

PERENNIAL CROP SUPPLY RESPONSE - A CASE STUDY OF HIMACHAL APPLES

THESIS

BY

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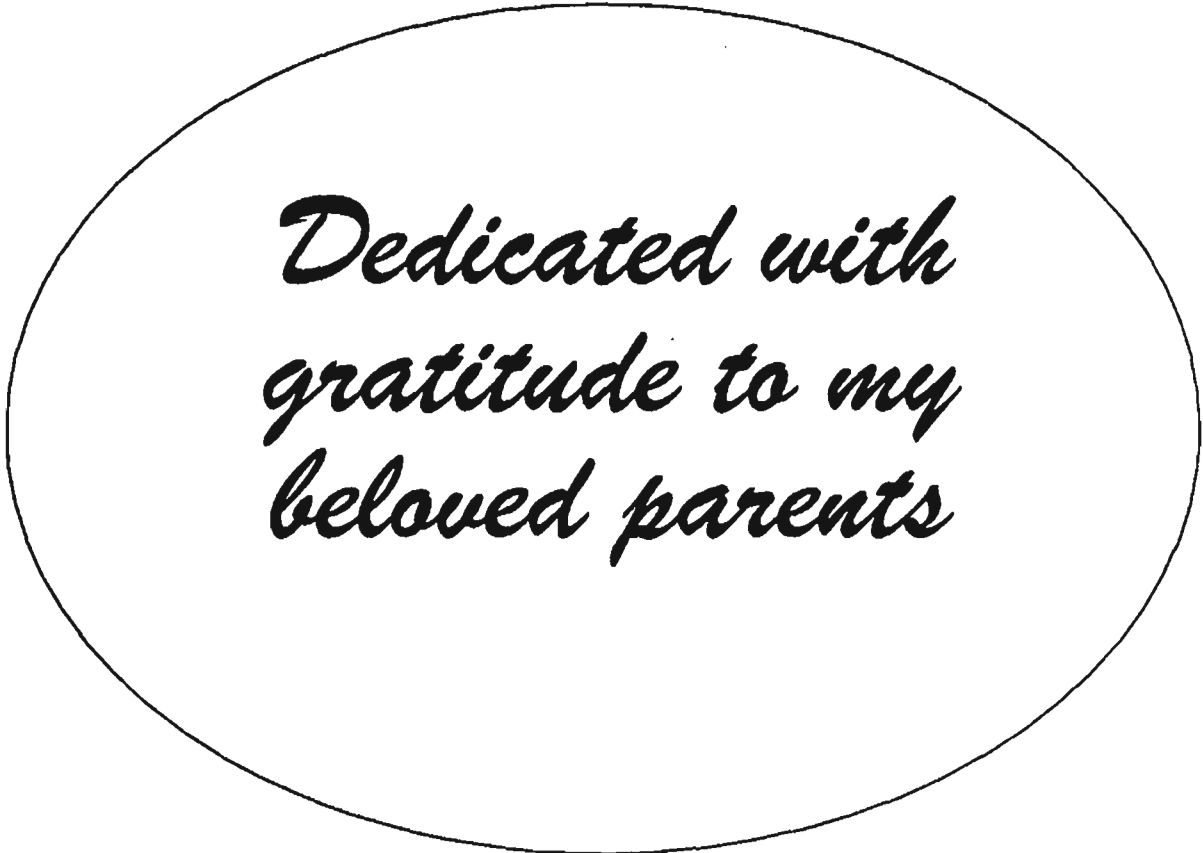
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*Dedicated with
gratitude to my
beloved parents*

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CERTIFICATE - I

This is to certify that the thesis entitled, "**Perennial Crop Supply Response - A Case Study of Himachal Apples**", submitted for the degree of **MASTER OF SCIENCE** in **AGRICULTURAL ECONOMICS** of Dr Yashwant Singh Parmar University of Horticulture and Forestry, Solan, is a record of bonafide research work carried out by **Manjusha Thomas**, under my guidance and supervision and that no part of this thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of investigation and the source of literature have been fully acknowledged.

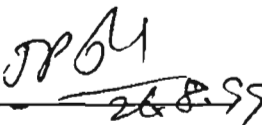
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CERTIFICATE - II

This is to certify that the thesis entitled "**Perennial Crop Supply Response - A Case Study of Himachal Apples**" submitted by **Manjusha Thomas** to Dr. Y.S. Parmar University of Horticulture and Forestry, Solan, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE** in **AGRICULTURAL ECONOMICS** has been approved by the Student's Advisory Committee after an oral examination the same in collaboration with an External Examiner.


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INTRODUCTION

CHAPTER - I

INTRODUCTION

Himachal Pradesh, the apple state of the country, lies in the lap of snowclad Himalayas. The entire topography of the state represents intricate mosaic of mountain ranges, hills and valleys interspersed with cultivated fields, forests, hills and valleys. The available land, ranging from 400 to 4000 meters above the mean sea level is mostly used for agriculture, horticulture, forestry and animal husbandry. The agro-climatic conditions vary from place to place constituting sub-tropical, temperate and dry temperate regions. The locational and agro-climatic advantages possessed by the state make it an ideal region for growing almost all kinds of fruits - temperate, sub-tropical and dry fruits; off-season vegetables and vegetable seed production

Awareness of potentiality of horticultural crops in promoting nutritional security, higher returns per unit area, employment to rural population and foreign exchange has been created about 50 years ago. Little attention was given for the improvement of fruit cultivation in the pre independence era. The policy makers of the post independence era has emphasized more on the economic upliftment of the rural people of the state, prominently and through emphasis on fruit cultivation. More emphasis there from has been given to this sector in various state plans. The Agricultural policy of 1991 has also emphasized on the creation of employment and income generation on sustainable basis in the rural areas by diversifying the existing land use system. Horticultural development has been considered as one of the most important land based activity for diversification.

Among various fruits of Himachal Pradesh, apple is of particular importance for a number of reasons. In terms of both area and production, apple is the most important fruit crop (nearly 40% of the total area under and 72% of total production of fruits is from apple). Apple cultivation in the state and its marketing all-over the country, as well as abroad, has been promoted directly or indirectly by several government programmes and policies, e.g. price and credit policies, input supply policy, quality control and outright purchases. However, the impact evaluation of these policy initiatives/incentives is still a matter of concern and thus of importance.

Apple plants have longer life than other fruits produced in the state. Insect pests and diseases, therefore, perpetuate adding another dimension to risk. Being perishable in nature, fruits need delicate handling and because of hilly tracks the growers find it difficult to perform marketing more efficiently - In spite of these problems, the comparative feasibility and profitability in apple production is believed to be better as compared to other farm enterprises.

Once an agricultural producer has embarked upon a productive venture he frequently finds that his choices as to production in the later periods are to a significant extent decisively influenced by economic considerations. There are two main factors that determine variations in production; viz. price and technology.

The most important economic determinant of production decisions is the price. Price changes influence the level of production and consumption via their impacts on supply of and demand for a product. However, in case of perennial crops like apple, the process of making adjustments in production, in response to price change, is slow due to the long gestation lag involved. Thus, the demand driven increase in price for the product leads to a long term response of increased production, whereas if the price increase was due to low yield, the expected change in production could be temporary. Thus, more the number of alternative uses of a product, the greater will be price stability and more is the long term response to increased production. The second important economic determinant of production is the technology and technology-supported additional input use. However, farmers will adopt the new technology or go for the use of additional inputs in the existing enterprise only if they are assured of the profitability of the same. Thus, economic determinants of production of a product play a major role in determining the supply of that product; under a given set of socio-technological environment.

The supply of a commodity refers to the quantity of the commodity that is offered for sale in market at a given price during a given period of time. A supply function identifies the immediate determinants of supply. An empirical estimation of such a supply function helps to quantify the relationship between the quantity supplied and the various price and non-price determinants of supply. Apple production is distinguished from the production of annual crops by (i) long gestation period between initial input and first output, (ii) an extended period of output flowing from the initial investment, and (iii) eventually a gradual

deterioration in the productive capacity of the plants. Apple is thus a perennial crop with a gestation period of 7 years followed by a productive period of 33 years and then a gradual deterioration of the productive capacity.

Thus, the adjustment of the apple industry's future productive capacity, in any given year, is the net effect of all planting decisions that modify both the total cultivated area and the age composition of the tree stock. In short run the supply can be increased only within the existing productive capacity; which again depends on the short run profit expectations of the orchardists.

The above stated factors represent the need to precisely quantify the role of price and other market related variables in determining the long and short run responsiveness of the apple industry. The present study thus, is an attempt in this regard; with the most prominent perennial crop-apple-being taken as the case.

The specific objectives of the study are :

- (1) To analyse the growth in area and production of apple in the state.
- (2) To estimate the supply response for Himachal apple.
- (3) To suggest appropriate policy measures for apple industry development in the state.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Several studies on supply response have been undertaken in the country and abroad but most of these studies are confined to supply response of annual crops. Very few attempts, however, have been made in the past to study the supply response of perennial crops in the country. A brief review of some of the studies conducted in India and abroad, having a direct or indirect bearing on the objectives of the present study, are presented under two sections.

1. Studies on Supply Response of Annual Crops
2. Studies on Supply Response of Perennial Crops

2.1 Studies on Supply Response of Annual Crops

Marc Nerlove (1956) attempted to estimate the elasticity of supply for corn, cotton and wheat in USA. His work deals primarily with the role the farmer's expectations of future prices play in shaping his decision as to how many acres they should devote to each crop. Nerlove tried to identify price variable appropriate in a supply function, with an observable variable or several observable variables. He developed a model based on the formulation of price expectation and area adjustment equation. The model provides the estimates of long run as well as short run elasticities of supply.

Many studies have been conducted in this subject in India during the last three decades which confirm that the economic forces operate both in developed and underdeveloped agriculture in a similar manner. In most of the studies, the basic tool employed for the estimation of such responses was Nerlovian Model, subsequently with modifications and by including various non-price factors as well.

Rao and Krishna (1965) in their study tried different specifications of expected prices such as the annual average price of the preceding three years, a modal price of the preceding year, modal of three years prices, price predicted from a trend etc. They found that magnitude of elasticities varied with different specifications. They ranked those models high which used average prices of preceding three years or prices predicted from a linear trend. The results of the study indicate that the inference relating to acreage response changes drastically depending on the estimate of the expected price used.

Krishna and Rao (1967) again attempted to quantify the degree of farmers responsiveness to changing relative prices. Nine alternative price expectation models and six different response equations have been used in the study. The results of the study indicate that acreage under wheat has been fairly elastic to changes in relative prices of wheat and substitute crops during the period of study. Further, the analysis suggests that the three year average of pre-sowing price of wheat deflated by the three years average of pre-sowing prices of substitute crops along with the relative yield of wheat and rainfall are most important factors influencing farmers decision on acreage allocation among wheat and substitute crops. Author also emphasised that the traditional regression model for estimating the supply response coefficient, if properly specified, can give a satisfactory (if not better) results as those obtained by using the Adjustment Lag Model of the Nerlovian type. Most of the short-run elasticities derived from the Nerlovian model been found to be non-significant. The long run elasticities obtained from the traditional model specification have been found to range between 0.60 and 0.72. These elasticities estimates compare favourably with those obtained from the Adjustment Log Model of the Nerlovian type. The Nerlovian type of models has been found to have an edge over the traditional one so far as the proportion of variations in wheat acreage is explained by the explanatory variables.

In an attempt to examine the responsiveness of agriculture in the underdeveloped countries, Behrman (1968) analysed four major annual crops - rice, cassava, corn and kneaf in Thailand during the period 1937-63. He examined Nerlovian dynamic total supply response model and the acreage planted under a crop was used as the dependent variable in his estimation of Thai supply response presuming the area planted as a better index of planned production in the given conditions. The study mainly concentrates upon the response to price changes. However, the responses to yield changes to crude representations of risk, to malaria control and to population changes were also examined. The results of the

study strongly support the hypothesis that farmers in economically underdeveloped countries respond significantly and substantially to economic incentives. No significant evidence has been found for the hypothesis that institutional constraints preclude significant responses to economic incentives in underdeveloped agriculture.

The National Council of Applied Economic Research (1969) also estimated the responsiveness of four selected food crops viz. rice, wheat, jowar, and gram to changes in prices. The study was undertaken to find out farmer's responsiveness between different crops and regions. The basic model used in this study is the Nerlovian Adjustment Model and it has been assumed that the price elasticity of the area planted under a crop is a good proxy to the elasticity of output. This study reveals that the area of the four selected crops respond little to the relative price variations - for the crops grown both for subsistence and for sale - wheat and rice on the surplus states such as Punjab. Andhra Pradesh and Madras, - the price elasticity of the area was in the medium range (short run area elasticity between 0.1 and 0.4).

Eckstein (1985) presented a dynamic rational expectations equilibrium model for a given crop. The dynamic supply equation has been derived from the former optimization problems, and the equilibrium movements of commodity prices, production and land allocations are solved analytically. It was shown that the observed dynamics of agricultural supply, which are usually explained and measured with the Nerlovian supply response model, can be explained and measured at least as well by the rational expectations equilibrium model. He defined explicitly the dynamic supply elasticities and presented an econometric method for consistent estimators for the parameters.

Krishnaiah and Krishnamoorthy (1989) examined the supply response of food grains in the costal Andhra Pradesh state, India. Farmers were found to be most responsive to technological innovations in costal Andhra and least responsive in Rayalaseema region. Paddy and Pulses showed a highly significant response to price changes in coastal Andhra while Sorghum exhibited a similar response in Rayalaseema. The South-West monsoon rainfall in the costal Andhra region has a positive effect on production of pulses and negative effects on sorghum.

Singh and Singh (1993) assessed the acreage response of sugarcane to price and non-price variables in Patna, Tirhut, Bhagalpur and Chhotanagpur regions of Bihar state, India. Using a Nerlovian lagged adjustment model the results show a significant positive relationship between lagged price and acreage of sugarcane in all regions except Tirhut. Both the short and long run elasticities of acreage with respect to price were positive in all regions except Tirhut.

Similarly many other studies have been conducted in different parts of India and abroad which throws light to the understanding of supply response of agricultural crops. A few to be noted here are Jha (1970), Reddy (1970), Singh et.al. (1974), Cummings (1975), Rao and Pandey (1976), Bapana (1977), Rajagopalan and Ramaswamy (1977), Jha (1979) Brunstein (1981), Deshpandey and Chandrashekar (1982), Basavaraja and Hiremath (1984), Raju and Nagabhushanam (1986), Ramesha et al. (1988), Krishna (1990), Gunawardana and Oczkowski (1992), Cauvery (1992), Jaforullah (1993), Barman and Hazarika (1995), Sreeja and chandrabhanu (1995), and Krause and Koo (1996).

2.2 Studies Related to Perennial Crops

Perennial crops once planted, yield a flow of output continuously or discretely, over a period of years. Many are tree crops which mature several years after planting before any output is forthcoming, and for which thereafter, yield are dependent upon the age of the tree and may also depend upon other inputs. Finally there will be a decline in the productive capacity of the plant. These characteristics of a perennial crop makes the formulation of a supply response model for the perennial crop different from that for an annual crop and a review of the attempts made in this direction are given as under.

2.2.1 Studies Conducted in India

Uma Devi (1977) appraised the supply response of the Indian natural rubber and found that for the small holders supply responded more to current price in the short run. This was more significant due to their predominance in the production of rubber. The

estates supply was not responsive to current price, while long-term planting decisions were influenced by the past six years prices.

Chowdhury and Ram (1978) examined the response of tea price to area, production, yield and employment of labour in tea gardens in the northern and southern regions of India during 1953-73. The supply response of tea was studied by using three models. (i) area as a function of lagged acreage, relative price and trend variable (ii) Industrial yield (yield of whole tea industry) as a function of non-bearing area, current price relative to last years price, a rainfall and trend variable and (iii) employment as a function of current relative price, yield, area under tea and trend variable. An additional model for output was derived from area model and yield model. It is shown that tea planters responded to price not in terms of acreage, but in terms of yield. The employment of labourers is surprisingly adversely affected by favorable price position, which may be due to labour substituting mechanisation. The possibility of increased tea production lies basically in yield improvements through intensive use of inputs.

Misra (1985) examined the nature of relationship between the production and price of tea in India. A Nerlovian adjustment model is developed to estimate supply response at a national and regional level. The coefficients of current price and one year lagged price variable in the short term yield model were found to be positive and statistically significant in all cases. Results of the long term response equations indicate that the price factor plays a weak role in influencing acreage allocation for tea. Planters generally respond to price in terms of yield rather than acreage. The low elasticity of yield to price changes in the short and long run may be found in the nature of production.

Nadda (1987) tested the validity of the hypothesis regarding responsiveness of Himachal apple growers to price/economic incentives. He found that other factors may enter into marketing decision process eg. profitability, parity prices, development indicators etc. The regression analysis indicated that they respond well to raw prices. The others exhibited positive impact and inverse relationship. In another study he examined the apple acreage response to prices in Himachal Pradesh. He considered price as a crucial factor for long term apple planting decisions. Although profitability has also positive impact on these decisions but the Himachal Pradesh apple industry showed a declining trend.

Ipe and Prabhakaran (1988) analysed the short and long-run supply response in Indian natural rubber sector, using the Nerlovian expectations model for 1953-84 data. The calculated long term estimates had the expected signs indicating increase in the area under cultivation, which was attributed to higher rubber prices and yield, change in income tax regulations and fall in productivity of coconuts (leading to increased rate of substitution of coconuts by rubber).

Chiranjeevi (1992) evaluated the performance of the Indian Tea Industry during the period 1976-86 in terms of trends and variations in output, area, yield, prices and exports. The sectoral changes in the industry are indicated by analysing such changes in size of holding and method of marketing. The supply response of the Industry was examined in terms of decision regarding new plantings, replantings and yield per hectare.

Indira (1993) studied the supply responsiveness of Indian coffee growers to gross returns using the data for 1960/61 - 1984/85. Arabica coffee producers were found to be more responsive to changes in per hectare returns than Robusta coffee producers. Arabica coffee growers were willing to invest in the better management practices required to obtain better yields only when returns were good.

Narayana (1994) noted that the adjustments in supply response to demand changes in case of perennial crops take place with a time lag because of gestation lags and particular yield profiles. This leads to a characteristic movement in price which in turn brings about phases of area expansion. In order to test the validity of this reasoning, a basic model of supply response is set out which is further extended by incorporating introduction of high yielding varieties, replanting and prices. The empirical analysis uses data on rubber for period 1955-89. The production of natural rubber is confirmed to be characterised by cycles due to phases in expansion of area in response to cyclical behavior of prices, one leading to the other and feeding it.

Kumar and Mittal (1995) examined the factors that determine exports of tea from India and observed that tea exports are insensitive to price incentives, changes in world demand and also decreases with an increasing share of domestic consumption. It also notes that the possibility of trade in tea links the domestic price of tea to the international

price, which suggests that if international trade is extended to other essential commodities, their domestic prices are likely to rise. It is thus concluded that prior to recommendations to encourage exports of essential commodities being made, the effect of such a move need to be examined carefully.

2.2.2 Studies Conducted Abroad

Bateman (1965) in his attempt to estimate the supply response for Ghanaian cocoa, began by assuming that the farmers maximise the present value of expected profits with respect to planted acreage. Thus acreage planted to cocoa becomes a function of present value of expected real prices, expected marginal yields per acre and expected marginal costs. Bateman assumed the price term would dominate, so he specified area planted as a function of the discounted value of the expected own and substitute prices. Price expectations were assumed to be formed adaptively and the models respecified in terms of output rather than planted acreage for which data were not readily available. But output is also a function of yields, which in turn depends on the age of the tree. After taking first differences (to avoid a nearly infinite time horizon) and combining output and planting equations, the finally estimated equation is a reduced form equation in which output is a function of lagged own and cross prices, lagged rainfall and lagged output.

Behrman (1968) also took a similar approach in his study of cocoa as by Bateman, but he specified desired acreage as a function of own and cross prices. He also transforms this acreage equation to an output equation because of lack of data, the latter being based on Nerlovian model of area adjustment. The final estimated equation is a reduced form equation in which output is a function of lagged own and substitute prices and lagged output.

Ady (1968) followed Bateman and Behrman in that she estimated, in first difference terms output as a function of lagged prices and lagged output, but she also included a world price term, an index of agronomic factors. None the less, the basic model remains the Nerlovian adjustment scheme based on planted acreage (or on tree stocks) and on prices, leading to a single reduced form equation in terms of first differences of output.

The production of perennial crops involves Planting, removal, yield and time dimension not similarly encountered in annual crops. French & Mathews (1971) developed a model to provide a structural base for estimating response relationship that encompass these dimensions. The model rests on assumptions of rational producer behavior which takes account of possible actions of other producers and of the aggregate effect of these actions on total production and profits. Because important data series often are not available, modifications of the basic model also suggested to facilitate estimation within a more restricted empirical framework. The model is illustrated by an application to asparagus, a perennial vegetable crop.

A study conducted by Maitha (1973) in Kenya using 'adaptive expectations' model indicate that coffee farmers are relatively responsive to prices. Acreage is less responsive to price movements than productivity. It will take several years of poor prices before farmers start removing coffee tree. However, poor prices affect productivity almost immediately as farmers neglect the coffee trees.

Saylor (1973) estimated the response of Sao Paulo coffee producers to price changes. Using the area planted in coffee as the dependent variable, a Nerlovian distributed lag model was employed to derive short run and long run price elasticities. Since coffee has characteristics of a capital good, in yielding income flows overtime, the usual assumption of supply reversibility seems questionable. Hence attempts were made to estimate irreversible functions using techniques outlined by Tweeten and Quance and Wolffram. The Wolffram technique yields satisfactory estimates when only price variables are included in the analysis but become highly unstable when other variables are included. Finally a modification suggested by Tomek was tested in order to ascertain whether the Nerlovian specification is appropriate. The results suggest that in this particular case, the Nerlovian model modified to permit supply shifts, yields satisfactory estimates. The estimates of price elasticity suggests that, although farmers response is inelastic, that the elasticities are of the same magnitude as those estimated for most annual crops in the developed countries.

Wickens and Greenfield (1973) attempted to quantify investment and harvest decision separately and estimated the supply response for Brazilian coffee. While they regard the preferred approach to be a direct specification and estimation of the structural relationships

in their model for perennial supply namely, an investment function, a harvesting decision function and a vintage production function data limitations usually preclude this. Hence the procedure adopted here is to specify the structural relationship and derive a reduced form supply function that can be estimated directly from available data. It is possible however to draw inferences about the structural relationships through the use of extraneous information on the age composition to determine the shape of the distributed lag-response of supply to changes in relative prices.

Baritelle and Price (1974) developed a supply response model for Washington apple plantings. This model incorporated the distinguishing characteristics of perennial crops like long term commitment of land, labour, and capital to derive a future stream of net revenue. The model was based on the assumption that the net change in the planting is a function of future profitability and as such is not an observable variable. Hence they hypothesised that expected future profitability is a function of recent past prices. The cost part was taken into account by deflating the price series with the index of prices paid by the growers, but it was revealed from the study that raw price series provided more explanatory power than the deflated price series. It emerged from the study that the estimated lagged equation consistently shows first an increasing and then a declining responses to past prices over time.

Oni and Olayemi (1974) after reviewing the pertinent factors affecting the planting of cocoa in Eastern Nigeria constructed an acreage response model. The model postulates that the amount of cocoa planted in any given year is determined by the expected real producer prices of cocoa and substitute crop, the existing stock of trees, their age distribution, the available area for further planting, and the changing technology involved in cocoa cultivation. Using time series data for 1937-1958, the model was tried to estimate the aggregate acreage response relations. Ordinary least square multiple regression techniques were used in empirically testing the model. The results of the regression analysis indicate that the cocoa farmers reacted positively to increases in real producer price of cocoa by planting more acres of the crop. Using the generated elasticities, an attempt was also made to project cocoa planting for the 1969-70 season and a price policy to generate this goal was examined. The price arrived at was almost double of the current price. A more realistic policy would therefore be to pursue a fairly favourable producer price policy simultaneously with government sponsored new planting and replanting programmes.

Rae and Carman (1975) specified a supply response model for New Zealand apples and equations for new planting, removals, yields and adoption of an innovation are estimated. The model expands on perennial crop models previously estimated by incorporating the time pattern adoption of a planting innovation and formulation of a measure of yield expectations given technological change.

Berry (1976) uses time-series data on cocoa plantings in Western Nigeria to re-examine some popular conclusions about the price responsiveness of farmers in underdeveloped economies. Annual variations in the rate of planting were found to be more closely related to farmers income from cocoa sales than to current price. Qualitative evidence suggested that long-term trends in cocoa plantings were also influenced by changing opportunity costs and by the institutional structure of the rural factor markets. These results cast some doubt on commonly accepted capital stock adjustment models of investment in tree crops, which assume that farmers rely heavily on forecasting future price trend when deciding how much to plant. Given the uncertainty of future crop prices, it seems more likely that farmers plant more trees when they can afford to do so, so long as opportunity costs are not prohibitive.

Cassino et.al. (1979) estimated short and long run blackpepper supply elasticities for the state of para in Brazil. A distributed lags model was used, backed by implicit characteristics of perennial crops. Acreage and yield models were adjusted by Two Stage Least Square methods. Price elasticities of acreage response were equal to 0.71 in the short run and 4.2 in the long run. Cross elasticity of yield response with respect to fertilizer prices was equal to 0.14. Rainfall is also an important factor affecting black pepper yields.

Gafar (1981) developed a model of the supply response for Jamaican sugar, bananas, coffee, and cocoa. The supply price elasticities for the commodities studied were low, which suggests that in addition to price policies, other measures to stimulate increase in output of agricultural products may be needed. The implications of adopting a programme of price stabilization on export revenue and the use of a system of dual exchange rates were also examined.

Ben et.al. (1985) noticed that the supply response for a perennial crop was influenced by the age composition of the existing fruit stocks which, in turn was determined by historical pattern of plantings and removals. The estimates for a function relating to plantings and removals of cling peach trees to measures of past profitability, potential future production from cling acreage and structural changes with market intervention programmes were developed. The analysis also provide indications of useful forms for these functions, pattern of yield variations by age of tree and non-linear relation of removal response to age of tree.

The econometric model for the world tea economy developed by Akiyama and Trivedi (1987) represents an advancement on previous models for perennial crops in several respects : (i) use of a conceptual framework based on the Vintage production model (ii) the detailed modelling of the supply side to incorporate new planting decisions in three leading producing countries viz. India, Srilanka, Kenya and (iii) the use of market clearing rational expectations approach to modelling of the world price of tea, which leads to a forward-looking price equation for tea. Compared with previous models, this model has greater disaggregation by country or geographical zone. There is also an attempt to use the appropriate retail price variable in place of producer price that is often used in demand equations. Price determination is based on a simplified linear rational expectations model in which a market clearing price is established in each period. In the estimated model, equilibrium is established very rapidly following an initial shock. This characteristic reflects the market clearing assumption and the absence of lags in price determination. More significantly, the dynamic simulation of the model based on such an assumption portrays the historical behaviour of prices reasonably accurately, in the specific sense that the spike-like behavior of the price of tea can be reproduced by the model.

Hartley et.al. (1987) focused their study on uprooting, replanting decisions in case of rubber and concluded that these decisions were very important for studying the rubber supply response in Srilanka where replanting activities dominate the new plantings. They also compared the approaches of supply response for rubber in Srilanka and Thailand. The two approaches were typical reduced forms and Dowlings analysis. These approaches did not explain supply response adequately.

Keith (1987) formulated a dynamic equilibrium model for perennial crop markets. Price expectations were formed according to perfect foresight and both the age composition

of the crop and the optimal rotation were determined endogeneously. The calculated long-run equilibrium acreage were quite close to average over the base period. The results also exhibited cyclical fluctuations in acreage with six per cent coefficient of variation. Thus, cyclical behavior could arise from technical characteristics of the production process as well as from imperfectly formed expectations or random exogenous shocks.

Taking advantage of area data for Colombia, disaggregated by variety and age since 1965, Jaramillo (1988), in their study presents the empirical estimation of a multi-equation perennial supply response model that captures the essential aspects of production response in the Colombian coffee sector. Five investment activities are estimated separately including new planting, replantings, stumpings, removals and short-term harvesting behaviour. The resulting model exhibits high explanatory power over actual production trends for the 1970-86 period. Using a simplified version of the estimated model a stochastic dynamic programming model for optimal price and storage determination is constructed. Assuming a specific objective function for Colombian coffee authorities, the maximization makes operational a model for precise-setting behavior for marketing boards. The dynamic programming approach constitutes a flexible policy analysis tool of potential use to the Colombian coffee authorities. The result of the model provides insights on the policies followed by the marketing board in the 1980's suggesting that actual prices have been above optimal levels.

Jones et al. (1989) analysed the supply response of cocoa in 52 copra producing districts of Solomon islands. Copra producers were found to respond positively to price, albeit in a very inelastic fashion, Remoteness does not appear to influence the degree of responsiveness, and price risk does not appear to be a factor influencing short run copra supply.

A state space model for perennial crop supply response was developed by Knapp and Konyar (1991). New planting and removals were dependent on the existing age structure of the crop and expected values for prices and other exogenous variables. Acreage in individual age categories was evolved depending upon existing acreage, new planting and removals. The Kalman Filter and iterative parameter search provide maximum likelihood estimates of the unknown parameters and age group acreage from observed

data on total acreage and production. An empirical application for alfa-alfa showed that existing acreage had differential impact on new planting and replantings depending upon age.

In perennial crop supply analysis, separate estimation of qualitatively different new planting and replanting decision is desirable. Commonly, data paucity restricts estimation to a single reduced form equation. Nicholas et.al. (1992) in their study develops a dynamic unobserved components method where separate estimation of the structural equations is possible in the absence of detailed data on new planting and replantings. The proposed method is empirically implemented in a case study of Florida grape fruit industry. In terms of both statistical and forecasting performance, the proposed structural approach is found superior to a single equation reduced form specification.

Nelson Perera (1995) developed an econometric model for the perennial crop sector for less developed countries with a view to analyse the impact of changes in international prices and government policies on Srilankan tea sector. The model consists of six equations and eight identities to determine endogeneous variables and incorporates the long-run and short-run responses to the price changes. The long-run supply responsiveness of the industry is represented by the equations for removals, new planting and replantings, while the equations for yield rate and fertilizer usage are treated as representations of the short-run responsiveness of the industry. The model was also used to evaluate the impact of change in international tea price on the Srilankan tea sector.

The foregoing review of existing literature on the subject suggests that whereas many studies have been conducted in India and abroad to investigate the supply response of annual agricultural crops, little evidence is, however, available on the supply response of perennial crops especially apple. The few attempts made on this subject utilized time series data which lack in adequate number of observations and provide only a very rough picture of the existing situation.

Apple being a perennial crop is of particular importance to the state economy for a number of reasons. a required approach to the supply behaviour estimation has great planning and policy implication. Accordingly, the present study is an attempt to examine the supply response of apple for Himachal Pradesh.



METHODOLOGY

Apple being a perennial fruit crop, careful attention has to be paid in modelling its supply side. The following four features of the production process needs special attention.

- i) the existence of a biologically determined gestation lag between planting and obtaining yield;
- ii) the dependence of current production on previous output and current as well as previous levels of inputs;
- iii) the existence of significant costs of adjustment in respect of planting and removal of trees and
- iv) the constraints on planting and removals, resulting not only from the past decisions but also from the existence of binding non-negativity constraints related to the adjustment process.

Features (i) - (iv) imply, that the investment behaviour of the productive firm cannot be myopic. Features (i) and (ii) imply that the relevant supply theory is intrinsically dynamic.

A major difficulty in the earlier analyses of perennial crop supply was their failure to distinguish clearly between the long-run and short-run dimensions of the producers supply decisions. Here, an attempt is made to estimate separately the short and long run supply response of apple industry in Himachal Pradesh. It is hypothesized that the short run and long run supply elasticities of apple in the state are positive.

3.1 Collection of Data

The present study is based on the data collected on area, production and prices of Himachal apple, weather parameters that affect apple production, wage index and consumer price index for agricultural labourers and the fertilizer wholesale price index for the period 1966-1997.

The statistics regarding district-wise area and production of apple in the state, and the number of nursery plants distributed each year is maintained by the state Directorate of Horticulture, Shimla. Using the information on number of plants distributed each year, the figures for yearly incremental area was estimated, after allowing 10-15% allowance for expected mortality. For this estimation a density of planting of 250 plants per hectare has been considered. The wholesale prices, used as a variable in the present study, pertain to the Delhi market. This is because nearly 80% of the total state produce is sold at Delhi market. The data on Delhi wholesale prices were collected from various sources viz; Directorate of Horticulture, Shimla; Agricultural Produce Market Committee, Delhi and National Horticultural Board, Gurgaon. The average price of three peak months that is, August, September and October was taken as a variable in the model. While allocating their resources the farmers generally take net prices as the decision making variable. Net prices have been arrived at by deducting the marketing costs incurred upto Delhi market from the Delhi wholesale prices for a given period. Due to the non-availability of time series data on the marketing cost, the information on marketing cost was collected from various studies on this aspect; conducted time-to-time by various authorities and agencies in the state. The gap in the data were filled through extrapolation.

The statistics regarding the consumer price index for agricultural labourers, total road length in Himachal Pradesh excluding the non jeepable roads and the labour wage for agricultural field workers for the period 1965-1997 have been obtained from the Directorate of Economics and Statistics, and Labour Bureau, Shimla. Fertilizer wholesale Price Indices for the period 1965-1997 were collected from the Statistical Abstract of India.

The data on daily maximum and minimum temperature for 6 months i.e. Jan, Feb, March, October, November and December, each year were collected from the records

kept at Regional Horticultural Research Station, Mashobra (Shimla). The data regarding weather parameters has been collected for Shimla district because bulk of the total apple produce in the State comes from this district alone.

3.2 Analytical Framework

In order to meet out the requirements of different objectives of the study, following analytical tools have been employed.

3.2.1 Estimation of Factors Affecting Supply

To examine the total supply response of apple, the short-run and long-run responses of apple industry to prices and other related variables have been considered separately. Apple being a perennial crop, the yield response function gives the short-run response and the new planting function gives the long-run response. The long-run and short-run elasticities have been estimated to study the farmers pattern of adjustment in response to changes in the price and price related variables.

3.2.1.1 Selection of Variables

In order to determine the long-run and short-run responsiveness of apple industry, the following are the important variables specified in this study; trend, chilling hours, short-run expectations for prices, profitability, parity ratios and yield, long run expectations for prices, yield, profitability and parity ratios, subsidy, price risk, yield risk, expectation for road length and lagged new planting area.

a) Short run Price expectation (P_t^s)

The yield of apple within the existing acreage could be increased through better management of the existing acreage, which could be through optimal allocation of variable inputs. The biological nature of apple production requires at least one year to change the productivity through cultural and managerial practices. Therefore, the farmers may take into account past one, two or three year prices ($P_{t-1}, P_{t-2}, P_{t-3}$) to arrive at a decision to go for intensive cultivation.

b) Short run profitability expectation (Pr_t)

The profitability of the crop decreases with increase in the input prices. The crop profitability induces growers to use more and more of input factors. The productivity in t^{th} period, in short run, is assumed to be influenced by the growers' short run profitability expectation, which due to the irregular bearing nature of the crop could be (Pr_{t-1} , Pr_{t-2} , Pr_{t-3}).

c) Short run parity ratio expectation (Pa_t)

Apple is a cash crop grown mainly with a profit motive. The favourable terms of trade will induce the growers to go in for intensive cultivation, leading to higher productivity. This effect is reflected in the yield response by including the lagged parity ratios as a variable. Due to the irregular bearing nature of the crop, three lags Pa_{t-1} , Pa_{t-2} , Pa_{t-3} have been tried in the present formulation.

d) Short run yield expectation (Y_t)

The lagged values of yield (output per hectare of bearing acreage) has been included in the yield response equation to take into account the dynamic dependance of production in successive periods i.e an alternate cycle. Three lags Y_{t-1} , Y_{t-2} , Y_{t-3} have been tried.

Different formulations of the short run expectation variables, i.e. prices, profitability, parity ratios and yield have been tried with the dependent variable (yield) and one formulation each of the above stated variables, which gives highest correlation with the yield, has been taken in the final analysis.

e) Chilling hours (Ch_t)

Apple is a temperate fruit crop which requires certain specific number of chilling hours to break its dormancy and renew its growth and production. To initiate production in t^{th} period, the dormancy which the crop has entered into in the $(t-1)^{\text{th}}$ period should be broken. This can be achieved only when the specific chilling requirement for the crop is

met in a 6 month period (October (t-1)th year to March tth year). The number of chilling hours per day have been calculated for the above said 6 months, which are summed-up to obtain the total number of chilling hours for production in tth period. The formula used is (Hartman and Kester, 1972).

$$\text{Ch} = \frac{7-m}{M-m} \times 24$$

Where ;

Ch - Number of chilling hours/day

M - Maximum daily temperature

m - minimum daily temperature

f) Trend

The effects of changing technology which act as supply shifters are represented by trend variable. In short-run, technological improvements mainly take place in the form of better fertilizers management practices, integrated pest management practices, irrigation practices and cultural practices like training, pruning etc. The trend variable is arrived at by running a regression equation of the form $Y_t = a + bt$ where, Y_t is the production of apple in year 't' and t is the time period.

g) Long run price expectations [P^e_t]

While allocating the limited land resources to competing enterprises, producers are generally guided by product and factor prices. Therefore, the prices are of crucial importance in a decision making process. Two price series are considered in this study, the wholesale price at Delhi market referred to as Prices (PA) and the net price (N_p). The degree of association of each price series with the new planting acreage and yield has been examined with the help of correlation coefficient and that series giving highest correlation is incorporated into the final estimating equation.

The prices which the farmers take into account for making production decisions are called the expected prices [P^e]. Traditionally, last year's price used to be regarded as the basis for forming expectation. But apple being a perennial crop with a gestation lag of about 7 years, it is considered wise to expect the farmers to take into consideration more than one year's price to form their expectation for a particular period. Thus, various formulations for price expectation, i.e. one-year lag, two-year lag, three-year lag, two-years lag average, three year lag average, and moving average models with periods 3, 4, 5, 6 and 7 years were tried. The formulations giving highest correlation with the dependent variable (new planting acreage) was taken into the final estimating equation.

h) Long run Profitability Expectation [Pr^e]

In order to estimate the profitability variable, it is a pre-requisite to have time-series data on cost of production. Due to the non-availability of such a series, profitability has been estimated on the basis of different studies on the economics of Himachal apples. From these studies it has been approximated that the labour and fertilizer together account for 70 per cent of the total recurring cost (45 per cent on labour and 25 per cent on fertilizer). This indicates that the profitability of the crop was, by and large, governed by the movement in wage rates and fertilizer prices. Thus, a composite price index was prepared with labour wages and wholesale fertilizer prices index. Weights were given to each component in proportion to their share in total recurring cost. Finally, prices received by the growers were deflated by the composite price index to arrive at profitability per box. Mathematically;

$$Pr_{bt} = \frac{NP_t}{WI_t + FI_t}$$

Where;

$$Pr_{bt} = \text{Profitability /box}$$

$$NP_t = \text{Net price received by the grower}$$

The apple production is a biological phenomenon and is subject to vagaries of weather. In spite of better management practices, adverse weather conditions can affect the production considerably, thereby reducing the profitability. Therefore, the profitability,

per hectare, has been taken into account and the same was arrived at by multiplying the profitability per box with yield boxes per hectare.

The expected long-run profitability, per unit area, associated with new planting area might be the actual profits realised in year $t-1$. However, the apple crop is typically subject to fairly long year-to-year fluctuations in prices, production and yield. It is therefore, likely that the producers might consider the experience of several previous years to form a better indicator of expected profitability. This indicator might be summarized in the form of simple or moving averages. Various formulations of profitability which can influence the decision making process of the growers are Pr_{t-1} , Pr_{t-2} , Pr_{t-3} , $Pr_{t-1} + Pr_{t-2}/2$, $Pr_{t-1} + Pr_{t-2} + Pr_{t-3}/3$, moving averages with periods 3,4,5,6 and 7 years. Each formulation were tried with the dependent variable and the one adjudged on the basis of 'r' and r^2 values were considered for further analysis.

i) Long run Expectation for Parity Ratios [Pa^e]

The parity between prices received for apple and the price paid for consumables is also assumed to be an important factor which determine the farmers' expectation behavior in the decision making process. Apple being a commercial/cash crop grown with profitability as a motive, the favourable terms of trade would induce growers to invest more for extending the area under apple. The various formulations of lagged parity prices that can influence the decision making process are Pa_{t-1} , Pa_{t-2} , Pa_{t-3} , $Pa_{t-1} + Pa_{t-2}/2$, $Pa_{t-1} + Pa_{t-2} + Pa_{t-3}/3$, moving averages with periods 3,4,5,6 and 7 years. Among these formulations, the one which is highly correlated with the dependent variable has been selected for further analysis.

j) Long run Yield Expectation (Y^e)

The new planting behaviour of the farmer is assumed also to be influenced by his/her expectation of yields (output per hectare of bearing acreage). Various formulations for yield expectations, Y_{t-1} , Y_{t-2} , Y_{t-3} , $Y_{t-1} + Y_{t-2}/2$, $Y_{t-1} + Y_{t-2} + Y_{t-3}/3$, moving average with periods 3,4,5,6 and 7 years were tried and the highly correlated one, with the dependent variable, has been taken for further analysis.

j) Price Risk [PR_t] and Yield Risk [YR_t]

The area allocations under the crop may also be conditioned by their expectations on price and yield risks. The squared deviations of expected values, from the actual values, were taken as an observation on risk.

Thus,

$$\text{price risk} = RP_t = (P_t - P^e)^2 \quad \text{and}$$

$$\text{yield risk} = RY_t = (Y_t - Y^e)^2$$

k) Expectation for Road Length [R^e_t]

Apple, being a commercial crop, is marketed at distant places which are located all over the country. Hence availability and improvement of roads is imperative. It is, therefore, hypothesized that if the transportation facilities like roads are extended to difficult hilly terrains, more and more people will be encouraged to take up apple cultivation. Various formulations of road length, R_{t-1} , R_{t-2} , R_{t-3} , $R_{t-1} + R_{t-2}/2$, $R_{t-1} + R_{t-2} + R_{t-3}/3$, have been tried and the one which is highly correlated with the decision variable is selected for final analysis.

l) Subsidy (S_t)

The incentive offered by the government for establishment and maintainance of apple orchards is also assumed to play a major role in the long run decision making behaviour of the growers in Himachal Pradesh

m) Lagged New Planting (N_{t-1})

In evaluating the possible future levels of industry output, the farmers may also be concerned with new planting in the previous periods. A higher than expected new planting response in year 't-1' might reduce the long run expectations and hence lead to lower plantings in year 't'; lower than expected response in 't-1' might have a reverse effect.

3.2.1.2 The Model

The proposed model for apple industry in Himachal Pradesh consists of equations for yield response and new planting response. The model thus, has incorporated short-run and long-run responsiveness of the industry to various specified variables. The structured equations of the model are estimated using ordinary least square method for the period 1966-1997. The estimated structured equations of the model are subjected to the statistical test of significance, which include the adjusted R^2 and 't' ratio tests. The presence of auto correlation is tested through Durbin-Watson test and that of multicollinearity through Condition Index test.

Yield Response

In the short-run, producers can adjust the supply through intensification of variable inputs. The biological nature of apple production requires at least one year to change the yield through cultural and managerial practices. Thus, the important variables influencing yield are, short-run expectations for price, profitability and parity prices, levels of technology, age composition of the trees and climate and other biological factors.

Assuming Nerlovian expectation model, the yield model becomes;

$$Y_t = a_0 + a_1 P_t^s + a_2 Pr_t^s + a_3 Pa_t^s + a_4 Y_t^s + a_5 Ch_t + a_6 T + U \quad \dots\dots\dots(1)$$

Where;

- Y_t = The average yield per hectare of bearing apple in year t.
- P_t^s = Short run price expectation for apple in year t.
- Pr_t^s = Short run profitability expectation for apple in year t
- Pa_t^s = Short run expectation for parity ratios in year t
- Y_t^s = Short run yield expectation for apple in year t.
- Ch_t = Number of chilling hours in year t.
- T = The trend variable.
- U = The random disturbance term.

The random disturbance term accounts for climatic factors other than chilling requirement and other miscellaneous factors.

Long term Response

A long-term response model for a perennial crop like apple must explicitly consider the new plantings, removals and the changes in bearing acreage. In case of apples in Himachal Pradesh, the removals are assumed to be negligible and so the change in bearing acreage is brought about exclusively through new plantings. It is assumed that the farmers, in general, have in mind a desired production and in the long-run they will adjust the actual area to attain the desired production. If the desired area is greater than the actual area under apple, they will undertake new plantings. On the other hand, if the desired area is less than or equal to the actual area, there will not be any new planting.

The major variables influencing the desired acreage are expected price of the crop concerned, expectations regarding the yield, profitability of the crop, parity prices, infrastructural development and subsidy. Thus the desired change in bearing area under apple in a year $(A_t^* - A_{t-1})$ may be specified as -

$$A_t^* - A_{t-1} = f(P_t^e, Pr_t^e, Pa_t^e, R_t^e, Y_t^e, S_t, U) \dots\dots(2)$$

A_t^* = the desired bearing area (hectare) in year t.

A_{t-1} = the actual bearing area (hectare) in year t-1.

P_t^e = the expected price of apples in year t.

Pr_t^e = the expected profitability of apples in year t.

Pa_t^e = the expected parity prices of apples in year t.

S_t = the variable to depict the effect of subsidy.

Y_t^e = the expected yield of apple in year t.

R_t^e = expectation for road length /infrastructure development in year t

U = the random disturbance term.

Being a perennial crop it requires 'k' years where 'k' is the gestation period to adjust the actual bearing area to the desired level. So operationally, A_t^* may be replaced by A_{t+k}^* in equation —(2). Thus,

$$A_{t+k}^* - A_{t-1} = f(P_t^e, P_r^e, P_{at}^e, R_t^e, Y_t^e, S_t, U) \dots(3)$$

Then the desired plantings in year 't' becomes

$$P_t^* = A_{t+k}^* - A_{t-1} + RK_t^e - Nb_{t-1} \dots\dots\dots(4)$$

Where;

P_t^* = the desired plantings in year 't'.

RK_t^e = the expected removals during next 'k' years including year 't'.

Nb_{t-1} = the non bearing area (young) in year t-1.

The desired plantings is an unobservable variable and will differ from actual new plantings due to resource restrictions. The relationship between actual and desired new plantings can be specified as

$$N_t = N_t^* + \beta(1 - \alpha)N_{t-1} + e \dots\dots\dots(5)$$

where;

N_t - the newplantings of year t

N_t^* - the desired newplantings of year t

N_{t-1} - the actual newplantings of year t-1

α - Coefficient of expectation

Assuming $\beta = 1$ and combining equations (3), (4) and (5) the planting model becomes

$$N_t = f(P_t^e, P_r^e, P_{at}^e, R_t^e, S_t, Y_t^e, A_{t-1}, N_{t-1}) + U$$

This final palnting model is estimated with and without risk response.

Expectations

The new planting model developed above involves price and yield expectations which are unobservable and so should be derived from actual observations. Nerlove's price expectation model has been the basis for many supply response studies, which previously have undergone into various dimensions of price expectation formulations. The studies by French & Mathews (1971) and Ipe & Prabhakaran (1988) have concluded that the expectations derived through simple averages or moving averages has performed better than the geometric lag weight model in terms of both the R^2 values and individual regressors. The expected values in the current study are thus derived from the observed values through the simple averages of different lags and moving averages of periods 3,4,5,6 and 7.

Linear function (Yield Response)

$$1.1 \quad Y_t = a_0 + a_1P_t^s + a_4Y_t^s + a_5Ch_t + u$$

$$1.2 \quad Y_t = a_0 + a_1P_t^s + a_4Y_t^s + a_5Ch_t + a_6T + u$$

$$1.3 \quad Y_t = a_0 + a_2Pr_t^s + a_4Y_t^s + a_5Ch_t + u$$

$$1.4 \quad Y_t = a_0 + a_2Pr_t^s + a_4Y_t^s + a_5Ch_t + a_6T + u$$

$$1.5 \quad Y_t = a_0 + a_3Pa_t^s + a_4Y_t^s + a_5Ch_t + u$$

$$1.6 \quad Y_t = a_0 + a_3Pa_t^s + a_4Y_t^s + a_5Ch_t + a_6T + u$$

$$1.7 \quad Y_t = a_0 + a_1P_t^s + a_2Pr_t^s + a_4Y_t^s + a_5Ch_t + u$$

$$1.8 \quad Y_t = a_0 + a_1P_t^s + a_2Pr_t^s + a_4Y_t^s + a_5Ch_t + a_6T + u$$

$$1.9 \quad Y_t = a_0 + a_1P_t^s + a_3Pa_t^s + a_4Y_t^s + a_5Ch_t + u$$

$$1.10 \quad Y_t = a_0 + a_1P_t^s + a_3Pa_t^s + a_4Y_t^s + a_5Ch_t + a_6T + u$$

$$1.11 \quad Y_t = a_0 + a_2Pr_t^s + a_3Pa_t^s + a_4Y_t^s + a_5Ch_t + u$$

$$1.12 \quad Y_t = a_0 + a_2Pr_t^s + a_3Pa_t^s + a_4Y_t^s + a_5Ch_t + a_6T + u$$

$$1.13 \quad Y_t = a_0 + a_1P_t^s + a_2Pr_t^s + a_3Pa_t^s + a_4Y_t^s + a_5Ch_t + u$$

$$1.14 \quad Y_t = a_0 + a_1P_t^s + a_2Pr_t^s + a_3Pa_t^s + a_4Y_t^s + a_5Ch_t + a_6T + u$$

Double Log function (Yield Response)

$$1.15 \log Y_t = \log a_0 + a_1 \log P_t^s + a_4 \log Y_t^s + a_5 \log Ch_t + u$$

$$1.16 \log Y_t = \log a_0 + a_1 \log P_t^s + a_4 \log Y_t^s + a_5 \log Ch_t + a_6 \log T + u$$

$$1.17 \log Y_t = \log a_0 + a_2 \log Pr_t^s + a_4 \log Y_t^s + a_5 \log Ch_t + u$$

$$1.18 \log Y_t = \log a_0 + a_2 \log Pr_t^s + a_4 \log Y_t^s + a_5 \log Ch_t + a_6 \log T + u$$

$$1.19 \log Y_t = \log a_0 + a_3 \log Pa_t^s + a_4 \log Y_t^s + a_5 \log Ch_t + u$$

$$1.20 \log Y_t = \log a_0 + a_3 \log Pa_t^s + a_4 \log Y_t^s + a_5 \log Ch_t + a_6 \log T + u$$

$$1.21 \log Y_t = \log a_0 + a_1 \log P_t^s + a_2 \log Pr_t^s + a_4 \log Y_t^s + a_5 \log Ch_t + u$$

$$1.22 \log Y_t = \log a_0 + a_1 \log P_t^s + a_2 \log Pr_t^s + a_4 \log Y_t^s + a_5 \log Ch_t + a_6 \log T + u$$

$$1.23 \log Y_t = \log a_0 + a_1 \log P_t^s + a_3 \log Pa_t^s + a_4 \log Y_t^s + a_5 \log Ch_t + u$$

$$1.24 \log Y_t = \log a_0 + a_1 \log P_t^s + a_3 \log Pa_t^s + a_4 \log Y_t^s + a_5 \log Ch_t + a_6 \log T + u$$

$$1.25 \log Y_t = \log a_0 + a_2 \log Pr_t^s + a_3 \log Pa_t^s + a_4 \log Y_t^s + a_5 \log Ch_t + u$$

$$1.26 \log Y_t = \log a_0 + a_2 \log Pr_t^s + a_3 \log Pa_t^s + a_4 \log Y_t^s + a_5 \log Ch_t + a_6 \log T + u$$

$$1.27 \log Y_t = \log a_0 + a_1 \log P_t^s + a_2 \log Pr_t^s + a_3 \log Pa_t^s + a_4 \log Y_t^s + a_5 \log Ch_t + u$$

$$1.28 \log Y_t = \log a_0 + a_1 \log P_t^s + a_2 \log Pr_t^s + a_3 \log Pa_t^s + a_4 \log Y_t^s + a_5 \log Ch_t + a_6 \log T + u$$

New planting response

Linear Functions (without risk response)

$$2.1 N_t = b_0 + b_1 P_t^e + b_2 Pr_t^e + b_3 Pa_t^e + b_4 R_t^e + b_5 Y_t^e + b_6 S_t + b_7 N_{t-1} + v$$

$$2.2 N_t = b_0 + b_1 P_t^e + b_2 Pr_t^e + b_4 R_t^e + b_5 Y_t^e + b_6 S_t + b_7 N_{t-1} + v$$

$$2.3 N_t = b_0 + b_1 P_t^e + b_2 Pr_t^e + b_4 R_t^e + b_5 Y_t^e + b_7 N_{t-1} + v$$

$$2.4 N_t = b_0 + b_1 P_t^e + b_3 Pa_t^e + b_4 R_t^e + b_5 Y_t^e + b_7 N_{t-1} + v$$

$$2.5 N_t = b_0 + b_2 Pr_t^e + b_4 R_t^e + b_5 Y_t^e + b_6 S_t + v$$

$$2.6 N_t = b_0 + b_1 P_t^e + b_3 Pa_t^e + b_4 R_t^e + b_5 Y_t^e + b_6 S_t + b_7 N_{t-1} + v$$

$$2.7 N_t = b_0 + b_1 P_t^e + b_3 Pa_t^e + b_4 R_t^e + b_5 Y_t^e + b_7 N_{t-1} + v$$

$$2.8 N_t = b_0 + b_2 Pr_t^e + b_6 N_{t-1} + b_7 N_{t-1} + v$$

$$2.9 N_t = b_0 + b_3 Pa_t^e + b_4 R_t^e + b_5 Y_t^e + b_6 S_t + b_7 N_{t-1} + v$$

Linear Functions (with risk response)

$$2.11 N_t = b_0 + b_1 P_t^c + b_2 Pr_t^c + b_3 Pa_t^c + b_4 R_t^c + b_5 Y_t^c + b_6 S_t + b_7 N_{t-1} + b_8 PR + b_9 YR + v$$

$$2.12 N_t = b_0 + b_1 P_t^c + b_2 Pr_t^c + b_4 R_t^c + b_5 Y_t^c + b_6 S_t + b_7 N_{t-1} + b_8 PR + b_9 YR + v$$

$$2.13 N_t = b_0 + b_1 P_t^c + b_2 Pr_t^c + b_4 R_t^c + b_5 Y_t^c + b_7 N_{t-1} + b_8 PR + b_9 YR + v$$

$$2.14 N_t = b_0 + b_1 P_t^c + b_3 Pa_t^c + b_4 R_t^c + b_5 Y_t^c + b_7 N_{t-1} + b_8 PR + b_9 YR + v$$

$$2.15 N_t = b_0 + b_2 Pr_t^c + b_4 R_{t-1} + b_5 Y_t^c + b_6 S_t + b_8 PR + b_9 YR + v$$

$$2.16 N_t = b_0 + b_1 P_t^c + b_3 Pa_t^c + b_4 R_t^c + b_5 Y_t^c + b_6 S_t + b_7 N_{t-1} + b_8 PR + b_9 YR + v$$

$$2.17 N_t = b_0 + b_1 P_t^c + b_3 Pa_t^c + b_4 R_t^c + b_5 Y_t^c + b_7 N_{t-1} + b_8 PR + b_9 YR + v$$

$$2.18 N_t = b_0 + b_2 Pr_t^c + b_6 N_{t-1} + b_7 N_{t-1} + b_8 PR + b_9 YR + v$$

$$2.19 N_t = b_0 + b_3 Pa_t^c + b_4 R_t^c + b_5 Y_t^c + b_6 S_t + b_7 N_{t-1} + b_8 PR + b_9 YR + v$$

New planting response

Double Log Functions (without risk response)

$$2.21 \log N_t = \log b_0 + b_1 \log P_t^c + b_2 \log Pr_t^c + b_3 \log Pa_t^c + b_4 \log R_t^c + b_5 \log Y_t^c + b_6 \log S_t + b_7 \log N_{t-1} + v$$

$$2.22 \log N_t = \log b_0 + b_1 \log P_t^c + b_2 \log Pr_t^c + b_4 \log R_t^c + b_5 \log Y_t^c + b_6 \log S_t + b_7 \log N_{t-1} + v$$

$$2.23 \log N_t = \log b_0 + b_1 \log P_t^c + b_2 \log Pr_t^c + b_4 \log R_t^c + b_5 \log Y_t^c + b_7 \log N_{t-1} + v$$

$$2.24 \log N_t = \log b_0 + b_1 \log P_t^c + b_3 \log Pa_t^c + b_4 \log R_t^c + b_5 \log Y_t^c + b_7 \log N_{t-1} + v$$

$$2.25 \log N_t = \log b_0 + b_2 \log Pr_t^c + b_4 \log R_t^c + b_5 \log Y_t^c + b_6 \log S_t + v$$

$$2.26 \log N_t = \log b_0 + b_1 \log P_t^c + b_3 \log Pa_t^c + b_4 \log R_t^c + b_5 \log Y_t^c + b_6 \log S_t + b_7 \log N_{t-1} + v$$

$$2.27 \log N_t = \log b_0 + b_1 \log P_t^c + b_3 \log Pa_t^c + b_4 \log R_t^c + b_5 \log Y_t^c + b_7 \log N_{t-1} + v$$

$$2.28 \log N_t = \log b_0 + b_2 \log Pr_t^c + b_6 \log N_{t-1} + b_7 \log N_{t-1} + v$$

$$2.29 \log N_t = \log b_0 + b_3 \log Pa_t^c + b_4 \log R_t^c + b_5 \log Y_t^c + b_6 \log S_t + b_7 \log N_{t-1} + v$$

Double Log Functions (with risk response)

$$2.31 \log N_t = \log b_0 + b_1 \log P_t^c + b_2 \log Pr_t^c + b_3 \log Pa_t^c + b_4 \log R_t^c + b_5 \log Y_t^c + b_6 \log S_t + b_7 \log N_{t-1} + b_8 \log PR + b_9 \log YR + v$$

$$2.32 \log N_t = \log b_0 + b_1 \log P_t^c + b_2 \log Pr_t^c + b_4 \log R_t^c + b_5 \log Y_t^c + b_6 \log S_t + b_7 \log N_{t-1} + b_8 \log PR + b_9 \log YR + v$$

$$2.33 \log N_t = \log b_0 + b_1 \log P_t^c + b_2 \log Pr_t^c + b_4 \log R_t^c + b_5 \log Y_t^c + b_7 \log N_{t-1} + b_8 \log PR + b_9 \log YR + v$$

$$2.34 \log N_t = \log b_0 + b_1 \log P_t^c + b_3 \log Pa_t^c + b_4 \log R_t^c + b_5 \log Y_t^c + b_7 \log N_{t-1} + b_8 \log PR + b_9 \log YR + v$$

$$2.35 \log N_t = \log b_0 + b_2 \log Pr_t^c + b_4 \log R_{t-1} + b_5 \log Y_t^c + b_6 \log S_t + b_8 \log PR + b_9 \log YR + v$$

$$2.36 \log N_t = \log b_0 + b_1 \log P_t^c + b_3 \log Pa_t^c + b_4 \log R_t^c + b_5 \log Y_t^c + b_6 \log S_t + b_7 \log N_{t-1} + b_8 \log PR + b_9 \log YR + v$$

$$2.37 \log N_t = \log b_0 + b_1 \log P_t^c + b_3 \log Pa_t^c + b_4 \log R_t^c + b_5 \log Y_t^c + b_7 \log N_{t-1} + b_8 \log PR + b_9 \log YR + v$$

$$2.38 \log N_t = \log b_0 + b_2 \log Pr_t^c + b_6 \log N_{t-1} + b_7 \log N_{t-1} + b_8 \log PR + b_9 \log YR + v$$

$$2.39 \log N_t = \log b_0 + b_3 \log Pa_t^c + b_4 \log R_t^c + b_5 \log Y_t^c + b_6 \log S_t + b_7 \log N_{t-1} + b_8 \log PR + b_9 \log YR + v$$

The method of least squares was used to estimate the regression coefficients. The related statistic used as empirical criterion to test the significance of regression coefficients was the student's 't' test which is as under

$$t^* = \hat{b}_i / SE(b_i)$$

Where;

t^* = estimated value of t

\hat{b}_i = estimated value of b_i

$SE(b_i)$ = standard error of b_i

It is a well known fact that the value of R^2 increases as the number of variables considered in a regression equation increases. To neutralise this effect \bar{R}^2 was calculated as follows :

$$\bar{R}^2 = 1 - (1-R^2) \frac{n-1}{n-k}$$

The significance of R^2 was tested with the help of **F test** as under

$$F = \frac{R^2}{(1-R^2)} \times \frac{n-1}{n-k}$$

Where;

R^2 = coefficient of multiple determination

\bar{R}^2 = adjusted coefficient of multiple determination

n - number of sample observations

k - number of parameters estimated from the samples.

Durbin-Watson (D-W) test was applied to test the incidence of autocorrelation (Koutsoyiannis, 1987), and was computed as follows;

$$D-W \text{ statistic} = \frac{\sum_{t=2}^n (e_t - e_{t-1})^2}{\sum_{t=1}^n (e_t)^2}$$

The incidence of multicollinearity was tested by applying **Condition Index test** (Gujarati, 1988) which is defined as

$$C.I. = \sqrt{\text{Maximum Eigen value/Minimum Eigen value}}$$

Where;

C.I. = Condition Index value

If $C.I. \leq 10$ - no multicollinearity

If $10 < CI \leq 30$ - moderate to strong multicollinearity

If $C.I. > 30$ - severe multicollinearity

Best Fit Equations

Best fit equations were selected on the basis of the following criteria

- i) Condition Index value
- ii) Durbin-Watson Statistic
- iii) Adjusted coefficient of multiple determination

Computation of Coefficient of Elasticities

1. Coefficient of elasticity of linear functions

The elasticity of dependent variable with respect to independent variables in linear functions is computed as,

$$E_{yxi} = \frac{dy}{dX_i} \times \frac{\bar{X}_i}{\bar{Y}}$$

Where;

Y = the dependent variable

X_i = the independent variable where $i = 1, 2, 3, \dots$

$dy/dX_i = b_i$ = the regression coefficient of X_i .

2) Coefficient of elasticity of double-log functions

The elasticity of dependent variable, with respect to independent variables in double-log functions, is the regression coefficient itself.

3) Coefficient of short run elasticity

It is the sum of all significant elasticities in the yield response equation.

4) Coefficient of long run elasticity

It is the sum of all significant elasticities in the planting response equation.

Comparison of R² values of double-log and linear functions

The equation for short run response in double log and linear format were compared as follows : (Gujarati, 1988)

$$\log Y_t = \log a_0 + a_3 \log P a_t^s + a_4 \log Y_t^s + a_5 \log Ch_t + u \quad \dots\dots\dots(1)$$

$$Y_t = a_0 + a_3 P a_t^s + a_4 Y_t^s + a_5 Ch_t + u \quad \dots\dots\dots(2)$$

Obtain $\log Y_t$ from the model (1) and obtain antilog \log of \hat{Y}_t . Then compute R² between antilog of $\log \hat{Y}_t$ i.e. (\hat{Y}_t) and Y_t as given below :

$$R^2 = \frac{(\sum y_t \hat{y}_t)^2}{(\sum y_t^2) (\sum \hat{y}_t^2)}$$

where

$$y_t = (Y_t - \bar{Y}_t)$$

$$\hat{y}_t = (\hat{Y}_t - \bar{\hat{Y}}_t)$$

This R² is comparable with the R² value of model 2

3.2.2 Growth in Area, Production and Productivity

Compound growth rates of total area, production and productivity were worked out by fitting exponential functions district-wise and for the state as a whole during the period 1967-1997. The ordinary least square method was used to fit exponential functions

in order to compute the growth rates. The form of the function is $Y = ab^x$, which was converted into linear function with the help of log transformations as under

$$\log Y = \log a + X \log b$$

Where Y is dependent variable (area, production & productivity) and X is independent variable (time in years) a is a constant. Compound growth rates (CGR per cent) were estimated by using the formula.

$$\text{CGR} = (b-1) 100$$

Standard error of compound growth rates was computed using the following formula

$$\text{S.E. of CGR} = 100b \cdot \text{SE} \log_e b / \log_{10} e$$

$$\text{S.E.} \log_e b = \text{standard error of } \log_e b$$

$$= \sqrt{\frac{\sum \text{Log} Y^2 - (\sum \text{Log} Y)^2 / N - \sum X_c^2 (\log_{10} b)^2}{(N - 2) \sum X_c^2}}$$

Where;

$$\sum X_c^2 = \frac{\sum X^2 - (\sum X)^2}{N}$$

$$N = \text{number of observations}$$

The students 't' distribution test was used to test the significance of growth rates.

The test statistic is as follows :

$$t = \text{CGR} / \text{S.E (of CGR)}$$

Where t is the estimated value of t and it follows a student t distribution with $N-K$ degrees of freedom.

Where;

$$K = \text{number of parameters.}$$

$$N = \text{number of observations}$$

RESULTS & DISCUSSION

RESULTS AND DISCUSSION

4.1 GROWTH IN AREA, PRODUCTION AND PRODUCTIVITY

Of the twelve districts of Himachal Pradesh, apple is grown mainly in Shimla, Kullu, Mandi, Chamba and Kinnaur districts. On a smaller scale, it is also grown in Sirmour, Kangra, Solan and Lahaul & Spiti districts. Shimla and Kullu however, are the two most important districts for the production of apples. These districts together account for nearly 62 per cent of total area and 84 per cent of the total production of apples in the state.

The compound growth rates, which give the annual growth rate, have been computed for area, production and productivity of apple in the state. The amount of growth in output is the outcome of the growth in both area and yield. Knowledge about sources of growth in agriculture and its relative importance in different agro-climatic conditions, is desirable for effective planning at regional or state level. The purpose of this analysis is to examine the performance of apple cultivation in various apple growing districts and the state as a whole.

The compound growth rates for area, production and productivity of Himachal apple are presented in table 4.1. There has been an increase in area under apple in the state from 17588 ha in 1967 to 83056 ha in 1997. The rate of change is erratic with some years showing an increase at increasing rate, some at decreasing rate and some others at constant. The compound growth rate for area under apple in the state is estimated to be 4.58 percent per annum. This suggests that due to high profitability of apple orchards, Himachal farmers have been attracted towards this enterprise. The production of apple is too much dependent upon weather conditions, elevation, age of the plant, etc. Further, apple being an irregular bearing crop, there can be large fluctuations in the production of apples. The production of apple in the state has increased from 39344 tonnes in 1967 to

Table 4.1 Annual compound growth rate (C.G.R.) of area production and productivity of apple in Himachal Pradesh (1967-68 to 1997-98)

Item	Compound growth rate (C.G.R. %)
Area (ha)	4.58* (0.16)
Production (Tonnes)	5.94* (0.95)
Productivity (Tonnes/ha)	-2.04** (0.8660)

* Significant at 1 per cent level of significance.

** Significant at 5 per cent level of significance.

Figures in parentheses are the standard errors.

234253 tonnes in 1997. The total production of apple in the state is found to be increasing at a compound growth rate of 5.94 per cent per annum. Productivity was found to be very high during late 60s and early 70s and is showing an increasing trend till 1971. Two series of productivity had been generated. They are, yield per hectare of bearing acreage under apple and yield per hectare of total acreage under apple termed as productivity (B) and productivity (T) respectively. The series productivity (T), gave negative compound growth rate not significantly different from zero even at ten per cent probability level. Hence this series was dropped. Productivity (B) series also gave negative compound growth rate but was significantly different from zero. Productivity (B) series was thus taken up for suitable discussion. From 1972 onwards, productivity is showing a general declining trend with very low productivity in alternate or once in two/or three years. The annual compound growth rate of productivity of apple in the state is negative -2.04. This trend could probably be accounted for by the weather factors, the ageing of the existing plants under bearing acreage, poor management and new plantations under marginal lands.

District-wise annual compound growth rates of area and production are presented in table 4.2. Perusal of the table indicated that area under apple increased by 11.61 per cent per annum in Lahaul & Spiti, the highest among all the apple growing districts, followed by Chamba (10.52%), Kinnaur (9.22%), Solan (5.35%), Mandi (5.17%), Kullu (4.23%), Shimla (3.74%), Kangra (3.10%) and Sirmour (3.10%). It may be noted here that maximum area under apple is in Shimla district, followed by Kullu and Mandi; but the highest growth, in this regard, has been recorded in Lahaul & Spiti, followed by Chamba, Kinnaur, and Solan. However, from absolute growth point of view, the latter four districts have small proportion of total area of the state and, therefore, do not affect the total picture significantly. Thus, the increase in apple acreage in these districts is an indication of exploration of newer areas (areas other than Shimla, Kullu and Mandi) to be brought under apple cultivation.

The highest annual compound growth rate of production, district wise, was found in Lahaul & Spiti (15.03%) followed by Kinnaur (10.65%), Shimla (7.15%) and Kullu (5.25%). In districts Kangra, Solan, Sirmour and Mandi, the compound growth rate is found to be negative and further for Mandi it is insignificant. The highest growth rate in production in Lahaul & Spiti could be accounted to the young plantations in full bearing age. The highest total production was witnessed in Shimla followed by Kullu and Mandi

Table 4.2 District-wise annual compound growth rates (C.G.R.) of area and production of apple in Himachal Pradesh (1966-67 to 1997-98)

District	Area (ha)	Production (Tonnes)
Shimla	3.74* (0.15)	7.15* (1.03)
Kullu	4.23* (0.15)	5.25* (1.09)
Mandi	5.17* (0.25)	-0.26 (1.35)
Chamba	10.52* (0.33)	4.53* (1.28)
Kinnour	9.22* (0.35)	10.65* (1.10)
Lahaul & Spiti	11.61* (0.30)	15.03* (1.46)
Kangra	3.10* (0.16)	-7.26* (1.76)
Solan	5.35* (0.55)	-6.01* (1.25)
Sirmour	3.10* (0.22)	-7.42* (1.55)

* Significant at 1 per cent level of significance.

districts. Shimla district alone accounts for more than half of the total production of apple in the state. Low growth rate in production in Shimla and Kullu, compared to Lahaul & Spiti and Kinnaur districts is probably due to the ageing of the existing stock. The negative growth rate in Mandi could be attributed to the extension of area under apples in marginal and climatologically unsuitable lands and new plantings.

4.2 ESTIMATION OF FACTORS AFFECTING SUPPLY

The estimation of factors affecting the supply of apple in Himachal Pradesh is done under two main heads.

- (i) Factors affecting short run supply and
- (ii) Factors affecting long run supply

4.2.1 Factors Affecting Short Run Supply (Yield Response)

4.2.1.1 Selection of Expectation Formulation

In the short run, the producers can adjust the supply only within the existing capacity. Therefore, the output per hectare (productivity) forms the dependent variable for short run supply response. Apple being a perennial crop, with irregular bearing, the farmers are assumed to take into consideration one year, two year or three year lags of different specified variables into considerations to form their short run expectation. To start with the analysis, the relationship of independent variables in different formulations was examined with the dependent variable so as to select a formulation which gives the best explanation of dependent variable for a given period. Statistically, the extent of relationship was examined with the help of correlation coefficient, and coefficient of determination.

The value of 'r' for different specifications of price revealed that the apple price factor (wholesale price) is negatively correlated to yield (productivity). This indicates that as the productivity decreases price was found to increase; which can be explained from the time series data on prices and productivity. The r^2 value is very low and not significantly different from zero at 5 percent probability level, indicating that this variable may not enter

into the short run expectation behaviour of the farmer. The formulation that was least negatively correlated with the dependent variable P_{t-1} (one year lag price) was incorporated into the final analysis as short run price expectation (P_t^e) variable.

The specifications for short run expectations of profitability, parity ratios and yield were positively correlated to the dependent variable. One specification for each of the variables which was highly correlated with the yield variable (high r_1 and r^2 values significantly different from zero at one percent probability level) was taken into the final estimation of yield response equations (annexure-2). They are Pr_{t-2} (2 year lag profitability), Pa_{t-3} (3 year lag parity ratios) and Y_{t-2} (2 year lag yield) and are later specified as Pr_t^e , Pa_t^e and Y_t^e in the subsequent analysis.

4.2.1.2 Selection of Functions

Two types of multiple regression models i.e. linear and double log format were tried with different combinations of independent variables as specified earlier. The ones giving best results on the considerations of coefficient of multiple determination, proper sign and significance of variables, together with the absence of multicollinearity and autocorrelation were selected. Since the number of observations in this analysis are 32, which is possibly a long time series, so it satisfies the properties of large sample estimates. The variables finally included in the model, have been tested for multicollinearity using Condition Index test. The presence of autocorrelation was tested by computing 'd' statistic. The significance of adjusted R^2 was tested using 'F' test and that of the regression coefficients using 't' test of significance.

The equations satisfying the above mentioned tests were considered fit for estimating the yield response. Fourteen regression equations, each with different combinations of independent variables, were tried in both the linear and double log format. In the linear format, the coefficient of determination varied from 0.34 (in Equation No. 1.1) to 0.53 (in Equation No. 1.6). Though the value of \bar{R}^2 was low, it was statistically significant at one percent probability level; indicating that the variables under consideration do have a role in explaining the variation in productivity of apple. Equation-1.14 was dropped due to the

presence of autocorrelation. The 'd' statistic computed for the equation was 2.3739, indicating a positive autocorrelation. Equations 1.1, 1.8 and 1.10 gave inconsistent sign to the regression coefficient of the short run price expectation variable and hence were not taken into consideration. The short run price expectation variable, though found to have a positive regression coefficient in equation no. 1.7, 1.9 and 1.13 but not significantly different from zero even at ten percent probability level led to the dropping of these equations. The short run profitability expectation and parity price expectation, when included separately in estimating equation gave positive regression coefficients and was significantly different from zero. These variables thus emerged to have greater influence on the farmers' short run decisions, as compared to the short run price expectation.

Taking into consideration the significance of the regression coefficients, consistent structural sign as well as comparatively high \bar{R}^2 values of the remaining equations, equation Nos. 1.2, 1.3, 1.4, 1.5, 1.6 and 1.9 were considered suitable for the discussion. The C.I. values of these equations were found to be less than 10 and 'd' statistic falls in the inconclusive region, indicating no autocorrelation and multicollinearity.

The specified double log models were also tried to select statistically superior equations for estimating the yield response. The results of the regression analysis indicate that the sign of the coefficients as well as their level of significance were consistently superior to the linear model. The value of 'd' statistic fall in the inconclusive region in all the cases and the Condition Index value was found less than 10. The equation no. 1.15 was dropped due to the inconsistent structural sign of the regression coefficient. The short run price expectation was found not to be a significant factor influencing the short run response of the farmers. The equations 1.16, 1.17, 1.18, 1.19, 1.20 and 1.23 were found to be statistically superior for estimating supply response, for reasons of significance of the regression coefficients with consistent structural sign and the comparatively high R^2 values.

4.2.1.3 Yield Response

The results of the finally selected models, both in linear and double log formats, taking yield as the dependent variable are given in table; 4.3 and 4.4. The yield elasticities with respect to various independent variables are given in table 4.5 and 4.6. The elasticities

Table : 4.3 - REGRESSION COEFFICIENTS OF SHORT RUN SUPPLY RESPONSE (YIELD RESPONSE) - LINEAR MODEL

[Yield as dependent variable]

Eq. No.	Model Specification	a ₀	a ₁	a ₂	a ₃	a ₄	a ₅	a ₆	CI	d	R ²	TYE
1.2	$Y_t = f(P_t^S, Y_t^S, Ch_t, T)$	-11.01** [5.344]	0.0103 [0.0095]			0.4081** [0.1701]	0.0034** [0.0015]	1.3057*** [0.6719]	3.97	1.7588	0.4003*	2.5
1.3	$Y_t = f(Pr_t^S, Y_t^S, Ch_t)$	-2.5842 [2.5494] (-1.01)		0.0121* [0.0039] (3.06)		0.1449 [0.1988] (0.73)	0.0037* [0.0013] (2.80)		2.77	2.2446	0.4923*	1.2
1.4	$Y_t = f(Pr_t^S, Y_t^S, Ch_t, T)$	-2.1268 [3.3485]		0.0129** [0.0057]		0.1365 [0.2060]	0.00380** [0.0011]	-0.10830 [0.5014]	2.99	2.2602	0.4744*	1.27
1.5	$Y_t = f(Pa_t^S, Y_t^S, Ch_t)$	-5.1548** [2.4530]			26.471* [7.7616]	0.2951*** [0.1545]	0.0033** [0.0013]		2.00	2.2034	0.5286*	1.78
1.6	$Y_t = f(Pa_t^S, Y_t^S, Ch_t, T)$	-4.8676 [2.8633]			28.073** [10.1346]	0.30117*** [0.1594]	0.00340** [0.0013]	-0.1084 [0.7517]	3.02	2.2176	0.5122*	1.857
1.9	$Y_t = f(P_t^S, Pa_t^S, Y_t^S, Ch_t)$	-5.4077*** [2.9133]	0.0008 [0.0051]		26.949* [8.2026]	0.2983*** [0.1585]	0.0034** [0.0013]		5.57	2.1963	0.5117	1.82

TYE - Total yield elasticity is the sum of all significant elasticities

- Figures in square brackets are standard errors

* - Significant at 1 per cent level of probability

** - Significant at 5 per cent level of probability

*** - Significant at 10 per cent level of probability

Table : 4.4 - REGRESSION COEFFICIENTS OF SHORT RUN SUPPLY RESPONSE (YIELD RESPONSE) - DOUBLE LOG MODEL
 [Yield as dependent variable]

Eq. No.	Model Specification	$\log a_0$	a_1	a_2	a_3	a_4	a_5	a_6	CI	d	R^2	TYE
1.16	$Y_t = f(P_t^S, Y_t^S, Ch_t, T)$	-6.0549 [1.7915]	0.6253*** [0.3395]			0.3762** [0.1583]	1.0786* [0.35104]	2.3770** [1.0691]	6.83	1.6933	0.4119*	4.4571
1.17	$Y_t = f(Pr_t^S, Y_t^S, Ch_t)$	-3.7067* [1.1335]		0.3512** [0.1497]		0.14069 [0.2184]	1.1295* [0.3427]		2.37	2.0043	0.4262*	1.4807
1.18	$Y_t = f(Pr_t^S, Y_t^S, Ch_t, T)$	-3.7364* [1.1529]		0.4265*** [0.2373]		0.09218 [0.2509]	1.1535* [0.3527]	-0.2167 [0.5245]	4.80	2.0490	0.4087*	1.5800
1.19	$Y_t = f(Pa_t^S, Y_t^S, Ch_t)$	-2.6858** [1.1745]			0.53128** [0.2253]	0.3595** [0.1586]	1.1271* [0.3425]		1.80	1.9673	0.4273*	2.0178
1.20	$Y_t = f(Pa_t^S, Y_t^S, Ch_t, T)$	-2.6449** [1.2501]			0.5555*** [0.3152]	0.3601** [0.1616]	1.1331* [0.3528]	-0.0518 [0.4626]	2.84	1.9730	0.4063*	2.0487
1.23	$Y_t = f(P_t^S, Pa_t^S, Y_t^S, Ch_t)$	-2.8267** [1.2162]	0.0714 [0.1289]		0.6180** [0.2767]	0.3575** [0.1607]	1.1505* [0.3494]		4.75	1.96	0.4127*	2.1260

TYE - Total yield elasticity is the sum of all significant elasticities

- Figures in square brackets are standard errors

* - Significant at 1 per cent level of probability

** - Significant at 5 per cent level of probability

*** - Significant at 10 per cent level of probability

of significant regression coefficients are taken up for suitable discussion. The results obtained from the selected models, both in case of linear and double log formats revealed that the value of coefficient of determination varied from 0.41 to 0.52. In spite of the low values of adjusted coefficient of multiple determination, it was significant at 1 percent level of significance, which indicate that the models specified commands strong explanatory power. Among the set of different explanatory variables, chilling hours emerged as the most crucial factor affecting the yield. The regression coefficient for the chilling hours variable emerged positive and was found significantly different from zero at one percent probability level in all cases in double log format and at five percent probability level in all cases of linear format. Apple being a temperate fruit, requires a certain minimum chilling period for its satisfactory growth and fruiting. The result obtained supports the hypothesis that chilling hours have a significant influence on the yield of the crop and that the yield increases with increase in the number of chilling hours. The yield elasticity with respect to chilling hours in linear as well as double log models lies between 0.82 to 1.15, indicating that the yield elasticity with respect to chilling hours is inelastic to elastic. The above stated discussion confirms the assumption that, yield in short run is, to a great extent, influenced by the number of chilling hours received by the crop during the given period.

Another important variable included in the model was the parity ratios. The regression coefficients of parity ratios are positive in all the selected cases of linear and double log formats. The coefficients were noticed to be significantly different from zero at five percent probability level in all the cases, except equation 1.20 where it was significant at ten percent probability level. These results indicated that yield increased in the same direction as the parity ratios. An increase in the parity ratios (an increase in apple prices at a rate higher than the rate of increase in Consumer Price Index) leads to a positive short run response of the orchardists. A higher parity ratio will in all probability induce the farmers to go in for intensive cultivation which increases the productivity of subsequent periods. The supply of apple in short run could thus be increased with terms of trade being in favour of apple industry. The yield elasticity of parity ratios is less than one and lies between 0.53 and 0.70. The yield response to parity ratios is thus relatively inelastic. One per cent increase in parity ratios leads to 0.53 to 0.70 per cent increase in apple productivity.

The short run profitability was associated positively with productivity in all the selected equations of linear and double log functions. It is also significantly different from zero in

equation no. 1.3 at one percent probability level; in equation nos. 1.4 and 1.17 at five percent probability level; and in equation no. 1.18 at ten percent probability level. The inclusion of this variable had reduced the significance of the short run yield expectation variable which is significant in all other selected cases. The profitability is a function of yield which reflects the effect of irregular bearing on profitability and similar effect emerged from the short run yield expectation variable. This could be the probable reason for the loss of significance of yield expectation variable, with the introduction of profitability variable in the model. The result obtained suggests that profitability had positive impact on the short run decision making behaviour of the orchardists. This variable has not emerged as strong as the parity prices, because of increase in prices of the inputs which had resulted into a decline in the overall profitability per unit of land. The increase in price of the inputs was at a higher rate compared to the increase in price of consumables, which may be considered as the most probable reason for this result. The yield elasticity of profitability is also positive and less than one (ranging from 0.33 to 0.42) indicating that yield is inelastic to profitability, but has still induced the growers to increase the short run supply of apple industry.

Short run yield expectation is yet another variable that had given positive regression coefficient in all the selected cases. It is significantly different from zero at five percent and ten percent probability level in most of the cases. This result supports the assumption that apple is an irregular bearing crop. The two year lag yield forms the short run expectation regarding yield, which has a positive and significant regression coefficient indicating that the yield in current (t) period will be high if the yield of the second previous year (t-2) was high. Thus the growers possibly will be induced to go for suitable cultural practices in alternate years. The yield elasticity of short run yield expectation lies between 0.31 and 0.42, it is positive and less than one. This indicates the yield of apple to be inelastic to short run yield expectation of growers. But its positive nature confirms that this variable induces the growers to produce more in alternate years.

The regression coefficient of the short run expected price emerged to be positive in all the selected cases of linear and double log format. It was significantly different from zero at ten percent probability level in only one case. Inclusion of parity ratios had reduced the significance of the price variable. The price thus does not seem to be an important factor influencing the short run behaviour of the orchardists. The probable reason for this

Table : 4.5 - YIELD ELASTICITIES OF LINEAR REGRESSION MODEL

Eq. No.	Model Specification	a ₁	a ₂	a ₃	a ₄	a ₅	a ₆
1.2	$Y_t = f(P^B_t, Y^B_t, Ch_t, T)$	0.171			0.4203	0.8454	1.2795
1.3	$Y_t = f(Pr^B_t, Y^B_t, Ch_t)$		0.3326		0.1492	0.9200	
1.4	$Y_t = f(Pr^B_t, Y^B_t, Ch_t, T)$		0.3546		0.1406	0.9200	-0.1061
1.5	$Y_t = f(Pa^B_t, Y^B_t, Ch_t)$			0.6618	0.3039	0.8205	
1.6	$Y_t = f(Pa^B_t, Y^B_t, Ch_t, T)$			0.7018	0.3102	0.8454	-0.1062
1.7	$Y_t = f(P^B_t, Pa^B_t, Y^B_t, Ch_t)$	0.013		0.6737	0.3072	0.8454	

Table : 4.6 - YIELD ELASTICITIES OF DOUBLE LOG REGRESSION MODEL

Eq. No.	Model Specification	a ₁	a ₂	a ₃	a ₄	a ₅	a ₆
1.16	$Y_t = f(P_t^S, Y_t^S, Ch_t, T)$	0.6253			0.3762	1.0786	2.3770
1.17	$Y_t = f(Pr_t^S, Y_t^S, Ch_t)$		0.3512		0.14069	1.1295	
1.18	$Y_t = f(Pr_t^S, Y_t^S, Ch_t, T)$		0.4265		0.09218	1.1535	-0.2167
1.19	$Y_t = f(Pa_t^S, Y_t^S, Ch_t)$			0.53128	0.3595	1.1271	
1.20	$Y_t = f(Pa_t^S, Y_t^S, Ch_t, T)$			0.5555	0.3601	1.1331	-0.0518
1.23	$Y_t = f(P_t^S, Pa_t^S, Y_t^S, Ch_t)$	0.0714		0.6180	0.3575	1.1505	

might be that inspite of a steady rise in price of apples, there has been a decline in the yield of the crop which could be accounted for by the ageing of the plants and extension of area under apples in marginal lands. The yield elasticity of price is 0.62 which is positive and less than one. A one percent increase in price leads to less than one percent increase in yield but still induces the growers to increase the production in short run.

The trend variable included in the model has given a positive regression coefficient significantly different from zero in only two of the selected cases in equation no. 1.2 and 1.16. In the rest of the cases it is negative and not significantly different from zero, even at ten percent probability level. The trend variable is assumed to include the effect of change in technology on the supply of apples in short run. This is positive and significant indicating that the technological changes adopted in the industry and yield changes take place in the same direction. The yield elasticity with respect to trend lies between 1.30 and 2.37 which is positive and more than one. Yield is thus highly elastic to trend which supports the assumption that, in short run, yield will be higher with technological improvements in the industry like improved fertilizers management practices, Integrated Pest Management Practices, irrigation practices etc.

4.2.1.4 Total Yield Elasticity (Short Run Elasticity)

In the study it is hypothesized that total yield elasticity is positive. The total yield elasticity is the sum of all significant elasticities of the independent variables included in the model, which are the regression coefficient themselves in case of double log functions. In the linear functions these elasticities were derived from the regression coefficient as specified earlier. Various specifications were tried in this study so as to estimate the short run yield response of apple Industry and the aggregate elasticities were computed in each case (Table 4.3 and 4.4). A glance on the tables shows that the total elasticity is positive and more than one in all the cases, but it ranged between 1.2526 to 4.4571. This is mainly because of the fact that the number of variables in each specification varies. Therefore, an attempt is made to choose a single equation from all the selected cases which gives higher explanatory power, as well as more independent variables coupled with their significance. Equation No. 1.16, though having four significant variables this equation, was not finally selected to discuss the total new planting elasticity as the price variable did not emerge as

important a variable as parity ratios. A glance at the data obtained revealed that there has been a steady increase in prices but still the yield declined through the years, while the parity prices and yield had moved in the same direction. Thus, not only the prices of the product, but also the purchasing power available with the growers should be considered. The trend variable in this equation was positive and significant; indicating that the technological improvements have significant influence in increasing the apple yield in the short run. But in practices, the apple orchards in Himachal Pradesh are aged and mostly under marginal lands which do not respond heavily to improved management practices. Thus, equation no. 1.16 was not finally selected. Equation No. 1.5 in linear format was found to give the highest \bar{R}^2 value and three significant independent variables. Equation No. 1.19 in double log format also gives the some level of significance of independent variables. But its \bar{R}^2 value ($\bar{R}^2_{(d)}$) is low (0.427). Since it is in the double log format, to compare its \bar{R}^2 value with the \bar{R}^2 value in linear format ($\bar{R}^2_{(l)}$), the $\bar{R}^2_{(d)}$ is converted to \bar{R}^2 value in linear format say $\bar{R}^{2'}$ and then $\bar{R}^{2'}$ and $\bar{R}^2_{(l)}$ could be compared. $\bar{R}^2_{(l)}$ was (0.528) and $\bar{R}^{2'}$ was computed to be (0.486). Thus the linear model was found to be a better model compared to the double log model. The total yield elasticity of the finally selected model (equation No. 1.5) is 1.7862. This indicates that yield is highly elastic to the simultaneous changes in the independent variables considered. A one per cent increase each in short run parity price expectation, yield expectation and chilling hours for period 't' together will lead to 1.7862 per cent increase in the productivity for tth period. Chilling hours represent the impact of climatic factors on yield of apples, a favourable change of which (in the open conditions) is beyond the reach of human beings. The yield expectation variable reflects the effect of irregular bearing nature of the crop. The farmers, therefore, adopt cultural practices which help them to get a good crop in all years. Thus, a terms of trade in favour of the apple industry could be concluded to play a major role in increasing the yield of apple industry in the short run.

4.2.2 Factors affecting long-run supply (New planting response)

4.2.2.1 Selection of Expectation Formulations

The orchardists, in general, are assumed to have in mind a desired production and in the long run they will adjust the actual area to attain the desired production. The change in

acreage under apples in Himachal Pradesh is brought about solely through new plantings. The removals are assumed to be negligible. Apple being a perennial crops with a gestation lag of six years, the long run decisions like acreage to be newly planted will be influenced by the expectations of the growers regarding prices, profitability, parity ratios, yield, etc.

The expectation formulations for each independent variable was derived through simple lags, simple averages and moving averages. As a first step to estimate the long run response, the relationship of independent variables in different formulations are examined with the dependent variable (new planting acreage), so as to select a formulation which gives the best explanation of the dependent variable. Statistically, the extent of relationship was examined with the help of correlation coefficient and coefficient of determination.

Two price series were considered, wholesale prices termed as prices and net prices. Of these two price series, the net prices was found to give better correlation with the new planting acreage, compared to the wholesale prices. The net price was thus, taken for final analysis. Within the expectation formulations of net prices, NP_{t-3} (3 year lag net price) was found to give the highest correlation coefficient with the dependent variable which is significantly different from zero.

The expectation formulations for profitability, parity ratios and yield gave positive correlation coefficient with the dependent variables. The two year lag average formulation of profitability expectation and yield expectation and 6 year moving average formulation of parity ratios expectation were found to be highly correlated with the dependent variable. It may thus be concluded that the producers do consider a few recent observations to arrive at the expectations for the current period. Of the different formulations for road length, R_{t-1} was found to give highest 'r' value with the new planting acreage and decreases with increase in the number of lags. This confirms that the farmers consider the previous year's road length ((t-1)th period) to form a decision on the acreage to be newly planted in year 't'. The expectation formulations for each of the specified independent variable at this step of the analysis is taken into the final analysis as P_t^e (long run price expectation), P_{π}^e (long run profitability expectation), Pa_t^e (Parity ratios expectation), Y_t^e (long run yield expectation) R_t^e (expectation for road length).

4.2.2.2 Selection of functions

This forms the second step in the estimation of the long run supply response. Several alternative specifications with different combinations of the independent variables were tried both in linear and double log formulations. Those equations which gave the best results on the considerations of coefficient of multiple determination, proper sign and significance of variables together with the absence of multicollinearity and autocorrelation were selected. The variables finally included in the model was tested for multicollinearity using zero order correlation matrix. The presence of autocorrelation and multicollinearity in the estimated equations was tested through 'd' statistic and Condition Index test, respectively. The significance of R^2 was tested using 'F' test and that of regression coefficient using 't' test of significance. The equations satisfying the above mentioned tests were considered fit for estimating the long run supply response of apple.

Nine equations, with different combinations of independent variables, excluding the risk response variables, were specified each in linear and double log format. From this, ten equations were selected on the basis of satisfactory results of different test criteria and these were further run with the risk variables to arrive at the risk response of the farmers. From the zero order correlation matrix, the price and subsidy variables were found to be highly correlated with 'r' value greater than 0.80. The profitability and parity ratios were also highly correlated with 'r' value greater than 0.90. This indicates that price and subsidy, profitability and parity ratios could not be taken together in the estimating equation. Profitability was also highly correlated with yield expectation ('r' value greater than 0.85) and highly negatively correlated with road length ('r' value less than - 0.85). In the linear format, equation No. 2.1 and 2.2 were discarded due to the incidence of multicollinearity as the value of Condition Index (CI) was found to be greater than 10 and less than 30, indicating the presence of moderate multicollinearity. Equation No. 2.5 and 2.8 were dropped on the considerations of the number of significant variables and low R^2 values. Taking into consideration, the significance of regression coefficients, the consistent structural sign as well as comparatively high R^2 values the equations numbered 2.3, 2.4, 2.6, 2.7 and 2.9 were considered for further discussion. The CI value of these selected equations were less than 10, and 'd' statistic falls in the inconclusive region; indicating the absence of multicollinearity and autocorrelation, respectively.

The specified equations were further run with the risk response variable. Equations no. 2.11 and 2.12 were discarded due to the incidence of severe multicollinearity indicated by Condition Index. value greater than 10. Further, Equations 2.13 and 2.14 were dropped due to the presence of autocorrelation. The 'd' statistics was 1.69 and 1.73 which lies out of the inconclusive region for the respective equations. The equations numbered 2.14 and 2.15 were not taken for suitable discussion of risk response due to low \bar{R}^2 values. Thus, the equations numbered 2.13, 2.15 and 2.19 each with comparatively high \bar{R}^2 values, consistent structural sign, significant regression coefficients and free from the presence of autocorrelation and multicollinearity were considered suitable for further discussion.

The double log model specified with different combinations of the independent variables was also tried to select the statistically superior model for estimating the longrun response. On the basis of the consistency of sign and significance of regression coefficients and R^2 values, the linear format was found to give better results compared to the double log format. Of the different specifications in double log model without risk response, equation No. 2.21, 2.22, 2.25 and 2.28 were dropped due to the incidence of multicollinearity in the first two cases and low \bar{R}^2 value in the latter cases. Equations numbered 2.23, 2.24, 2.26, 2.27 and 2.29 are taken up for further discussion of the new planting response without risk. For the discussion of new planting response with risk factor, three equations numbered 2.34, 2.35 and 2.39 were selected. All other equations were dropped due to low explanatory power of the independent variables included, and low significance of the regression coefficients. The selected equations had comparatively high explanatory power, significance of regression coefficients and consistent structural signs.

4.2.2.3 New planting Response

The new planting response was studied under two heads;

- (i) Without Risk
- (ii) With Risk

(i) Without Risk

The results of the finally selected models both in linear and double log models are given in table No. 4.7 and 4.8. The elasticities of the different independent variables with respect to new planting acreage is given in table No. 4.11 and 4.12. The elasticities of the variables with significant regression coefficients are taken up of discussions. The results obtained reveal that the value of coefficient of multiple determination ranged from 0.57 to 0.62 in linear models and 0.44 to 0.48 in double log models. Though, the R^2 values were found not to be very high, still they were significantly different from zero at one per cent probability level, indicating that the specified models command strong explanatory power.

Among the set of different explanatory variables, the regression coefficient of price expectation was found to be positive in all the selected cases. This shows the consistency of structural sign with the theory. It was significantly different from zero at five and one per cent probability level in equation No. 2.3, 2.23, 2.4, 2.24 and 2.27. This result confirms the hypothesis that farmers are price responsive. The producers respond to prices while taking long term apple plantation decision. This decision is not simply based on the wholesale price per box of apples, but on the net prices per box received by the growers. The growers thus take into consideration what they receive in return for their efforts to arrive at the long term planting decisions. The net prices at 3 year lag is considered a better index of price expectation than the immediate lags. This could probably be attributed to the growers' awareness of the irregular bearing nature of the crop and a hike in price is expected in the two year lag period due to low production. The growers thus, consider a recent low price for a long term decision. The new planting acreage elasticity of price in linear as well as double log models for significant regression coefficients ranged from 0.32 to 0.48; indicating that the new planting response to price is inelastic. One per cent rise in net price of apple per box leads to 0.32 to 0.48 per cent increase in new planting acreage, which is positive and less than one. The new planting responds to the increase in the prices at a decreasing rate which indicates the maturity of the farmers in this respect. The findings of the study conducted by Nadda (1987), on the supply response of apples in Himachal Pradesh, also confirm the same results.

Another important variable included in the model is parity ratios. The magnitude of the coefficient exhibited positive sign and significantly different from zero in the most of the

Table : 4.7 - REGRESSION COEFFICIENTS OF LONG RUN SUPPLY (NEW PLANTING RESPONSE WITHOUT RISK) - LINEAR MODEL

(New Planting Acreage in Hectares as Dependent Variable)

Eq. No.	Model Specification	b ₀	b ₁	b ₂	b ₃	b ₄	b ₅	b ₆	b ₇	CI	d	R ²	TNE
2.3	$N_t = f(P_t^e, Pz_t^e, R_{t-1}, Y_t^e, N_{t-1})$	-1008.9 (764.78)	12.081** (5.9577)	4.5196*** (2.5870)		0.0889* (0.0659)	56.483 (93.371)		0.0905 (0.17226)	8.74	1.7740	0.5773*	0.7058
2.4	$N_t = f(P_t^e, Pa_t^e, Y_t^e, N_{t-1})$	-754.33 (524.68)	17.188* (4.2438)		4301.2 (3248.9)		127.82 (62.951)		0.1799 (0.16102)	2.50	2.0326	0.5721*	0.8731
2.6	$N_t = f(P_t^e, Pa_t^e, R_{t-1}, Y_t^e, S_t, N_{t-1})$	-4164.3** (1690.3)	9.6312 (6.9059)		16474** (6494.0)	0.16902** (0.0793)	184.63* (66.236)	-4.5557 (5.7276)	0.0204 (0.1635)	9.74	2.0116	0.6141*	2.6636
2.7	$N_t = f(P_t^e, Pa_t^e, R_{t-1}, Y_t^e, N_{t-1})$	-3422.2 (1441.2)	7.4406 (6.2822)		14266** (5873.1)	0.1381*** (0.0687)	186.77* (66.148)		0.0637 (0.1620)	7.95	1.8393	0.6203*	2.3502
2.9	$N_t = f(Pa_t^e, R_{t-1}, Y_t^e, S_t, N_{t-1})$	-4780.4 (1664.7)			19014 (6360.3)	0.2157* (0.0734)	207.09* (66.081)	-1.3701 (5.3593)	0.0686 (0.1669)	8.34	1.9606	0.5982*	3.1115

TNE - Total New planting elasticity is the sum of all significant elasticities

- Figures in parentheses are standard errors

* - Significant at 1 per cent level of probability

** - Significant at 5 per cent level of probability

*** - Significant at 10 per cent level of probability

Table : 4.8 - REGRESSION COEFFICIENTS OF LONG RUN SUPPLY RESPONSE (NEW PLANTING RESPONSE WITHOUT RISK) DOUBLE LOG MODEL
(New Planting Acreage in Hectares as Dependent Variable)

Eq. No.	Model Specification	logb ₀	b ₁	b ₂	b ₃	b ₄	b ₅	b ₆	b ₇	CI	d	R ²	TNE
2.23	$N_t = f(P_t^e, Pr_t^e, R_{t-1}, Y_t^e, N_{t-1})$	1.7386 (0.7491)	0.4504** (0.1193)	0.0027 (0.2533)		-0.1125 (0.1129)	0.3878 (0.3973)		0.2771 (0.2047)	6.4	2.2384	0.4489*	0.4504
2.24	$N_t = f(P_t^e, Pa_t^e, Y_t^e, N_{t-1})$	1.7639* (0.5977)	0.4818* (0.1679)		0.3209 (0.3443)		0.4206*** (0.2403)		0.1918 (0.1868)	2.71	2.1256	0.4610*	0.9050
2.26	$N_t = f(P_t^e, Pa_t^e, R_{t-1}, Y_t^e, S_t, N_{t-1})$	2.1789* (0.6399)	0.1998 (0.2507)		0.2027 (0.4043)	-0.0911 (0.1145)	0.4197 (0.2490)	0.1123 (0.0834)	0.2492 (0.1994)	4.6	1.882	0.4770*	-
2.27	$N_t = f(P_t^e, Pa_t^e, R_{t-1}, Y_t^e, N_{t-1})$	1.8334* (0.6098)	0.4759* (0.1695)		0.1502 (0.4126)	-0.0899 (0.1173)	0.3665 (0.2525)		0.2522 (0.2043)	3.96	2.2123	0.4516*	0.4759
2.29	$N_t = f(Pa_t^e, R_{t-1}, Y_t^e, S_t, N_{t-1})$	2.2484* (0.6288)			0.1325 (0.3915)	-0.0943 (0.1135)	0.4307 (0.2466)	0.1723 (0.1536)	0.2979 (0.1882)	3.65	1.8546	0.4818*	0.4307

TNE - Total New planting elasticity is the sum of all significant elasticities

- Figures in parentheses are standard errors

* - Significant at 1 per cent level of probability

** - Significant at 5 per cent level of probability

*** - Significant at 10 per cent level of probability

Table : 4.11 - NEW PLANTING ELASTICITIES OF LINEAR REGRESSION MODEL (WITHOUT RISK)

Eq. No.	Model Specification	b_1	b_2	b_3	b_4	b_5	b_6	b_7
2.3	$N_t = f(P_t^e, Pr_t^e, R_{t-1}, Y_t^e, N_{t-1})$	0.3262	0.3796		0.4853	0.1807		0.0890
2.4	$N_t = f(P_t^e, Pa_t^e, Y_t^e, N_{t-1})$	0.4641		0.3010		0.409		0.1776
2.6	$N_t = f(P_t^e, Pa_t^e, P_{t-1}, Y_t^e, S_t, N_{t-1})$	0.2600		1.15	0.9228	0.5908	-0.6469	0.0201
2.7	$N_t = f(P_t^e, Pa_t^e, R_{t-1}, Y_t^e, N_{t-1})$	0.2209		0.9986	0.7540	0.5976		0.0629
2.9	$N_t = f(Pa_t^e, R_{t-1}, Y_t^e, S_t, N_{t-1})$			1.3319	1.117	0.6626	-0.1945	0.0607

Table : 4.12 - NEW PLANTING ELASTICITIES OF DOUBLE LOG REGRESSION MODEL (WITHOUT RISK)

Eq. Model specification No.	b ₁	b ₂	b ₃	b ₄	b ₅	b ₆	b ₇
2.23 $N_t = f(P_t^e, Pr_t^e, R_{t-1}, Y_t^e, N_{t-1})$	0.4504	0.0027	-	-0.1125	0.3378	-	0.2271
2.24 $N_t = f(P_t^e, Pa_t^e, Y_t^e, N_{t-1})$	0.4818	-	0.3209	-	0.4206	-	0.1918
2.26 $N_t = f(P_t^e, Pa_t^e, R_{t-1}, Y_t^e, S_t, N_{t-1})$	0.1998	-	0.2027	-0.0911	0.3378	-	0.2271
2.27 $N_t = f(P_t^e, Pa_t^e, R_{t-1}, Y_t^e, N_{t-1})$	0.4759	-	0.1502	-0.0899	0.3665	-	0.2522
2.29 $N_t = f(Pa_t^e, R_{t-1}, Y_t^e, S_t, N_{t-1})$	-	-	0.1325	-0.0943	0.4307	0.1723	0.2979

cases in linear format. In double log format, though the regression coefficients were positive, they were not significantly different from zero. The positive regression coefficient of parity ratios with respect to new planting acreage indicate that, a terms of trade in favour of apple industry induces the growers to go for higher production in long term which could be achieved by increasing acreage under apple through new planting. A rise in apple prices at a rate higher than the rate of rise of Consumer Price Index leads to an increase in parity ratios, responding to which the growers will decide to increase the area under apple through new planting so as to achieve a desired production in future. The above discussion supports the hypothesis that, the Himachal apple growers respond positively to parity ratios while taking the new planting decision. They take into considerations a six year moving average of parity ratios for their expectation regarding the variable i.e. they consider a few recent observations. The new planting acreage elasticity of parity ratios in the linear format for significant regression coefficients lies between 0.99 to 1.33. The coefficient of elasticity is positive and greater than one indicting that the new planting acreage is least inelastic to elastic with respect to parity ratios. An increase in parity ratios by one percent leads to a 0.99 to 1.33 increase in new planting acreage.

The long run profitability was associated positively in all the selected equations of linear and double log models. It was significantly different from zero in linear format at ten per cent probability level. The profitability expectation though found to move in same directions as the new planting acreage, it did not emerge as strong as parity ratios and prices. The reason attributed to this could be an increase in prices of inputs which has resulted in an overall decline in profitability. The consistent sign of the regression coefficient indicate that, a higher product prices compared to the factor prices reflect a positive new planting decision from the orchardists. The result obtained has confirmed the hypothesis that the elasticity of profitability is positive. The coefficient of elasticity of long run profitability expectation with respect to new planting acreage is 0.38 which indicates an inelastic response. The percent increase in profitability per hectare leads to 0.38 percent increase in acreage under new planting. The profitability of apple per hectare also thus plays a role in inducing the growers to go in for long term decisions of increased production.

Another crucial factor identified for the expansion of area under apple is the expansion of infrastructural facilities, particularly the roads. This has facilitated the growers to carry their marketable surplus to the market. The magnitude of the regression coefficient of one

year lag road length with respect to new planting acreage was positive and significantly different from zero in most of the selected cases in linear format. It was negative, but not significantly different from zero even at ten percent level of significance in double log format. An increase in the road length thus induces the farmers to take up the long term decision of new planting. The new planting elasticity of road length of significant regression coefficients lies between 0.75 to 1.12. The new planting response to road length is thus inelastic to slightly elastic. The introduction of this variable along with the parity ratios has made the price variable non significant. Road length thus emerges as a strong variable. Hence it can be inferred that for the growth of horticultural industry particularly in hilly states like Himachal Pradesh, the expansion of roads should be given prime importance.

The long run yield expectation variable was introduced in the long run response equation to take into account the expectation behaviour of the grower with respect to yield in making the long term planting decision. The regression coefficient gave positive sign and was significantly different from zero at one percent level of significance in most of the selected cases in linear format. In double log models also it gave positive sign but was significantly different from zero only in a few cases. Through this result, the hypothesis that the apple growers of Himachal Pradesh respond positively to yield expectations while taking a long term planting decision is being confirmed. The higher the yield expectation, higher will be the acreage brought under new planting. The elasticity of new planting acreage to yield expectation is positive and its value in the case of significant regression coefficients in both linear and double log functions lies between 0.41 and 0.66 i.e. it is inelastic. The new planting acreage increases at a decreasing rate in response to increase in the growers' yield expectations. The orchardists thus could be induced to adopt long term new planting decisions, when there is a favourable change in yield expectation.

The regression coefficients of the subsidy variable gave positive sign in the selected cases of double log format and a negative sign in linear format. In both the cases they were not significantly different from zero even at ten percent level of significance. The result indicates that the growers are reluctant to take up the subsidy they receive for planting and maintenance of orchards, to make a long run decision on new planting. The magnitude of the regression coefficient of lagged new planting acreage, with respect to new planting acreage, was positive but not significantly different from zero in all the selected cases of linear and double log formats. The growers thus seem to be unconcerned about the

new planting acreage of the previous year to decide on how many acres to be planted this year, so as to attain a desired production in the planned future.

ii) With Risk

The statistically superior specifications with the risk response variable, which have been selected at the second stage of the analysis of linear and double log functions, are presented in table No. 4.9 and 4.10. The elasticities of the different independent variables with respect to new planting acreage is given in table No. 4.13 and 4.14. A glance at the selected equations giving the new planting response with price and yield risk variables, clearly indicate that the introduction of the yield risk variable into the response equation had reduced the level of significance of the yield expectation variable. The magnitude of the regression coefficient of yield risk is positive in all the cases of double log and linear format. But it is not significantly different from zero. This indicates that the farmers are not responsive to yield risk. They are able to contain the risk in yield expectation.

The price risk was associated positively with the new planting acreage in almost all the cases of linear and double log format except in equation No. 2.33 where the sign of the regression coefficient is negative. But in all these cases, the regression coefficients are not significantly different from zero. This, coupled with the observation that the introduction of price risk variable in equation No. 2.35 increased the level of significance of the price expectation variables, indicates the non responsiveness of the growers to rice risk. A negative regression coefficient for price risk suggests that larger variations in prices do have an adverse impact on new planting. A positive regression coefficient infers that larger variations in prices do not have an adverse impact on new planting decision. The non significance of the regression coefficient indicates the non responsiveness of the growers to the price risk factor while taking a long term planting decision. This result confirms that the orchardists are capable of containing the risk factor in price expectation and carry on with their decision for new planting on the consideration of price expectation.

Table : 4.9 - REGRESSION COEFFICIENTS OF LONG RUN SUPPLY RESPONSE (NEW PLANTING RESPONSE WITH RISK) - LINEAR MODEL
(New Planting Acreage in Hectares as Dependent Variable)

Model Specification	b ₀	b ₁	b ₂	b ₃	b ₄	b ₅	b ₆	b ₇	b ₈	b ₉	CI	d	R ²	TNE
3 $N_t = f(P_t^e, Pa_t^e, Y_t^e, N_{t-1}, PR, YR)$	-1136.3 (615.59)	26.410* (5.778)		5906.3 (3448.3)		81.759 (71.429)		0.2896 (0.1799)	-0.0337 (0.03912)	9.196 (7.1438)	3.54	1.9106	0.5714*	0.4132
5 $N_t = f(PR_t^e, R_{t-1}, S_t, N_{t-1}, PR, YR)$	-1425.1 (977.79)		6.8262* (2.2655)		0.1729** (0.0759)		-1.1709 (0.3391)	0.1197 (0.2672)	0.03512 (0.0388)	3.7122 (7.087)	8.30	1.7761	0.5079*	1.5174
19 $N_t = f(Pa_t^e, R_{t-1}, S_t, N_{t-1}, Y_t^e, PR, YR)$	-4862.8 (1704.8)			19754* (6653.3)	0.2194* (0.0754)	185.27** (75.385)	-3.345 (6.1724)	0.1033 (0.1916)	0.0204 (0.0351)	4.9101 (6.9936)	9.00	1.9589	0.5799*	3.1737

- Total New planting elasticity is the sum of all significant elasticities
- Figures in parentheses are standard errors
- Significant at 1 per cent level of probability
- Significant at 5 per cent level of probability
- Significant at 10 per cent level of probability

Table : 4.13 - NEW PLANTING ELASTICITIES OF LINEAR REGRESSION MODEL (WITH RISK)

Eq. No.	Model Specification	b ₁	b ₂	b ₃	b ₄	b ₅	b ₆	b ₇	b ₈	b ₉
2.13	$N_t = f(P^e_t, Pa^e_t, PR, YR, Y^e_t, N_{t-1})$	0.7131		0.4134		0.2616		0.2858	-0.02	0.0330
2.15	$N_t = f(Pr^e_t, R_{t-1}, PR, YR, S_t, N_{t-1})$		0.5734		0.9440		-0.166	0.1181	0.0209	0.0134
2.19	$N_t = f(Pa^e_t, R_{t-1}, S_t, N_{t-1}, Y^e_t, PR, YR)$			1.383	1.1979	0.5928	0.4750	0.1019	0.0121	0.0018

Table : 4.14 - NEW PLANTING ELASTICITIES OF DOUBLE LOG REGRESSION MODEL (WITH RISK)

Eq. No.	Model specification	b ₁	b ₂	b ₃	b ₄	b ₅	b ₆	b ₇	b ₈	b ₉
2.34	$N_t = f(P_t^e, Pa_t^e, Y_t^e, N_{t-1}, PR, YR)$	0.4496	-	0.3666	-	0.4060	-	0.2019	0.0089	0.0159
2.35	$N_t = f(Pr_t^e, R_{t-1}, S_t, N_{t-1}, PR, YR)$	-	0.1502	-	0.1601	-	0.1765	0.4472	0.0009	0.0278
2.39	$N_t = f(Pa_t^e, R_{t-1}, S_t, N_{t-1}, Y_t^e, PR, YR)$	-	-	0.1124	-0.1266	0.4084	0.1844	0.3459	-0.0044	0.0233

4.2.2.4 Total New Planting Elasticity (long run response)

It had been hypothesised in the study that the total new planting elasticity is positive. The total new planting elasticity is the sum of all significant elasticities in an estimating equation. It is the sum of significant regression coefficients themselves in double log models. In linear format, the aggregate elasticity is arrived at by adding up the coefficient of elasticity of significant regression coefficients. Various specifications with different combinations of the independent variables were tried in this study so as to estimate the long run new planting response of apple industry in Himachal Pradesh. An attempt is made to estimate the new planting response with and without risk response variables so as to study the impact of risk factors on new planting decisions of the growers. Through the results obtained, growers have emerged to be highly mature, and can contain the risk in yield and prices of apple. The aggregate elasticity thus, computed in the selected cases of new planting functions without risk response in linear and double log format is taken into consideration to test the hypothesis - "The total new planting elasticity is positive". The elasticities computed in each of these cases is given in table No. 4.7 and 4.8. The total new planting elasticity varies from 0.4307 to 3.117. This is mainly because of the fact that the number of variables varied in each specification. Therefore, an attempt is made to choose a single equation from all the selected cases which gives highest explanatory power, as well as more independent variables coupled with their significance. The equations in the double log functions did not give more than two significant variables in any of the selected cases. Thus, the linear model was considered to be a better model compared to the double log model. Equation No. 2.7 in linear format was found to have the highest \bar{R}^2 value of 0.6203 and was thus, finally selected for the discussion of total new planting elasticity. Total new planting elasticity of the finally selected equation is 2.3502 which is positive and greater than zero i.e. new planting is highly elastic. An aggregate one per cent increase in long run parity price expectation, yield expectation and one year lag road length leads to 2.3502 per cent increase in new planting acreage. The yield expectation of the growers could be increased by increasing the area under apples in agro-climatically suitable areas for the crop and uprooting and replanting of existing aged stock with high yielding new clonal varieties. A terms of trade in favour of apple industry and improvement in infrastructural facilities like construction of new roads would thus play an important role in increasing the apple acreage in Himachal Pradesh.

SUMMARY & CONCLUSIONS

SUMMARY AND CONCLUSIONS

The policy makers' emphasis on the economic upliftment of Himachal Pradesh brought in focus the most appropriate option of fruit cultivation. Thus, this sector has figured prominently in the various state plans. In terms of both area and production, apple, at present, is the most important fruit crop of the state; mostly, for reasons of the comparative feasibility and profitability of this crop in the state. Apple, being a perennial crop, possesses certain specific growth characteristics, due to which it requires a long term commitment of land, labour and capital to derive a future stream of net income. Thus, these characteristics and the importance of the crop for the state call for study of the role of price and other market related variables in determining the long run and short run responsiveness of the apple growers of Himachal Pradesh. Specifically, the study thus attempted;

- i) To analyse the growth in area and production of apple in the state.
- ii) To estimate the supply response for Himachal apple.
- iii) To suggest appropriate policy measures for apple industry development in the state.

To achieve these objectives time series data on acreage, production, prices and subsidy for apples in Himachal Pradesh, daily maximum and minimum temperature for six months each year, consumer price index, labour wages for agricultural workers of the state, and fertilizer wholesale price index were obtained from Directorate of Horticulture, Shimla; Regional Horticultural Research Station, Mashobra; Labour Bureau, Shimla; and Statistical Abstract of India, respectively. These data related to the period 1966-67 to 1997-98. The data were analysed by adopting various statistical and mathematical tools. The main findings of the study are summarized as under :

- Apple acreage in the state has increased at a compound growth rate of 4.58 per cent per annum suggesting that the high profitability of the crop has attracted the growers of Himachal Pradesh towards this farm enterprise.

- Production of apples has increased at a compound growth rate of 5.94 per cent per annum.
- The productivity of apples, however, has declined over the years (with a compound growth rate of -2.04%). This could be attributed to weather factors, the ageing of existing plants under bearing acreage, poor management practices and new plantations in areas which are not climatically suitable for apple plantations.
- Maximum area under apples was noted in Shimla district, followed by Kullu and Mandi. But the highest growth rate in this regard has been recorded in Lahaul & Spiti (11.61%) followed by Chamba (10.52%), Kinnaur (9.22%) Solan (5.35%), Mandi (5.17%), Kullu (4.23%) and Shimla (3.74%). This result indicates the exploration of newer areas to be brought under apple cultivation.
- Highest total production was witnessed in Shimla followed by kullu and Mandi districts. But the highest growth rate in production was observed in Lahaul & Spiti (15.03%) followed by Kinnaur (10.65%). The compound growth rate of production of apples in Shimla was (7.15%), Kullu (5.25%) and was negative in Mandi, Kangra, Solan and Sirmour districts. The negative compound growth rate could be attributed to the extension of area under apples in marginal & climatically unsuitable lands and new plantings under non bearing age. The low growth rate in shimla and Kullu is probably due to ageing of existing stock and low growth rate of area.
 - The results obtained from linear and double log formats of yield response functions revealed that the values of adjusted coefficient of multiple determination varied from 0.41 to 0.52. In spite of the low values, they were significantly different from zero at one per cent level of significance indicating that the model specified commands strong explanatory power. In short run, one year lag of prices, two year lag of profitability and yield and three year lag of parity ratios form the farmers' expectations regarding the specified variables.
 - Chilling hours emerged to be the most significant variable influencing the variation in yield in the short run. The yield elasticity with respect to chilling hours lies between 0.82 to 1.15. The yield in short run is thus, to a great extent influenced by the number of chilling hours received by the crop during the year.

– Short run expectation for parity ratios is another significant variable with a positive regression coefficient. The yield response to parity ratios is inelastic with coefficient of elasticity ranging between 0.53 and 0.70. So favourable terms of trade will induce the farmers to increase the supply in short run.

– The short run profitability expectation variable had a significant positive impact on the short run decision making behaviour of the orchardists. The yield elasticity of profitability is also positive and less than one (ranging from 0.33 to 0.42) indicating that yield is inelastic to profitability, but it still induces the growers to increase the short run supply of apple.

– The short run yield expectation of the growers gave a positive and significant regression coefficient with the dependent variable indicating that the yield in current (t^{th}) period will be high if the yield of $(t-2)^{\text{th}}$ period is high. The yield of apples is inelastic to short run price expectations of the growers as the coefficient of elasticity of yield with respect to the short run yield expectation lies between 0.31 and 0.42. This variable thus induces the growers to produce more in alternate years.

– The short run expected price of apple though emerged to be positive in all the selected cases, but, is not significantly different from zero in all the cases. The yield elasticity of price is 0.62 in the function with significant price variable.

– Inclusion of parity ratios variable had reduced the significance level of price variable. The price variable thus does not emerge as strong a variable as parity ratios but still induces the growers to increase the productivity of existing area in short run.

– The trend variable included in the model had given a positive regression coefficient, significantly different from zero in only two of the selected cases (when it was included in the function along with the price-variable). The inclusion of important variables like parity ratios had reduced the significance of the trend variable. With price variable, the yield elasticity of trend lies between 1.30 to 2.37 indicating thus yield is elastic to trend.

– The total yield elasticity of the finally selected function was 2.02 indicating that yield is highly elastic to simultaneous changes in the independent variables considered (Chilling hours, short run yield expectation and parity ratios).

- The coefficient of multiple determination of the selected equations in linear and double log format of the new planting response function ranged between 0.44 to 0.62 and was significantly different from zero indicating that the specified model commands a strong explanatory power.

- In the long run, three-year lag of net prices, two-year lag average of profitability and yield, six year moving average of parity ratios and one-year lag road length formed the basis of expectations of the growers regarding the respective variables.

- The long run price expectation variable had a positive regression coefficient and the same significantly different from zero in some of the selected cases confirming the hypothesis that the apple growers in Himachal Pradesh are price responsive. The new planting elasticity with respect to price lies between 0.32 to 0.48 indicating that the new planting acreage is inelastic to long run price expectation.

- A positive regression coefficient of the parity ratios with respect to new planting acreage indicated that the terms of trade in favour of the apple industry had induced the growers to opt for long term new planting decisions. The new planting acreage elasticity of parity ratios for significant regression coefficients lies between 0.99 and 1.33. The new planting acreage is thus least inelastic to elastic with respect to parity ratios.

- The long run profitability was associated positively in all the selected equations. The consistent sign of the regression coefficient indicated that, higher product prices compared to factor prices reflect a positive new planting decision from the orchardists.

- The regression coefficient of one year lag road length with respect to new planting acreage was positive and significantly different from zero in most of the selected equations in linear format. The new planting elasticity of road length lies between 0.75 and 1.12. The expansion of infrastructural facilities was thus felt of prime importance by the orchardists of the state for the growth of horticultural industry.

- A long run yield expectation variable introduced in the long run response equation gave positive regression coefficient significantly different from zero in most of the selected

equations. The elasticity of new planting acreage to yield expectation is positive and its value lies between 0.41 and 0.66. A favourable change in yield expectation thus induces the growers to adopt long term new planting decisions. A favourable change in the yield expectation could be achieved by increasing the acreage under apples in areas climatically suitable for the crop, and replanting the aged stock acreage with new and highly productive cultivars.

- The subsidy and lagged new planting acreage variables do not seem to influence orchardists' new plantings decisions as the regression coefficients are not significant for these variables.

- The regression coefficients of both the price risk and yield risk variables were not significantly different from zero in all the long run response functions estimated with risk response. This result shows that the growers are able to contain the risk in yield and price expectation and carry on with the decision of new planting on the considerations of price and yield expectations.

- Total new planting elasticity of the finally selected equation is 2.3502 indicating that the new planting acreage is highly elastic to simultaneous changes in independent variables (long run expectations for yield and parity ratios, and road length) considered in the model.

POLICY IMPLICATIONS

A striking feature of apple industry in Himachal Pradesh is that the growers respond positively to a rise in parity ratios in both short and long run. But the parity ratios of apple cultivation in the state had shown a declining trend over the years. This could be attributed to inflationary trend on consumables, which was inconsistent with rise of apple prices. Remedial measures or policies are therefore required to improve the terms of trade of the industry. This could be achieved through appropriate price policies which will ensure high price to apple growers.

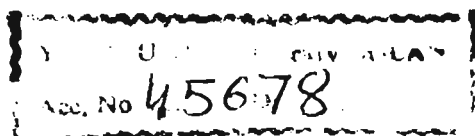
One of the greatest problems faced by the growers is the erratic price of apples in the market. Delhi is the main market for Himachal Apples. The glut in Delhi market during harvest season leads to a fall in the prices of apple. The state government has no control over this market to safeguard the interest of fruit growers. The entire apple trade is in the hands of middle-men. Upto date information regarding the prices of apple prevailing in different markets should be made available to the growers through an efficient market intelligence system. This would help the orchardists to take advantage of high prices prevailing in a market. Therefore, market intelligence for fruits need to be strengthened. The government should also ensure regulated supply of only high quality apples to the markets, particularly Delhi market.

The processing facilities for culled apples within the state should be increased. All these factors will lead to an increased parity ratio expectation of the apple growers which in turn will increase the supply of apples in the long and short run.

Expansion of infrastructural facilities, particularly the roads had a significant positive influence in increasing the acreage under apples in long run. The interior fruit growing areas are not well connected with roads which makes fruit transportation cost very high. Moreover, it takes many days for fruit boxes to reach road heads and by the time it reaches the markets, the fruits get over-ripened and thus fetch a lower price. In order to reduce the losses in fruit quality and lessen the cost of marketing, adequate road network

in the fruit growing areas will ensure transportation efficiency; and hence a reduction in transit costs which increases the growers' profitability expectations and induce them to increase the area under apple. This leads to an increased long-run supply of apples.

An increase in the short and long run yield expectation of the orchardists increases the supply of apples in the short and long run. A major reason for decline in productivity was concluded to be the existing old bearing stock of trees with low productivity and cultivation of apples in agro-climatically unsuitable regions. To improve productivity, incentives should thus be offered for replacing the old stock with high yielding clones. Expansion and proper maintenance of infrastructural facilities like transport and communication network in fruit belts of the state will increase growers confidence and thus area under apples. This will also increase the short and long run yield expectations of farmers. The results of the study, thus, suggest a need for multi-pronged strategy to efficiently manage and further promote the all important apple industry of the state.



REFERENCES

REFERENCES

- Ady, P. 1968. Supply Functions in Tropical Agriculture. *Oxford Institute of Statistics Bulletin*. 30(2) : 157-188
- Akiyama, T. and P.K. Trivedi, 1987. "Vintage Production Approach to Perennial Crop Supply. An Application to Tea in Major Producing Countries. *Journal of Econometrics*. 36(1) : 133-161
- Azad, K.C.; R. Swarup and B.K. Sikka. 1988. *Horticulture Development in Hill Areas, Mittal Publications, Delhi*.
- Barman, K.K. and S. Hazarika. 1995. "Price Behaviour and Supply Response of Jute versus Adu paddy in Assam". *Bihar Journal of Agricultural Marketing*. 3(3): 269-274.
- Bapna, S.L. "Aggregate Supply Response of crops in a Developing Region". *Chand and Sons, New Delhi*, 1980
- Baritelle, J.C. and D.W. Price, 1974. "Supply Response and marketing Strategies of Deciduous crops". *American Journal of Agricultural Economics*. 56(2) : 245-253
- Basavaraja, H. and K.C. Hiremath 1984. "Supply Response of Cotton in Karnataka : An Econometric Analysis", *Agricultural Economics Research Bulletin, University of Agricultural Sciences, Dharwad*.
- Bateman, M.J. 1965. Aggregate Regional Supply Functions for Ghanaian Cocoa. *Journal of Farm Economics*. 47(2) : 384-401
- Behrman, J.R. 1968. "Monopolistic Cocoa Pricing". *American Journal of Agricultural Economics*. 50(3) : 702-719
- Behrman, J.R. 1968. "Supply Response in Underdeveloped Agriculture : A Case Study of Four Major Annual Crops in Thailand", 1937-63, *North Holland Publishing Company, Amstredam*.

- Ben, C.F., A.K. Gordon and D.M. Dwight 1985. "Planting and Removal Relationships for Perennial crops : An Application to Cling Peaches". *American Journal of Agricultural Economics*. 67(2) : 215-233
- Berry, S.S. 1976. "Supply Response Reconsidered : Cocoa in Western Nigeira". *Journal of Developmental Studies*. 13(1) : 4-17
- Brunstein, H. 1981. "A Behavioural Mmodel of Corn Acreage Response under Conditions of Uncertainty", *In Proceedings AAEA Meeting July, US Department of Agriculture, Washington, DC, U.S.A.*
- Cassino, F.W., S.A. Brandt, R.W. Taylor, E. Paniago, and L. Limados Santos 1979. "The Supply of Perennial Crops : Black Pepper in Para State". *Experientiae*. 25(2) : 19-34
- Cauvery, R. 1992. "Acreage Response of Groundnut in North Arcot District, Tamil Nadu". *Economics and Social Science Review*. 1(1): 51-60.
- Chiranjeevi, T. 1992. "Indian Tea Industry". *Journal of Indian School of Political Economy*. 4(2) : 263-290
- Chowdhury, A. and G.S. Ram 1978. "Price Response of a Perennial crop - A case of Indian Tea". *Indian Journal of Agricultural Economics*. 23(3) 74-83
- Cummings, J.T. 1975. "The supply Responsiveness of Indian Farmers in the Post-Indendence Period : Major Cereal and Cash crops", *Indian Journal of Agricultural Economics*. 30(1): 25.
- Deshpandey, R.S. and H. Chandrashekhar. 1982. "Growth and Supply Response of Slow Growth Crops. A case of Pulses", *Indian of Agricultural Economics*. 37(3): 386-393.
- Dayanantha, Jha, 1970. "Acreage Response of Sugarcane in Factory Areas of North Bihar". *Indian Journal of Agricultural Economics*. 25(1) : 79-90
- Eckstein, Z. 1985. "Dynamics of Agricultural Supply and Reconsiderations", *American Journal of Agricultural Economics*. 67(2): 202.

- French, B.C. and J.L. Mathews 1971. "A Supply Response Model for Perennial Crops". *American Journal of Agricultural Economics*. 53(4) : 478-490
- Gafar, J. 1981. "The responsiveness of Agricultural Exports to Prices in Jamaica : Evidence and Policy Implications". *Indian Journal of Agricultural Economics*. 36(1) : 67-78
- Gujarati, D.N. 1988. *Basic Econometrics*, Macgraw Hill Book Company, Singapore. pp. 301-302, pp. 183-184.
- Gunawardana, P.J. and E.A. Oczkowski. 1992. "Government Policies and Agricultural Supply Response : Paddy in Srilanka". *Journal of Agricultural Economics*. 43(2): 231-242.
- Goyal, P. 1988. "Supply Response of Pulses in Himachal Pradesh". *M.Sc. Thesis (unpublished)* HPKVV, Palampur.
- Hartley, M.J. M. Nerlove, and R.K. Peters 1987. "An Analysis of Rubber Supply in SriLanka". *American Journal of Agricultural Economics*. 69(3) : 755-761
- Hartman, T.H and Kester, D.F. 1972. *Plant Propagation : Principles and Practices*, 2nd Ed. Prentice Hall of India Pvt. Ltd. New Delhi
- Indira, M. 1993. "Supply Responsiveness of Coffee Producers". *Journal of Coffee Research*. 23(1) : 43-46
- Ipe, V.C. and T. Prabhakaran 1988. "Price Response of a Perennial Crop : A Case of Indian Natural Rubber". *Indian Journal of Agricultural Economics*. 43(4) : 624-630
- Jaforullah, M. 1993. "A Symmetric Agricultural Supply Response : Evidence from Bangladesh Agriculture". *Journal of Agricultural Economics*. 44(3): 490-495.
- Jha, D. 1970. "Acreage Response of Sugarcane in Factory areas of North Bihar", *Indian Journal of Agricultural Economics*. 25(1): 79.
- Jhala, M.L. 1979. "Farmers Response of Suġarcane in Factory Areas of North Bihar". *Indian Journal of Agricultural Economics*. 34(1) : 55.

- Jaramillo, C.F., 1989. "Supply Response and Optimal Pricing for a Perennial crop. The case of Colombian Coffee". *Dissertation Abstracts - International. A Humanities and Social Sciences*.
- Jones, S.C., Rees-Jones, H., Mwesigye, D.K., Frazer, I. and Fleming, E.M. 1989. "The Economics of small holder tree crop Production in Melanesia : Selected case studies". *Occasional-paper-south-pacific-small holder-project, -university of NewZealand*. 13(11) : 78
- Kanwar, S.M. 1987. Apples production technology and economics. *MacGraw Hill Publishing Company Ltd. New Delhi*.
- Keith, C.K. 1987. "Dynamic Equilibrium in Markets for Perennial Crops". *American Journal of Agricultural Economics*. 69(1) : 97-104
- Knapp, K.C. and K. Konyar 1991. "Perennial Crop Supply Response : A Kalman Filter Approach". *American Journal of Agricultural Economics*. 73(3) : 841-849
- Koutsoyiannis. A, 1987. "Theory of econometrics". *Macmillian Education Ltd., London*. pp. 212-213.
- Krause, M.A. and W.W. Koo. 1996. "Acreage Response to Expected Revenues and Price Risk for Minor Oilseeds and Progress Crops in the Northern Plains". *Journal of Agricultural and Resource Economics*. 21(2): 309-324.
- Krishna, Jai and M.S. Rao 1967. "Dynamics of Acreage Allocation for Wheat in Uttar Pradesh". *Indian Journal of Agricultural Economics*. 22(1) : 37
- Krishna, R. 1990. "Supply Response of Commercial Crops : A Case Study". *Yojana*. 34(3): 27-29.
- Krishnaiah, J. and Krishnamoorthy, S. 1989. "Regional Supply Response Functions for Foodgrain in Andhra Pradesh". *Margin* 21(4): 43-52.

Kumar, T.K. and A. Mittal 1995. "On Liberalising Agricultural Trade. A note of Caution from India's Experience with Tea Trade". *Economic and Political Weekly*. 30(48) : 3069-3074

Madhuri, V. 1987. "Supply for Estimation and Projection of some Important Foodgrain Crops in Kullu and Kangra Districts of Himachal Pradesh". *M.Sc. thesis (unpublished)*, HPKVV, Palampur.

Maitha, J.K. 1973. "The Price Responsiveness of Coffee Farmers". *Kenya Coffee*. 39(64) : 315-318

Misra, S.R 1985. "A study of Supply Response of a Perennial Crop - A Case Study of Tea". *Indian Journal of Agricultural Economics*. 65(3) : 447-486

Nadda, A.L. 1987. "Supply Response of Perennial Crops - A Study of Himachal Apples". *Indian Journal of Agricultural Economics*. 42(3) : 446-455

Nadda, A.L. 1987. "Economics of Apples". *ISAE. B.R. Publishing Corporation New Delhi* pp. 14

Narayana, D. 1994. "Perennial Crop Production Cycle Models : Influence of High Yielding Varieties and prices". *Indian Journal of Natural Rubber Research*. 7(1) : 25-37

National Council of Applied Economics Research, *Structure and Behaviour of Prices of Food Grains*, New Delhi, May 1969

Nelson Perera. 1995. "Modelling the Perennial Crop Sector in Less Developed Countries. A Case of Tea in Srilanka". *Indian Journal of Agricultural Economics*. 50(4): 649-659.

Nerlove, Marc. 1956. "Estimates of the Elasticities of Supply of Selected Agricultural Commodities". *Journal of Farm Economics*. 38(3) : 496-509

- Nicholas, G.K. and J.S. Shonkwiler 1992. "A State Space Approach to Perennial Crop Supply Analysis". *American Journal of Agricultural Economics*. 74(2) : 343-352
- Oni, S.A. and J.K. Olayemi 1974. "Acreage Response in a developing Country : A Case Study of Western Nigerian Cocoa Farmers". *African Studies Review*. 17(2) : 381-395
- Rae, A.N. and H.F. Carman 1975. "A Model of New Zealand Apple Supply Response to Technological Change". *Australian Journal of Agricultural Economics*. 19(1) : 39-51
- Rajagopalan, V. and C. Ramaswamy 1977. "Price-Hectarage Behaviour of sugarcane in `Tamil Nadu'; The cop web Analysis". *Centre for Development Studies. Ulloor (Trivandrum)*.
- Raju, K.S.R. and T.D.J. Nagabhushanam. 1986. "Supply Response of Major Oilseed Crops in Different Regions of Andhra Pradesh", *Agricultural Situation in India*. 61(9): 747.
- Ramesha, Y.S.; R. Ramanna and L. Achoth. 1988. "Supply Response of Rice in Karnataka", *Agricultural Situation in India*. 63(1): 9-13.
- Rao, K.P.C. and V.K. Pandey 1976. "Supply Response of Paddy in Andhra Pradesh". *Indian Journal of Agricultural Economics*. 31(2) : 46-52
- Rao, M.S. and Jai Krishna 1965. "Price Expectation and Acreage Response for Wheat in Uttar Pradesh". *Indian Journal of Agricultural Economics*. 20(1) : 19-23
- Reddy, J.M. 1970. "Estimation of Farmer's Supply Response. A Case Study of Groundnut", *Indian Journal of Agricultural Economics*. 25(4): 57.
- Saylor, R.G. 1973. "The Response of Coffee Area in Sao Paulo to Price Variations". *Agricultura-em-Sao-Paulo*. 20(2) : 43-59

- Singh, R.D., D. Singh, and P.R. Rao 1974. "Estimation of Agricultural Acreage Response Relationship; some Methodological Issues". *Indian Journal of Agricultural Economics*. 29(1) : 26.
- Singh, L.N. and K.M. Singh. 1993. "A Study on Acreage Response to Price and Non-Price Determinants for Sugarcane in Bihar". *Indian Sugar*. 42(10): 755-759.
- Sreeja, S. and P. Chandrabhanu. 1995. "Cobweb Theory Approach : an Application to Rice Production in Kerala". *Journal of Tropical Agriculture*. 33(1): 66-69.
- Swarup, R. and B.K. Sikka. 1987. "Production and Marketing of Apples". *Mittal Publications, Delhi*.
- Uma Devi, S. 1977. "Price Response of a Perennial Crop : The case of Indian Natural Rubber". *Indian Journal of Agricultural Economics*. 32(4) : 62-73
- Wickens, M.R., and J.,W. Greenfield 1973. "The Econometrics of Agricultural Supply " An Application to the World Coffee Market". *Review of Economics and Statistics*. 55(4) : 433-440

APPENDICES

Appendix-i

AREA, PRODUCTION PRODUCTIVITY AND WHOLESAL PRICE OF APPLE IN HIMACHAL PRADESH

Year	Total area (ha)	Bearing area (ha)	Production (T)	Productivity (T/ha of bearing acreage)	Whole- sale price (Rs./box)
1967-68	17588	3808	39344	10.33	61.31
1968-69	20230	4774	50524	10.58	49.42
1969-70	23482	6643	72250	10.88	42.60
1970-71	26735	9263	103120	11.13	49.12
1971-72	28308	10800	125061	11.58	40.57
1972-73	31003	12508	29800	2.38	51.30
1973-74	32127	13121	118676	9.04	41.85
1974-75	33628	17614	43299	2.46	59.04
1975-76	35076	20188	200000	9.91	50.70
1976-77	36709	23517	119228	5.07	55.57
1977-78	38900	26713	131617	4.93	53.78
1978-79	40630	28328	121896	4.30	58.05
1979-80	41922	31003	135445	4.37	60.45
1980-81	43331	32127	118013	3.67	76.87
1981-82	45335	33628	306798	9.12	68.55
1982-83	47354	35076	139086	3.96	88.05
1983-84	48292	36709	257913	7.03	98.26
1984-85	49840	38900	170629	4.39	99.47
1985-86	51103	40630	174618	4.30	109.17
1986-87	52399	41922	359321	8.57	95.13
1987-88	54912	43331	259277	5.98	132.02
1988-89	57447	45335	165156	3.64	162.70
1989-90	59988	47354	394868	8.34	108.75
1990-91	62828	48292	342071	7.08	118.24
1991-92	66767	49840	301730	6.05	203.80
1992-92	69439	51103	279051	5.46	200.31
1993-93	72406	52399	294734	5.63	221.25
1994-95	75469	54912	112782	2.24	349.46
1995-96	78292	57447	276681	4.82	272.15
1996-97	80338	59988	288538	4.81	274.73
1997-98	83056	62828	234253	3.73	360.59

Appendix - ii

VALUES OF PARAMETERS SHOWING ASSOCIATION OF DEPENDENT VARIABLE (YIELD) WITH VARIOUS SPECIFICATIONS OF INDEPENDENT VARIABLE

Variables	Correlation coefficient	Coefficient of determination
Prices		
PA_{t-1}	-0.3463	0.1199
PA_{t-2}	-0.3585	0.1285
PA_{t-3}	-0.3556	0.1264
Profitability		
Pr_{t-1}	0.5389**	0.2904*
Pr_{t-2}	0.6252**	0.8909*
Pr_{t-3}	0.5798**	0.3356*
Parity Prices		
Pa_{t-1}	0.6517**	0.4247*
Pa_{t-2}	0.4847**	0.2349*
Pa_{t-1}	0.6705**	0.4496*
Yield		
Y_{t-1}	0.2193	0.0481
Y_{t-2}	0.4902**	0.2403
Y_{t-3}	0.1964	0.0386

** Significant at 5 per cent level of significance

* Significant at 1 per cent level of significance

Variable	Correlation Coefficient	Coefficient of Determination
Parity Ratios		
Pa_t	0.3049	0.0930
Pa_{t-1}	0.1111	0.0123
Pa_{t-2}	0.1903	0.0362
Pa_{t-3}	0.1838	0.0338
$Pa_{t-1} + Pa_{t-2} / 2$	0.1612	0.0260
$Pa_{t-1} + Pa_{t-2} + Pa_{t-3} / 3$	0.1760	0.0310
3 Year Moving Average	0.2224	0.0495
4 Year Moving Average	0.2217	0.0491
5 Year Moving Average	0.2180	0.0475
6 Year Moving Average	0.2551	0.0651
7 Year Moving Average	0.2353	0.0554
Yield		
YA_t	0.0892	0.0079
YA_{t-1}	0.2796	0.0782
YA_{t-2}	0.2484	0.0617
YA_{t-3}	0.1149	0.0132
$YA_{t-1} + YA_{t-2} / 2$	0.2899	0.0840
$YA_{t-1} + YA_{t-2} + YA_{t-3} / 3$	0.2420	0.0586
3 Year Moving Average	0.1729	0.0299
4 Year Moving Average	0.1768	0.0312
5 Year Moving Average	0.1681	0.0282
6 Year Moving Average	0.1539	0.0237
7 Year Moving Average	0.1354	0.0183

Variable	Correlation Coefficient	Coefficient of Determination
Road Length		
R_t	0.2488	0.0619
R_{t-1}	0.2201	0.0484
R_{t-2}	0.1817	0.0330
R_{t-3}	0.1789	0.0320
$R_{t-1} + R_{t-2} / 2$	0.2008	0.0403
$R_{t-1} + R_{t-2} + R_{t-3} / 3$	0.1936	0.0375
Probability		
Pr_t	0.2298	0.0528
Pr_{t-1}	0.2968	0.0881
Pr_{t-2}	0.2922	0.0854
Pr_{t-3}	0.1594	0.0254
$Pr_{t-1} + Pr_{t-2} / 2$	0.3089	0.0954
$Pr_{t-1} + Pr_{t-2} + Pr_{t-3} / 3$	0.2679	0.0718
3 Year Moving Average	0.2973	0.0884
4 Year Moving Average	0.2828	0.0800
5 Year Moving Average	0.2706	0.0732
6 Year Moving Average	0.2478	0.0614
7 Year Moving Average	0.2261	0.0511

Appendix - iv

ZERO ORDER CORRELATION MATRIX FOR THE INDEPENDENT VARIABLES IN
NEW PLANTING RESPONSE

	P_t^e	Pr_t^e	Pa_t^e	Y_t^e	R_t^e	S_t	N_{t-1}	PR	YR
P_t^e	1.000								
Pr_t^e	-0.4153	1.0000							
Pa_t^e	-0.3986	0.9276	1.0000						
Y_t^e	-0.2295	-0.8585	0.6482	1.0000					
R_t^e	0.7245	-0.8501	-0.8577	-0.6179	1.0000				
S_t	0.8448	-0.4319	-0.4306	-0.3162	0.7449	1.0000			
N_{t-1}	0.3193	0.3211	0.2198	0.4347	0.0390	0.2970	1.0000		
PR	0.7394	-0.2228	-0.1843	-0.1155	0.4404	0.6854	0.3562	1.0000	
YR	-0.1200	0.0572	-0.079	0.1886	-0.0576	-0.0931	-0.2528	-0.0018	1.0000

CURRICULUM VITAE

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B.Sc. (Agri.)	Kerala Agri. University	First	1997

Whether sponsored by some State
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ICAR Nominee for M.Sc

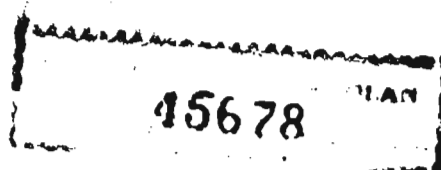
Scholarship/Stipend/Fellowship
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Title of Thesis	:	Perennial Crop Supply Response - A Case Study of Himachal Apples
Pages in Thesis	:	72 + VII + VI

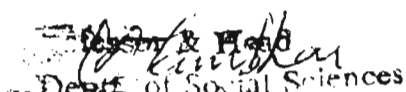
Apple being the most important perennial fruit crop of the state, it becomes inevitable on the part of the policy makers to focus their attention on the supply behaviour of this sector. In the present study an attempt has been made to estimate the role of price and other market related variables in determining the short and long run responsiveness of apple growers of Himachal Pradesh.

The data related to acreage, production, prices, subsidy for apples, Consumers Price Index, etc. for the period 1966-1997 were collected. The compound growth rates of area, production and productivity of apple in the state were computed to examine the performance of apple cultivation in various apple growing districts and the state as a whole. The study revealed that acreage and production under apples in the state increased at a compound growth rate of 4.58 per cent and 5.94 per cent, respectively, while the productivity declined through the years with a negative compound growth rate of -2.04 per cent. The compound growth rates of area and production computed district wise revealed exploration of newer areas to be brought under apple cultivation, extension of area under apple in marginal and climatically unsuitable land and ageing of the existing stocks.

Apple being a perennial crop, the yield response function gives the short-run response and the new planting function gives the long-run response. The long-run and short-run elasticities have been estimated to study the pattern of adjustment in response to changes in the price and price related variables. The total yield elasticity and the total new planting elasticity were estimated to be 1.7862 and 2.3502, respectively, indicating that yield in short-run and new-planting acreage in long-run are highly elastic to simultaneous changes in the independent variables considered. Chilling hours, and short run expectations for yield and parity ratios emerged as significant independent variables influencing yield in short-run with a elasticity coefficient of 0.8205, 0.6618 and 0.3039 respectively. Long-run expectations for parity ratios, road length and yield were found to be the significant variables influencing the long-run new-planting decision making behaviour of the orchardists each with a coefficient of elasticity of 0.9986, 0.7540 and 0.5976 respectively. The long-run response function was also estimated with risk variables and the growers emerged to be non responsive to risk in yield and price expectations for apple.

Thus, the long and short-run expectations for parity ratios and yield, chilling requirement and expectation for road length were concluded to be significant policy variables for increasing the total supply of apple in H.P. Therefore, the need for a multipronged strategy to efficiently manage and further promote all important apple industry of the state had been suggested which include improved market intelligence network, regulated supply of only high quality apples to markets, particularly Delhi market, improved processing facilities for apples with in the state, expansion of infrastructural facilities, particularly roads especially in areas suitable for apple cultivation; inducing the growers to replant old bearing stock of trees with new and highly productive clonal varieties suitable for a particular region etc.


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