CHAPTER - V
TECHNOLOGICAL CHANGE AND IT’S IMPACT ON SERICULTURE DEVELOPMENT

5.1. Need for Technology

As a major sector, agriculture continues to be the life line for millions of farmers in India. Change in the production and productivity in the field of agriculture is possible in India due to a massive diversion from the traditional agriculture to new commercial agriculture. In the post-green revolution era, the agricultural production was targeted through change in area under cultivation, increasing cropping intensity and increasing productivity per unit area.\(^1\) Though first two strategies are the state related subjects, the improvement in productivity mainly depends on the infrastructural, technological, institutional and environmental factors.\(^2\) A number of government sponsored programmes were directed towards the improvement in the productivity in agriculture in the form of introduction of new technologies in agriculture, which led to the green revolution in the mid sixties. Green revolution in India has been the cornerstone of India’s agriculture achievement, transforming the country from one of food deficiency to self sufficiency.\(^3\)

The strategy around the technology is in the form of a package of programmes woven around High Yielding Varieties (HYVs) and other supporting inputs such as adequate irrigation, chemical fertilizers, plant protection chemicals, mechanization of agriculture, supply of electricity, credit and marketing facilities on a co-operative basis and a system of superior prices and buffer stocking. The whole idea is to demonstrate how productivity can be raised without increasing the area under cultivation.\(^4\) The benefits of the technologies disseminated as a result had the trickle down effect on other allied sub sectors like dairying, sericulture, horticulture etc. The introduction crossbreeds (new technology) in place of indigenous breeds (old

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technology in dairy industry and the introduction of bivoltine hybrids (new technology) in place of crossbreeds (old technology) in sericulture stand to be one of the major achievements in the form of improving productivity in the recent years. Mere introduction of improved breeds in dairying or sericulture may not necessarily be a technological improvement over existing technologies. But the higher gain in the yield may occur due to the increased input use. This was true in case of sericulture, as there was a generation of series of technologies directed towards improvement of productivity per unit area.

Sericulture is employment oriented low capital-intensive and remunerative, which is ideally suited to the labour abundant economy of India. The introduction of new technologies in sericulture began during 1980s and the impetus for development in sericulture was seen with the introduction of “National Sericulture Project”. Silk productivity in India between 1960 and 1970 was very low and ranged from 14 kg to 20 kg per hectare. However, a significant leap in productivity was observed in the eighties and nineties, when it reached to around 85.02 kg per hectare during 2004-05.

India has gained in production and productivity of raw silk in the last three decades due to the new technologies evolved and popularized in the field. High yielding mulberry varieties such as V-1 and S-36 were introduced during the period replacing the traditional, low yielding local and Kanva – 2 varieties. Similarly, many farm improvement technologies including nutrient management in mulberry, control of pest and diseases in mulberry were evolved and passed onto the field. In case of silkworm rearing, high yielding robust silkworm races (multivoltine cross breeds and bivoltine hybrids) were introduced in the field. Appropriate rearing technologies including chawki (young age) silkworm rearing, shoot feeding method for rearing, disinfection methods, mounting were evolved and transferred to the field. Construction of separate rearing houses for silkworm rearing was advocated.

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5.2. Technical Change: Background Studies

Many studies have dealt with the technical change relating to agricultural crops. However, a few specific studies have been undertaken by research workers on assessment of technical change in an allied sector like sericulture. By taking successful examples of agriculture and allied sectors including sericulture, dairying, fisheries, etc., which have benefited through the introduction of technologies, a review of some of the important studies on the impact of technological change on production and productivity and returns accrued to research as a result, was made and presented as below. The reviews are presented under three classifications.

5.1.1. Technical change – definition and concept
5.1.2. Technical change – Impact on input use and output growth
5.1.3. Returns to investment in research, education and extension

5.2.1 Technical Change: Definition and Concept

Ruttan\textsuperscript{10} stated that technological change has traditionally been defined in terms of changes in the parameters of a production function or the creation of new production function. The traditional procedure has been to use a partial productivity index (average output per unit of labour/capital) or total productivity index (output per unit of total input) as a measure of the impact of technological change.

Another approach is production function approach. The increase in the current level of output over the level of projected from the base period production function is attributed to technological change. Comparisons have been made between the level of output that would have been produced using the current level of inputs with production function of same base period and the level of output obtained with the same inputs currently.

Hicks\textsuperscript{11} classified technical change as a neutral and non-neutral. Technical change is neutral, if the marginal rate of substitution between inputs is not affected. Non-neutral technical change is generally described as either labour-saving (capital-using) or capital-saving (labour-using). Technical change is said to be labour saving if the marginal product of capital rises relative to marginal product of labour.

\textsuperscript{11} Hicks, J.R. (1932) The Theory of Wages, McMillan and Company Ltd., London
Solow\textsuperscript{12} defined technical change as a “catch-all” expression for any kind of shift in production function assuming returns to scale, homogeneous inputs and competitive equilibrium. According to him, any increase in output not explained by increase in capital and labour is assigned to technical change.

Harrod\textsuperscript{13} defined technical change as capital saving or labour saving according to whether capital/output ratio decreases, remains unchanged or increases with a constant rate of interest.

Schmookler\textsuperscript{14} defined technological change to denote the art or producing new knowledge and technical change to incorporation of this knowledge in the production process of firms. In the literature no much distinction seems to be kept in view.

According to Srivastava \textit{et al.}\textsuperscript{,15} the technological innovations in agriculture can be divided into two broad types, viz., Biological and Mechanical. Biological innovations refer mainly to inputs that increase the productivity of a given land base. High yielding plant varieties and fertilizer are the examples. Biological innovations are found to raise total farm cost. Mechanical innovations mainly are those that cause a reduction in total costs, while biological innovations are labour saving. Green revolution is frequently described as a seed-fertilizer technology. In a sense it falls in the class of biological innovations.

Shaw\textsuperscript{16} defined a technological innovation as concrete identifiable new factor of production material as well as non-material to which the increase in production is attributed and which is not explained by the traditional factors of production. The discovery of high yielding variety of seeds, the package of practices for realizing their production potential, mechanization of agriculture are regarded as technological innovations in agriculture. There are technological innovations in farm mechanizations, post harvest technology, milk and poultry production, frozen semen technology.

\textsuperscript{14} Schmookler (1966) \textit{Invention and Economic Growth}, Harvard University Press, Cambridge, United Kingdom
Nair (1980)\textsuperscript{17} defined technical progress, as those changes in the production processes which reduce the marginal cost of output. This change can occur either employing the existing inputs but in different composition (a change in technique) or by introducing new factors of production either for replacing old ones or simply as additional inputs (technological innovation). Thus the technological change in either case is associated with a shift in the production function which describes the technical relation between output and inputs. Shifting production functions with rising marginal productivities are more appropriate in a dynamic situation.

5.2.2. Technical Change: Impact on Input Use and Output Growth

Using the output decomposition models many research workers have attempted to quantify the contribution of several factor inputs as well as technical change to output. Empirical studies attempted to isolate influences of input growth (movement along a production function) and technical change (shift in production function), have been reviewed as under.

Bisaliah\textsuperscript{18} decomposed the growth per acre wheat output in Punjab into its sources. He found that technical change contributed 15 per cent and increase in the use of labour, fertilizer and capital per acre under Mexican wheat contributed about 25.5 per cent to increased output (40.5 per cent). Individual contribution of labour, fertilizer and capital were 2 per cent, 15 per cent and 8 per cent in that order.

Kunnal\textsuperscript{19} studied the effect of introduction of new jowar technology on output growth in Hubli taluk of Karnataka state by using output decomposition model. He observed that a new technology farm produced about 72 per cent more output than an old technology farm of which, 33 per cent was due to technical change and 38 per cent was due to the increase in input levels.

Kumar and Singh\textsuperscript{20} attempted to examine how much of the growth in milk yield was due to technological change i.e., breed and how much of it was due to increased quantity of feeds and fodder. The incremental contribution of each

explanatory variable, namely feed and lagged milk production revealed that feed nutrients contributed 3 per cent for crossbred cows, 2 per cent for “Sahiwala” cows. The lagged milk production contributed 47 per cent and 27 per cent in the total variation in milk yield for crossbred cows and “Sahiwala” cows respectively. The contribution of technological change to the total change in milk production was estimated to be 36 per cent. An increased use of feed inputs for crossbred cow contributed about 34 per cent to the total change in milk yield.

Alshi\textsuperscript{21} studied the impact of technical change on output in cotton economy in Akola district of Maharashtra state. The per hectare production on American cotton and hybrid cotton farms was more by 43 per cent and 306 per cent than the desi cotton farms. The contribution of technical change to this output growth was 27.77 per cent and 110.57 per cent, respectively. Increased use of labour, fertilizer, FYM and capital per hectare contributed 16.4 per cent in American cotton and 199.87 per cent in hybrid cotton. Among the various inputs, capital turn out to be an important source of output growth.

Gundu Rao \textit{et al.},\textsuperscript{22} fitted the Cobb-Douglas production function to ragi data on both local and improved varieties in Bangalore. The authors found out a positive productivity differential (14 per cent), which emerged with the introduction of transplanting method into broadcasting local variety of ragi. About 45 per cent positive productivity differential has been generated with the introduction of new varieties of ragi to local variety farms, following the transplanting method. New technology (improved variety of ragi) contributed about 32 per cent more output over the local technology (TLV). Another dominant factor to the productivity differential (15 per cent) has been identified to be capital.

Umesh and Bisaliah\textsuperscript{23} using output decomposition model examined the impact of technical change in paddy production in Karnataka. They observed that HYV

\textsuperscript{21} Alshi, H. R. (1981) Impact of Technological Change on Production Employment and Factor Shares in Cotton In Akola District (Maharashtra), Ph.D. Dissertation Submitted at Indian Agricultural Research Institute, New Delhi, India
paddy variety Sona masuri yielded 34 per cent more than masuri variety, of which technical change contributed 17 per cent and increased input levels of labour and plant nutrients contributed 17 per cent.

Suligavi\textsuperscript{24} examined the impact of technological change in rainfed cotton in Dharwad district using output decomposition model. He observed that hybrid DCH-32 cotton variety (new technology) produced 115 per cent more output per farm than local cotton variety Jayadhar (old technology). To the 115 per cent more output, new technology contributed 82 per cent and increased level of inputs contributed 35 per cent. The individual input contribution of seed plus fertilizer was 19 per cent, plant protection chemicals 3 per cent and capital 13 per cent. The results indicted that the technical change was a major source of output growth in cotton technology.

Hiremath\textsuperscript{25} employed the Cobb-Douglas production function through restricted UOP profit function with constant returns to scale. The structural break was observed (Chow test) in A-2 and A-119 bidi tobacco varieties (new technology) over S-20 (old technology). The estimated total growth in output of A-2 over S-20 was 105 per cent of which, the contribution due to technical change was 72 per cent and of total inputs was 33 per cent. The estimated total growth in output of A-119 over S-20 was higher by 154 per cent, to which technical change contributed 90 per cent and changes in the level of inputs contributed 64 per cent. In both technologies the new seed technology, fertilizer and labour were identified as the major sources of growth in tobacco output.

Lalwani\textsuperscript{26} studied the impact of technological change on Dairy farming sector in India under the Operation Research Project (ORP) of the National Dairy Research Institute (NDRI) with an objective of decomposing the output gain in milk yield occurring as a result of shift in dairy technology. It was found that the adoption of

\textsuperscript{24} Suligavi, B.S. (1988) Impact of Technical Change in Rainfed Cotton on Output, Employment and Factor Shares in Dharwad District, Karnataka; An Economic Analysis, An Unpublished M.Sc (Agri.) Thesis Submitted at the University of Agricultural Sciences, Dharwad, India


milch cross breed cattle, brought about upward shift in the threshold level of milk yield, enabling the farmers to get more milk at the existing levels of input use. However due to negative contribution of non-neutral variant of technological efficiency, the dairy farmers failed in consolidating such technological gains as they were unable to adjust to the new requirement of the cross breed dairy technology.

Hiremath and Shankar Murthy\textsuperscript{27} studied the impact of technical change on factor shares in the production of beedi tobacco in Karnataka. They found that the actual factor shares under old technology variety S20 for land, labour, fertilizer, capital and manure were 0.5641, 0.01708, 0.0511, 0.1360 and 0.0437, respectively. They were not significantly different from the estimated factor shares of the corresponding factors which implied that all the inputs were paid their due share under old technology. Similar pattern was evident under new technology varieties like A-2 and A-119. Per acre absolute actual income has increased by 78\% and 204\% under new technology varieties (A-2 and A-I 19).

Suligavi and Shankar Murthy\textsuperscript{28} studied the impact of technological change on employment and production relationship in cotton in Dharwad district, Karnataka. The study was based on a stratified random sample of 135 farms of which 72 farmers grew high yielding varieties (HYVs) and 63 farmers grew local cotton. It was observed that the input and output mean levels differed significantly between technology levels. The HYV technology was better by as many as three times as that of local technology. The new technology was not only high yielding, but also input use intensive in respect of inputs.

Deoghare\textsuperscript{29} using the Cobb-Douglas production function through restricted UOP profit function with constant returns to scale studied the effects of technical change in cotton crop in Maharashtra state during 1989-90. The structural break was

\textsuperscript{29} Deoghare (1993) Effects of Technical Change on Output, Employment and Factor Share in Rainfed Cotton in Maharashtra State: An Economic Analysis, An Unpublished Ph.D. thesis submitted at the University of Agricultural Sciences, Dharwad, India
observed in LRA 5166, H-4 and AH 468 cotton hybrids (new technology) over AKH 4 (old technology). The estimated total growth in output of LRA 5166, H-4 and AH 468 over AKH 4 was 69.52 per cent, 60.37 per cent and 103.97 per cent respectively. The contribution due to technical change was 40.24 per cent, 22.02 per cent and 51.89 per cent respectively for the above cotton hybrids. The total change due to human labour, bullock labour, fertilizer and capital inputs was 29.28 per cent, 38.37 per cent and 52.08 per cent for LRA 5166, H-4 and AH 468 over AKH 4 cotton variety respectively.

Thakur and Sinha\textsuperscript{30} examined the impact of technical change in rice production in Bihar agriculture. He observed that the contribution of new rice production technology is more pronounced in southern region as compared to northern region of the state. New rice production technology produced 43.47 per cent and 47.77 per cent higher yield in northern and southern regions, respectively. The technological bias with respect to factor inputs in rice production was estimated as land and labour saving as well as fertilizer and capital using in northern region. Whereas, it was labour, fertilizer and capital using and land saving in southern region.

Sharma and Singh\textsuperscript{31} analyzed the impact of technological change on investment pattern and resource structure in Kangra and Kullu districts of Himachal Pradesh. The investment in capital assets for productive purpose increased with the farm size. The average investment per farm in crop farming in case of adopted farmers was Rs. 17,571.53, Rs. 17,699.21 and Rs. 23,716.99 on small, medium and large categories, respectively. Where as in case of non-adopted farmers, it was Rs. 7,867.36, Rs. 8,262.28 and Rs. 12,275.40 on small, medium and large categories. The study pointed out that due to implementation of various development programmes, the investment on productive assets, cropping intensity and productivity increased more on adopted group of farmers. The study also revealed that adoption of new technology i.e. growing of high yielding varieties was significantly and positively related to farm size, education level of farmer, availability of family labour and technical knowledge.


On measuring the sources of output growth in new milk production technology, Gaddi and Kunal\textsuperscript{32} opined that, the total growth in milk yield per cow per lactation, by shifting to new production technology was about 145 per cent. However the estimated growth in milk output was 146 per cent of which 47 per cent was contributed by new milk production technology with the existing level of inputs. The contribution of increased level of inputs was 99 per cent. Among the inputs, the contribution of feed (40 per cent) was the highest, followed by labour (26 per cent), fodder (21 per cent) and capital (12 per cent).

Mattigatti and Iyengar\textsuperscript{33} conducted a study to evaluate and compare the resource use efficiencies on sericultural and non-sericultural farms in the Hassan district of Karnataka. The results revealed that both sericultural and non-sericultural farms had significantly different production functions. Sericulture farms used less fertilizers and a higher amount of farmyard manure (FYM). Labour had a significant contribution in the case of sericulture farms and gave more scope for additional use of labour. Non-sericulture farms inefficiently used the labour. The gross profit of sericulture farms (Rs. 5,981.16 per acre) was comparatively higher than that of the non-sericulture farms (Rs. 4,066.62 per acre). The neutral technological efficiency for sericultural farms was 25.46\% more than for non-sericulture farms. Labour (92.69\%) and chemicals (18.44\%) while fertilizers indicated the non-neutral technological efficiency more and FYM showed technological inefficiency. The overall non-neutral technological efficiency was positive (7.28\%). The gain in gross profits of sericulture farms as a result of change in quantity of input use was comparatively less i.e. 5.84\%, out of which FYM contributed 6.45\% and labour 2.29\%, respectively. Other inputs like fertilizers and chemicals contributed negatively. The total gain in gross profits of sericulture farms was 38.58\% more than that of non-sericulture farms per acre.

Kumar Singh\textsuperscript{34} made an attempt to evaluate the effect of change in rice production technology on functional income distribution and determine the extent of


change in the effects of factor specific technical bias on functional income distribution. The results revealed that the new agricultural technology introduced in Manipur was biased towards the more use of labour and fertilizer and the saving of pesticide and insecticide in own holdings. Technical bias with respect to land was neutral and its estimated factor share remained unaltered under new technology.

Badal and Singh\textsuperscript{35} studied the technological change in maize production in Samastipur, Vaishali and Hazaribagh districts in Bihar. A test of structural break between production functions for local varietal technology and high yielding varietal technology of maize revealed that shift in production function of HYV technology was due to change in slope as well as shift in the intercept, implying thereby the existence of neutral as well as non-neutral technological change. The total differences in the productivities per hectare between local or traditional varieties and HYVs of maize were estimated to be 69 per cent in kharif and 80 per cent in rabi.

Kunnal et al.,\textsuperscript{36} studied that the impact of new technology on output, factor shares and employment in bengalgram production in Karnataka. Growing of high yielding varieties of bengalgram (technical change) resulted in about 25 per cent of additional output. To this increased output, the technology (HYV) component accounted for 10.76 per cent, while increased use of inputs accounted for 14 per cent. All the inputs stood to gain with the introduction of new technology in bengalgram production.

Mattigatti et al.,\textsuperscript{37} evaluated the technological change in the management of small-scale to large-scale irrigated sericulture farming by employing Cobb-Douglas production function and the technological decomposition model. The technological gap between different scales of farming was found to be significant. The shifts in technology from small-scale to medium-scale and medium-scale to large-scale have

proved their efficiency in attaining higher profitability with 54.96% and 82.97% efficiency, respectively. The shift from small-scale to large-scale ultimately proved efficiency to the extent of 137.93%.

Ganesh Kumar\textsuperscript{38} measured the technological change in dairy farming in Tamil Nadu with the view to formulate some guidelines for increasing the growth in milk production. The total gain in per day milk yield due to shift in technology was found to be 44.42 per cent, of which, 36.55 per cent occurred due to technological change and 7.82 per cent was due to the difference in the level of input use.

Kumaresan \textit{et al.,}\textsuperscript{39} studied the nature of technological changes in silk cocoon production through the measurement of productivity differences between new bivoltine sericulture (CSR hybrid) technologies and the conventional multivoltine sericulture (Cross Breed) technologies and analysed the constituent sources of such differences. The production function analysis indicated that farm yard manure, chemical fertilizer and cocoon feed ratio were the important variables that significantly influenced the CSR hybrid cocoon production. The total gain in cocoon production due to the shift from cross breed to CSR hybrid was found to be 35.22 per cent, which was mainly due to the difference in the levels of input use. The results indicated the adoption of CSR hybrids in place of cross breeds would bring an upward shift in the cocoon yield. The positive contribution of neutral technological change (15.40 per cent) was offset by the negative contribution of non-neutral technological change (14.28 per cent) resulting in meager yield gain due to technological change. The yield gain due to changes in input use was significant with 34.10 per cent.

Basavaraja \textit{et al.,}\textsuperscript{40} studied the technological change in paddy production in Andhra Pradesh by comparing the profitability of SRI (System of Rice Intensification) method of rice cultivation with the traditional methods. The yield realized in traditional method was 6.07 tonnes per hectare, while it was 8.51 tonnes


under SRI method. The production functions for SRI and traditional methods were also estimated separately. Using the decomposition model, the productivity difference between the SRI and traditional method was decomposed into its constituent sources. It was inferred that, between the technological and input use differentials, which together contributed to the total productivity difference of the order of 33.72 per cent, the former alone accounted for 31.61 per cent. This implied that paddy productivity could be increased by about 31.61 per cent if the farmers could switch over to from traditional method to SRI method with the same level of resource use as in traditional method. However, the contribution of differences in input use between SRI method and traditional method of paddy cultivation to the productivity difference was meager at 2.10 per cent.

Based on the decomposition analysis carried out for assessing the total difference in income from cocoon production between the large-scale and the small-scale sericulture farmers carried out by Kumaresan et al., was found to be 31.08 per cent. Among the different sources contributing to the income difference, the technology or the management practices contributed maximum (25.01 per cent) to the income gap for the large-scale farmers compared to the small-scale farmers. Among the components of technical change, the contribution of neutral technical change in the income reduction was estimated to be 25.72 per cent in contrast to the positive contribution of 0.72 per cent by the non-neutral technological change towards the net income in cocoon production.

5.2.3. Returns to Investment in Research, Education and Extension

The studies on returns to investment in research, education and extension in the past have been reviewed and presented below.

Griliches computed the widely quoted 743 per cent rate of return to investment in hybrid corn research, using a cash flow technique with annual research cost as outflows and annual value of consumer surplus as inflows.

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Bisaliah\textsuperscript{43} estimated the value of additional resources required to produce the new technology level of output by old technology as Rs.67 per acre. The farm firms in Ferozepur district (Punjab) would have required additional resources valued at Rs.67 per acre to produce the new technology level of output during the year 1967-68 in the absence of new technology using old technology. For the entire state of Punjab, the total value of resources saved was estimated to be Rs. 10.6 crores and for all India Rs.48.7 crores for the year 1967-68.

Karam Singh\textsuperscript{44} estimated the Cobb-Douglas production functions based on the cross district and time series data for the pre-technology (1960-65) and post-technology (1969-72) periods for Punjab and estimated growth in output to be 33 per cent. He opined that every rupee spent on research in Punjab has yielded a return of Rs.28.64.

Kumar \textit{et al.},\textsuperscript{45} treated the value of inputs saved by adopting the new technology of milk production (Indo-Swiss Cattle Breeding Programme), a product of research and extension as benefit of the project. Benefits and costs over the years were estimated by using 1973-74 prices. They reported that the value of inputs saved increased with increase in productivity over the years and was maximum in 1999. The expenditure on research and extension attained its maximum value in 1976 and continued into perpetuity. The internal rate of return was found to be about 29 per cent, implying that on an average one rupee invested in the research and extension activities of Indo-Swiss cross-breeding project yielded a return of 29 per cent annually from the date of investment.

Alshi\textsuperscript{46} estimated the gross value of inputs saved as a result of development of new varieties of cotton to be Rs.163.5 million for Akola district, and Rs.1202.2 million for entire state of Maharashtra for the year 1979-80. Also, the additional


\textsuperscript{44} Karam Singh (1977) “Returns to Investment on Agricultural Research in Punjab”, \textit{Indian J. Agric. Econ.}, Vol. 32 (3): pp. 202 – 216


quantity of cotton output with no extra cost was estimated at 36.17 thousand tonnes for the Akola district and 265.80 thousand tonnes for the Maharashtra state during the year 1979-80 at the existing level of adoption of new cotton seed technology.

Hiremath\textsuperscript{47} estimated the gross value of inputs saved as a result of development of new varieties of tobacco to be Rs.7.31 crores for Belgaum district and Rs.7.97 crores for the entire state of Karnataka during the year 1983-84. During the same year due to the adoption of new technology in tobacco, additional output gained was estimated at 9.159 million kg for Belgaum district and 10.44 million kg for Karnataka state.

Deoghare\textsuperscript{48} studied the returns to investment in cotton research in Maharashtra state. On account of the adoption of American and hybrid varieties of cotton, the value of inputs saved was estimated to be Rs. 1102.12 per hectare, while additional output was estimated to be 1.5 quintal per hectare. The extent of additional output projected for Vidarbha region and Maharashtra was about 1.70 lakh tonnes and 2.67 lakh tonnes, respectively. The total value of inputs saved due to adoption of new technology was around Rs.124.3 crores for Vidarbha region and Rs.195.56 crores for Maharashtra state for the year 1988-89.

Based on the decomposition of output growth into technical change and increased levels of input use Gaddi and Kunnal\textsuperscript{49} provided the essential information to work out the returns to investment in research. They opined that the technical change has been the outcome of investment in research, extension and education. They observed a downward shift in the unit cost function on account of new milk production technology. The estimated value of total inputs saved for Dharwad district and Karnataka state separately was to the extent of Rs. 14.5 crores and Rs. 272 crores respectively for the year 1994-95.


5.3. Methodology: Technical Change

The adoption of technologies brings about changes in output, employment and factor shares.\textsuperscript{50} For determining the structural break in production relations, accounting for the sources of output growth and for evaluating the effects of new technology on factor shares, the production function is proposed as relevant conceptual framework. Production function analysis was used to find out the input – output relationship, marginal value productivity of inputs used and also to examine the resource use efficiency in silk cocoon production for cross breed and bivoltine hybrids. The production function relationship refers to technical relationship between the factors of production and the output. It provides the information on expected variation in the quantity of silk cocoon when certain quantities of inputs are used in production.

The transformation of a set of inputs into output which is described by a production function, can be written for silk cocoon production as

\[ Y = f(X_1, X_2, X_3, \cdots, X_n) \]

Where;

Output ‘Y’ is treated as the dependent variable and inputs $X_1, X_2, X_3, \cdots, X_n$ as independent variables. In a functional analysis, it would be essential to choose an appropriate form of production function depending on the type of the data to be analysed.

Biologically derived production function for sericulture data was evolved choosing between the Cobb-Douglas (CD) and the Constant Elasticity of Substitution (CES). The CES production function accommodates elasticities of substitution different from zero (Leontief case) or unity (CD case), elasticities under this form remain constant at all levels of input use. Besides, the general appeal of the CES function is restricted due to its estimation through non-linear models. The function is also uneconomical in using the degrees of freedom and is highly sensitive to changes in data, measurement of variables and methods of estimation.\textsuperscript{51}

The Cobb-Douglas production function framework has been widely used in studies related to Indian agriculture.\textsuperscript{52} The Cobb-Douglas specification is easy in estimation and interpretation. It is a homogenous function that provides a scale factor enabling one to measure the returns to scale and to interpret the elasticity coefficients with relative ease. Cobb-Douglas production function also makes several restrictive assumptions like elasticity coefficients are constant, implying constant share for the inputs and the elasticity of substitution among the factors is unity in the Cobb-Douglas form. Moreover, this being linear in logarithm, output is zero if any of the input is zero and output expansion path is assumed to pass through the origin.\textsuperscript{53} Based on the past studies\textsuperscript{54,55,56} indicating the merits of Cobb-Douglas production function, in the present study also the Cobb-Douglas production function as stated below was employed for further investigations.

\begin{equation}
Y = b_0 X_1^{b_1} X_2^{b_2} X_3^{b_3} X_4^{b_4} X_5^{b_5} e^{DX_6} e^u
\end{equation}

In log linear form the above function can be written as:

\[\ln Y = \ln b_0 + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + D X_6 + u\]

Where;

Y = Silk Cocoon Production (kg/acre/year)
X_1 = Cost of Farm Yard Manure (Rs/acre/year)
X_2 = Cost of chemical fertilizers (Rs./acre/year)
X_3 = Labour used in mulberry cultivation and silkworm rearing (Man days/acre/year)
X_4 = Disease Free Layings (DFLs) used in rearing (Number/acre/year)
X_5 = Use of disinfectants and materials in silkworm rearing (Rs/acre/year)
D = Intercept dummy which takes the value ‘1’ if it is new technology farm, and value ‘0’ otherwise.
b_0 = Intercept term (Scale parameter)
b_1, b_2, b_3, b_4 and b_5 = Regression coefficients of farmyard manure, chemical fertilizers, labour, DFLs, and disinfectants & material respectively.
u = error term independently distributed with zero mean and finite variance.

The function was fitted for two separate groups of farmers who were classified based on the level of technologies adopted in their farms. The farmers were post classified into new technology farms and old technology farms based on the level of adoption of technologies in mulberry production and silkworm rearing. The major deciding technologies for the classification of new technology farms included the adoption of following four important technologies in their respective farms.

- Farmers growing V-1 mulberry, a robust and high yielding mulberry variety
- Farmers having a separate silkworm rearing house
- Farmers adopting productive bivoltine (CSR) hybrids for silk cocoon production
- Farmers adopting shoot rearing technology

The rest of the farms were classified as old technology farms. The classification yielded 104 farms that were adopting the above said technologies in their farm and were categorized as new technology farms and the rest 136 farms were classified as old technology farms.

Parameters of regression equation (1) were estimated by the Ordinary Least Square (OLS) method using the logarithmic form. All the five coefficients taken together measure the total percentage change in output for a given percentage change in inputs. The sum of all the regression coefficients is the degree of homogeneity of the Cobb-Douglas production function. The error term (u) was assumed to follow the assumptions of the Linear Stochastic Regression Model. It was further assumed that the explanatory variables in the Linear Stochastic Regression Model were not perfectly linearly correlated and were free from the aggregation error.57

5.3.1. Structural Break in Production Relation

To identify the structural break if any in the production relations with the introduction of new technology in silk cocoon production, output elasticities were estimated by Ordinary Least Square (OLS) method by fitting log linear regression separately for, old technology farms and new technology farms. The pooled regression function was run in combination with, old technology farms and new technology farms. The rest of the farms were classified as old technology farms. The classification yielded 104 farms that were adopting the above said technologies in their farm and were categorized as new technology farms and the rest 136 farms were classified as old technology farms.

Parameters of regression equation (1) were estimated by the Ordinary Least Square (OLS) method using the logarithmic form. All the five coefficients taken together measure the total percentage change in output for a given percentage change in inputs. The sum of all the regression coefficients is the degree of homogeneity of the Cobb-Douglas production function. The error term (u) was assumed to follow the assumptions of the Linear Stochastic Regression Model. It was further assumed that the explanatory variables in the Linear Stochastic Regression Model were not perfectly linearly correlated and were free from the aggregation error.57

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technology farms including technology as dummy variable with value ‘one’ for new technology and ‘zero’ for old technology.

The following four log linear estimable forms of equations were used for examining the structural break in production relation;

- Old technology farms
- New technology farms
- Aggregate of old and new technology farms (without dummy variable)
- Aggregate of old and new technology farms (with dummy variable) \( D = 1 \), for “new technology farm” and \( D = 0 \), for “old technology farm”

\[
\begin{align*}
\ln Y_1 &= \ln A_1 + b_{11} \ln X_{11} + b_{21} \ln X_{21} + b_{31} \ln X_{31} + b_{41} \ln X_{41} + b_{51} \ln X_{51} + U_1 \quad \ldots \quad (2) \\
\ln Y_2 &= \ln A_2 + b_{12} \ln X_{12} + b_{22} \ln X_{22} + b_{32} \ln X_{32} + b_{42} \ln X_{42} + b_{52} \ln X_{52} + U_2 \quad \ldots \quad (3) \\
\ln Y_3 &= \ln A_3 + b_{13} \ln X_{13} + b_{23} \ln X_{23} + b_{33} \ln X_{33} + b_{43} \ln X_{43} + b_{53} \ln X_{53} + U_3 \quad \ldots \quad (4) \\
\ln Y_4 &= \ln A_4 + b_{14} \ln X_{14} + b_{24} \ln X_{24} + b_{34} \ln X_{34} + b_{44} \ln X_{44} + b_{54} \ln X_{54} + b_{4D} + U_4 \quad \ldots \quad (5)
\end{align*}
\]

Where;

Subscripts 1, 2 and 3 in the above equations represent ‘old technology’, ‘new technology’ and ‘pooled’ production function with technology as dummy variable respectively.

\( b_{11}, b_{21}, b_{31}, b_{41}, b_{51}, b_{12}, b_{22}, b_{32}, b_{42}, b_{52}, b_{13}, b_{23}, b_{33}, b_{43}, b_{53} \) and \( b_{63} \) represent individual output elasticities of respective inputs. Variables in (2), (3) and (4) are defined in the same way as in equation (1).

Chow’s test\(^{58}\) was employed to identify whether the parameters governing the production relations in the “old technology farms” are different from that of “new technology farms”. The standard error estimated for dependent variables by running the above three regression functions (2), (3) and (4), were used to compute the ‘F’ ratio.

---

The ‘F’ ratio is computed as

\[ F_{(p,n+m-2p)} = \frac{(SSE_3 - SSE_1 - SSE_2)}{(SSE_1 + SSE_2)(n + m - 2p)} \]

Where;

- SSE1 = Residual variation of “old technology farms”
- SSE2 = Residual variation of “new technology farms”
- SSE3 = Pooled residual variation
- n = Sample size of “old technology farms”
- m = Sample size of “new technology farms”
- p = Number of variables including intercept

The computed ‘F’ value is compared with ‘F’ critical value ‘p’ and (n+m-2) degrees of freedom at appropriate level of significance. A not significant ‘F’ value indicates that the corresponding parameters of production function are the same. This implies that the two technologies are structurally same. If the ‘F’ value is significant, it indicates that the corresponding parameters of production are not the same, thus implying parameters of regression function generated by the new production technology are structurally different from those generated by the old production technology.

Similarly, if the regression coefficient of dummy variable and computed ‘F’ value for the pooled regression function (5) is significant, then it can be said that there is a structural break between old production technology and the new production technology in silk cocoon production.

5.3.2. Sources of Output Growth

Technical change in the production function can be defined as a change in the parameters of the production function or creation of new production function. For any production function, the total change in output is brought about by the shifts in the parameters of production function and the changes in the volume of inputs. A rise in the total output under ‘new’ technology over the ‘old’ technology with the use of same level of inputs can be attributed to the technical change. This change in total output due to technology is measured by changes in scale (intercept) and slope (elasticities) parameters. Out of this total change, shift in the intercept in equation (1)
measures the neutral component of the technical change and the shift in the slope parameters \((a_i\) and \(b_i’s\)) measure the non-neutral component of the technical change which together constitutes technological contribution to the difference in output under the ‘old’ and ‘new’ silk cocoon production technologies. Another contribution to the total output is due to the disequilibrium caused by new production relations. The total change in output due to adoption of new silk cocoon production technology (bivoltine breeds) is decomposed into the factors of technology and changes in the quantities of inputs. The output decomposition model as developed by Bisaliah\(^{59}\) and used by Lalwani\(^{60}\) and Ganesh Kumar\(^{61}\) is used to decompose the difference in output per acre between ‘old’ and ‘new’ silk cocoon production technologies into technical change and change in quantities of inputs used. Equations (2), (3) and (4) were used to find out the sources of output growth.

Taking difference between equations (4) and (2) and similarly the difference between equations (4) and (3) adding some terms and subtracting some terms, the yield decomposition models can be written for old technology farms and new technology farms;

\[
\ln Y_2 - \ln Y_1 = (\ln A_2 - \ln A_1) + (b_{12} \ln X_{12} - b_{11} \ln X_{11}) + (b_{22} \ln X_{22} - b_{21} \ln X_{21}) + (b_{32} \ln X_{32} - b_{31} \ln X_{31}) + (b_{42} \ln X_{42} - b_{41} \ln X_{41}) + (b_{52} \ln X_{52} - b_{51} \ln X_{51}) + (u_2 - u_1) \quad \ldots (6)
\]

Rearranging the terms,

\[
\ln Y_2 - \ln Y_1 = (\ln A_2 - \ln A_1) + [(b_{12} - b_{11}) \ln X_{11} + (b_{22} - b_{21}) \ln X_{21} + (b_{32} - b_{31}) \ln X_{31} + (b_{42} - b_{41}) \ln X_{41} + (b_{52} - b_{51}) \ln X_{51}] + (b_{12} (\ln X_{12} - \ln X_{11}) + b_{22} (\ln X_{22} - \ln X_{21}) + b_{32} (\ln X_{32} - \ln X_{31}) + b_{42} (\ln X_{42} - \ln X_{41}) + b_{52} (\ln X_{52} - \ln X_{51})) + (u_2 - u_1) \quad \ldots (7)
\]


By using the logarithmic rule, the equation (7) can also be written as:

\[
\ln \left( \frac{Y_2}{Y_1} \right) = \left[ \ln \left( \frac{A_2}{A_1} \right) \right] + \left[ (b_{12} - b_{11}) \ln \left( \frac{X_{11}}{X_{21}} \right) + (b_{22} - b_{21}) \ln \left( \frac{X_{21}}{X_{31}} \right) + (b_{32} - b_{31}) \ln \left( \frac{X_{31}}{X_{41}} \right) + (b_{42} - b_{41}) \ln \left( \frac{X_{41}}{X_{51}} \right) + (b_{52} - b_{51}) \ln \left( \frac{X_{51}}{X_{61}} \right) \right] + \left[ (b_{12} \ln \left( \frac{X_{12}}{X_{11}} \right) \right] + \left[ (b_{22} \ln \left( \frac{X_{22}}{X_{21}} \right) \right] + \left[ (b_{32} \ln \left( \frac{X_{32}}{X_{31}} \right) \right] + \left[ (b_{42} \ln \left( \frac{X_{42}}{X_{41}} \right) \right] + \left[ (b_{52} \ln \left( \frac{X_{52}}{X_{51}} \right) \right] + (U_2 - U_1)
\]

..... (8)

The decomposition of equations (8) involves decomposing the logarithm of the ratio of ‘new’ to ‘old’ production technology. It is approximately a measure of percentage change in output with the introduction of the new technology. These equations are the output decomposition models used for decomposition of total output into its causal components, i.e. technological change and increased level of inputs used.\(^\text{(62)}\)

The equation (8) decomposes the total difference in per acre yield between ‘old’ and ‘new’ production technologies (on left hand side of equation) into;

i) Neutral technological change (first bracketed expression on right hand side)
ii) Non-neutral technological change (second bracketed expression on right hand side)
iii) Changes in the level of inputs (third bracketed expression on right hand side)

On the right hand side of the equation, the first two bracketed expressions summed up measures joint contribution of the component of technology.

The first bracketed expression on the right hand side is a measure of percentage change in output due to shift in scale parameters (A) of the production function. The second bracketed expression is the sum of the arithmetic changes in output elasticities, each weighted by logarithm of volume of that input used under old technology, as a measure of change in output due to shifts in slope parameters (output elasticities) of the production function.

The third bracketed expression is the sum of the logarithm of the ratio of input used in new technology to input used in old technology, each weighted by the output

elasticity of that input under new technology. This expression is a measure of change in output due to changes in the inputs used per unit, given the output elasticities of these inputs under new production technology. The last bracketed expression is related to the difference in error terms.

5.4. Input-output Relationship in Silk Cocoon Production

In order to assess the efficiency of resources used in silk cocoon production, a Cobb-Douglas type of production function was fitted separately for ‘old technology farms”, and ‘new technology farms’, considering important inputs in production like farm yard manure, chemical fertilizers, human labour, Disease Free Layings (DFLs) or the silkworm eggs and disinfectants and materials. The parametric estimates of silk cocoon production with respect to old technology farms, new technology farms and pooled farms, were calculated using Ordinary Least Square Techniques (OLS) and presented (Table 5.1).

In the case of old technology farms, the variation in the silk cocoon production could be explained up to 90 per cent (adjusted $R^2$) by the variables used in the model, such as farm yard manure, chemical fertilizers, human labour, Disease Free Layings (DFLs) or the silkworm eggs and disinfectants and materials. It was found that the elasticity coefficients for chemical fertilizers (0.139) and number of DFLs (0.843) were found to be positive and significant. The elasticity coefficient for farm yard manure (0.031) and disinfectants and materials (0.026) though were positive, but not significant. However the elasticity coefficient for labour (-0.004) was found to be negative and non significant. The calculated ‘F’ value (191.60) of the function was found to be statistically significant.
Table 5.1: Production Function Estimates for Silk Cocoon Production

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Variables</th>
<th>Regression Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Old Technology Farms</td>
</tr>
<tr>
<td>1</td>
<td>Constant</td>
<td>-1.049</td>
</tr>
<tr>
<td>2</td>
<td>Chemical fertiliser (Rs./acre/year)</td>
<td>0.139 **</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(5.342)</td>
</tr>
<tr>
<td>3</td>
<td>Farm Yard Manure (Rs/acre/year)</td>
<td>0.031 ** NS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.780)</td>
</tr>
<tr>
<td>4</td>
<td>Labour (Mandays/acre/year)</td>
<td>-0.004 NS **</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(-0.095)</td>
</tr>
<tr>
<td>5</td>
<td>No. of Disease Free Layings (Number/acre/year)</td>
<td>0.843 **</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(20.437)</td>
</tr>
<tr>
<td>6</td>
<td>Disinfectants and materials (Rs/acre/year)</td>
<td>0.026 NS **</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.691)</td>
</tr>
<tr>
<td>7</td>
<td>Dummy (New technology = 1, Old technology = 0)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adjusted R²</td>
<td>0.90</td>
</tr>
<tr>
<td></td>
<td>F - Value</td>
<td>191.603 **</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.035</td>
</tr>
</tbody>
</table>

Note: Figures in the parenthesis indicate t-values.
* - Significant at 5 % level; ** - Significant at 1 % level.

In case of new technology farms, the variation in the silk cocoon production could be explained up to 48 per cent (adjusted R²) by the variables used in the model, such as farm yard manure, chemical fertilizers, human labour, Disease Free Layings (DFLs) or the silkworm eggs and disinfectants and materials. The OLS estimates bear the expected signs except in case of labour and disinfectants and material. It was found that the elasticity coefficients for chemical fertilizers (0.197) and number of DFLs (0.748) were found to be positive and significant. The elasticity coefficient for farm yard manure (0.045) was positive and not significant. The elasticity coefficient for labour (-0.169) was found to be negative and significant. Further the elasticity coefficient of disinfectants and materials (-0.014) was found to be negative and non-significant. The calculated ‘F’ value (21.49) of the function was found to be statistically significant.
The expression for pooled production function (4) indicated that excepting labour all the other variables in the function were positive. The elasticity coefficients of chemical fertilizers (0.142) and number of DFLs (0.912) farm yard manure (0.108) was positive and significant. The elasticity coefficients of disinfectants and materials (-0.034) was found to be negative and non significant. The elasticity coefficient for labour (-0.143) was found to be negative and significant. The calculated ‘F’ value (113.08) of the function was found to be statistically significant. The variation in the silk cocoon production could be explained up to 72 per cent (adjusted R²) by the variables included in the model, such as farm yard manure, chemical fertilizers, human labour, Disease Free Layings (DFLs) and disinfectants and materials.

5.5. Structural Break in Production Relation

To test, if the shift from ‘old technology’ to ‘new technology’ led to structural break through in silk cocoon production, the Chow test⁶³ utilizing the Ordinary Least Square (OLS) estimates from the production functions (2), (3) and (4) were used. The null and alternative hypotheses set out under the test are:

\[
H_0: A_1 = A_2; b_{11} = b_{12}; b_{21} = b_{22}; b_{31} = b_{32}; b_{41} = b_{42}; b_{51} = b_{52}
\]

\[
H_1: A_1 \neq A_2; b_{11} \neq b_{12}; b_{21} \neq b_{22}; b_{31} \neq b_{32}; b_{41} \neq b_{42}; b_{51} \neq b_{52}
\]

The null hypothesis under the study was rejected, as the observed ‘F’ ratio exceeded its critical value at 5 per cent level of significance. This implied that population structures defining the competing technologies, were different and that the adoption of ‘new technology’ for silk cocoon production in place of the ‘old technology’ led to structural break through in the process of silk cocoon production.

The expression (5) of pooled silk cocoon production function with technology as dummy variable was also used to identify the structural break through in production relations with the introduction of new technology in silk cocoon production. The regression coefficient for dummy variable (0.050) was significant at 5 per cent level of significance and also the calculated ‘F’ value (96.44) was greater than ‘F’ calculated value at 5 per cent level of significance.

5.6. Geometric Mean Levels of Silk Cocoon Output and Inputs Used in Production

The per acre estimates of geometric mean levels of silk cocoon output and the level of different inputs used in silk cocoon production were worked out and presented in Table 5.2. It is clear from the table that the silk cocoon production in ‘new technology farms’ was 33.09 per cent more than ‘old technology farms’. With regard to input use the ‘new technology farms’ tended to use 34.32 per cent more chemical fertilizers, 76.92 per cent more farm yard manure, 17.72 per cent more number of DFLs and 15.38 per cent more disinfectants and materials in silk cocoon production. Labour was one of the components used at a lower rate than ‘old technology farms’ at – 6.56 per cent. It was found that the, human labour was the only input which was not used in excess than the ‘new technology farms’. This was mainly to support the fact that, the ‘new technology’ components in sericulture were mainly directed towards the reduction of drudgery to labour, thereby saving the excess labour utilized in the production of silk cocoon.

Table 5.2: Geometric Mean Levels of Inputs Used and Output Produced

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Components</th>
<th>New technology farms</th>
<th>Old technology farms</th>
<th>Per cent change in input use/Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Silk cocoon yield (kg/acre/year)</td>
<td>691.21</td>
<td>519.36</td>
<td>33.09</td>
</tr>
<tr>
<td>2</td>
<td>Chemical fertiliser (Rs./acre/year)</td>
<td>4186.36</td>
<td>3116.8</td>
<td>34.32</td>
</tr>
<tr>
<td>3</td>
<td>Farm Yard Manure (Rs/acre/year)</td>
<td>4794.31</td>
<td>2709.86</td>
<td>76.92</td>
</tr>
<tr>
<td>4</td>
<td>Labour (Mandays/acre/year)</td>
<td>359.72</td>
<td>384.97</td>
<td>-6.56</td>
</tr>
<tr>
<td>5</td>
<td>No. of Disease Free Layings (Number/acre/year)</td>
<td>1094.12</td>
<td>929.46</td>
<td>17.72</td>
</tr>
<tr>
<td>6</td>
<td>Disinfectants and materials (Rs/acre/year)</td>
<td>2741.19</td>
<td>2375.82</td>
<td>15.38</td>
</tr>
</tbody>
</table>

5.7. Decomposition of Output Growth

From the analysis of the structural break through in silk cocoon production, it revealed that the contribution from the new technology was significant. Further the per acre output gain in silk cocoon production due to the shift in the new technology of production was decomposed using production function parameters (Table 5.1) and geometric mean inputs (Table 5.2) with the help of the decomposition function (8).
Table 5.3: Decomposition of Productivity Gain in Silk Cocoone Production

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Sources of Technical Change</th>
<th>Percentage contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Total observed productivity gain</td>
<td>33.09</td>
</tr>
<tr>
<td>B</td>
<td>Productivity gain due to technological change:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 Neutral technological change</td>
<td>142.67</td>
</tr>
<tr>
<td></td>
<td>2 Non-neutral technological change</td>
<td>-135.65</td>
</tr>
<tr>
<td></td>
<td>Total productivity gain due to technological change (1 + 2)</td>
<td>7.02</td>
</tr>
<tr>
<td>C</td>
<td>Productivity gain due to input use:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 Chemical fertiliser</td>
<td>5.82</td>
</tr>
<tr>
<td></td>
<td>2 Farm Yard Manure</td>
<td>2.59</td>
</tr>
<tr>
<td></td>
<td>3 Labour</td>
<td>1.15</td>
</tr>
<tr>
<td></td>
<td>4 No. of Disease Free Layings</td>
<td>12.20</td>
</tr>
<tr>
<td></td>
<td>5 Disinfectants and materials</td>
<td>-0.20</td>
</tr>
<tr>
<td></td>
<td>Total productivity gain due to input use (1+2+3+4+5)</td>
<td>21.56</td>
</tr>
<tr>
<td>D</td>
<td>Total estimated productivity gain (B + C)</td>
<td>28.58</td>
</tr>
</tbody>
</table>

The results of the decomposition analysis (Table 5.3) indicated a slight discrepancy between observed and estimated gains in productivity between old technology farms and new technology farms. This may be attributed to the random term, which among others, accounts for variable management input which could not be included in the model.

The total gain in production due to the shift from ‘old technology’ to ‘new technology’ was found to be 28.58 per cent, which was mainly contributed due to the difference in the levels of input use. The contribution of technological change to the yield gain was 7.02 per cent, which implies that the output of the cocoon production could not be increased with the same levels of inputs used under the old technology. Among the components of technological change, the contribution of neutral technological change in total productivity was estimated to be 142.67 per cent. This indicates that mere adoption of modern sericultural technologies in place of ‘traditional’ practices would bring an upward shift in the silk cocoon yield. But this gain was offset by the negative contribution (- 135.65 per cent) of the non-neutral technologies to the yield gains. The negative non-neutral technologies implied that there was decrease in efficiency of inputs used with the adoption of new technology, as the farmers were not able to adjust to the requirements of new methods of mulberry
cultivation and silkworm rearing techniques. It was observed in the study that most of the farmers did not continuously rear the bivoltine hybrids. As the farmers rear bivoltine hybrids and cross breeds interchangeably, they were not in the habit of adjusting to the new requirement of bivoltine hybrids.

With regard to the difference in the level of input use, number of disease free layings contributed to 12.20 per cent gain in the silk cocoon production of the total 21.56 per cent of gain due to input use. The increase in number of disease free layings is the result of the productivity gain through the production of quality mulberry leaves in the field. With the introduction of new technologies, it was possible with the new breeds of mulberry to produce the quality mulberry leaf to the extent of nearly two folds. Hence with the increase in the productivity level of mulberry (especially V1 variety of mulberry), the food plant of silkworm, and the rearing capacity also got increased, which had reflected in terms of increase in number of disease free layings. The contribution of chemical fertilizers to the productivity gain was up to 5.82 per cent followed by farm yard manure (2.59 per cent) and labour (1.15 per cent). The productivity gain from the use of disinfectants and materials used in silkworm rearing was found to be negative (-0.20 per cent), indicating the over use of this input mainly due to free available nature through the extension agencies. The total contribution of the differences in levels of input use to the productivity gain was 21.56 per cent, which indicted that the productivity of the old technology practices can be increased to an extent of 21.56 per cent, if the input use levels on these farms could be increased to the same level of ‘new technology farms’.

Thus it can be inferred that from the decomposition analysis, that the ‘new technology farms’ were not able to consolidate the technology gain due to the introduction of new technology alone. The yield gain was mainly due to the adjustments made in the level of input used. Hence the extension agencies should make efforts to train the farmers about the new technological practices of sericulture very effectively. The decomposition analysis revealed that the yield gain in new technology was mainly due to the number of disease free layings used in production. This could happen only if the leaf yield of mulberry was increased. The leaf yield of mulberry is further is influenced by good irrigation facilities and the nutrient availability. Hence methods should be employed to effectively disseminate the popular sericultural technologies in the field by the extension experts.
5.8. Returns to Investment on Research in Sericulture

The decomposition of output growth into the technical change and increased level of inputs used provides essential information to workout the returns to investment in research. Schultz\textsuperscript{64} argued that the technical change is not “manna from heaven”. Resources must be devoted for that and must know the costs of and returns to producing new technology. The technical change has been the outcome of investment in research, extension and education.\textsuperscript{65}

There are three quantitative methods of evaluation of returns to investment in agriculture research.

- Consumer surplus approach
- Marginal product approach
- Value of inputs saved approach.

In consumer surplus approach\textsuperscript{66,67} the extra value of output obtained from a given quantity of resource is estimated using discounted cash flow technique. By estimating annual research costs as outflows and annual value of consumers surplus as inflows and from this the rate of returns to research investment is computed.

With marginal product approach,\textsuperscript{68} the marginal product from the production function can be computed directly. But the marginal products cannot be interpreted as marginal rate of return unless the returns are forth coming in the same year when research investment is made.

With the value of inputs saved approach\textsuperscript{69} the resources required to produce the per unit new technology (per kg of silk cocoon) level of output by old technology are estimated. The difference between the cost of resources used to produce the new technology level of output using old technology and the cost of inputs under new


\textsuperscript{67} Peterson, W.L. (1967) “Returns to Poultry Research in the United States”, J. Farm Econ., Vol. 49 (3) : pp. 656 – 669

\textsuperscript{68} Grilliches, Z., (1964) Op. Cit. pp. 961 - 974

technology represents the value of input saved because of higher level of efficiency due to new technology, as used by Bisalaiah.\textsuperscript{70}

The methodology used and adopted by Gaddi and Kunal\textsuperscript{71} in dairying, was employed in the present study to estimate the returns to investment in sericulture research employed in this study which is summarized below;

\begin{itemize}
  \item SNT = Silk cocoon output per acre with new technology,
  \item SOT = Silk cocoon output per acre with old technology,
  \item IRNT = Requirement of inputs (value of FYM, chemical fertilizers, material, labour and capital) in producing SNT output using new technology
  \item IROT = Requirement of inputs (value of FYM, chemical fertilizers, material, labour and capital) in producing SNT output using old technology
  \item IROT = (1 + r) IRNT, where, \( r = \frac{R}{100} \)
  \item R = Percentage increase in output per acre under new technology by using inputs at the level of old technology.
\end{itemize}

Value of inputs saved (VIS) = IROT – IRNT

Another way to evaluate the returns to investment in sericulture research is to estimate the quantity of extra output obtained by using new technology as compared to the old technology at same level of input use.

\[ \text{AO} = (\text{SOT}) \cdot (r) \]

Where,

AO = additional silk cocoon output obtained with new production technology ‘POT’ and ‘r’ are defined in the same way as defined above.

From the decomposition analysis of output growth under new production technology, it is clear that the technical change has brought about changes in productivity in sericulture. Due to technical change there would be saving in input use, when the same level of output is produced by employing new production technologies in silk cocoon production. Higher level of output would be produced if the same level of inputs were used under new production technology in place of old


production technology. In this regard an analysis was done to know how much inputs would be saved or how much additional output would be produced if the production shifts from old technology to new technology.

By using the information provided in the Table 5.2 and the method employed by Schultz, the amount of inputs saved and additional output obtained by employing new production technology in silk cocoon production, were calculated and are presented in Table 5.4.

Table 5.4: Value of Inputs Saved and Quantity of Extra Output Obtained under ‘New Technology’ as Compared to ‘Old Technology’ in Silk Cocoon Production

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Particulars</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Silk cocoon output per acre with new technology (kg/acre/year) (SNT)</td>
<td>691.21</td>
</tr>
<tr>
<td>2</td>
<td>Silk cocoon output per acre with old technology (kg/acre/year) (SOT)</td>
<td>519.36</td>
</tr>
<tr>
<td>3</td>
<td>Requirement of inputs (value of FYM, chemical fertilizers, disinfectants, material, labour and capital) in producing SNT output using new technology (Rs/acre/year) (IRNT)</td>
<td>55013.15</td>
</tr>
<tr>
<td>4</td>
<td>Requirement of inputs (value of FYM, chemical fertilizers, disinfectants, material, labour and capital) in producing SNT output using old technology (Rs/acre/year) (IROT)</td>
<td>62124.1</td>
</tr>
<tr>
<td>5</td>
<td>Value of inputs saved (Rs/acre/year) (VIS)</td>
<td>7110.94</td>
</tr>
<tr>
<td>6</td>
<td>Additional Output (kg/acre/year) (AO)</td>
<td>171.85</td>
</tr>
</tbody>
</table>

It revealed that the value of additional inputs required per acre to produce the ‘new technology’ level of output by the ‘old technology’ was estimated as, Rs. 7110.94 per acre per year. It indicates that to produce ‘new technology’ level of output (691.21 kg/acre/year) by adopting old technology farmers needed about Rs. 62124.10 per acre per year, as against Rs. 55013.15 per acre per year with new

production technology. So there was a saving of Rs. 7110.94 per acre per year with the introduction of ‘new technology’ of silk cocoon production in the field.

Similarly, the additional output obtained without extra cost due to adoption of new production technology for silk cocoon production in place of old production technology was estimated to be 171.85 kg/acre/year. Further, an estimate of the total value of inputs saved and the additional output obtained due to the adoption of new technology in Karnataka state for the year 2006 – 07 was done. This indicated that with the existing acreage of 2,18,142 acres during 2006-07, it is estimated that, an amount of Rs. 155.11 crores of inputs saved.