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RAPPORTEUR'S REPORT

ON

TECHNOLOGICAL CHANGE AND ITS DIFFUSION IN AGRICULTURE

Rapporteur : D. K. DESAI*

One who is interested in the development of Indian agriculture is aware that for the achievement of the 'take off' stage it needs technological revolution. If the interest of policy-makers and agricultural economists who influence the decisions of policy-makers is any indication one can predict that this revolution will take place in India in the near future. It is not an accident that in the history of quarter century of the Indian Society of Agricultural Economics that this topic is being discussed for the first time in the Annual Conference. This topic has attracted the largest number of contributors among all the topics discussed at the Annual Conference held so far. The coming revolution is casting its shadow.

There are 38 papers on this topic. The most encouraging thing about the contribution is that for the first time we are having an inter-disciplinary approach. Not only the writers with economics and agricultural economics background have contributed, but a substantial number of writers with sociology background has also contributed. Unfortunately, agronomists and other physical scientists have not been drawn in yet. A large number of contributors has based their observations on empirical studies rather than relying on general opinions and beliefs. It is difficult to group the papers under broad categories of items as each paper deals with different items which may fall under different categories. Hence the items which are discussed in the papers are grouped under broad categories instead of grouping the papers. The items discussed can be divided into two parts: Part I dealing with technological change and Part II dealing with diffusion. There has been a little confusion in some papers where technological change and diffusion of technological change have been synonymously used. However, the differentiation between the two becomes evident from the discussions of the definitions. The following items are discussed in the papers:

Part I : Technological Change :

1. Definition.
2. Studies of technological changes at macro level.
3. Studies of technological changes at micro level (specific situations).
4. Factors affecting technological changes.
5. Process of technological change.
6. Measurement of technological change.

Part II : Diffusion of Technological Change :

1. Definition.
2. Factors affecting diffusion.
3. Measurement of rate of diffusion.

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The brief summary of discussions under these items is as follows :

TECHNOLOGICAL CHANGE

Definition

Goutam K. Sarkar has defined technological change by classifying it into two types : (a) Changes brought about by movement up the existing production function; (b) Changes brought about by shift in production function. The latter comes about by innovations. In agricultural context, the innovations are classified into two types : (1) 'resource saving' and (2) 'resource using'.

One of the authors in his paper on "Scale, Productivity and Technological Adoption in Agriculture" has also tried to make a notional distinction between technological changes in terms of movement along production function and shift in production function.

In another paper on "Diffusion of Technological Change in Agriculture," the term 'neutral' has been borrowed from Solow for describing the changes which will leave the marginal rates of substitution between resource inputs unchanged. It calls a change 'non-neutral' which would change unequally the rate of output with respect to one or more inputs.

Most of the other writers who have tried to define technological change have defined it in terms of shift in production function. A few authors (B. S. Rathore and R. K. Patel, T. Ramakrishna Rao) have quoted Stout and Ruttan saying "technological change can be broadly defined as a change in the parameters of a production function resulting directly from the use of new knowledge." Some authors have defined technological change more or less in terms of shifting of production function. Usha Dar has defined the technological change as the entire process starting from investment which results in the flow of goods and services that make up the introduction of change possible to actual introduction of the change at the field level.

Studies of Technological Changes at Macro Level

Out of 38 papers, 10 papers deal with the topic at the macro level. Among these, two papers deal with the problems of evaluation of benefits likely to occur due to technological change.

Usha Dar deals with technological change brought about by an irrigation project. In evaluating the cost-benefit of this change she raises the problems of estimation such as (*i*) what period should be considered as project age ? (*ii*) Is it possible that the economic benefits from a project can be improved by postponing construction ? (*iii*) How should we take into account the discount rate ? She suggests that it will be useful to have alternative sets of time streams of benefits and costs. If the time period for which the benefits and costs are being discounted is sufficiently long then a constant rate should preferably not be used.

Rathore and Patel have raised a problem of evaluation of benefits accruing from investment in agricultural research. They have enumerated some attempts of research workers in U.S.A. to estimate the rate of returns on funds invested in agricultural research.

The remaining eight papers deal with the problems of technological changes at all-India level. These are descriptive in nature. Almost all these paper-writers have discussed the problems of different types of technological changes and have also given their opinions for solving these problems. One author in his paper on "Problems of Agriculture Development in India : Technological Change and Its Diffusion" has given an account of major technological changes and also the problems connected with these changes. Another author has drawn on the experiences of other countries for introducing technological changes such as co-operative farming in U.A.R., small tractors in Taiwan, rice mechanization in Japan and development of tools and implements in East Africa. One of the authors has written a very long paper discussing different types of technological changes. The scope of technological changes in irrigation, fertilizers, improved seeds and implements has been shown in another paper.

One of the paper-writers discusses the problems of technological changes in the context of emergency food production drive and cautions that the planning for food production would always be a continuous and of a long term nature and in a very short period if spectacular results are not visible there is no cause to be frustrated and disappointed.

V. G. Panse and D. Singh have tried to assess the extent of technological changes in India from the data which the Institute of Agricultural Research Statistics gathers from experimental stations, trials on cultivators' fields and surveys conducted in the districts of Intensive Agricultural Programme. They have shown that the common belief that the major fraction of fertilizers consumed in the country is applied to commercial crops is not correct. On the contrary, 75 per cent of both nitrogenous and phosphatic fertilizers are applied to food-grain crops in I.A.D.P. districts.

The problems of technological changes at all-India level have been examined in one of the papers from the angle of adequacy of the existing institutional systems. It deals with mainly land tenure, credit and extension.

Studies of Technological Changes at Micro Level (specific situations)

About 19 papers discuss the problems of technological changes in specific situations. These are mostly empirical studies. Four of them are conducted at village level, five at block level and three in the districts of Intensive Agricultural Programme. Three papers deal with specific products such as tea (Goutam K. Sarkar), paddy, and jute. Three papers deal with specific factors, (1) for mechanization (K K. Sarkar and M. Prahladachar and (2) for fertilizers (D. K. Desai and B. M. Sharma). Other two papers deal with soil conservation and arid agriculture.

Factors Affecting Technological Changes

As many as 18 papers deal with this topic. Almost all paper-writers have tried to base their observations regarding the factors affecting technological changes on the empirical studies. Broadly speaking, these factors can be classified into two categories : (1). economic factors, and (2) sociological and demographic factors.

The following factors were studied by different writers:

Economic Factors :

1. Size of farm.
2. Irrigation facilities on the farm.
3. Farm and non-farm income.
4. Liquidity.
5. Tenancy.
6. Availability of supplies and credit.
7. Profitability of technological change.
8. Attitude towards risk.
9. Price stabilization.

Sociological and Demographic Factors :

1. Caste.
2. Education.
3. Age.
4. Extension agencies.

Economic Factors

(1) *Size of farm* :—About eight writers have taken this factor into account. There is no unanimous observation regarding the positive effect of the size of farm on the adoption of technological change. The division of opinion is reflected in five papers which observed positive effect while three papers did not observe any positive effect.

(2) *Irrigation facilities on the farm* :—Six writers have studied the effect of this factor. Almost all have found that farmers having irrigation facilities tended to adopt technological changes. Only in one case (Desai and Sharma) no significant difference in irrigation facilities was noticed between farmers adopting and not adopting a technological change (use of fertilizers).

(3) *Farm and non-farm income* :—Three authors have observed positive correlation between economic status and adoption of technological change.

(4) *Liquidity* :—N. S. Shetty has considered this factor in considering the rate of diffusion. He has found that farmers having more liquidity were quicker to adopt technological changes of improved seed and fertilizers.

(5) *Tenancy* :—In this case we have two opposite observations. Shetty found that with the increase in the area in tenancy the farmers were low to adopt technological changes whereas R. S. Savale did not find any significant relationship between tenancy position and adoption of technological change.

(6) *Availability of supplies and credit facilities* :—Many writers have made the observation that non-availability of adequate supplies and credit is one of the bottlenecks in bringing about technological changes in agriculture. This seems to be a major factor.

(7) *Profitability of technological change* :—Four authors have observed that farmers adopt the technological changes if marginal returns are high. The farmers seem to discriminate one type of technological change against the other on the basis of relative profitability.

(8) *Attitude towards risk* :—Many writers have referred to this factor and observed that farmers do not adopt technological change because of aversion to risk. No empirical study in Indian conditions has been cited. In one study (Desai and Sharma) where attempt was made to investigate this aspect no significant difference was found between the attitudes of adopters and non-adopters of technological change towards risk.

(9) *Price stabilization* : Here again we find a general observation that for introducing technological changes prices should be stabilized.

Sociological and Demographic Factors

Although much is talked about the effect of these factors on the adoption of technological changes in Indian conditions, very few writers laid emphasis on these factors in their studies. The writers with the sociology background also seemed to pay more attention to economic factors than to sociological factors. The sociological and demographic factors which were considered in different studies were as follows :

(1) *Caste* :—One of the papers did not find significant difference between castes (higher caste and lower caste) in adoption of technological change. Similarly, Savale also did not find any significant relationship between caste and adoption.

(2) *Education* : There is a general belief that education and technological change are positively correlated. Empirical studies conducted by three writers do not support this belief. This points to the need of more empirical work on this aspect.

(3) *Age* :—In this case also the empirical studies of three writers show that it is not necessary that younger farmers will adopt technological changes earlier than middle aged farmers.

(4) *Extension agencies* :—Communication play an important role in the process of technological change. This is evident from the studies of four writers. Unfortunately, no paper-writer has attempted to go into the question of cost-benefit evaluation of the extension work.

Process of Technological Change

The process of technological change is a long chain of activities involving different stages. One of the writers has listed the following stages: (1) Ignorance,

(2) Awareness, (3) Interest, (4) Decision, (5) Trial, (6) Adoption, and (7) Rejection. He has collected data of big, medium and small farmers with respect to each of the above stages while discussing ten different types of technological changes in farming in a tribal village of Madhya Pradesh. Another writer has collected data on awareness and adoption from different types of farmers for Japanese method of paddy cultivation in the Tanjore district of Madras State.

Savale has listed five stages : (1) Awareness, (2) Interest, (3) Education or decision, (4) Trial, and (5) Adoption. He has collected data on 20 types of technological changes to find out the proportion of farmers adopting the changes.

Although a substantial number of farmers (varying from 40 to 86 per cent) adopted a technological change which was introduced, Savale's study shows that about 75 per cent of the total respondents was unable to identify the source of information. One of the studies relating to a tribal village, referred above finds that a significantly larger number of respondents was aware of technological changes which were introduced in the area; however the number of adopters was quite low. Again among different types of technological changes there was a great variation in awareness as well as adoption. Use of fertilizers as a technological change tops the list of different types of changes even in a tribal village.

Techniques of Measurement of Technological Change

Although technological change has been defined as shift in production function, but for three exceptions no attempt is made to measure this shift in quantifiable terms. Two joint authors in a paper have given the formula for technological change as $\frac{\triangle A(t)}{A(t)} = \frac{Y_1 - Y_0}{Y_0}$ where Y_1 is the output at time t_1 and Y_0 is the output at time t_0. However, they do not say how the inputs are kept constant. An attempt is made by Desai and Sharma for measuring the magnitude of technological change. Two similar types of production functions were fitted to a sample of farms where the technological change had taken place and to a sample of farms where the change had not taken place. The difference of the estimated outputs ($Y_1 - Y_2$) at the iso-input levels obtained from these production functions is the measure of shift in production function. It could be reduced in percentage by the following formula :

$$P = \frac{Y_1 - Y_2}{Y_2} \times 100$$

Where Y_1 = estimated outputs on farms having technological change;

Y_2 = estimated output on farms *not* having technological change.

In her excellent paper, Tara Shukla has attempted to measure technological change. She has outlined two approaches: (i) output-input approach and (ii) Solow approach.

The output-input approach gives an interesting trend since 1920. However, one would question the assumption of keeping the constant weights while construc-

ting the input series. Implicitly it assumes a constant technique of production. The ratio of output-input then in reality becomes an approximation of the ratio of actual output divided by the estimated output obtained from the combination of inputs in a given production technique. The variation in this ratio could be attributed to weather or other variables. It is difficult to attribute this variation to technological change solely. However, if the actual outputs of different years are significantly different from the estimated outputs obtained from a given production function, one can say that there is a shift in technique and then the difference could be attributed to technological change partly.

In Solow approach the attempt is to separate two components of labour productivity—(a) productivity due to technological change and (b) increase in labour productivity due to capital intensity. In the application of this approach to Indian data, it is not clear how the net value added per worker for different periods was arrived at and secondly, the constant value of r*p* assumes the same production function for different periods. Unless the actual outputs are significantly different from the estimated outputs for different periods obtained by the application of the production function, it would be difficult to arrive at the measure of technological change.

S. B. L. Gupta and S. B. Singh refer output-input ratio as a measure of technological changes. They use this measure for different crops for comparison between two blocks to show the effect of technological change. From the data one can hardly conclude that output-input ratios in Chiraigaon were significantly different from those in Harahua (in the Varanasi district of Uttar Pradesh).

DIFFUSION OF TECHNOLOGICAL CHANGE

Definition

Only two writers who have attempted to measure the rate of diffusion have explicitly defined the term diffusion.

Shetty defines it as the spread of an innovation from its original sources among a group of potential users in a given region. Ramakrishna Rao has quoted Lionberger and says,

"The final adoption process is very slow at first, after an initial slow start;... they increase at an increasing rate until approximately half of the potential adopters have accepted the change; after this acceptance continues, but at a decreasing rate."

Quoting Malinvaud, he says, "The growth over time in the number of introductions of an innovation should conform to a logistic function, an S-shaped growth curve frequently encountered in biology and social sciences."

Thus the concept of spread of the adoption of technological change over time and space is involved in the process of diffusion.

Factors Affecting Diffusion of Technological Change

All those factors which affect technological change would naturally affect its diffusion. Many writers have dealt with these factors while discussing the diffusion of technological aspects. However, one important factor which emerges from the discussion of diffusion of technological changes is the number of changes which are introduced at a given point of time. It seems that the rate of diffusion of different technological changes is different.

One of the writers in his paper on "Technological Change and Its Diffusion in Two Blocks in Orissa: A Case Study" shows that among six different types of technological changes introduced in two blocks in Orissa, chemical fertilizers had the highest rate of growth. Kalyan Mal Choudhary and Madhukar Maharaja show how the diffusion indice of acceptance and of area declined as the number of practices in the "package" increased.

A case study in Assam shows that with the introduction of package programme in Cachar district the farmers were prepared for technological change in agriculture. However, their response to different types of technological changes was different. The use of chemical fertilizer received the greatest response from farmers. Out of 100 respondents interviewed nearly 80 had used fertilizers.

However, another case study conducted in Sabalanga village in the Cuttack district of Orissa shows that farmers were nearly equally responsive to different types of technological changes.

A study on "Diffusion of Improved Techniques among Farmers in the Tanjore District" in Madras shows that farmers begin to differentiate between types of chemical fertilizers and the rates of diffusion differ over the period of time. Panse and Singh have found that farmers who accept one improved practice also accept other similar practices more readily than farmers not employing any improved practice. They suggest that if extension efforts are concentrated on the most important improved practice, namely, fertilizer, which a very large proportion of farmers can adopt profitably under their present methods of cultivation then they will also be induced to adopt other improved practices like plant protection, improved implements, etc.

Techniques of Measurement

There are two good papers dealing with this topic. Both have applied the logistic functions. Shetty has used the mathematical expression :

$P = \frac{1}{1 + e^{-(a+bt)}}$. Here P is the proportion of the farmers adopting a particular innovation, t is the time variable. Ramakrishna Rao has used the function :

$$Y_t = Y_0 \ (1 + r)^t$$

where Y_t = the number of motors in year t ;

Y_0 = the number of motors in year 0 ;

r = rate of progress.

In both cases, the curves were good fit.

ISSUES FOR DISCUSSION

Many issues would arise from the discussions of the papers. However, the following issues are suggested for group discussions :

1. The problem of definition of technological change and diffusion of technological change.

2. Which factors are affecting the adoption of technological changes more? Would it help the decision-making of policy-makers if priorities are given in tackling these factors ?

3. Where does the bigger difficulty lie in the process of technological change now ? Is it at the stage of awareness or at the stage of adoption ?

4. Could we differentiate between the process of adoption of early adopters and the late adopters ?

5. Which is the best agency useful in expediting the change of late adoption ?

6. If the difficulties are more at the adoption stage than at the awareness stage will the decision-making of shifting the emphasis from extension work to provision of adequate supplies help the process of expediting adoption of technological change ?

7. Do we have any procedure to evaluate the cost-benefits of the alternative approaches for bringing about a technological change ?

8. Do various studies point to the fact that farmers are discriminating among the various types of technological changes ?

9. Is this behaviour related to the relative profitabilities of various technological changes ?

10. Does this point to the need of more intensive agricultural research and its better management ?

11. How do we measure technological change ?

12. In order to have speedier diffusion would it be better to concentrate the efforts on the most "promising" technological change at one time than to diffuse efforts on many technological changes simultaneously ?

13. Could we use the same logic for farmers adopting technological change ? *i.e.*, could we identify early adopters and concentrate our efforts on the groups of farmers having a high number of early adopters ?

14. How do we measure the rate of diffusion ?

SUMMARY OF GROUP DISCUSSION

Chairman : D. K. DESAI

Definition

In the beginning the Group discussed the problem of the definition of technological change and the diffusion of technological change. One writer had given the definition as (1) changes brought about by movement up of the existing production function and (b) changes brought about by shifting production function. The discussion was focussed on whether the former changes should be called as technological changes and the general concensus was that the definition of technological change should be in terms of shift in production function.

Secondly, the definition of diffusion of technological change was taken up. The definition as outlined in the Rapporteur's Report was generally accepted. Diffusion involves the concept of spread of the technological change over time and space.

Process of Technological Change

Then the problem of the process of technological changes was taken up. Several stages are involved in this process such as (1) Ignorance, (2) Awareness, (3) Interest, (4) Decision, (5) Trial, and (6) Adoption.

One writer had included the stage of rejection in this process. The Group felt that rejection comes because of introduction of another technological change. Hence the stage of rejection is really an in-between stage of two technological changes. A point was raised whether there could not be a diffusion process with each of the stages from awareness to adoption. It was suggested that there could be the diffusion process at each stage. However, it was proposed that while discussing the problem of technological change and its diffusion in agriculture, it was better to concentrate on the diffusion of adoption of technological change.

Evaluation of Technological Changes

The work done by the Institute of Agricultural Research Statistics in this connection was elaborated: (1) Data from the experimental research statistics are collected and used for assessment for the improvement in technology which could be suggested to farmers. (2) Data are collected from the Trials on Cultivators' fields and from the Intensive Agriculture District Programme (I.A.D.P.) districts particularly in case of fertilizer applications. These data are used to assess the responsiveness of fertilizers in actual farm conditions in the former case and to assess the rate of diffusion of technological changes in the latter case.

In the specific case of the technological change of fertilizers an issue was raised whether it was more useful to suggest a very high dose of 100 to 150 pounds of nitrogen per acre in case of hybrid crops (particularly maize) or it would be better to use 50 pounds of nitrogen per acre and thus cover more acres of hybrid maize.

Another technological change which was discussed was major irrigation. A question was raised whether from the experience of the implementation of some of the major irrigation works we could find out the period that was likely to lapse between the stages of sanctioning the amount for such a project and actual implementation in terms of use of irrigation water by farmers resulting into increased production. This period was divided into two parts : (1) period required for completing the physical facilities of bringing water to the cultivators' fields and (2) period required by farmers to learn water management and adopt necessary changes. It was felt by the Group that there was a good scope in reducing both the periods. So far as irrigation is concerned the farmer does not require to be educated for the benefits of irrigation farming. What is needed is the improvement in water utilization.

Factors Affecting Technological Change

The consensus of the Group was that for studying the process of technological change an inter-disciplinary approach in which both economists and sociologists would work together is required. In the discussion of sociological factors some conflicting observations were made regarding the influence of caste on technological change. In this connection it was pointed out that perhaps it would be more relevant to study the effects of group behaviour and also the psychological factors such as fear of losing the face if one fails alone while adopting technological changes.

Among the economic factors affecting technological changes (listed in the Rapporteur's Report) the question of only the size of farm was discussed. Here again there were conflicting observations. Some participants observed that the size of farm had a positive correlation with the rate of adoption of technological change. Others observed that in the beginning when a change is introduced farmers with sufficient resources come forward to experiment, but once this trial stage is over, the size of farm has very little effect on the rate of adoption of technological change.

Agency for Technological Change

It was observed that in our situation the agency which is responsible for bringing the technological change to farmers is the extension agency. It was complained that this agency mostly operates as a one-way traffic. It brings to the farmers the recommendations of technological changes which have been evolved at the research stations. The agency hardly does anything to help research workers to invent changes that are required and immediately applicable in farming conditions. Therefore, there is a need for proper co-ordination of research workers, extension workers and farmers. This should be incorporated in the system of education of extension workers.

Another complaint against the present extension workers was that they did not possess any farming experience and hence they did not create confidence among farmers. It was suggested therefore that every extension worker should be required to work on a farm and he should himself be convinced that whatever recommendations he was making to farmers were practical and profitable.

A suggestion was made that in each village or a group of villages there are a few experiment-oriented farmers. Their help should be taken in extension work not making them merely propaganda workers but as demonstrators of technological changes.

The Group discussed the practicality of the proposition of the extension workers being required to demonstrate the profitability of particular technological change on the farming area to be managed by themselves. Some participants felt that at present there were demonstration plots on cultivators' fields and hence it was not necessary to have the new experiment of making extension workers to manage such farms themselves. If the extension workers take real interest in their work even the present method of helping the farmers by way of information helps the process of technological change.

Farmers' reaction Towards a Single Technological Change Versus a Package of Changes

Several studies pointed to the fact that when farmers were recommended several technological changes at the same time, they started discriminating and adopted the most profitable change first. Technological change of chemical fertilizers has preceded the changes of improved seeds and insecticides.

A question was raised whether a rigid approach of recommending to farmers a package of technological changes was useful. It was observed that the additive effects of individual technological changes would have perhaps the same effect on total production as the package of technological changes would have if the rate of adoption of such package is taken into account.

It was argued that the concept of "package" has to be understood in the light of the total farm technology and it is much better to approach the farmers with a view to improving the farm management rather than recommending single technological changes.

Measurement of Technological Change and Diffusion

This aspect could not be discussed at length because of want of time. However, an observation was made that in Indian conditions the change in yield per acre over a longer period could be used as a measure of technological change. The point was raised regarding separating the weather effect from the trend of yield per acre over time. This required further discussion.

The matter of measurement of technological change has been discussed to some extent in the Rapporteur's Report. A distinction was made between the technological change and the diffusion of technological change while defining them. The methods of measurements for both differ. In the measurement of diffusion of technological change a suggestion was made to use logistic function having S-type curve. Further research work is required for applying appropriate techniques for measurement of technological change and the diffusion of technological change.