapers ·····1.1 per 10 ha, and

4). binders .....0.6 per 10 ha.

Notice that the number of rice transplanters remains unchanged for any situation defined in the model.

In summary, it is apparently true that the farm labor force now has enough decreased such that rice transplanters and reapers, in addition to power tillers, can be profitably introduced, perhaps not for every village, but at least for many villages, depending on the man-land ratio. Nevertheless, these two machines are not currently made available for farmers' use. Lack of an appropriate program on farm mechanization can be attributed to past research work. The analytical tool that was often used is the "break-even point analysis" technique. Since an individual farm is assumed to be a production unit, and interactions existing among farms, farm machines or operations are all disregarded, the result often seem to recommend that it is profitable to mechanize only for farms larger than, say, 8 ha. The implication is that either Korean farms should be reorganized or mechanization should wait until the average farm size becomes, say, 8 ha. On the other hand, there are several studies at the macro-level. In this type of study, the nation as a whole or a large region is defined as a production unit, which implies perfect mobility of labor among farms, villages, or districts. Thus this implicit assumption is likely to lead to an underestimation of the optimal level of farm mechanization since labor deficiency in one village or one district is surely cancelled out by labor surplus in other villages or districts.

Now we want to conclude with three remarks. First, assumptions implicitly made of non-interactions among farms and perfect mobolity of labor among villages are clearly not realistic. Any model used for policy analysis should be able to well represent at least the important aspects of the real world. Otherwise, the model will lead to a wrong conclusion. Secondly, Korean farms seem to have wisely behaved so as to adequately adjust to any change. What is needed for farm mechanization is not to establish a new institution, but to supply desired machinery and technology at a resonable price at an appropriate time, since there is an age old efficient institution already-custom work to which Korean farms have long been accustomed. Thirdly, we should realize that there always exists an adoption delay for any technology or innovation. In order to prevent a possible reduction in agricultural production, it would be better to introduce the desired technology in advance so that farmers have enough time to fully adjust.