STATISTICAL ANALYSIS OF AGRICULTURAL TIME SERIES DATA

कृषि काल - श्रेणी समंको का सांख्यिकीय विश्लेषण

HEMANT KUMAR JAIN

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SUBMITTED TO THE

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FOR

THE DEGREE OF

DOCTOR OF PHILOSOPHY IN AGRICULTURE

(AGRICULTURAL STATISTICS)

BY

HEMANT KUMAR JAIN

2002

Maharana Pratap University of Agriculture and Technology,Udaipur
Rajasthan College of Agriculture, Udaipur

CERTIFICATE - I

Dated : 25/06/2002

This is to certify that this thesis entitled "***Statistical Analysis of Agricultural Time Series Data***" submitted for the degree of ***Doctor of Philosophy in Agriculture*** in the subject of ***Agricultural Statistics*** embodies bonafide research work carried out by ***Mr. Hemant Kumar Jain*** under my guidance and supervision and that no part of this thesis has been submitted for any other degree. The assistance and help received during the course of investigation have been fully acknowledged. The draft of the thesis was also approved by the advisory committee in the pre-thesis submission seminar held on 18.06.2002.

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This is to certify that this thesis entitled "***Statistical Analysis of Agricultural Time Series Data***" submitted by ***Mr. Hemant Kumar Jain*** to Maharana Pratap University of Agriculture and Technology, Udaipur in fulfillment of the requirement for the degree of ***Doctor of Philosophy in Agriculture*** in the subject of ***Agricultural Statistics*** after recommendation by the external examiner was defended by the candidate before the following members of the examination committee. The performance of the candidate in the oral examination was satisfactory. We therefore, recommend that the thesis be approved.

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Place : Udaipur

(HEMANT KUMAR JAIN)

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1. INTRODUCTION

Agriculture is the main stay of Indian Economy. Total land available for agriculture has its limitations and it's tending to stabilize during the recent years. It is essential to mobilise all efforts to enhance the productivity of high fluctuations from year to year. The rainfall in large parts of the cropped area is low and uncertain in its distribution.

1.1 AGRICULTURE AND INDIAN ECONOMY:

The importance of agriculture to Indian economy has been quantified extensively by researchers and users of data over the years. Agriculture (including livestock and fishing) sector has a dominating presence in the Indian Economy, despite its direct contribution reducing over the years (at current prices), from 52.7 per cent in 1950-51 to 26.0 per cent in 1996-97. This sector contributed as much as Rs. 2,98,851 crores to the gross domestic product (GDP) of the country, at current prices in 1996-97, while its value of output in the same year was Rs. 3,68,743 crores. The total export of primary agricultural products during 1996-97 was Rs. 16,500 crores, accounting for 4.5 per cent of total value of output. The contribution of agricultural and allied products to exports during 1996-97, was Rs. 25,040 crores, accounting for over 20 per cent of total exports of the country. About 78 per cent of the rural workforce and 71 per cent of rural households are dependant on agricultural activities. Among the workers (rural and urban combined), according to both principal and subsidiary status, as many as 21 crores or 65 per cent are working in the agriculture sector. According to the Economic Census, 1990 about 2.33 million enterprises (9 per cent) were engaged in agricultural activities. Besides this direct contribution, the sector has a multiplier effect on the performance of secondary and services activities like

manufacturing, trade, hotels & restaurants, transport and other services. A good agriculture year boosts up the economy from the demand side with increasing rural incomes resulting in higher demand for industrial goods and services.

Foodgrain production in the country has significant growth almost quadrupled in the last 5 decades. The production increased from 51 MT. in 1950-51 to 80MT in 1960-61. Further it increased to 108MT in 1970-71 and then to 129 MT in 1980-81 increasing further to 176MT in 1990-91. During 1996-97 it reached an all time record of 199MT. The most important commodity to witness improved growth in the country are Wheat (11 folds) and Rice (4 folds), Oilseeds, Sugarcane and Cotton has exhibited (5 folds), increase each whereas there has been 3 folds increase in the production of Jute and Mesta.

The annual growth rate of foodgrains production during the post independence period has been at 2.5 per cent slightly higher than the population growth of 2.1 per cent. During the decade of 1980's the growth has been most impressive at about 3.7 per cent. However, a deceleration in the growth at 1.8 per cent in 90's has been a cause of concern. But year 1996-97 has been again reversed this trend resulting in the bumper production of 199 MT of foodgrain production.

The above analysis indicates that agriculture sector is central to the socio-economic development in India. It provides foodgrain to 940 million people in India & raw material to agro based industries of the country. Nearly 2/3rd of the country's population depend on agriculture for its livelihood. Nearly 30 per cent of the country's gross domestic product (GDP) comes from the agriculture sector. Agriculture provides employment in rural areas.

The area covered by foodgrain has been almost constant from 1994-95 to 1996-97. It increased marginally from 124 million hectare whereas production

rose from 191 million tonnes to 199 million tonnes. The yield per hectare increased from 1546 kgs. to 1601 kgs. Oilseeds like Groundnut Soybean, Repeseed and Mustard etc. have shown substantial growth in production & yield. The area however, has not increased significantly during the period 1994-95 to 1996-97. For the nine oliseeds the area increased from 25 million hectare to 27 million hectare during the year 1995-96 to 1996-97. The production improved from 21 MT to 25 MT.

There has been steady increase in the consumption of fertilizer (NPK) over the years. From 0.03 MT in 1960-61, fertilizer consumption in terms of nutrient rose to 5.5MT in 1980-81 and further to 12.5 MT in 1990-91. During 1996-97 consumption of all nutrients at 14.31 MT was only 430 thousand tonnes more than 13.88 MT in 1995-96*. While consumption of N increased from 9.82 MT to 13.30 MT consumption P increased marginally from 2.90 MT to 2.98 MT. Consumption of K declined from 1.6 MT to 1.03 MT. As a result imbalance in NPK use ration worse worsened from 8.5:2.5:1 in 1995-96 to 10.0:2.9:1.

1.2 AGRICULTURE IN RAJASTHAN:

Rajasthan is the largest state of the Indian Union with a geographical area of 3.42 lacs sq. km. Rajasthan state accounts for 10.4 per cent of India's total geographical area but only 5.5 percent of the population. The present density of population is only 128, which is lowest in the country and allows highest per capita land, next to only the hilly states of Jammu & Kashmir. Obviously, the agriculture and allied sectors are most important contributor in the state's economy. It contributes nearly 40 per cent of the status income and absorbs 69.3 per cent of the work force. The unfavorable natural conditions are the most

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* Fertilizer News, Jan. 1998

limiting factors in shaping a dynamic agricultural system in the state. The state has less than 1 per cent of the country's water resources and scanty-erratic rainfall pattern. The 58 cm average rainfall in the state is the lowest in the country and ranges from a low of 10 cm in dry hot (arid) west to 100 cm in the humid southern parts. The state has the largest animal population of around 54.34 million (12.5 million cattle, 9.96 million buffaloes, 14.31 million sheep 16.93 million goats and 0.67 million camels.).

1.2.1 Area:

Agriculture in Rajasthan is predominantly rainfed with only 25 per cent of the cropped area under irrigation. Roughly, 40 per cent of its land area fall under desertic condition. Over 60 per cent of irrigation area are accounted for by ground water, which too is faced with a severe problem of declining water tables. The land use patterns in the state is emerging with problems for sustainable development of agriculture sectors. The forest cover is less than 10 per cent geographical area in 22 out of 32 districts and in six districts it is less than one per cent of the geographical area, The large share of area are put under plough. In 13 out of 32 districts, the share of net sown are is more than 55 per cent. In some of the districts in western dry region the share of net sown area in more than three fourth of the geographical area. During 1986-87, the net sown area and area under forest increased by 8.81 and 10.61 per cent over that of 1996-97 in the state. During past one decade the total cropped area increased from 176.40 lac ha (1986-87) to 206.93 lac ha (1996-97). The net irrigated area through major three sources viz. canal system, open well and tube wells were 15.34, 30.14 and 7.79 lac ha respectively during 1996-97.

Pearlmillet occupies largest cropped area in the State. The area under this crop varied from 47 to 52 lac ha during last ten years. Being predominantly a rainfed crop, its area as well as productivity are mainly dependent on amount and distribution of rainfall during the crop season. The area under sorghum crop has largely been replace by soybean in southern Rajasthan. Maize is another important kharif cereal grown in an area of 9 lac ha in Rajasthan.

Wheat is the most important rabi cereal crop in the State. During past one decade the area under wheat crop significantly increased from 18.43 lac ha (1986-87) to 24.74 lac ha (1996-97). Barley is another important rabi cereal crop and the area under this crop has decreased to the extent of 33 per cent during last one decade. Shrinkage of barely acreage can be attributed to increase in area under mustard and wheat crop in the state. The area under oilseeds has increased from 14.99 lac ha (1986-87) to 38.83 lac ha during 1996-97. Rapeseed and mustard occupied 7.63 lac ha during 1986-87 which increased to 26.16 lac ha during 1996-97.Similarly, area under Kharif pulses, viz. mothbean mungbean, cowpea, urdbean etc. has increased from 17.51 lac ha (1986-87) to 21.45 lac ha during (1996-97) in the state. Chickpea is the predominant rabi pulse crop grown in an area of 15.19 lac ha (1996-97) in the state. The area of cumin increased from 0.44 lac ha (1986-87) to 1.98 lac ha 1996-97. The soybean occupies an area of 4.65 lac ha and having an increasing trend since its introduction in southern Rajasthan. Among the cash crop the area under cotton has also increasing trend during last one decade (3.65 lac ha to 6.54 lac ha).

1.2.2 Production:

Agriculture production is however subject to wide fluctuations depending on monsoon conditions. Despite of so many odds Rajasthan has attained the status of the leading producing state for a large number of agricultural

commodities like bajra, moth guar, mustard, wheat, maize, cotton and seed spices. It contributes, 6.1 per cent of the country foodgrain production (8.6 per cent of wheat, 13 per cent of coarse cereals, 35.8 per cent of bajra and 7.4 per cent of maize). The state also contributed significantly by producing more than 14 per cent of the pulse produced in the country. The role played by the state in oilseed production has been very impressive, as more than 14 per cent of total oilseed production and 39.4 per cent of mustard production in the country is from this state. About 8 per cent of soybean production and 9.6 per cent of the cotton production is, also shared by this state. Rajasthan has emerged as the largest producer of seed spices like cumin, coriander, fennel and fenugreek. The state accounts for nearly 50 per cent of cumin, 40-50 per cent of coriander and 80 per cent of fenugreek production in the country. Rajasthan also accounts for 8.2 per cent of milk, 30 per cent in meat and 42.8 per cent of wool production at the national level. The other animal products like meat, skin and hides, etc. the state contributes substantially.

The performance of different crops as a result of multifaceted approach devised to increase the production of crops in Rajasthan, a state characterized for resource constraints, extreme climatic conditions and inadequate water resources. As a result of multi pronged strategies, the production of crops like wheat, rabi pulse (other than gram), moong, groundnut, soybean, mustard, castor, cotton, etc., can be considered as steadily growing in the state. The production of crops like bajra, maize, jowar, paddy, gram, moth, urad, arhar, sesamum, guar, linseed, sugarcane and cumin remained highly erratic in the state. The production of small millet (kharif) and barley has been gradually declining in the state.

The total production of foodgrain in the state has increased from 6.79 million tonnes in 1986-87 to 12.82 million tonnes in 1996-97, out of which

Cereals increased from 5.84 to 10.9 million tonnes and pulses from 0.95 to 1.84 million tonnes. Similarly the production of oilseed was also having same fashion as in foodgrain, increased from 0.88 million tonnes to 3.53 million tonnes. But the production of sugarcane was remained static (1.29 million tonnes) during this decade. However, the production of cotton behaving same trend as that of oilseed and foodgrain during past one decade. Its production was increased from 0.7 million tonnes in 1986-87 to 1.36 million tonnes in 1996-97. There was a significant increased in the production of guar (5 folds) during past one decade. Its production increased from 0.13 million tonnes to 0.74 million tonnes.

The per capita availability of pulses, oilseed, milk, meat, etc. in the state is much higher to the national average. For cereals also it is very much close to the national average. However, for fruits and vegetables the per capita availability is very much less than the national average. Thus the role of agriculture in shaping the rural economy of the state has so far been quite significant and is going to be more vibrant and vital in the years to come.

1.2.3 Productivity:

The state is bestowed with diverse agro-climatic and micro-farming situations a variety of field crops, vegetables and spices are grown, during last ten years, more than 45 improved varieties of different crops have been developed and recommended for cultivation in different zones of the State. During 1996-97,the productivity of pearlmillet was 4.92 q/ha. However, its productivity varied from 2.5 q/ha during last one decade. Maize is an important Kharif cereals crop grown in the state. The productivity of this crop has increased to 11.09 q/ha (1996-97) from 6.65 q/ha in 1986-87. However, in certain years its productivity has gone below the optimum level. Wheat is the another important

rabi cereal crop in the state. The productivity of this crop also rose from 18.46 q/ha in 1986-87 to 27.4 q/ha during 1996-97, because of development of high yielding, rust resistant varieties and generation and adoption of improved production and protection technologies. Barley is another important rabi cereal crop of the state. The productivity level also increased from 14.52 q/ha to 20.11 q/ha during past one decade. The productivity of rapeseed and mustard increased from 8.59 q/ha (1986-87) to 10.02 q/ha (1996-97). Sesame is another kharif oilseed crop of state grown under rainfed condition. The productivity of sesame in the state was merely 0.2 q/ha which increased to 1.70 q/ha during 1991-92 and further rose to 2.10 q/ha during 1996-97.

The average productivity of kharif pulses increased from 0.50 q/ha (1986-87) to 3.21 q/ha during 1996-97. The productivity of soybean was 9.75 q/ha during 1996-97. The productivity of chickpea has increased from 5.83 q/ha (1986-87) to 7.05 q/ha during 1996-97. Among the seed spices, the productivity of coriander increased from 8.22 q/ha (1986-87) to 9.91 q/ha during 1996-97. The productivity of cumin decreased from 4.8 q/ha in 1986-87 to 0.65 million 3.3 q/ha in 1996-97. In a similar way, the productivity of cotton, guar and other important crops have increased significantly during the past one decade in the state.

The productivity of crops like wheat, other rabi pulses, soybean, rapeseed & mustard, sugarcane and cotton, has been growing or improved over the plan periods. But for crops such as bajra, maize, jowar, kharif pulses (moong, moth, urad, arhar), sesamum , groundnut, guar and linseed the productivity remained erratic over plan periods.

1.3 STATE OF AGRICULTURAL STATISTICS:

Agricultural statistics has played an indispensable role in the macro as well as micro planning process of the country. For a country like India where agriculture had been the major contributor to the national economy, the domain of dependency for majority of its population and the chief architect of its food security, self reliance and socio-economic strength, the exhaustive and reliable data base on diverse facets of agrarian economy has been realised as the foremost requirement for evolving the development strategies.

Collection of primary or secondary data for the purpose of understanding the behaviours of various socio-economic variables has a long history. Agricultural statistics is closely related with this concept, which is to be described the state. Statistical inference is an important part of the discipline. The inference will be meaningless if the basic data are inaccurate or faulty or unreliable.

The current status of agricultural statistics in India and the continuous deterioration in the quality of agriculture statistics over the past few years are well known. As far as agricultural statistics are concerned the system is currently languishing with poor quality statistics with reference to traditional statistics and with absolutely no information with reference to the recent emerging high valued crops.

1.3.1. System of Agricultural Statistics:

India has one of the oldest and well established and internationally acknowledged agricultural statistical system. The system is a decentralised one with the State Agricultural Statistics Authorities (SASAs) playing a predominant role in collection and compilation of agricultural statistics. However, the state governments and statistical organizations of the state are engaged in collecting and generating data on number of variables. Even where the responsibilities for

policy formulation lies with the central ministries, the actual collection of data may be done by the state government through their agencies. For example, agricultural statistics related to crop area and yield data are collected by state governments through various agencies initiated by the central ministry of agriculture. The Department of Agricultural & Cooperation (DAC) at the Centre does the compilation of agricultural statistics at all-India level based on the figures received from the SASAs. In respect of Livestock, while the state Animal Husbandry & Dairying Departments (State AHDs) collect and compile the basic data, the DAC (for livestock census) and the Department of Animal Husbandry & Dairying (DAHD) (for livestock products) at the Centre compile all-India level figures. Besides, this large scale statistical operation such as population census, Economic census and nationwide sample survey are largely central activities. In addition to these two organisations, the National Sample Survey Organisation (NSSO), the Indian Agricultural Statistics Research Institute (IASRI) and the State Directorates of Economics and Statistics (State DESs) are involved in the system of agricultural statistics. The Reserve Bank of India also conducts the All-India Debt and Investment Survey (AIDIS) through the NSSO, which gives information on debt and investment relating to the agriculture sector.

The system of agricultural statistics generates land-use statistics, area under principal crops through the Timely Reporting Scheme (TRS) and also one complete enumeration basis, yield estimates through the General Crop Estimation Surveys (GCES), cross-checks the reliability of TRS and yield estimates through the scheme of Improvement of Crop Statistics (ICS), cost of production through the scheme of Cost of Cultivation Studies (CCS), agricultural wages, irrigation statistics, conducts Agricultural Census and Livestock Census on quinquennial basis, generates data on livestock products through the scheme of Integrated Sample Survey (ISS), collects wholesale/retail prices, conducts market intelligence and monitors rainfall and weather conditions.

1.3.2. Agricultural Time Series Data Publications:

In the state of Rajasthan mainly three agencies are involved in publishing agricultural time series data viz. Directorate of Economics & Statistics, Directorate of Agriculture and Agricultural Census (Revenue), Department, Government of Rajasthan Jaipur. The frequency of these publications are annually, decadal or special issue in series by all the above mentioned agencies The informations consist in these booklets also on agriculture and allied fields is very useful in agricultural planning, decision making and formulation of plans/projects of agriculture and rural developments in the state. The data presented in these publication related to the calendar year/ financial/Agriculture/ Co-operative year as per the nature of services provided by the different departments of state governments.

The largest publication comes out on Agricultural Time Series Data from Directorate of Economics and Statistics (DES), Government of Rajasthan, Jaipur. The following are the regular publications of DES:

1. Statistical Abstracts (1958) *
2. Basic Statistics (1956) *
3. Economic Review Rajasthan (1994-95) *
4. Socio-Economic Statistics (1995-96) *
5. District Statistical Outline (जिला सांख्यिकी रूपरेखा) (1970) *
6. Some Facts About Rajasthan (1980) *
7. Agricultural Statistics (1985-86) *
8. Annual Vital Report (1973) *
9. T.R.S. Report of Crops (1972-73) *
10. Annual Survey of Industries (1961) *
11. Study of States Finance (1960-61)*
12. Classification of State Budget (1977-78)*
13. Census of State Government Employee (1956-73) *
14. Budget at a Glance (1994-95) *
15. Budget Study, Rajasthan (1959-60) *

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* Year in bracket indicates the first issue of the publication

The above publications containing the informations pertaining to different sectors of the economic of the state. Besides this DES also publishing the following special booklets (adhoc-publications) on various agricultural and socio-economic aspects, from time to time for dissemination of data on Agricultural Statistics.

1. 25 Years Agril. Statistics of Rajasthan (1973-74 to 1997-98)* *
2. Population Projections, Rajasthan (1991-2011)* *
3. Consumer Index No. for Industrial Workers. (1995-99)* *
4. Household Consumer Expenditure and Employment Situation (1994-95)* *
5. Estimates of Gross Fixed Capital Formation in Rajasthan. (1990-91 to 1998-99)* *
6. Price Indices in Rajasthan (1985-87)* *
7. Women and Men in Rajasthan (1999)* *
8. Some Development Facts of Rajasthan (1956-99)* *
9. Survey of Housing Conditions 49th Round of NSS (1993) **
10. Fourth Economic Review (1998, Vol. I, II part I, Vol II part II) **
11. State Domestic Product and Capital Formation, Rajasthan (1997-98) **
12. Estimates of Gross State Domestic Product of Rajasthan (1980-81 to 1998-99)* *
13. Estimate of Net State Domestic Product of Rajasthan (1954-55 to 1997-98)* *
14. Rajasthan in Indian Economy (1996-97) **
15. Report on Index Number of Industrial Production, Rajasthan. (1954-55 to 1997-98)**

Second agency viz., Directorate of Agriculture (DOA), Government of Rajasthan, Jaipur also bringing out very special issues. Since 1990-91, DOA, Jaipur publishing booklet entitled **"Vital Agriculture Statistics"** regularly. This publication contains the district level data on agriculture production, land use and

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** indicates the current issue of the publication

resource base available to agriculture. Another publication entitled **"Agriculture in Rajasthan Some Facts"** released by DOA contains useful information/data on agriculture development in the state over the last 4-5 decade. A very useful publication titled 'Districtwise Trends of Agricultural Production" contains the data related to agriculture over the past 35-40 years. This publication which was the second after the very popular publication "Agriculture in Rajasthan (Statistical Hand Book)". District wise time series data relating to rainfall at district headquarters published in form of booked entitled "Rainfall in Rajasthan by this Directorate for the period 1950 to 1995. Recently, booklet entitled **"50 Years of Agricultural Development in Rajasthan"** gives clear picture of rapid stride made by the state in the field of agriculture and allied sectors during the last five decades, published by the same agency.

Lastly the another agencies i.e. Agriculture census (Revenue) department, Jaipur publishing **Agricultural Census** consisting the data related to input survey on agriculture, fertilizer, farm machinery, etc.

1.3.3 Inconsistency in Data :

Plenty of data are available for agricultural research, the quality of data is often not that good. A number of reasons may be for that: (Gujarati, 1995)

i. Mostly social science data are non-experimental in nature. Therefore, there is possibility of observational error due to omission or commission.
ii. There is possibility of errors of measurement in experimentally collected data due to round off or approximation.
iii. In questionnaire-type survey study, the problem of non response.
iv. Sampling technique used in obtaining the data may vary so widely that it is often difficult to compare the results obtained from the different samples.

v. Economic data are generally available at a highly aggregate level. Such highly aggregate data may not clear about the individual or micro units that may be ultimately object of study.

A steady deterioration in the quality of data on crops, which are traditionally covered under the system of agricultural statistics has occurred. In addition to this, there are several data gaps on new crops and ancillary agricultural activities. The quality of land use and crop data has suffered seriously for a variety of reasons one of the main reason behind it may be village officials, who is key person collecting land use statistics, do not take much interest/importance to this job. Higher level revenue officials too do not pay adequate attention to this activity at the time of supervision. These factors have much contributed to the deterioration in the quality of crop statistics even though efforts have been made to bring about improvement through Timely Reporting Scheme (TRS) and the Improvement of Crop Statistics (ICS). Thus the pillars on which the entire edifice of agricultural statistics rest have been weakened. The main reasons for poor quality of area statistics may be:

- Failure of the Patwari agency to devote adequate time & attention to the Girdawari operations.
- The yield estimates suffers due to the poor performance of field operations
- Heavy work load of the primary agency
- Lack of adequate administrative and technical supervision over the work of primary agencies.

Because of all these and many other problems, the non-experimental nature of the data used in most social science studies researches very often have no choice but to depend on the available data. Therefore, there is need to pay more attention for the data collection in all its dimensions. A good statistical system is a prerequisite for sound decision making and for the formulation and monitoring of public policies.

A number of studies conducted on special pattern so for have taken the state as basic unit and very limited number of researches have under taken to analyse the growth pattern of agricultural output as well as output of individual crops at the district level. In these studies univariate, bivariate and multivariate approaches have been used to analyse the growth in area, production and productivity over the years. A comprehensive study of all the district of Udaipur division embodying different aspects of agricultural development, stationary of agricultural time series has not been conducted so far in the state of Rajasthan. In this background of existing information, apparent gaps inadequacies and future imperatives have promoted the present study.

1.4 SPECIFIC OBJECTIVES OF THE STUDY :

(i) To study the performance of Agriculture .

(ii) To identify the factors responsible for its growth.

(iii) To examine the data generation process of the agricultural time series.

(iv) To study the nature of area, production and productivity.

(v) To study the long term equilibrium in area, production and productivity in agriculture.

1.5 LIMITATIONS OF THE STUDY:

The entire study is based on the secondary data, published or unpublished. The information of newly formed district viz., Rajsamand have been included in the original district from which it have been bifurcated, since the data related to new district are not available for all the period under study. The accuracy of the results and implications drawn from the study depends on the accuracy of the data collected the aggregates/ averages worked out by the different agencies involved in data collection.

1.6 CHAPTER SCHEME:

The study is organised into five chapters including the present one, which deals with introduction, importance, state of agricultural statistics, objectives and limitations of the study. Chapter second described the review of literature. The methodology used in the present study discussed in the chapter third. Results and discussion have been described in Chapter fourth. This chapter divide into two sections. Section A contains the performance of agriculture in area, production and productivity of selected crops at districts level and section B related to parametric analysis of time series using unit root and cointegration technique in area, production and productivity of selected crops. The last chapter relates with summary and conclusions followed by bibliography.

2. REVIEW OF LITERATURE

This chapter presents the brief account of the research work carried out on the subject in the past. The review of literature informs and guides the researcher through furnishing the knowledge about the kind of studies conducted in the past, regarding their place or area, period, methodology to handle the problem, findings of the study and limitations thereon. The relevant reviews also support the result and discussion of the study. It also helps us to avoid the duplicity of work.

The literature pertaining to most of the studies conducted hitherto has been grouped into four categories for convenience of better presentation and understanding of the subject matter. The four categories for citation of review of literature have been formed as:

2.1 Trend Analysis

2.2 Growth Rates

2.3 Decomposition Analysis

2.4 Co-integration Analysis

As all above mentioned categories involves separate techniques to estimate the parameters, these needed separate treatment in review.

2.1 TREND ANALYSIS:

Mitra and Roy (1964) examined regional variations in yield per acre of ten principal crops in India during the period 1950-54 to 1959-60. A linear equation (Y = a +bt) was fitted to the index of yield per acre for each crop as well as each state. The initial and final year computed values of yield

per acre obtained from the fitted trend for each crop over the state was compared. For each crop they arranged the initial and final year computed yield figures for all the states as well as for the all India figures. By taking all India equals to 100, the figures for each state had been expressed in terms of the all India figure of that year.

Another study in this direction conducted by Herdt, (1971). He consider 16 states of India for two years 1960-61 and 1964-65 and revealed that labour, drought, cattle or carts were highly inter correlated inputs. Log-linear production function were fitted. None of the production elasticities estimated from 1961 data was found significant, while all the 1965 equations had atleast two significant coefficients. The productivity of land was at par in both the years but productivity of labour and fertilizers were substantially higher and productivity of irrigated land considerably lower in the year of good weather.

Saha and Swaminathan (1994) analysed the districtwise and crop wise change that occurred in agricultural production in West Bengal in the 1980s by using two functional forms viz., exponential and log quadratic ($\log Y_t = a + bt + ct^2$). They revealed that aggregate crop output grew at 6.4 per cent a year for the state as whole, the phenomenon of this high agricultural growth was wide spread. All but the two northern districts of Darjeeling and Jalpaiguri had rates of growth of aggregate agricultural output of over 5 per cent per annum. With the exception of potato, growth rates were higher in the Gangetic districts, as compared to the four northern Sub-Himalayan districts. The high growth in output was not on account of good weather condition. In most districts, the contribution of productivity

growth to total output growth was very high and higher than the contribution of growth in area. The period of high growth was not associated with greater instability in the levels of production. The production of rice (major crop of the state) increased rapidly during the period. Among the other crops, rates of growth of output were high for potato and oilseeds. The gross cropped area under potato and oilseeds increased and the yields of both improved between 1980-81 and 1988-89. Production of wheat stagnated and downs the yield levels in most districts.

Srinivasan (1979) estimated trends in area, production and productivity of important crops during the period 1949-50 to 1977-78 and two sub-periods; 1949-50 to 1964-65 and 1965-66 to 1977-78, employing log-linear and log-quadratic functions. He revealed that there had been a decline in the rate of growth of gross sown area in particular under nonfood crops in the decade 1967-68 compared to the 15 years ending in 1964-65 but the output and yield per unit area of food crops and all crops grew more or less uniformity over the entire period 1949-50 to 1977-78 with no evidence of either acceleration or deceleration since 1967-68. The slow down in the growth of crop area in the period after the mid 1960s compared to the earlier period was shared by almost all crops expect wheat. Among cereals, coarse grains, namely jowar, maize and bajra actually lost area in the decade starting from 1967-68. It was again wheat which showed faster growth in output and yield per unit area in the later decade compared to the earlier decade and a half. There was no evidence for such a change in growth of output or yield per unit of area of rice though the yield of jowar had grown faster in the later period. In other words, there was as yet no green revolution but it was mainly a wheat revolution.

Patil and Jha (1978) attempted to measure and analyse output and productivity changes in Maharashtra agriculture for the period 1951-52 to 1971-72. The results suggested that according to present trends areas which receive relatively higher rainfall (Zone I, IV and V) were likely to record further advances in output growth. Zone II and to a lesser extent, Zone III, were found to be the really depressed areas of Maharashtra.

Bhalla and Tyagi (1989) investigated the growth performance of Indian agriculture at the state and district levels with a view to capturing the spatial pattern of changes between the triennia 1962-65, 1970-73 and 1980-83. In this direction an attempt was also made by Bhalla and Alagh (1979), they examined the pattern of growth of Indian agriculture at the district level during the period 1962-65 to 1970-73. Later on, Dev (1985) extended, the districtwise analysis of agricultural performance up to the period 1975-78. Bhalla and Tyagi identified the various technological institutional and other causal factors that were responsible for determining growth and yield levels of aggregate agricultural output at the state and district level and also identified the factors that explain inter-district/ interstate variations in levels and growth of agricultural output. The study revealed that the new seed fertilizer technology had played a major role in raising yield levels of various crops and thereby augmenting agricultural production in India since the mid-sixties. The new technology was adopted in highly irrigated districts of Punjab and other north-western states over the years and technology gradually spread to many more areas. The new technology had been replicated only in those areas, which had assured irrigation base although some of the central states which were primarily dependent on rainfall had also registered big increases in output during 1980-83 with large variability in output. The analysis suggested that new technology had made a

significant headway in some of the dryland crops like jowar, ragi and cotton because of appropriate dryland technology. The plan targets of achieving a rate of growth of foodgrain and agricultural output of about 4.5 per cent per annum could be achieved if new technology being employed in the existing areas and simultaneously extended to newer areas through large investments in water management, including flood control and provision of irrigation particularly in the eastern region. This would have to be followed up by large investments in the infrastructure like roads, markets, communications, power, research and extension. The problem of regional disparities in male agricultural workers productivity and of their accentuation over time had serious implications. The increase in variation in labour productivity implied that the existing disparities in the living standards of agricultural population among various regions were getting further accentuated. Further, in order to reduce inter-regional inequalities large infrastructure investments would have to be directed towards hitherto neglected eastern and central parts of India.

Chopra (1982) conducted a study for the period 1950-51 to 1976-77 on pulse growing states of India for two seasons viz., Kharif & Rabi reveals that in the region which largely grew rabi crops was important for wheat production, usage of modern inputs due to higher irrigational facilities had led to a decline in the rabi pulse acreage because wheat had offered a tough competition to these crops and in particular to gram. But in the states of the relatively dry region, the acreage under rabi and kharif pulses had increased. The former responded mainly to higher cropping intensity alongwith improved yield and higher price of rabi pulses while kharif pulses acreage had positively responded mainly to irrigated area and to a relatively favoured price ratio. Rainfall turned out significantly in both the seasons in the relatively dry region of the states.

George and Mukherjee (1986) observed that the increase in area accounted for 53 per cent of the production changes of rice crop in Kerala for the period 1960-61 to 1974-75, while the contribution of increased yield was 41 per cent. However, for the period 1975-76 to 1983-84, area accounted for a large negative share as against a large positive share of yield. For the combined period 1960-61 to 1983-84, 89 per cent of the change in output was accounted for by change in yield per hectare and only 9 per cent was explained by change in area.

Baghel and Gupta (1997) studied the variability and stock of growth pattern of foodgrains in India during period 1949-50 to 1994-95 by dividing the period into four sub periods viz 1949-50 to 1965-66, 1966-67 to 1979-80, 1980-81 to 1994-95 and period fourth taken as an overall period. They worked out coefficient of variation to see the measurement of variability in the pattern of production of foodgrains. They also fitted two trend equations viz $Y= AX^B$ and $Y = a+bx + cx^2$ to see the growth rate of crop and rate of change of growth in the variables. They revealed that the maximum area had been cropped in foodgrains crops in kharif season, which was accounted 60 per cent as compared to total area for almost all the years. The total area under foodgrains increased 25 per cent more in 1994-95 as compared to 1949-50. The productivity of kharif and rabi season showed a diverse picture, production and productivity of total foodgrains as well as in both the scenario recorded a significant simple and compound growth rates for all the short run periods and overall period. They further revealed that productivity of rabi season was found higher than that of kharif season. The temporal character of variability in all the periods of study under consideration showed variation in production due to variations in yield.

Shah (1975) studied the growth of agriculture in India by fitting trends to the share of area under different crops in total gross cropped area during the period 1954-55 to 1969-70. He observed that typical substitution seems to obtain between superior cereals on the one hand and coarse cereals and pulses on the other. Among pulses, gram presented a declining trend in irrigated and unirrigated area. On the other hand wheat, a superior cereals, increased its area in irrigated land. The aggregate results of individual state for changes in crop pattern showed stickiness in cropping pattern. Foodgrains, for instance had only a marginal shift in their share declining from 76.28 per cent (average for 1954-55 to 1956-57) to 75.09 per cent (average for 1967-68 to 1969-70) over a period of more than 13 years. The share of cereals during the same period increased by two percentage points, matched by a larger decline in share of pulses, including gram. Among cereals share of small millets, jowar and Barely declined. Major increase was in the share of wheat, rice and maize. Among non-foodgrains, share of oilseeds mainly groundnut, to fruits and vegetables and miscellaneous crops increased primarily at the cost of cotton.

Raddy (1998) studied trends in Agricultural wages in different agro-climatic Zones in Andhra Pradesh. The analysis reveals that the real wages of all categories of labour have increased at the state as well as Zonal levels though the magnitude differed from zone. It also indicates contineous persistence of zonal variations in wages.

Acharya (1975) reported that there had been horizontal expansion in the cropped area in Rajasthan during 1952-53 to 1972-73. The relative area under foodgrains and non-foodgrains crops during this period remained almost the same i.e.90 per cent and 10 per cent of the cropped area

respectively bajra crop dominated the cropping pattern of the state (36.5 per cent of the cropped area). Gram and wheat improved their position in the cropping pattern at the expense of jowar crop over time.

Acharya and Agarwal (1979) analysed the cropping pattern in various region of the Rajasthan state and observed that relative area under non-food crops increased in Ganganagar, Sirohi and Ajmer Zones whereas it decreased in Kota Zone during the period 1956-57 to 1974-75. The production of rabi crop in the total cropped area increased in Sirohi, Ajmer and Dungarpur Zones and decreased in Chittorgarh and Kota Zones. The relative area under Bajra crop was increased in Chittorgarh and Dungarpur Zones. There was substantial change in the relative area under wheat in Rajasthan state through it increased in Ajmer, Dungarpur, Jaipur and Kota Zones and decrease in Chittorgarh. In Dungarpur area under rice had substantially decreased and increased under pulses. They concluded that the cropping pattern of different Zones were not static except Bikaner Zone where the change in the cropping pattern over time was almost negligible. They also observed that area under foodgrains and the production of cereals were increased at the rate of 0.6 per cent and 1.68 per cent per annum, respectively during the period. The increased in the area and production of pulse was significant. There was no significant increase in production of bajra and maize despite the increase in area. The production of wheat increased (3.53 per annum) mainly due to the increase in productivity. There was no significant change in area, production and productivity of jowar, rice, barley and gram. The production of all the oilseeds increased in the state but the increase was highest for groundnut as compared to seasamum & rapeseed and mustard.

On the basis of linear growth model Panda (1993) examined the trends in area, production and productivity of pulses in Orissa over the decade 1981-90. He revealed that arhar had achieved statistically significant growth in area, production and productivity. Among the rest of the crops, moong had achieved a significant growth in relation to yield but not in respect to area and production. On the contrary, black gram and red gram had recorded significant growth in terms of area and production but not in productivity. Regionally wide differences existed in the cultivation of pulses in the state.

Kvalseth (1985) suggested the coefficient of determination (R^2) is perhaps the single most extensively used measure of goodness of fit for regression models. Eight different expressions for R^2 are given in this article. He addressed the R^2 problem generally, compared various statistics for different types of models, pointed some common mistakes and provided a recommendation for the most appropriate and generally applicable R^2 statistic.

2.2 GROWTH RATES:

Parthasarathy (1984) conducted study on inter district variations in the growth rates of Agril. production, variations in growth rates between pre and post-green revolution period in each district and differences between the districts and variations in instability indices between pre and post-green revolution periods. He used log-linear & log-quadratic functions equation to the indices of Agricultural productions for period (1955-56 to 1978-79) as a whole and two sub periods viz. 1955-56 to 1966-67 and 1967-68 to 1978-79. He revealed that except none of the district in Andhra Pradesh showed a rise even up to 3 per cent except some of the Telanga districts. North coastal Andhra region showed the worst performance, particularly in respect of food

grains. The growth rates for post-green revolution period exceeding the growth rates of earlier period but only a few districts showed significant difference between these two. Many districts showed acceleration in the post-green revolution period but this was not significant. The degree of instability as judged by percentage deviation was quite high in all the districts. It was higher for foodgrains than for all crops. It was also observed that districts, which had higher growth rates had higher instability.

Ray (1977) conducted a study in the growth of area, production and yield of selected crops for the country as a whole. He introduce weather alongwith time trend and specified the following types of relationship.

$Y = a_0 + a_1 t + a_2 \log Wt$

Where Y stands for Area (At) production (Pt) or yield (Yt) on the year 't' and Wt represents rainfall in year 't'. He concludes that rainfall has a statistically significant effect on behaviour of area, production and yield. The weather corrected trend growth rates differ significantly from the unadjusted rates in 8 out of 11 cases. The adjusted growth rates are in general higher than the unadjusted ones.

In a study Mahajan (1973) aimed at explaining growth behaviour in agriculture sector of 14 Indian states during last 15 years of planning, it was revealed that four of the seven states like Kerala, West Bengal, Tamil Nadu, and Assam experienced growth above the Indian average. This was owned to both better cropping pattern and relatively higher productivity. Bihar to better cropping pattern alone and Punjab and Andhra Pradesh to high productivity. Four of the five states with below average gross value per hectare, Rajasthan, M.P. Maharastra & Karnataka owed this performance both to the inferior cropping pattern and below average productivity and Gujarat to inferior cropping pattern alone.

Ramesh Chand and Sharma (1994) analysed the factors underlying the growth in agricultural output in major state for the period 1967-68 to 1988-89. Growth rates in area, production and yield of important crops achieved by eleven major states of India were also computed from simple linear trend equations. The state wise trends in agricultural income, per capita of rural population revealed that agricultural development in India had been characterised by rising regional disparities. The gap between rich and poor states, in terms of net state domestic product of agriculture per capita of rural population, had widened over the past two decades ending eighties. In majority of the states, the growth of agriculture sector, in real terms, could not keep pace with the rise in population, making rural population of these states economically worse off in late eighties compared with the year 1970 - 71. The post-green revolution period showed tremendous variation in growth rate of area, output and productivity across states and crops which led to severe crop imbalance and regional differentiation's. The pattern of growth of agricultural incomes, output, area and productivity, largely resulted from spatial variations in use of critical farm inputs. Investment in irrigation development, provision of electricity to farm sector, promotion of fertilizer use and spread of high yielding varieties in agriculturally backward states, appear to be the potent measures to develop these states and to achieve the goal of growth with equity.

Billore and Joshi (1998) examined the trend in the growth rate of area, production and productivity of soybean in India for different states during the period 1980 to 1994 for assuring performance and contribution to the national production. They revealed that in case of area, production and productivity, the highest positive contributions from Madhya Pradesh, Maharashtra and Rajasthan State. Whereas in country as a whole, it was the

production which found to be most encouraging followed by area and productivity. On the basis of present growth trends, the area of soybean will stabilised around 12 to 13 m.ha. during 2010 AD and the highest productivity will be expected from Maharashtra, Karnataka, Meghalaya, Andhara Pradesh and Rajasthan. They also reveals that the major contribution of production will be likely from M.P., Maharashtra and Rajasthan. The decomposition analysis indicated that the yield effect is dominating in Gujarat, H.P. and Meghalaya and major contribution for both area and yield effect only in Andhra Pradesh and Mizoram. While rest of the states showed area effect dominance.

Sawant and Achuthan (1995) analysed Indian agricultural growth across crops and regions in the post-green revolution period 1968-69 to 1991-92 as well as in two sub-periods viz., 1970s : 1968-69 to 1981-82 and 1980s : 1981-82 to 1991-92. The performance was evaluated on the basis of estimates of compound annual growth rates in area, production and yield of principal crops and index numbers of area, production and yield of foodgrains, non-foodgrains and all crops at all India and state level by fitting log linear and log quadratic functions and also by using log y= a +bt +cR where R represents the all-India annual rainfall index constructed by the Indian meteorological department. The study revealed that the role played by yield improvement in inducing higher output growth had been more important than that of expansion in area indicated that the process of growth had been technologically more dynamic too. The acceleration in yield growth in recent years had been significant for rice, maize, other pulses, rapeseeds, sesamum, soybean, rubber and cotton. Again, unlike the past, enhancement in yield growth had been more impressive for non-foodgrains as compared to foodgrain and among the foodgrains for kharif foodgrains

vis-a-vis the rabi foodgrains with the wider dispersal of growth across crops and regions. The performance of the western region had been most unsatisfactory in the 1980s among all the regions of India, as also compared to its own performance in the 1970s due to adverse weather conditions and greatly reduced pace of expansion in irrigation. The southern region showed a distinct down turn in the foodgrains output growth due to shift of area away from foodgrains to non foodgrains. In the north-western region, high growth in foodgrains output (4%) continued in the 1980s.

Suseendra Babu (1997) examined the variability and trends of area, production and productivity of arecanut in karnataka during 1965-66 to 1994-95 and sub periods 1965-66 to 1969-70, 1970-71 to 1979-80, 1980-81 to 1989-90, 1990-91 to 1994-95 and for the whole period by employing two standard statistical tools viz Index number and co efficient of variation. The study revealed that the growth rates of area, production and yield during seventies were the highest. Whereas, during eighties and nineties the growth rates of productivity were 0.3 per cent and 0.0. per cent respectively, it showed that the productivity became stagnant. The analysis suggested that the trends of the arecanut productivity which were not healthy one especially during nineties.

Tripathy (1996) analysed the performance of rice production in Orissa during post-green revolution period (1970-71 to 1989-90) and two sub-periods viz. 1970-71 to 1979-80 and 1980-81 to 1989-90. The results of the study revealed that the output of rice during the post-green revolution period grew at an annual rate of 1.43 per cent and this was contributed solely by in area under rice due to diversion of area of oilseeds and pulses. The study further, revealed that during the seventies there existed regional disparities

in the growth rate of area, yield and production in most of the districts. He observed that per hectare yield of rice showed improvement during eighties. The productivity of rice is almost stagnated in three districts namely Kalahandi, Sundargarh and Keonjhar, respectively.

Sagar (1980) commented on the growth of productivity in Indian Agriculture and calculated the effect of shift in the base period to the triennium ending 1954-55. It was shown that the contribution pattern of the three effects showed no significant shift as compared to 1950's during the 1960's and thereafter. Inspite of an impressive use of fertilizer high yielding varieties as well as the extension of irrigated area, the share of pure yield effect in the total increase in productivity has not taken place by more than 10 per cent during this period. The location effect showed that regions of higher initial productivity favoured during first period by shift in the crop area, were not same during second period.

Bhatia (1980) examined (i) the growth rate of production and productivity of major foodgrains in India in two periods of time viz. 1960-61 to 1978-79 and 1967-68 to 1978-79 (ii), the rates of growth of production and productivity of major cereals crops in different state and (iii) the factors which determine the rate and pattern of growth of foodgrain production and productivity. Compound growth rates were computed by fitting a exponential function of the form $Y= AB^t$ where Y is index number of production/productivity and 't' is the time. Productivity functions were fitted to the cross section data of different states for the year 1976-77. The study has shown that the modern technology help in accelerating the rate of growth of production of foodgrains in India. While the growth rate of wheat & rice were reported to be quite encouraging, growth rates of production of pulses

and maize were not found satisfactory. Results revealed that about two third of growth of production of foodgrains has came through increase in productivity.

Chattopadhyaya and Bhattacharaya (1986) determined the growth rate for foodgrains, non-foodgrains and all crops as a whole for a time period of 1950-51 to 1982-83. Using various techniques like Gomportz and logistic curves. The study reveals that the new technology had no impact on inferior cereals.

Ram (1993) estimated the growth rates of area, production and productivity of groundnut and total oilseeds in kharif and rabi season for each district in Orissa for the period 1976-77 to 1991-92. He found that area under groundnut and total oilseed in the state increased in both the seasons. The compound growth rate in the production of groundnut and total oilseeds was found positive in both season in each districts. He also revealed that compound growth rate in productivity of groundnut was positive in all the districts except Ganjam.

Singh et al. (1997) studied (i) the district wise growth rates in the productivity of principal crops in Hariyana, (ii) the inter-district variations in Agril productivity in the state and their trend and (iii) the factor associated with inter-district variations in the productivity of major crops of the state for the period of 1972-73 to 1994-95. All the principal crops of the state namely wheat, paddy, bajra, sugarcane, gram, barley and cotton which constitute about 80 per cent of the total cropped area of the state. The coefficient of variation were calculated to determine the degree of inter-district disparities in Agricultural productivity as well as quantity the degree

of instability in the yield for various district over the years 1972-73 to 1994-95. The growth rates were calculated by fitting exponential functions. To measure the Agricultural productivity in each district the composite productivity indices were calculated. The results of the study reveals that wide inter-district variations in the yield of all the crops in Haryana during 1994-95 the highest being in the case of cotton (American) followed by maize and paddy. On the other hand, the lowest variation was observed in the case of cotton (desi), wheat and gram. Inspite of wide inter-district variations in the growth rates of yield for the state as whole, the yield of all major crops except gram and cotton has increased, particularly in case of wheat, paddy and barley. The study further reveals that variations in yield was relatively less in the case of wheat, paddy, cotton and sugarcane because of assurance of irrigation facilities and adoption of new biological & chemical technology. The variations was found much greater in gram and bajra crops because of their production in the rainfed areas, low fertilizer application and negligible plant protection. measures. It was also revealed that the districts of Kurukshetra, Karnal, Ambala, Sonepat and Faridabad are better off in respect of productivity level than the state average productivity index of 2666 Kg. per hectare.

Singh and Singh (1997) studied growth performance of agriculture in the different zone of the plateau region of Bihar during the period 1970-71 to 1989-90. The chotanagpur plateau region of Bihar consists of three agroclimatic zones i.e. zone 4, zone 5and zone-6. The zone wise results of growth rates of area production and productivity of wheat in the seventies was found positive in all the Zone, however zone-4 and 5were supericr to zone-6 in respect to yield growth rate during eighties the growth rate trend of area production and yield was not maintained. During this period the

productivity declined at the annual compound rate of 10 per cent and 2.20 per cent respectively in zone -6 and zone-5 and the area has shown negative growth rate in zone-4 and 6. The high productivity per hectare of wheat was positively associated with high variability in most of the zones. In gram crop, the growth rate of area, production and productivity it was found that the growth rate of area was positive in all the zone except zone-6 during the seventies. It was negative in case of productivity during the same period for all the zones. During eighties growth rate of area, production and productivity were negative in all the zones. In this case also high productivity was associated with high variability. It was also observed that the area was more stable than yield during both the periods in all the zones. While yield was more stable in period I than that in period II in all the zones. They further observed that high variability in winter rain was accompanied by high variability in the productivity of wheat and gram crop was experienced in period III as compared to period in all the zones of plateau region of Bihar. The high instability in productivity during the eighties may be one of the reasons for high instability/variability in winter rainfall during the production period in the plateau region.

Abraham and Raheja (1967) conducted a study of contributions of major inputs, viz., land, irrigation and fertilizers in the growth of production of rice and wheat crops in India during the period 1951-52 to 1964-65 and revealed that total increase in production of rice during the period was estimated at 12.6 million tonnes. The unirrigated area, irrigated area and fertilizers consumption accounted for about 7,16 and 77 per cent of total increase in the production of rice, respectively. The coefficient for unirrigated area showed wide variation from state to state, being significant

only in Bihar. The coefficient for irrigated area was significant and positive in A.P., Kerala, Madras & Punjab and negative in some of the states but significant only in Madhya Pradesh. The coefficient for fertilizer application was positive in all the states except negative and negligible in Punjab. Fertilizer had a significant contribution in crop output only in Andhra Pradesh, Gujarat, Kerala, Mysore and Uttar Pradesh. For wheat crop, coefficient for unirrigated area was significant only in Madhya Pradesh. For irrigated area coefficient was significant in Madhya Pradesh and Punjab. The contribution to the growth of production of wheat for fertilizer use showed wide variation from state to state. On the whole, fertilizer contribution was significant and positive only in Gujarat state. In remaining states, fertilizer had non-significant effect on wheat production.

Dev (1985) observed the change in performance of all crops in Indian agriculture at district level and agro-climatic regions in late 1970s. He revealed that in 1975-78 as compared to 1970-73, whereas the relative share in terms of area and output declined for the low productivity districts, that of high productivity districts increased substantially. Thus, the share of 106 low productivity districts in the aggregate output declined from about 16 per cent during 1970-73 to 11 per cent during 1975-78 and that of the 48 high productivity districts increased from 36 per cent to 42 per cent during the same period. Further, the output per unit area for high productivity districts increased from about Rs. 1730 per hectare to about Rs. 1829 per hectare while that for low productivity districts declined from Rs. 550 per hectare to Rs. 481 per hectare. The analysis further revealed that during the period 1970-73 and 1975-78, 16 districts recorded negative growth as compared with the 70 districts that had recorded negative growth during the Bhalla-Alagh (1979) study period.

The pattern of growth in the area production and productivity of important crops in Haryana state during 1970-71 to 1985-86 was examined by Tomer (1989). Two tools of analyses were tried; first annual compound growth rates were worked out by fitting exponential function and second the indices were estimated on the basis of triennial average of first three years (1970-71 to 1972-73) as base. He revealed that there has been an increased both in area and productivity of rice, wheat, cotton and rapeseed & mustard and thus a significant increase in their production since 1970-73 in the state. While crops like gram, jowar and sugarcane registered a significant decrease in their production, there was non-significant decrease in production of bajra. maize and barley. Thus it appeared that with the expansion of irrigation and new technology a new trend of specialisation had emerged in which high input intensive crops (except sugarcane) were replaced the other coarse grains and pulse crops.

Panda (1991) attempted to highlight inter-regional disparity and instability in agricultural growth created during a period of 10 years (i.e. 1978-79 to 1987-88) in Orissa state of three principal crops groups by fitting the linear growth model. To analyse yield instability of the crops over the time period coefficient of variation was also worked out. He revealed that the area under cereals showed a negative growth and that of pulses and oilseeds showed a positive growth at state level. The coastal plains and the central table (agriculturally advanced regions) had witnessed negative growth in area under cereals, whereas other two agriculturally less advanced regions had achieved positive growth in area under cereals during the period. The area under pulses and oilseeds had shown positive growth in all four regions. The production growth of cereals and pulses had been positive in all the four regions. In oilseeds, production growth was found to be higher than

that was achieved in case of cereals and pulses in respect to all the regions (excepting the eastern ghats). The yield of oilseeds had performed better than that of cereals and pulses at the state level. Among the four regions, the coastal plains and the eastern ghats had achieved better yield performance in oilseeds than the other two regions. Higher yield instability was found in the central table land as compared to any other region of the state. Crop-wise instability was observed to maximum with oilseeds and minimum with pulses in almost all the region during reference period. The analysis revealed positive association between higher growth in yield and higher fluctuations in case of oilseeds.

Alagh and Sharma (1980) estimated trend in growth rates for foodgrains, sugarcane, major oilseeds, cotton, jute and mesta for country as a whole and major states for three time periods such as 1960-61 to 1969-70, 1969-70 to 1978-79 and 1960-61 to 1978-79. They have found that growth rates at the all India level for all crops were higher in period II as compared to period I. The similar trend was also observed in most of the states. The growth pattern was more evenly spread across regions in period II in comparison to position in period I. Out of 62 pairs of estimated growth rates through regression method, only 9 pair estimates were significant difference existed between the growth rates in 6 pair estimates in the two time periods. The position in the commercial crops showed greater instability in production.

Venkataramanan and Prahladachar (1980) examined the changes in cropping pattern for Rajasthan and five other states (Punjab, Uttar Pradesh, Bihar, Maharashtra and Andhra Pradesh). They observed that the share of foodgrains in the gross cropped area increased from 65 per cent in the

quinquennium 1950-55 to 76 per cent in the quinquennium 1970-75 and correspondingly the share of non- foodgrains declined from 35 to 24 per cent. Among foodgrains, the share of bajra, wheat and pulses in the gross cropped area increased from 26 to 31 per cent, 6 to 9 per cent and 16 to 21 per cent, respectively. Among non- foodgrains, the share of oilseeds and cotton in the gross cropped area slightly improved. The share of miscellaneous crops declined sharply from 28 to 15 per cent in Rajasthan. They also observed that output growth in Rajasthan during 1950 to 1975 was highest for wheat followed by bajra, maize and oilseeds. The highest growth rate in yield was in wheat followed by jowar, bajra, maize and total oilseeds. While, the highest area growth was recorded in wheat followed by maize, pulses, oilseeds, bajra and cotton.

Angrish (1981) estimated the compound growth rates of important crops for western Rajasthan and rest of Rajasthan for the period 1961-62 to 1971-72 and 1966-67 to 1971-72. It was found that growth rates of production of foodgrains as a group bajra, wheat, barley and gram were negative in western Rajasthan during both the periods expect wheat, as against significant and positive growth rates in production of these crops in rest of Rajasthan expect growth in production of barley in former period. There was significant improvement in production and productivity of these crop in the later period over the former. It was concluded that there were imbalances in the agricultural development of the two areas of the state.

Vidya Sagar (1981) analysed the changes in agricultural production and productivity in Rajasthan during 1953-77. A general analysis indicated that the growth path of the gross agricultural output and productivity had been cubic in nature in most of the agricultural regions as well as in the state

as a whole. The gross agricultural output made growth at the enhanced rate of 4.7 per cent per annum during 1965-77 as against 2.9 and 2.5 per cent during 1962-64 and 1952-53 to 1976-77 respectively. Further, against the zero growth during 1952-64, the gross agricultural productivity during 1965-77 grew at the rate of 3.98 per cent per annum. This implied that the productivity alone accounted for the bulk of the output growth during the period 1965-77 as against the growth of area capturing the major share during 1952-64.

Acharya and Gupta (1982) conducted a study to measure the growth in area, production and yield of pulses in the state of Rajasthan. The results revealed that the growth rate of pulse production in the last 25 years was 1.72 per cent per annum. The area and yield almost equally contributed to the growth of production. Gram alone took lion's share in contributing to the growth in pulse production. The growth rate of gram production was more in the post green revolution period. It may be mentioned that more than two-third of the variation in the area and more than half of the variation in the production of all pulses owed to annual rainfall.

Dhaka and Verma (1989) computed and compared the growth rates of area, production and productivity of crop groups (cereals, pulses and oilseeds) and some important crops viz., bajra, guar, wheat, gram and rapeseed & mustard in Rajasthan state, most productive zone (Zone I-B) and III-A (represents the average condition of the state) during entire period 1956-57 to 1987-88 and two sub-periods 1956-57 to 1965-66 and 1966-67 to 1987-88 using exponential function. They revealed that productivity of foodgrains, cereals and oilseeds which was negative during pre green revolution period increased significantly in the state during post-green

revolution period and whole period. This showed that modern technology of high yielding varieties had helped in accelerating the rate of growth in production and productivity of these crop groups. Productivity of pulses was also negative during pre-green revolution period, which improved slightly during post- green revolution period over the pre-green revolution period in the state as well as in both the zones. Production of wheat and rapeseed & mustard increased significant in the state and zones during post-green revolution period and whole period which was contributed both by increase in area as well as productivity. Production of gram also recorded positive growth rate. Productivity of guar crop showed negative growth in the state and zone III-A which caused output to decline during post green revolution period.

Jaganathan (1994) estimated the growth rates of area, production and yield of seven selected crops separately in all periods viz., 1951-52 to 1964-65, 1965-66 to 1990-91 and entire period 1951-52 to 1990-91 in Tamil Nadu by employing linear and log-linear functions. Quadratic and log-quadratic functions were used to estimate and examine whether compound growth rates of area, production and yield were accelerating or decelerating. In order to examine whether growth rates and the compound rates of change in the growth rates for each of the seven major crops with regard to area, production and yield differ significantly, 't' test was used. The study revealed that green revolution had negatively affected the growth rates of area and yield of the selected crops and thereby production either by making the growth rates into negative or by reducing the positive growth rates in period II. The difference between the growth rates of period-I and period-II were statistically significant for area, production and yield. It was mainly due to

the influence of short-term limiting factors, namely unfavourably seasonal factor, insufficient flow of institutional credit to apply the green revolution technology in agriculture and unfavourable terms of trade to the farmers due to high rate of inflation and the long term limiting factors namely the limitation to further exploitation of surface and ground water. These factors reduced the area cultivation and yield and thereby production of the selected crops.

Sundarevaradarajan et al. (1998) studied the performance of agricultural in the union territory of Pondicherry during the period 1956-57 to 1994-95 by dividing the period into five sub periods as pre-green revolution (1956-57 to 1967-68) post-green revolution (1968-69 to 1994-95) overall period (1956-57 to 1994-95) and post-green revolution further divided into two periods viz., early post-green revolution period (1968-69 to 1979-80) and late post-green revolution period (1980-81 to 1994-95). They observed performance of crops in the union territory of Pondicherry in terms of area, production and productivity by employing exponential growth curve (Gujarati, 1995) as A_t or P_t or $Y_t = \beta_0\beta_1^t e^{\mu}t$. The analysis of performance of various crops revealed that cereals registered negative growth rate in area but productivity exhibited a positive growth rate in union territory of Pondicherry. In case of pulses and sugarcane both area and productivity together contributed for higher production. Oilseed showed a declining tendency in area but registered a positive growth rate especially in gingelly due to increase in the productivity. They also analysed the traditional foodgrains like rice and millets, observed decreasing on one side in area while commercial crops such as sugarcane showed a positive shift in area.

Pani and Naik (1997) examined the inter district trends in area, production and productivity of sugarcane in Orissa during 1973-74 to 1990-91 and compared the same with national and global levels. The compound growth rates of area, production and productivity was estimated by using usual formula ($Y= ab^t$). The study further reveals that trend of growth in area (1.04 per cent), production (2.18 per cent) and productivity (1.42 per cent) are positively significant at all India level. Among the sugarcane growing states, Gujarat registered highest growth rate both in area (6.10 per cent) and production (9.89 per cent). Whereas highest declining trend in growth rate of area and production was observed in Rajasthan. The area, production and productivity of sugarcane increased from 41 thousand hectares to 49 thousand hectares 240.63 thousand tonnes to 354.90 thousand tonnes and 59.69 quintals per hectare to 72.43 quintals per hectares respectively during the period of study i.e. 1973-74 to 1990-91 in Orissa state. The trend of growth rates of area is positive and statistically significant in the district of Kalahandi, Bolangir and Garijam. The growth rate of area was negative and statistically significant in Kalahandi, Sambalpur and Sundargarh districts indicating substitution of area under sugarcane by some other crops. They further revealed that the negative productivity growth was mainly due to lack of suitable need based location specific technology at the farmer level. However, the trend of growth in area, production and productivity of sugarcane are positive at all Orissa level indicating gradual improvement in performance of this crop at state level during the period. On an average positive trend in area, production and productivity of sugarcane in Orissa makes it evident that the performance of the crop in the state is satisfactory compared to national level. The growth rates in this state in respect of area, production and productivity of sugarcane was 0.60, 1.47 and 0.76 respectively.

Singh et al. (1997) conducted a study to see the regional variations in agricultural performance in India during period 1960-61 to 1981-82.They estimated growth rates for important food and non-foodgrain crops for the three periods viz., period I (1960-61 to 1967-68). Period II (1968-69 to 1980-81) and period III (1981-82 to 1992-93). Compound growth rates of area, production and yield were estimated by fitting log linear functions of the form, log y= a + bt and growth rates were estimated by (e^b-1) x100. The results of the study showed that in the case of total foodgrains as well as for all the individuals foodgrain crops, yield witnessed higher growth rates as compared to acreage in the last two decades. For individual states, the state of Bihar, Haryana, M.P., Rajasthan, Tamil Nadu and U.P. performed much better than the other states. In the case of non-foodgrain crops, oilseeds maintained steady trend in growth rates during the last two decades. The states of Gujarat, Karnataka, Maharashtra and Tamil Nadu although experienced stagnation in the growth rate of sugarcane production. Cotton maintained an increasing trend in its production and yield growth rates over the years at the national level. The state, Haryana, Punjab, Rajasthan and Karnataka maintained impressive growth rates in the production and productivity of cotton.

Ali and Singh (1995) examined growth rates and variabilities in area, production and productivity of wheat crop in Chattisgarh region and its constituent districts as well as the state of Madhya Pradesh as a whole using time series data from 1970-71 to 1989-90 by divided into two sub periods viz., 1970-71 to 1979-80 and 1980-81 to 1989-90. The study revealed greater variability in area, production and productivity of wheat. They computed coefficient of variation for all the district, region and the state as a whole in

respect of area, production and productivity it ranged from 19.23 per cent in Bilaspur district to 40.40 per cent in Rajnandgaon district. The highest coefficient of variation (36.51 per cent) was observed in the districts of Rajnandgon for area also. The significant growth rates were mostly due to improvement in productivity levels.

Parikh (1966) conducted state wise analysis, covering the states of Bihar, Kerala, Madhya Pradesh, Madras, Mysore, Rajasthan, Uttar Pradesh and West Bengal, showed that coefficient of land was found to be positive and sgnificant in all the states expect Madras. The growth of crop output was explained in terms of land, irrigation and fertilizer. The coefficient of irrigation was positive in Madras, Bihar, Kerala and Uttar Pradesh but significant only in Madras. In other states, it was negative being significant only in Rajasthan. Coefficient of fertilizer was positive in all the states, except Uttar Pradesh and in about half of these states, this coefficient was significant. The contribution of fertilizer was 49 per cent in Kerala, 31 per cent in Madras, 14 per cent in Bihar and less than 8 per cent in all other states.

2.3 DECOMPOSITION ANALYSIS:

Minhas and Vaidyanathan (1965) employed the techniques of, component analysis to estimate the contribution of various factors in the growth production. The study was conducted on country level data for the period of 1951-54 to 1958-61 for 28 major crops of 14 states. Growth in output was decomposed in area, yield, cropping pattern and interaction between yield and cropping pattern. They observed that area and yield attributed 45 and 46 per cent respectively to the growth of output.

Sharma and Subramanyam (1984) attempted for modification of models in order to decompose the output growth in components. They developed the additive model of Minhas and Vaidhyanathan (1965). The study revealed that during 1964-73 there was a significant increase in yield of cereals over the period 1956-65. The study also showed that technology changed the cropping pattern.

The component analysis of the growth of agricultural production in India was pioneered by Minhas and Vaidyanathan (1965) who used for the first time the additive scheme of decomposition. In this scheme, the growth of production was disagregated into area, yield rate i.e. production and cropping pattern as well as an interaction between the later two. Later on, the same model with slight modification was used by Mishra (1971) for decomposition of crop production in Gujarat. Sondhi and Singh (1975) used it for a comparative analysis of the pre-green revolution and green revolution periods.

Bhatia and Sinha (1975) conducted a study for the period 1950-51 to 1970-71 and analysed the relative contribution of different components towards total foodgrains production in Uttar Pradesh, by using decomposition approach. The results of the study showed that during 1950-53 to 1960-63, 56.46 per cent of the additional foodgrain production was contributed by the growth in productivity. Whereas extension of area contributed 34.43 per cent. The contribution of changes in cropping pattern was non-significant during the period. During the period 1960-63 to 1969-72, major contribution to the increased production of foodgrains was again due to increase in yield (61.56 per cent). Extension of acreage under foodgrains had contributed relatively less during this period as compared to

the period 1950-53 to 1960-63. The changes in cropping pattern had contributed more during 1960-63 to 1969-72 as compared to the period 1950-53 to 1960-63.

Vidya Sagar (1977) in his study on growth of agricultural production in Rajasthan in terms of physical components viz., area, level of productivity and prices. He revealed that cropwise maximum increase in the acreage allocation went to bajra whose share in the gross cropped area increased by 10 per cent, the increase in the yield rate being more than fifty per cent. Wheat and oilseeds registered an increase of 7 and 1 per cent in the acreage allocation while the increase in the yield of these crops was 9.29 and 40 per cent, respectively. On the contrary, barley, gram and small millets lost the ground in both, the yield rate as well as their share in the gross cropped area. All those crops which showed an increase in the yield rate but a decrease in the proportion of area had also recorded area increase in absolute. A higher yield rate implied a higher level of production and this may cause price to go down or increase less as compared to the overall price level.

2.4 COINTEGRATION ANALYSIS:

Nelson and Plosser (1982) attempted an exercise to text the aggregate variables for trend stationarity on fourteen annual series. The series started in different years between 1860 and 1909 and ended in 1970. All series except the bond yield was transformed to natural logarithms. Analysing simple autocorrelations of levels first they found the sample auto correlation coefficients to typically start at a value above 0.95 and decay slowly with increasing log for all the series with the exception of unemployment rate which exhibited a more rapid decay. They further reveals that there was a similar pattern of sample autocorrelations of deviations from fitted trend

tines After then they curried out the formal tests of Dickey and fuller and finally concluded that the evidence consistent with the difference stationary representation of non-stationarity in all cases except unemployment rate.

Krishna Kumar and Mittal (1995) studied (i) what factors will determine the performance of Indian tea exports, (ii) what will be the long-term relation between tea exports and its determinants, (iii) will tea exports responsive to changes in world price for tea and exchange rates, (iv) What will be the long-term trends in production, domestic consumption & exports of tea in India and (v) will there be a perfect competition in tea trade. They used unit root test in each time series and see whether it is stationary or non-stationary. They further, see that a time series found to be non-stationary, its first difference is stationary. This technique was repeated till the order of integration of time series. They also employed the co-integration techniques to examine now will the tea markets in various locations are integrated. They concluded the factors that determine exports of tea and observes that tea exports are insensitive to price incentive and to changes in world demand and decrease with increasing share of domestic consumption. It is also observed that the possibility of trade in tea links the domestic price of tea to international price suggesting that if trade products is extended to essential commodities, their domestic price are likely to rise. They also suggested that a policy of export of Agril commodities, particularly essential commodities can not be recommended without caution.

Marjit and Raychaudhari (1997) attempted to test the aggregate variables for trend stationarity. They considered five variables viz. export, import, nominal effective exchange rate (NEER), real effective exchange rate (REER) and unemployment, all in levels through they could not reject

the unit root hypothesis in levels of any of them, they could do that in their first difference and that too without trend.

Mathew et al. (1997) conducted a study to test whether the price of coconut in a central market is integrated with that of the nearly markets in Kerla state during the period Jan.,1970 to December, 1992. The co-integration technique developed by Granger (1986) and Engle and Granger (1987) was employed in this study to test the coconut market integration. The results of the study revealed that the farm prices of coconut in various market of Kerla were integrated of order 1. They also estimated pairwise co-integration regressions with the farm price of Trichur market as independent variable and the respective farm prices in other market as dependent variables, after establishing the order of integration of each variable. The study revealed that all coconut market except Calicut were integrated with Trichur market.

Sinharoy and Nair (1994) examined the movements in international prices of Indian pepper reflects the variations in such prices of the other economies and the domestic price of pepper moved synchronously with the international price by employing a co-integration methodology during the period 1970 to 1990. They reported that two integrated variables can be "co-integrated" when they are convergent (equilibrium) in the long run despite short period divergences. They also reported that the necessary condition of "stationary" in their levels. They used the equation with the first difference as :

$$\Delta P_t = \Phi_0 + \Phi_1 P_{t-1} + \Sigma \Phi_k + \Delta P_{t-k} + Ut$$

Where

$$\Delta P_t = P_t - P_{t-1}$$

$$P_t = \log P_t$$

If with the above first difference the series does not attain stationarity, second order difference were use as

$$\Delta^2 P_t = \theta_0 + \theta_1 P_{t-1} + \Sigma\theta_k \Delta^2 P_{t-k} + Vt$$

Where Δ^2 denotes second difference

They also used Dicky-Fuller (DF) and Augmented Dicky-Fuller (ADF) unit root test to assured stationarity (Dicky & Fuller, 1979). They established the relationship between two price series and expressed as

$$Pit = \alpha_0 + \alpha_1 + Pjt + e_t$$

Where, Pit and Pjt prices of same order of integration e_t is deviations from equilibrium and tends to zero in the long run. The results of the study revealed that due to open trade status for pepper, prices are move synchronously indicating integration of world pepper market. They further revealed that this result is quite striking when the markets for India pepper are considered as against those of other countries. They reported that integration process also implied that the domestic supply variables are responsive to international market conditions.

Raju (2000) attempted a study to examine the relationship between fiscal deficits (FDGI and FISDEF) and Macroeconomic variables (GDCFC, GFCEC, HPM, MJ, GBRT, PFCEC, TFCEC, BKRT) by employing the co-integration techniques using annual data for 46 years period 1952-53 to 1996-97. The unit root test and co-integration test were applied on logges measures of fiscal deficit and macroeconomic variables. Results indicated that the macroeconomic variables and two deficit measures were integrated or order one i.e. I(1). The results further reveals that the two deficit

measures, FDGI and FISDEF and following macroeconomic variables GDCFS, GFCEC, HPM, M3 and GBRT enjoy a cointegration relationship while no cointegration was found for the deficit measures PFCEC, TFCEC and BKRT.

From the available review of literature it can be concluded that most of the researchers have conducted studies in univariate, bivariate and multivariate approaches to analyses the growth pattern of agriculture output of individual crops at the district as well as state level. No study have been undertaken to analyses the agricultural time series data by employing stationary, unit root and co-integration techniques in respect of area, production and productivity of crops at district as well state level so far. This is evident from the fact that such an analysis has never been attempted in the articles published in leading Journal of the Indian Society of Agricultural Statistics.

3. MATERIALS AND METHODS

The present chapter seeks to explain the methodology used in the selection of crops, study period, source of data and analysis by employing various statistical tools in the area, production and productivity of major crops in Udaipur division and Rajasthan state. This chapter is organised into six sections. Section 1 deals with descriptive statistics pertaining to performance and variability analysis of area, production and productivity. The methodologies used for achieving different objectives of the study have been given from section 3.2 to 3.6.

3.1 PERFORMANCE AND VARIABILITY ANALYSIS OF AREA, PRODUCTION AND PRODUCTIVITY:

The comparative study of the variables taken into consideration can be performed with respect to the four fundamental statistical characteristics i.e. central tendency, dispersion, skewness and kurtosis".

3.2 BIVARIATE TIME SERIES ANALYSIS :

The trends in area, production and productivity of selected crops for each district of Udaipur division as well as State of Rajasthan for the study period were studied by using following equations.

Linear Equation: A Linear trend equation is given as below

$$Y_t = a + bt$$

Where Y_t = Area/Production/Productivity in t^{th} year

t = Time variable which take the values 1,2,3, ... n

a = Intercept

b = Regression coefficient

The parameter a and b were estimated by the least squares method.

Exponential Equation:

The compound growth rates of area, production and productivity of selected crops for each district in Udaipur division as well as Rajasthan State were worked out by employing the following formula

$$Y_t = ab^t \quad (1)$$

or $$\log Y_t = \log a + t \log b \quad (2)$$

or $$\log Y_t = A + Bt \quad (3)$$

Where, A = log a and B = log b

Compound growth rate was estimated as follows

Compound growth Rate (CGR) = (Antilog b-1) x 100

Second Degree Curve Fitting to logarithms:

The following equation was used for fitting second degree curve (in logarithms)

$$Y_t = a\, b^t\, c^{t^2} \quad (1)$$

$$\log Y_t = \log a + t \log b + t^2 \log c \quad (2)$$

$$\log Y_t = A + Bt + Ct^2 \quad (3)$$

Where, A = log a, B = log b and C = log c

The values for a, b and c were calculated with the help of least squares techniques.

Where, b = Slope of curve

c = Rate of Change in slope

Further, for each trend equation estimated values of coefficient i.e. regression coefficient (b), CGR (r) and rate of change in the slope (c) were tested for their significance by student t-test. The coefficient of determination (R^2) was also estimated and its significance was tested with the help of F-test for each equation.[1]

3.3 DECOMPOSITION ANALYSIS:

Decomposition of production increase in the current period over the base period was using the method given by Vidya Sagar (1977, 1980) in order to measure the relative importance of area, productivity and their interaction on the change in production.

Decomposition of production increase can be given as

$$P_n - P_0 = A_n Y_n - A_o Y_o \qquad (1)$$

Where,

$$An = Ao + \Delta Ai$$
$$Yn = Yo + \Delta Yi$$
$$= (Ao + \Delta Ai)\ (Yo + \Delta Yi) - AoYo \qquad (2)$$

The equation (2) can be reduced as

$$\Delta Pi = \Delta AiYo + \Delta YiAo + \Delta Ai\Delta Yi$$

1. In case of R^2 gives poor performance modified R^2 would be used.

Change in Production = Area effect + Yield effect + Interaction effect

Here (Pn-Po), (An-Ao), (Yn-Yo) shows current period and based period of production, area and yield respectively. Three year average has been taken on each end.

3.4 STATIONARY AND UNIT ROOT ANALYSIS IN AREA PRODUCTION AND PRODUCTIVITY:

The Augment Dickey and Fuller (ADF) test for unit root has been used to test for non-stationarity. The following equation is estimated using OLS

$$\Delta X_t = \alpha + \beta X_{t-1} + u_t \qquad (1)$$

and this equation is augmented on the right hand side by the lags of independent variable, so that the residuals are not auto correlated. The order of augmentation is chosen in such a way that the LM test for auto correlation does not reject the hypothesis of no auto correlation at 5%.

If the t-value for 'β' exceeds in absolute terms the DF critical value at 5% the hypothesis of unit root is rejected indicating that series is stationary in level, otherwise, it is not rejected.

If the hypothesis of unit root is not rejected at level the equation (1) is estimated with a deterministic linear trend. Rejection of null hypothesis of unit root indicated by higher absolute value of the t-ratio β, than the corresponding critical value implies that the series is stationary about a linear deterministic trend, otherwise it is not even trend stationary. In this case equation (1) is estimated with first difference of X_t in place of X_t .

3.5 COINTEGRATION ANALYSIS:

To see the existence of long run equlibrium relationship between two or more variables, cointegration techniques will be used. The simplest methodology suggested by Engle & Granger (1987) and popularly known as Engle-Granger "two step" method. The method is based on the test the residuals for stationarity using DF/ADF type test for the hypothesis of non-stationarity.

Specifically, the "two steps" of the method are as follows:

Firstly, estimate relationship among the series typically with an intercept and a time trend of the series have a drift, i.e. run the regression.

$$Y_t = \alpha + \beta X_t + u_t$$

In the above equation more variables may be added to the right hand side.

Secondly, to run a (if necessary augmented) Dickey -Fuller regression on the residual (disturbance) agains including an intercept (Granger - Engle, 1991). Thus the following regression equation is run.

$$\Delta \hat{U}_t = \hat{U}_o + \gamma t + \delta \hat{U}_{t-1} + \varepsilon_t$$

lag independent variables are added to the right hand side if the residual is found to be autocorrelated. The t-ratio have a different distribution from the Dickey-Fuller, it is termed as Engle-Grangar distribution and the critical values for this may be found in aforementioned book of these authors.

Finally variables which are stationary in levels of first difference of variables, which are integrated of order 1, may be tested for relationship using OLS regression directly.

3.6 SELECTION OF CROPS, PERIOD AND SOURCES OF DATA:

Selection of crops:

Rajasthan is the largest state of the Indian Union where large variation in the pattern of agricultural development is displayed from one district or region to another. Under this situation, the aggregate analysis is not expected to depict a clear picture about districtwise disparities, due to location specific problems specially tribal belt of the state. All the districts of Udaipur division[1] have been considered for the study.

The following criteria have been employed for the selection of crops (Sharma, 1997). Firstly a crop is selected if it accounts for atleast 5 per cent of the total cropped area (based on five years average i.e. 92-93 to 96-97) in that particular districts. By this many important crops viz. sugarcane, tur, linseed, etc. can not included in the study. To overcome such problems this criteria was modified as follows.

Crops accounts atleast 4 per cent of the total cropped area of that particular crop on the state was also selected from each district of Udaipur division. In the second stage, the criterion of four percent instead of five per cent of the area has been adopted. To include important crop of the district both the criteria were adopted simultaneously. Thus, all the important crops were selected and the total cropped area under the selected crops was more than 75 per cent in all the districts of Udaipur division.

Besides, this important principal crops of Rajasthan state have been also considered for this study. The selected crops of each district of Udaipur division and major principal crops in Rajasthan state are given in the following table.

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1 .Presently, Udaipur division comprises six districts Rajsamand carved out of Udaipur district in the year 1992. All the related figures of Rajsamand district from 1992-93 to 1996-97 were therefore pooled in the data collected from Udaipur district.

Table 3.1 Selected Crops in Udaipur Division and Rajasthan State

S. No.	District/State	Selected Crops
1.	Banswara	Wheat, Maize, Rice, Small Millets, Gram, Kharif Pulses, Tur and Sugarcane
2.	Bhilwara	Jowar, Maize, Wheat, Barley, Sesamum, Groundnut, Linseed and Cotton.
3.	Chittorgarh	Jowar, Maize, Wheat, Gram, Kharif Pulses, Rapeseed & Mustard, Groundnut, Soybean, Linseed and Sugarcane
4.	Dungarpur	Maize, Rice, Small Millets, Kharif Pulses, Gram, Tur and Wheat.
5.	Udaipur	Jowar, Wheat, Maize, Barley, Rice, Small Millets, Tur, Sugarcane and Urd.
6.	Rajasthan	Jowar, Bajra, Maize, Wheat, Barley, Gram, Groundnut, Rapeseed & Mustard, Guarseed and Kharif Pulses.

Selection of Study period:

A period of twenty seven years i.e. 1970 to 1996 has been covered for the study. The said period which has witnessed post-green revolution era.

Sources of Data:

The time series secondary data pertaining to area, production and productivity of selected crops for all the districts of Udaipur division vis-a-vis State of Rajasthan were collected from various published reports of Directorate of Economics and Statistics. Government of Rajasthan, Jaipur. Yearly data related to total cropped area of each district of Udaipur division

and the State as a whole were also taken from the records of Directorate of Agriculture. Government of Rajasthan, Jaipur. The figures of area production and productivity of urad crop of Udaipur district were available from the year 1974-75. Likewise the data for soybean crop in chittorgarh district were available from the year 1983-84, as soybean crop was introduce in Rajasthan state recently.

4. RESULTS AND DISCUSSION

A: PERFORMANCE ANALYSIS OF MAJOR CROPS AT THE DISTRICT LEVEL

The observation on area, production and productivity of different selected crops in the districts of Udaipur division as well as the state of Rajasthan for the years 1970-71 to 1996-97 were subjected to descriptive statistics evaluated by working out average, standard deviation, co-efficient of variation, Skewness and Kurtosis in order to have an idea of temporal distributions for the period under reference. The results have been presented in table 4.1 to 4.6 for area production and productivity of the selected crops.

4.1 INTER -TEMPORAL ANALYSIS:

Banswara:

A temporal view of individual crop in case of maize the average area over different years is 91 thousand hectares with a standard deviation (14.84 thousand hectare) and with a reasonably coefficient of variation (16.37%). Here, the distribution of area over different years is slightly positively skewed as indicated by its value of skewness (0.17). The value of kurtosis (-1.33) indicates the curve is platykurtic shape.

Rice is the next important crop which occupied about 42 thousand hectares of cultivated land when considered over 1970-71 to 1996-97. It remained very consistent over the years as indicated by very small value of standard deviation (4.79 thousand hectares) resulting 11.44% CV The value of skewness and kurtosis here also indicates that the distribution of area under rice during the period under study is positively skewed and platykurtic curve (Table 4.1).

The average area occupied by the small millets is next in order being 15.58 thousand hectares. Here also the SD (5.42 thousand hectares) indicates that the variability is not much high. However, it is slightly higher than what it is observed in case of rice. When compared in terms of CV it can be seen that variability is relatively high (34.83%). Moreover in case of small millets distribution of area over different years positively skewed and the shape of the curve is leptokurtic.

Tur is the only crop among the kharif pulses grown in Banswara district. The average area under tur is 7.69 thousand hectares. In this case also CV indicated high variability though the value of SD is least among all kharif crops. Tur also exhibits positively skewed and slightly leptokurtic curve.

Wheat is the principal cereal crop grown in rabi season, which occupies on an average about 39 thousand hectares of area with substantial variability CV (39.51%). Again area under wheat is observed to be distributed with positive skewness and platykurtic curve.

Gram is the next preferred crop in rabi season. Average area under gram over the years under study is about 36 thousand hectares with 8.36 thousand hectare SD resulting a value of CV (23.41%). The distribution of curve of area under gram is negatively skewed having platykurtic shape.

Average area under kharif pulses over the period under study is 23.36 thousand hectares with relatively high CV(40.98%). The shape of the curve is platykurtic and negatively skewed.

Sugarcane possesses very small area. Over different years the average area under sugarcane is 1.29 thousand hectares. This also depicted relatively high variability indicated by CV (36.8%). Table further reveals that area under sugarcane exhibited highest skewness (1.51) with highly peaked curve with kurtosis (1.47).

The observations on area alone do not provide complete picture of the agricultural situation of the district. It should be coupled with the information pertaining to production and productivity (yield) as well. The statistical

Table 4.1 Statistical Summary of Area, Production and Productivity of Selected Crops in Banswara District

Area (000ha)

Crops	Period 1970-71 to 1996-97				
	AV	SD	CV%	Skew	Kurtosis
Maize	90.6270	14.8442	16.3794	0.1696	-1.3325
Wheat	39.4222	15.5745	39.5069	0.1466	-1.1698
Rice	41.8481	4.7901	11.4463	0.2637	-1.0097
Small millets	15.5852	5.4283	34.8300	0.7927	0.5906
Gram	35.7444	8.3676	23.4096	-0.6525	0.6561
Kh-Pulses	23.3667	9.5766	40.9839	-0.2898	-1.1392
Tur	7.6963	3.3696	43.7821	0.9079	0.1110
Sugarcane	1.2937	0.4770	36.8711	1.5122	1.4789

Production (000 tonnes)

Crops	Period 1970-71 to 1996-97				
	AV	SD	CV%	Skew	Kurtosis
Maize	136.7967	240.7454	175.9877	3.2691	9.9170
Wheat	70.7963	45.5471	64.3354	0.5664	-1.0489
Rice	28.2407	16.3085	57.7483	0.0230	-0.8736
Small millets	2.0689	2.0998	101.4947	1.3717	1.1695
Gram	28.2556	11.7501	41.5850	0.3489	-0.2797
Kh-Pulses	8.1111	6.2833	77.4650	1.4781	2.3258
Tur	3.8852	2.8860	74.2822	1.0026	0.0610
Sugarcane	50.8815	23.8491	36.8711	1.3160	3.0670

Yield (kg/ha)

Crops	Period 1970-71 to 1996-97				
	AV	SD	CV%	Skew	Kurtosis
Maize	796.7407	457.2102	57.3851	0.6096	0.1480
Wheat	1646.0741	513.7609	31.2113	0.0980	-0.9457
Rice	684.0370	428.5605	62.6517	0.5415	-0.2043
Small millets	109.6667	94.5914	86.2536	0.8900	-0.6354
Gram	788.6667	244-8836	31.0503	0.5227	0.2303
Kh-Pulses	391.556	229.3986	58.5865	0.7946	0.2013
Tur	445.7778	191.8867	43.0454	-0.1574	-0.9631
Sugarcane	39540.2222	8649.2796	21.8746	0.1281	-0.0813

summary of production figures of the selected crops for the period under study is presented (Table 4.1). From the table it can be seen that average production of maize for the study period is about 137 thousand tonnes. There is very high variability in the production of maize as indicated by SD (240.74 thousand tonnes). The value of SD is much high than the value of mean. This resulted the value of CV (175.99%). Such a high CV for production indicates that non consistent inference about this crop can be drawn on the basis of production figures. It also resulted very high skewness (3.26) and sharply peaked shape of the curve i.e. leptokurtic kurtosis (9.92).

Rice is the another kharif cereal popular crop in this district after maize. It's average production is about 28 thousand tonnes. This also had CV on higher side (57.74%). The curve of the rice production in Banswara district is slightly positively skewed and platykurtic.

After rice, kharif pulses comes in order, which occupies about 8 thousand tonnes of production during the period under study. The CV here also indicates high variability (77.46%). In this case also one can not much depend for drawing inference on production figures. Relatively much high skewed and peaked curve further brings this crop similar to the maize crop in this regard.

Though the contribution of small millets in total agricultural production of the district is not very high yet its contribution is about two thousand tonnes. Here also very high variability indicated by CV (101.49%) that restricts one to draw reliable inferences. The value of skewness (1.37) and kurtosis (1.17) also suggests similar observations.

Tur is major kharif pulse. Its average production for the period under consideration is about four thousand tonnes. In view of its higher variability (74.28%) and values of skewness (1.00) and kurtosis (0.06) not of much reliance can be considered on production figures about Banswara district.

The average production of sugarcane is about 51 thousand tonnes with high coefficient of variation (46.87%). The distribution curve of the sugarcane production is positively skewed and highly leptokurtic (kurtosis -3.07).

In rabi season, Banswara district produces about 71 thousand tonnes of wheat with CV (64.33%) and coefficient of skewness and kurtosis are (0.56) and (-1.05) respectively.

Similarly, the average production of gram is 28.25 thousand tonnes with corresponding CV as 41.58 per cent. The distribution curve of production of gram positively skewed and slightly platykurtic shape.

Yield is one parameter, which includes area as well as production in it. From the table 4.1, it is clear that maize, rice, tur, kharif pulses and small millets have their respective average yield level as 797, 684, 446, 392 and 110 kg/ha with their corresponding CV as 57.38, 62.65, 43.05, 58.59 and 86.25 per cent. This indicates that only tur has less than 50 per cent CV whereas all remaining kharif crops exhibited with higher variability in productivity. Similarly distribution of productivity figures of only tur is observed negatively skewed whereas that of all remaining kharif crops exhibited positively skewed distribution of their yield data over the year. Moderate departure from normality i.e. laptokurtic shape of the curve is observed in maize and kharif pulses respectively whereas in case of tur and small millets relatively more flatness in curve is discerned. However, in case of rice slightly platykurtic shape of the distribution curve can be seen.

The highest productivity of 39540 kg/ha is obtained for sugarcane with minimum CV (21.87%). Shape of the distribution curve of sugarcane yield over different years is slightly positively skewed and nearly normal (kurtosis -0.08).

The average yield levels of wheat and gram over different years under consideration are 1646 and 788 kg/ha with their respective CV as 31.21 and 31.05 per cent. The positive skewness in case of gram (0.52) is slightly higher than that of wheat (0.09). As regard the extent of flatness or peakedness of the yield distribution curve is concerned, the curve of wheat platykurtic whereas in case of gram laptokurtic.

Bhilwara:

Jowar and maize are two cereal crops of the district in kharif season. The average areas covered under these crops are 29.81 and 135.69 thousand hectares respectively. There is high variability in jowar crop CV (45.33%). Whereas reasonable variability in case of maize CV (11.45%). The distribution curves of area of jowar positively skewed and leptokurtic but in case of maize negatively skewed and platykurtic shape (Table 4.2).

Table 4.2 Statistical Summary of Area, Production and Productivity of Selected Crops in Bhilwara District.

Area (000ha)

Crops	Period 1970-71 to 1996-97				
	AV	SD	CV%	Skew	Kurtosis
Jowar	29.8111	13.5153	45.3364	0.1347	0.3722
Maize	135.6926	15.5388	11.4515	-0.0401	-1.1252
Wheat	77.3852	22.5421	29.1297	0.8799	0.5985
Barley	30.2333	10.8306	35.8233	0.8445	-0.1750
Sesamum	21.3370	9.5560	44.7860	0.9313	0.6105
Groundnut	21.2481	5.6888	26.7732	0.5195	0.3656
Linseed	1.9489	0.8956	45.9551	0.7055	0.7552
Cotton	24.2333	7.6360	31.5103	0.1938	-0.2200

Production (000 tonnes)

Crops	Period 1970-71 to 1996-97				
	AV	SD	CV%	Skew	Kurtosis
Jowar	9.3511	8.6418	92.4147	1.1011	0.8112
Maize	126.0667	47.9594	38.0429	0.7989	0.9122
Wheat	126.5111	78.2593	61.8596	2.0015	4.3485
Barley	39.6889	12.3452	31.1049	0.1721	-0.7692
Sesamum	3.3437	3.4335	102.6857	2.2867	5.5027
Groundnut	12.6089	5.2515	41.6489	0.2401	-1.2311
Linseed	0.5070	0.3226	63.6213	1.4257	2.2239
Cotton	3.8042	1.4870	39.3505	0.0911	-0.0809

Yield (kg/ha)

Crops	Period 1970-71 to 1996-97				
	AV	SD	CV%	Skew	Kurtosis
Jowar	298.1852	178.8211	59.9698	0.3421	-1.2204
Maize	925.2963	327.2993	35.3724	0.8034	0.9126
Wheat	1585.9259	516.6509	32.5772	0.7216	0.0618
Barley	1361.1481	315.2479	23.1604	0.4124	-0.7718
Sesamum	140.0000	81.0859	57.9185	1.0077	1.1375
Groundnut	602.2593	230.2139	38.2250	0.5206	-0.1149
Linseed	242.4074	94.2200	38.8684	0.8396	0.4567
Cotton	158.7778	46.1689	29.0777	0.5249	1.5162

The only case crop in Bhilwara district is cotton, which occupies an average area of 24.23 thousand hectares with moderate variability (31.51%). The distribution curve of area for cotton is positively skewed and platykurtic.

Wheat and barley are two cereal crops of rabi season. The average area under these crops is 77.38 and 30.23 thousand hectares with variability of 22.54 and 10.83 thousand hectares. The values of skewness of the distribution curves are positive (0.88 and 0.84) with shape leptokurtic and platykurtic.

Sesamum and groundnut are oilseeds crops in kharif season. The average areas under both the crops are almost at par that of 21 thousand hectare. There is high variability in case of sesamum CV (44.79%) as compare to groundnut CV (26.77%). Both are positively skewed and the curves are of the leptokurtic shape.

Linseed is another oilseeds crop of rabi season. The average area of crop occupies 1.95 thousand hectares with high variability (45.96%). The value of skewness (0.71) indicates positively skewed and the shape of the curve is of laptokurtic.

The statistical summary for production reveals that among kharif crops maximum production (126.07 thousand tonnes) is under maize followed by groundnut (12.61 thousand tonnes) and jowar (9.35 thousand tonnes). Besides this sesamum, cotton and linseed also contributes significant production of 3.34, 3.80 and 0.51 thousand tonnes respectively. When viewed the variability among kharif crops the highest CV (102.69%) is for sesamum and the least (38.04%) in case of maize. The distribution curves of production in case of all kharif crops are positively skewed and leptokurtic (except for groundnut and cotton).

Wheat and barley are two cereal crops in rabi season with their respective average production as 126.51 and 39.69 thousand tonnes. Wheat exhibited much higher variability (61.86%) as compared to that of barley (31.10%). The distribution curves for the production of wheat positively

skewed and leptokurtic (Kurtosis 4.35) but in case of barley positively skewed and the curve platykurtic shape.

Perusal of table 4.2 for the statistical summary of yield figure indicate that among cereals (Kharif) the maximum productivity is in maize with 925.30 kg/ha and moderate CV (35.37%). The shape of the curve in case of yield of maize is positively skewed and laptokurtic.

Jowar is next to maize in kharif season. The average productivity under this crop is 298.18 kg/ha with high variability (59.97%) as compare to maize. The distribution curve of productivity in case of jowar is positively skewed and platykurtic shape.

Among oilseeds crop during kharif, the average yield levels in respect of sesamum and groundnut are 140 and 602 kg/ha with their corresponding CV as 57.92 and 38.22 per cent respectively. The distribution curves of yield of both of these crops are positively skewed. The shape of curve for yield of sesamum is leptokurtic whereas for groundnut platykurtic.

The cash crop cotton has average yield level of 158.78 kg/ha with variability CV (29%). The shape of curve is positively skewed and leptokurtic.

In rabi season wheat and barely are two cereals crops with average productivity levels 1585.93 and 1361.15 kg/ha. The per cent of variability in these crops are about 33 and 23 respectively. The distribution are curves one positively skewed and the are slightly leptokurtic near to normal (Kurtosis 0.06) in case of wheat whereas in case barley platykurtic shape.

Linseed is rabi oilseeds crop and has a productivity level of 242.41 kg/ha with moderate CV 38.86%. The distribution curve of yield in case of linseed is positively skewed and leptokurtic shape.

Chittorgarh:

The average area under jowar crop in Chittorgarh district is 39.77 thousand hectares when considered over the period 1970-71 to 1996-97. It did not remained consistent over the years as it can be seen from the value of SD (12.12 thousand hectares) resulting high variability as indicated by CV (30.46%). The distribution of area curve under jowar is negatively skewed and the shape of curve platykurtic (Table 4.3).

The highest coverage of average area under maize crop which occupies 118.14 thousand hectares. It remains consistent over the year as indicated by reasonable value of CV (14.17%). Moreover, in case of maize, distribution curve of area is observed negatively skewed and the curve is more that as compare to that of jowar i.e. value of kurtosis (-1.05).

The average area under kharif pulses is 39.68 thousand hectare with variability CV (25.02%). The values of skewness and kurtosis here indicate that the distribution curve of area under kharif pulses is nearly normal and the shape leptokuritc.

The kharif oilseeds crop, groundnut which occupied an average area of 44.97 thousand hectares with reasonable CV (19.88%). Here distribution of area curve under groundnut observed to be negatively skewed and platykurtic shape.

Another oilseeds crop in kharif season is soybean that occupied on an average 37.27 thousand hectares of area in the district which is nearer to that of jowar crop area. The corresponding CV (88.98%) indicates very high variability in the area. Due to high variability the inferences to be drawn are not much reliable. Table further reveals that area under soybean exhibited skewness (0.47) with kurtosis (-1.58).

Under cash crop sugarcane occupies small area of 3.36 thousand hectares with SD (1.29 thousand hectares) indicating the moderate variability CV (28.32%). The variability is more than other kharif crops (except soybean) in the district. The distribution curve of area under sugarcane during the period under study is positively skewed and laptokurtic.

In rabi season the highest average area is under wheat (84.98 thousand hectares) followed by gram (45.79 thousand hectares), rapeseed and mustard (18.59 thousand hectares) and linseed (5 thousand hectares) respectively. The corresponding CV of these crops are 25.02, 42.51, 126.22 and 73.51 per cent respectively. The highest variability among these crops comes out for the rapeseed and mustard followed by linseed gram and wheat respectively. The positive skewness is observed in all the rabi crops as well as positive kurtosis (except linseed). However, the highest skewness (1.58) is observed in wheat, whereas in case of linseed (0.59). As regards the extent of flatness or peakedness of the area distribution curve is little more laptokurtic towards peak in case of wheat whereas that of gram leptokurtic and for linseed platykurtic. However in case of rapeseed and mustard the curve is very near to normality i.e. mesokurtic.

The results of production figures pertaining to selected crops are presented in table 4.3, which reveals that average production of jowar crop is 25.43 thousand tonnes with high variability, CV (56.57%). The high value of CV for production does not permit to have an idea about the preference of the crop. So valid inference can not be drawn on the basis of production figures. The production under jowar is observed to be distributed with positive skewness and platykurtic shape.

The average production of maize occupied 160.63 thousand tonnes. There is high value of CV (35.84%) for production indicates that no reliable inference pertaining to this crop can be drawn with production figures. The distribution curve of the maize production is positively skewed and platykurtic shape.

An another crop kharif pulse that occupies average production of 6.04 thousand tonnes with variability CV (99.21%). Here also one can not draw a reliable inference about the choice of the crop on the basis of production figures. The distribution curve of production is positively skewed and platykurtic shape.

Likewise the average production under sugarcane crop is 153.94 thousands tonnes with moderate variability, CV (41.14%). The shape of the distribution curve of sugarcane production over different years is positively skewed highly peaked (Kurtosis 3.96) i.e. leptokurtic.

The average production of groundnut and soybean is 41.46 and 37.64 thousand tonnes respectively with their corresponding moderate and very high CV as 40.64 and 102.21 per cent. The distribution curve of both of these crops for production are positively skewed and platykurtic shape. The very high variability in production follows the high variability in area in case of soybean crop.

The average production of wheat and gram is 165.28 and 29.96 thousands tonnes with their corresponding moderate and high CV as 45.10 and 55.05 percent. It can be further seen that the average production in rabi season for wheat crop is maximum compares to other rabi crops. The distribution curves of both of these crops are positively skewed and shape of curve platykurtic.

Among oilseeds crops in rabi seasons the average production of rapeseed & mustard and linseed is 17.58 and 1.49 thousand tonnes. The value of CV for these crops is very high i.e. 132.29 and 67.54 percent. The shape of the distribution curves of rapeseed of mustard and linseed production over different years are positively skewed and leptokurtic and platykurtic shape.

Results of yield pertaining to selected crops are presented in table 4.3. From the table it can be observed that the yields of jowar, maize and kharif pulses are 629, 1353 and 358 kg/ha with their corresponding CV as 41,29 and 37 per cent. While among oilseeds crops in kharif season the yield levels for groundnut & soybean are 913 and 774 kg/ha with their respective CV as 31 and 56 percent. This indicates that only maize had less than 30 percent CV whereas all rest among cereals crop exhibited moderate variability in productivity. Among all the oilseeds crops groundnut has lowest CV (31.14%) The distribution curve of productivity value of the jowar is positively skewed where as maize negatively skewed. Similarly among oilseeds crops kharif season, the distribution curve of productivity values of groundnut is positively skewed whereas in case of soybean negatively skewed. The distribution curve is nearly normal (Kurtosis -0.09) in case of maize whereas in case of jowar and kharif pulses playkurtic shape. The shape of distribution curve in case of groundnut and soybean also remain platykurtic shape.

Among crop of rabi season highest yield level achieved by wheat (1852 kg/ha) followed by gram (632 kg/ha) with their corresponding moderate CV as 34 and 31 percent respectively. The distribution curves of yields of both of these crops are positively skewed. The shape of curve in case of wheat is leptokurtic but approaching towards peakedness whereas in gram platykurtic.

Among oilseeds crop of rabi season the yield levels in respect of rapeseed & mustard and linseed are 748 and 344 kg/ha respectively with their corresponding moderate CV as 32 and 31 percent. The distribution curve of yield of rapeseed & mustard is negatively skewed and platykurtic whereas in case of linseed positively skewed and leptokurtic.

Table 4.3 Statistical Summary of Area, Production and Productivity of Selected Crops in Chittorgarh District.

Area (000ha)

Crops	Period 1970-71 to 1996-97				
	AV	SD	CV%	Skew	Kurtosis
Jowar	39.7741	12.1165	30.4632	-0.3126	-0.5955
Maize	118.1370	16.7428	14.1724	-0.4485	-1.0579
Wheat	84.9852	21.2638	25.0206	1.5779	4.1647
Gram	45.7926	19.4651	42.5071	1.1210	0.9150
Kharif Pulses	39.6815	10.1337	25.5376	0.0052	0.1110
Rape & Mustard	18.5940	23.4646	126.2190	1.1329	0.0854
Groundnut	44.9704	8.9406	19.8810	-0.2925	-0.5649
Soybean	37.2571	33.1549	88.9892	0.4773	-1.5824
Linseed	5.0000	3.6756	73.5119	0.5982	-1.1025
Sugarcane	3.3630	1.2888	38.3219	1.0661	1.5442

Production (000 tonnes)

Crops	Period 1970-71 to 1996-97				
	AV	SD	CV%	Skew	Kurtosis
Jowar	25.4333	14.3882	56.5722	0.6233	-0.3960
Maize	160.6348	57.5727	35.8408	0.2729	-0.5110
Wheat	165.2852	74.5472	45.1022	1.3544	0.8677
Gram	29.9630	16.4933	55.0456	1.0134	0.8819
Kharif Pulses	6.0407	5.9931	99.2112	0.7692	-0.7439
Rape & Mustard	17.5815	23.2594	132.2951	1.2195	0.2134
Groundnut	41.4593	16.8492	40.6404	0.5370	-0.5160
Soybean	37.6404	38.4728	102.208	0.7037	-0.9037
Linseed	1.4881	1.0050	67.5359	0.4346	-1.3028
Sugarcane	153.9385	63.3245	41.1362	1.7124	3.9565

Yield (kg/ha)

Crops	Period 1970-71 to 1996-97				
	AV	SD	CV%	Skew	Kurtosis
Jowar	628.6296	259.7166	41.3147	0.1964	-0.6517
Maize	1353.0741	401.4714	29.6711	-0.1121	-0.0902
Wheat	1852.2963	630.4251	34.0348	1.3297	2.3661
Gram	631.6667	192.7386	30.5127	0.3542	-0.6220
Kharif Pulses	358.2593	133.3479	37.2211	-0.4993	-1.2384
Rape & Mustard	748.7037	242.2521	32.3562	-0.0801	0.2005
Groundnut	912.7037	284.2420	31.1429	0.4259	-0.3658
Soybean	774.0754	436.3445	56.3701	-0.1382	-0.9774
Linseed	343.7407	107.0221	31.1346	1.2619	1.5722
Sugarcane	47628.9259	9451.7082	19.8445	0.1504	-0.8468

The highest productivity level achieved by the sugarcane is 47629 kg/ha with reasonably CV (19.84%). The shape of the distribution curve of sugarcane yield over different years is positively skewed and platykurtic. Due to low value of CV the reliable inferences can be drawn.

Dungarpur:

The selected crops during the kharif season are maize, rice, small millets, kharif pulses and tur respectively whereas in rabi season only wheat and gram in Dungarpur district for the period under study.

Maize is major kharif crop, which occupied on our average 49.54 thousand hectares of area for the period 1970-71 to 1996-97. During the period it remained consistent as indicated by the value of SD (5.65 thousand hectare) and resulting CV (11.41%). The values of skewness and kurtosis indicated that the distribution of area under maize crop in negatively skewed and the shape of curve platykurtic (Table 4.4).

After maize, another important crop rice is preferred in the district. The average area under rice is 32 thousand hectares. Here also the SD (7.74 thousand hectares) indicating that the variability is slightly higher than maize crops. Further when compare in terms of CV it can be seen that variability is more than twice i.e. CV (24.19%). Looking at the values of skewness and kurtosis, the distribution of the area under rice over different year is negatively skewed and the curve remains similar as that of maize i.e. platykurtic.

The average area under small millets is 9.68 thousand hectares. In this crop CV (37.48%) indicates high variability though the value of SD is least as compared to maize and rice crop. Further, area under small millets is observed to be distributed positively skewed and the shape of curve platykurtic.

Besides this, kharif pulses occupied average area about 16 thousand hectares during the study period. On observing CV (42.34%) it indicates very high variability as compared to other kharif crops like maize rice and small millets. However, for kharif pulses area distributions curve is positively skewed and having platykurtic shape.

A very small area is occupied under tur crop. Over the different years, the average area under tur is 2.07 thousand hectares. This shows relatively very high CV (88.71%) though the value of SD is least among all the kharif crops. Table further reveals that area under tur exhibited highest value of skewness (3.93) with sharply peaked curve (kurtosis 18.04) i.e. leptokurtic shape.

Table 4.4 Statistical Summary of Area, Production and Productivity of Selected Crops in Dungarpur District.

Area (000ha)

Crops	Period 1970-71 to 1996-97				
	AV	SD	CV%	Skew	Kurtosis
Maize	49.5444	5.6535	11.4111	-0.2729	-0.3657
Rice	32.0074	7.7436	24.1931	-0.0784	0.7725
Small millets	9.6778	3.6276	37.4838	0.5905	-0.8225
Kharif pulse	15.6222	6.5985	42.2379	0.0937	-1.0226
Gram	17.2652	7.5719	43.8564	0.7723	1.7135
Tur	2.0741	1.8401	88.7174	3.9270	18.0442
Wheat	24.7185	6.5197	26.3757	0.2090	-0.6637

Production (000 tonnes)

Crops	Period 1970-71 to 1996-97				
	AV	SD	CV%	Skew	Kurtosis
Maize	37.8296	17.9911	47.5583	-0.0279	-0.8030
Rice	23.2741	16.1991	69.6016	0.6155	-0.2212
Small millets	3.8685	4.0303	104.1811	1.0043	-0.4568
Kharif pulse	6.2185	4.4641	71.7877	0.3683	-1.0177
Gram	12.9070	5.6799	44.0059	0.5354	0.4066
Tur	0.7776	0.7291	93.7648	1.1251	1.9750
Wheat	37.5000	13.7481	36.6615	0.4945	-0.2263

Yield (kg/ha)

Crops	Period 1970-71 to 1996-97				
	AV	SD	CV%	Skew	Kurtosis
Maize	757.1852	351.4859	46.4201	-0.0675	-1.0739
Rice	668.4815	380.6616	56.9442	0.0269	-1.1357
Small millets	332.6985	287.2295	86.3333	0.4728	-1.4765
Kharif pulse	428.2593	297.0016	69.3509	0.2524	-1.2909
Gram	803.2222	300.1805	37.3720	0.8390	0.5635
Tur	421.5556	254.2490	60.3121	-0.0670	-1.2961
Wheat	1504.7037	366.4557	24.3540	1.5470	4.8453

In rabi season wheat is the major crop grown in Dungarpur district, which occupied on an average about 24.72 thousand hectares of area with variability CV (26.37%). The values of skewness and kurtosis here also indicates that the distribution curve of area under wheat during the period under study is positively skewed and of platykurtic shape.

The average area occupied under the crop gram is next in order being 17.26 thousand hectares. Here the value of SD (7.5 thousand hectares) indicates the variability is not much high. However it is little higher than the crop wheat. When compared in terms of CV it can be seen that variability in gram is relatively high (43.86%) than the wheat. The distribution of area curve under the crop gram is positively skewed and with leptokurtic shape.

To have an overall scenario of agricultural situation in the district only area figures do not reflect correct picture. Therefore the figures related to productions and yield should be coupled with it. The statistical summary of production figures for selected crops are presented in table 4.4, which reveals that average production of maize is about 39 thousand tonnes. There is high CV (47.56%) for production indicates that no reliable inference in relation to this crop can be drawn on the basis of production figure. The distribution curve of the maize production slightly negatively skewed and having platykurtic shape.

Another major crop of the district is rice in kharif season, which occupies an average 23 thousand tonnes of production. The value of CV here also indicates high variability (69.61%), one can't draw reliable inferences. Table also reveals that production distribution curve of crop rice exhibited positive skewness (0.61) and the shape of curve platykurtic (kurtosis, -0.22).

The average production of small millets for the period under study is about four thousand tonnes with very high variability observed i.e. CV (104.18%). Here it is to be observed that the values of SD is greater than

mean resulting the very high value of CV. For such a high CV in production data, no consistency is exhibited therefore reliable results are not possible to draw. The production distribution curve under small millets is positively skewed and having platykurtic shape.

Likewise kharif pulses also occupies six thousand tonnes of production .The CV here also indicates high variability (71.79%). Similarly in this case also reliable inference can't be obtained for this crop. The values of skewness and kurtosis express that production distribution curve of kharif pulses positively skewed and platykurtic shape.

The average production of tur is very less i.e. 0.77 thousand tonnes with SD (0.73 thousand tonnes) resulting the value of CV (93.76%) since the value of SD being nearer to value of mean, it resulted very high CV The values of skewness and kurtosis are 1.12 and 1.97 respectively resulting the shape of the curve positively skewed and leptokurtic.

During rabi season the average production of the crops wheat and gram is 37.50 and 12.91 thousand tonnes respectively with their corresponding CV as 36.16 and 44 per cent. The shape of the curves of production of these crops are positively skewed and platykurtic in case of wheat but leptokurtic in case gram.

The statistical summary table of productivity of selected crop in Dungarpur district presented in table 4.4, which reveals that average yield of maize crop (757.18 kg/ha) under kharif season is highest followed by rice (668.48 kg/ha), kharif pulses (428.26 kg/ha), tur (421.56 kg/ha) and small millets (332.69 kg/ha) respectively with their corresponding CV as 46.42, 56.94, 69.35, 60.30 and 86.33 per cent. This clearly indicates that only maize crop had less than fifty per cent CV whereas other remaining kharif crops exhibited very high variability in productivity. The distribution curves of productivity of maize and tur are negatively skewed but approaches towards

normal whereas of all other remaining kharif crops exhibited positively skewed. The distribution curves of yield of all the kharif crops viz., maize, rice, small millets, kharif pulses and tur have platykurtic shape.

In rabi season the average yields in respect of wheat and gram over the different years under study are 1504.70 and 803.22 kg/ha with their CV as 24 and 37 per cent respectively. Table further reveals that average yield under wheat exhibited highest value of skewness (1.54) and highly peaked curve i.e. leptokurtic shape due to value of kurtosis (4.86). Whereas in case of gram the value of skewness (0.83) and kurtosis (0.56) expresses positively skewed and leptokurtic shape of the curve.

Udaipur:

From table 4.5 the statistical summary of area, production and productivity of selected crops for the year 1970-71 to 1996-97 can be discerned in respect of Udaipur district.

Among the kharif crops average area (199 thousand hectares) under maize is maximum followed by Jowar (18 thousand hectares). Urad too occupy a significant average area (17.33 thousand hectares) of the area under kharif crops. Average area under the rice is about 15 thousand hectares. Sugarcane and small millets occupied an average area of 8 thousand hectares and five thousand hectares, respectively and minimum of about two thousand hectares among the kharif crop is occupied by tur. When viewed about the variability, the highest variability CV (63.42%) is observed in case of small millets and the least (10.15%) in case of maize. The curves of distribution of area in case of all (except rice and maize) are positively skewed and leptokurtic for the crop of jowar, rice and urd only whereas for the remaining kharif crops it is platykurtic.

In the rabi season only wheat and barley are the discernable crops with their respective average area as 77 and 32 thousand hectares. Barley exhibited much higher variability CV (45.12%) as compared to the wheat (25.12%). The distribution curve for the area figures of wheat is negatively skewed and leptokurtic whereas that of barley is positively skewed and platykurtic.

Table 4.5 Statistical Summary of Area, Production and Productivity of Selected Crops in Udaipur district.

Area (000ha)

Crops	Period 1970-71 to 1996-97				
	AV	SD	CV%	Skew	Kurtosis
Jowar	18.0630	6.4219	35.5529	0.8132	0.6522
Wheat	76.6407	19.2532	25.1213	-0.4770	0.6581
Maize	199.4889	20.2437	10.1478	-0.5965	-0.7226
Barley	32.0963	14.4813	45.1182	0.5003	-0.6119
Rice	14.6926	3.3209	22.6026	-0.8664	1.4014
Small millets	5.4444	3.4529	63.4207	0.6374	-0.1241
Tur	1.8889	0.9001	47.6546	0.6149	-0.8343
Sugarcane	8.3667	2.5066	46.7070	0.3417	-0.6348
Urd	17.3391	2.5353	14.6221	0.4524	2.3515

Production (000 tonnes)

Crops	Period 1970-71 to 1996-97				
	AV	SD	CV%	Skew	Kurtosis
Jowar	7.1926	5.4755	76.1264	1.5911	2.1666
Wheat	136.0111	50.1235	36.8525	0.4701	0.3711
Maize	192.1852	73.1438	38.0590	0.1203	-0.5031
Barley	46.7444	18.7507	40.1133	0.8535	0.6564
Rice	9.7593	6.5995	67.6235	0.3940	-0.9183
Small millets	1.7259	2.0427	118.3559	1.5110	1.5944
Tur	0.8326	0.8219	98.7180	1.9868	4.7875
Sugarcane	217.6778	119.1402	54.7324	0.7479	0.0523
Urd	4.8739	2.6595	54.5660	0.3116	-0.1875

Yield (kg/ha)

Crops	Period 1970-71 to 1996-97				
	AV	SD	CV%	Skew	Kurtosis
Jowar	386.7407	212.5173	54.9508	0.6804	0.2578
Wheat	1758.9259	475.6581	27.0425	1.1783	2.5075
Maize	960.1852	343.4332	35.7674	-0.0926	-0.7819
Barley	1536.6296	348.9804	22.7108	0.6511	-0.3774
Rice	632.7037	348.5397	55.0873	-0.0701	-1.2529
Small millets	292.9259	206.5500	70.5127	0.2837	-1.2332
Tur	379.2593	220.5491	58.1526	0.6237	0.7674
Sugarcane	40239.02	7483.2822	18.5994	-0.1245	-0.9062
Urd	280.3913	155.8620	55.5837	0.4774	-0.0666

Further view on the table for statistical summary figures indicate that average production of maize in Udaipur district is 192.18 thousand tonnes with 38.06% of CV and positive skewed, platykurtic shape of distribution curve. The average production of urd, rice, jowar, small millets, tur and sugarcane is about 5, 10, 7, 2, 1 and 218 thousand tonnes respectively. Among these kharif crops highest variability CV (118.36%) is exhibited by small millets which has positive skewness and leptokurtic shape of the distribution curve for production figures. The higher variability in case of tur, jowar, rice, sugarcane and urd is observed as 98.72, 76.13, 67.62, 54.73 and 54.57 per cent respectively. The curve of all these kharif crops is positively skewed. The extent of positively skeweness is much higher in case of tur, small millets and jowar as compared to other crops. The distribution curves for production figures in case of kharif crops are platykurtic in case of maize, rice and urd whereas for others leptokurtic.

Perusal of statistical summary for yield reveals that among the kharif crops highest productivity in case of sugarcane being 40239 kg/ha with least CV (19%). The shape of the curve in case of yield figure of sugarcane is negatively skewed and platykurtic.

Average productivity for maize, jowar, barley, rice, small millets, tur and urd is about 960, 387, 1537, 633, 293, 379 and 280 kg/ha respectively with their corresponding values of CV as 35.77, 54.95, 22.71, 55.09, 70.51, 58.15 and 55.58 per cent respectively. For the crops of maize and rice the distributions of yield is negatively skewed whereas for the others positively skewed. When the flatness or peakedness of the curve relative to normal curve is judged through kurtosis it is discerned that the curves of yield in case of maize, rice, small millets and urd are platykurtic whereas those of other kharif crops are laptokurtic.

Rajasthan:

The information on various statistical parameters in case of selected crops for different districts can be meaningfully viewed and interpreted if same information about similar parameters for state and/or nation is also readily available for quick comparisons. In view of this an attempt has been made for state of Rajasthan to have an idea of temporal distribution for the period under study. The statistical summary of area, production and productivity of major principal selected crops in the state presented in (Table 4.6).

Major principal crops in kharif season are jowar, bajra, maize, kharif pulses and guarseed whereas for rabi season wheat, barley and gram has been selected for the study. Besides this groundnut and rapeseed & mustard also included among oilseeds crops. Among kharif cereals the highest coverage of area is under bajra (4696.67 thousand hectares) followed by maize (869.55 thousand hectares) and jowar (731.95 thousand hectares) respectively. A very reasonable co-efficient of variation is obtained for maize (9.61%) and bajra (12.00%). The distribution curves of area in all the three crops are negatively skewed and the shape of the curves is platykurtic. The same results in case of maize crop have been obtained in Bhilwara, Dungarpur, and Udaipur district whereas in case of jowar, it is similar to Chittorgarh district.

In the state the average area occupied under groundnut is 244.02 thousand hectares and with again reasonable CV (17.75%). The shape of distribution curve in this case is positively skewed and leptokurtic i.e. peaked one. This also supports the result of Bhilwara district in case of groundnut crop.

Guarseed is kharif crop, which occupied an average area of 1727.76 thousand hectare with variability (25.32%). The distribution curve of area in case of guarseed is negatively skewed and platykurtic shape.

Likewise kharif pulses in the state occupied larger area than guarseed i.e. 1890.39 thousand hectares with reasonable CV (13.75%). The shape of distributions curve is negatively skewed and leptokurtic nearly normal. The same results have been obtained in case of kharif pulses in Dungarpur district pertaining to the distribution of curve.

Table 4.6 Statistical Summary of Area, Production and Productivity of Selected Crops in the State of Rajasthan.

Area (000ha)

Crops	Period 1970-71 to 1996-97				
	AV	SD	CV%	Skew	Kurtosis
Jowar	731.9452	313.1191	42.7790	-0.8694	-0.2312
Bajra	4696.6719	563.6863	12.0018	-0.3288	-0.1601
Maize	869.5496	83.5852	9.6125	-0.5598	-0.8527
Wheat	1839.7985	280.5512	15.2490	0.4777	-0.3432
Barley	369.8622	165.2669	44.6834	1.0282	0.5440
Gram	1514.4885	305.0069	20.1393	-0.7058	0.6005
Groundnut	244.0219	43.3138	17.7500	1.0341	3.2355
Rape & Mustard	1051.9615	836.2516	79.4945	0.7936	-0.9034
Guarseed	1727.7637	437.5183	25.3228	-0.7096	-0.3517
Kharif Pulses	1890.3893	259.8672	13.7468	-0.5639	2.9940

Production (000 tonnes)

Crops	Period 1970-71 to 1996-97				
	AV	SD	CV%	Skew	Kurtosis
Jowar	329.8874	126.3087	38.2884	0.4521	-0.2989
Bajra	1479.8256	776.4028	52.4658	0.4718	-1.0970
Maize	799.9026	275.0405	34.3843	0.3277	-0.4455
Wheat	3339.3689	1305.3023	39.0883	0.9381	0.4875
Barley	515.6400	169.5626	32.8839	1.2721	1.8499
Gram	1032.1259	317.4659	30.7584	0.3098	-0.7379
Groundnut	171.6337	52.8177	30.7735	0.2342	-0.2927
Rape & Mustard	864.8067	795.2300	91.9547	0.8554	-0.5886
Guarseed	476.3507	364.8308	76.5887	1.9133	5.6707
Kharif Pulses	364.4052	201.9762	55.4263	-0.0654	-1.4293

Yield (kg/ha)

Crops	Period 1970-71 to 1996-97				
	AV	SD	CV%	Skew	Kurtosis
Jowar	374.2963	114.3409	30.5482	0.1145	-0.8379
Bajra	308.8519	145.6512	47.1589	0.3229	-1.1139
Maize	915.4815	286.4215	31.2864	0.1124	-0.7400
Wheat	1774.1111	486.3026	27.4111	0.4414	-1.1150
Barley	1473.8148	270.0511	18.3233	0.4743	-0.5540
Gram	672.9259	108.0566	16.0577	0.3884	-0.4274
Groundnut	708.9630	203.3399	28.6813	0.3799	0.7443
Rape & Mustard	722.9630	202.0955	27.9538	-0.6697	-0.4305
Guarseed	226.1852	115.1173	50.8952	0.2463	-1.0739
Kharif Pulses	187.8519	99.7866	53.1198	0.0459	-1.1025

The rabi crops viz. wheat, barley and gram occupied an average area of 1839.80, 369.86 and 1514.49 thousand hectares respectively. A reasonable CV in case of wheat (15.25%) and gram (20.14%) is obtained whereas in case of barley it is on higher side (44.68%). The value of skewness is positive in case of wheat and barley but it is negative in case of gram. The shape of the curve is leptokurtic in case of barley and gram but it is platykurtic in case of wheat crop. Further it is also observed that the shape of distribution curve of area is similar in case of wheat as in Banswara and Dungarpur district. However in case of gram the result is similar in Banswara district as far as the distribution curve of area is concerned.

Rapeseed & mustard, which occupies an average area of 1051.96 thousand hectares with very high variability (79.49%). The distribution curve of area is positively skewed and platykurtic shape.

Perusal of statistical summary for production reveals that among kharif cereal highest production is obtained in case of bajra (1479.83 thousand tonnes) followed by maize (799.90 thousand tonnes) and jowar (329.89 thousand tonnes) respectively. When viewed the variability, it is observed that bajra accounts highest CV as compared to rest of two. The shape of distribution curve of production of all three crops are positively skewed and platykurtic. The result is similar in case of jowar and maize crop in Chittorgarh district as regard to the distribution curve of production is concerned.

The average production of groundnut in the state during the period under study is 171.63 thousand tonnes with variability CV (30.77%). The distribution curves of production is positively skewed and platykurtic shape. It is similar as in case of jowar and maize.

Likewise the average production of guar is 476.35 thousand tonnes with very high value of CV (76.59%) and shape of distribution curve is positively skewed and leptokurtic.

A significant contribution is also from kharif pulses, which has an average production of 364.41 thousand tonnes with very high variability (201.98 thousand tonnes) resulting high value of CV (55.43%). The distribution curve of production figures in case of kharif pulses negatively skewed and platykurtic in shape.

Among rabi crops maximum production is from wheat (3339.37 thousand tonnes) followed by gram (1032.13 thousand tonnes) and barley (515.64 thousand tonnes) respectively. All these are having high value of CV and ranging from 31 to 39 per cent. The curves of distribution of production in all three crops are positively skewed and leptokurtic in shape for wheat barley but in case gram platykurtic. Further, the distribution of curve for production of wheat in case of Bhilwara, Chittorgarh and Udaipur district are same as that of State. However in case of barley the results of Udaipur is same as that of state.

The average production of rapeseed & mustard is 864.81 thousand tonnes with very high value of CV(91.95%) and shape of distribution curve is positively skewed and platykurtic in shape.

From table 4.6 the statistical summary pertaining to yield figures, which reveals that among kharif cereals maximum yield level is of maize (915.48 kg/ha) followed by jowar (374.29 kg/ha) and bajra (308.85 kg/ha) with their corresponding values of CV are as 31.28, 30.54 and 47.16 per cent respectively. The shape of the curves of yield of all the three crops are positively skewed and laptokurtic. The results of distribution curves in respect of jowar in Bhilwara and Chittorgarh district are same as that of state.

The productivity level in case of groundnut is 708.96 kg/ha with CV (28.68%) and shape of distribution curve is positively skewed and leptokurtic. The yield levels in respect of guarseed and kharif pulses are 226.18 and 187.85 kg/ha with their corresponding CV as 50.90 and 53.12 per cent. The shape of distribution curves are positively skewed and platykurtic.

Among rabi crop maximum yield level is obtained in wheat (1774.11 kg/ha) followed by barley (1473.81 kg/ha) and gram (672.93 kg/ha) respectively. When considering the values of CV of these crops there is reasonable CV in case of barley (18.32%) and gram (16.06%) whereas in case of wheat (27.41%). The distribution curves for all these crops are positively skewed and platykurtic shape. Further in case of wheat and gram the distribution curve in Banswara district is similar to that of state. Moreover the distribution curve in case of barley in Bhilwara and Udaipur districts are similar to the state.

Rapeseed & mustard has a yield level of 722.96 kg/ha with CV (27.95%) and shape of the distribution curve is negatively skewed and platykurtic. The result is similar to that of Chittorgarh district in case of rapeseed & mustard crop as regards to the distribution of curve is concerned.

4.2 BIVARIATE TIME SERIES ANALYSIS :

Trend analysis is an important technique for the studying the performance of a variable over long period of time. In present investigation an attempt has been made to have an idea of relative growth of an area, production and productivity of individual crop in different district of Udaipur division vis-à-vis that of some important crop at state level. This analysis is of immense use in taking policy decision and identifying specific strategies for a balance development of the district.

A number of linear and non-linear model can be built up but mostly the linear modal ($Y_t = a + bt$) is found capable of explaining much of the variation in the data pertaining to area, production and productivity. However, in present study suitability of linear, log linear, quadratic and log quadratic equations were examined for explaining the trend.

In the linear equation ($Y_t = a + bt$) b gives an estimate of the absolute increase in area or production or productivity per unit time. If the linear rate of growth ($r = b/H.M \times 100$) is constant over the period; the compound rate of growth can not be constant; in fact the former implies a declining compound rate of growth. This has been made the basis for fitting both the linear and the log linear equations. A log linear equation $\log Y_t = a+bt$ is also fitted on the 'a priori' consideration that change in output in a year would depend upon the output in the preceding year. To test whether the rate of growth is in fact constant over the period, is same as to test whether 'C' in equation $\log Y_t = a +bt+ct^2$ is significantly different from zero. It is evident that if the rate of growth is not uniform over the period, it is either increasing or decreasing depending upon the sign of 'C'.

Trend in area, production and productivity of major crops:

In this section trend in area, production and productivity of selected crops at the district level have been analysed for the period from 1970-71 to 1996-97 by using all the four trend equations mentioned above. However, the results have been interpreted on the basis of R^2 values obtained through different equations. To judge whether the compound growth rate was uniform or not over the period, the coefficient 'C' in the equation $\log Y_t = a+bt+ct^2$ was tested. The regression coefficient, compound growth rates and coefficients of determination in respect of area, production and productivity of selected crops are presented in tables 4.7 to 4.12 for Banswara, Bhilwara, Chittorgarh, Dungarpur, Udaipur district and Rajasthan state respectively.

Banswara:

It is clear from the table 4.7 that in case of maize there is a significant R^2 in case of area, production and productivity. Further, the value of R^2 in case of area ranged from 0.93 (linear equation) to 0.94 (quadratic equation). Likewise in case of production it ranged from 0.84 (linear equation) to 0.89 (quadratic equation) and in case of productivity 0.49 (log linear equation) to 0.62 (quadratic equation).

The explained variation in case of linear equation is almost of the same order as it was in quadratic or other equation. Therefore, for the sake of clarity and ease of understanding it is recommended that for Banswara district in maize crop linear equation ($Y_t = a+bt$) can be considered as suitable equation for explaining the trend. The regression co-efficient (b) clearly indicates that in case of area, there is growth of 1.9 thousand hectare per year. Similarly every year production is augmented by 5.27 thousand tonnes and corresponding increase in the productivity per year is 49.26 kg/ha. Table further reveals that in case of wheat, kharif pulses and small millets the equation significantly explained the variation in area and production as indicated by the significant R^2 values. In case of wheat log quadratic equation individually explained maximum variation (36%) in production where as in case of area all the four equations could explained 93% variation. Therefore, use of log quadratic equation is more suitable for this crop.

Similarly in case of small millets linear equation though capable of explaining slightly less variation in case of area than the log linear equation, can be preferred on account of its capacity to explained significantly (30%) the variation in production also. Interestingly all the three i.e. area, production and productivity of small millets declined. From table it can be seen that there is a reduction of 0.52 thousand hectares area per year, 0.1458 thousand tonnes production per year and 4.83 kg/ha. productivity per year when viewed through linear equation.

Table 4.7 **Regression Co-efficients, Compound Growth Rates and Coefficient of Determination of Area, Production and Productivity of Selected Crops in Banswara District for Various Equations**

Crops	Equation	Period 1970-71 to 1996-97								
		Area			Production			Productivity		
		t	t^2	R^2	t	t^2	R^2	t	t^2	R^2
Maize	1	1.9002** (0.0979)	-	0.9378**	5.2739** (0.4523)	-	0.8447**	49.2680** (8.3961)	-	0.5794**
	2	5.3444** (0.339)	-	0.9170**	8.4940** (0.724)	-	0.8600**	3.0043** (0.616)	-	0.4910**
	3	1.4368** (0.4030)	0.0165 (0.0140)	0.9412**	0.3630 (1.6134)	0.1754** (0.0559)	0.8898**	-7.8523 (13.4695)	2.0400 (1.1601)	0.6274**
	4	0.032** ($)	-£ (£)	0.9268**	0.0282* (0.012)	£ (£)	0.8622**	-$ (0.0105)	£ (£)	0.5412**
Rice	1	0.1969 (0.1141)	-	0.1065	-0.2292 (0.4084)	-	0.0124	-10.7082 (10.5842)	-	0.0393
	2	0.4849 (0.277)	-	0.1135	0.1747 (2.168)	-	£	-0.3517 (2.134)	-	$
	3	0.4194 (0.4809)	-$ (0.0167)	0.1149	-3.1190 (1.6193)	0.1032 (0.0561)	0.1344	-91.2965* (41.5000)	2.8782* (1.4385)	0.1767
	4	$ ($)	-£ (£)	0.1210	-0.0602 (0.0377)	$ ($)	0.1037	-0.0652 (0.0368)	$ ($)	0.1176
Small Millets	1	-0.5176** (0.0894)	-	0.5728**	-0.1458** (0.0441)	-	0.3039**	-4.8278** (2.1791)	-	0.1641*
	2	-3.3650** (0.547)	-	0.6174**	-14.1548 (8.026)	-	0.0964	-11.3613 (7.817)	-	0.0695
	3	-0.5923 (0.3783)	$ (0.0131)	0.5735**	-0.2753 (0.1850)	$ ($)	0.3186**	-13.4475 (9.0496)	0.3078 (0.3137)	0.1964
	4	-0.0119 ($)	-£ (£)	0.6190**	-0.2142 (0.1690)	$ ($)	0.1260	-0.1317 (0.1615)	$ ($)	0.0793

Crops	Equation	Period 1970-71 to 1996-97								
		Area			Production			Productivity		
		t	t^2	R^2	t	t^2	R^2	t	t^2	R^2
Wheat	1	1.8062** (0.0970)	-	0.9328**	13.9728** (5.3842)	-	0.2122*	9.1154 (11.3755)	-	0.0250
	2	2.0207** (0.117)	-	0.9332**	7.5256** (2.550)	-	0.2727*	2.2033 (1.929)	-	0.0504
	3	1.2226** (0.3920	0.0208 (0.0136)	0.9388**	-27.4736 (21.0720)	1.4802 (0.7304)	0.3273*	-30.0852 (47.4684)	1.4000 (1.6453)	0.0536
	4	$** ($)	£ (£)	0.9338**	-0.0408 (0.0409)	$ ($)	0.3612*	-0.0189 (0.034)	$ ($)	0.0784
Gram	1	0.2074 (0.2067)	-	0.0387	1.0096** (0.2165)	-	0.4640**	23.7613** (3.9359)	-	0.5931*
	2	0.7888 (0.696)	-	0.0491	3.9684** (0.909)	-	0.4413**	3.1197** (0.546)	-	0.5721**
	3	0.8514 (0.8650)	-0.0230 (0.0300)	0.0617	0.9688 (0.9170)	$ (0.0318)	0.4652**	14.7883 (16.5626)	0.3205 (0.5741)	0.5984**
	4	0.0114 (0.0125)	-£ (£)	0.0663	0.0201 (0.0161)	-£ (£)	0.4423**	$ ($)	£ (£)	0.5751**
Kharif Pulses	1	1.0286** (0.1261)	-	0.7268**	0.2673 (0.1490)	-	0.1140	-8.7210 (5.5109)	-	0.0911
	2	5.5837** (0.754)	-	0.6972**	5.3102** (1.867)	-	0.2545*	-2.3559 (1.574)	-	0.0800
	3	2.0060** (0.4931)	-0.0349* (0.0171)	0.7672**	1.2531* (0.5961)	-0.0352 (0.0207)	0.2096	-4.5488 (23.3240)	-0.1490 (0.8085)	0.0923
	4	0.0603** (0.0107)	-$** (£)	0.8013**	0.0806* (0.0302)	-$ ($)	0.3597*	-0.0243 (0.0296)	£ ($)	0.0890

Crops	Equation	Period 1970-71 to 1996-97								
		Area			Production			Productivity		
		t	t^2	R^2	t	t^2	R^2	t	t^2	R^2
Tur	1	-0.0503 (0.0843)	-	0.0140	-0.0380 (0.0723)	-	0.0109	-3.4731 (4.7849)	-	0.0206
	2	0.9062 (1.069)	-	0.0285	-1.7521 (2.217)	-	0.0242	-0.8919 (1.438)	-	0.0150
	3	0.1245 (0.3567)	$ (0.0124)	0.0159	-0.1412 (0.3055)	$ (0.0106)	0.0159	-28.8875 (19.5483)	0.9077 (0.6776)	0.0888
	4	-0.0150 (0.0194)	£ (£)	0.0422	-0.0516 (0.0403)	$ ($)	0.0730	-0.0425 (0.0259)	$ (£)	0.1063
Sugarcane	1	$ (0.0119)	-	0.0197	0.5118 (0.5922)	-	0.0290	-61.1575 (217.5979)	-	$
	2	0.6348 (0.788)	-	0.0253	0.8252 (1.161)	-	0.0199	-0.2999 (0.574)	-	0.0109
	3	0.0271 (0.0503)	-£ (£)	0.0256	-0.0794 (2.5049)	0.0211 (0.0868)	0.0314	-142.5984 (463.4448)	2.9086 (7.9987)	$
	4	$ (0.0144)	-£ (£)	0.0283	-$ (0.0212)	£ (£)	0.0252	-$ (0.0105)	£ (£)	0.0110

Figures in brackets are standard errors

1. Linear Equation
2. Exponential Equation
3. Quadratic Equation
4. Second Degree Curve Fitting to logarithms

* Significant at 5 per cent level of significance

** Significant at 1 per cent level of significance

$ Indicates three significant digits after decimal

£ Indicates four or five significant digits after decimal

The units of area and production are thousand hectares and thousand tonnes.

In case of Kharif pulses best equation which could explained 80% variations in area and 36% variation in production is log quadratic equation.

The table further reveals that no equation could significantly explained the variation in area production and productivity over the period under consideration for the crops rice, tur and sugarcane, respectively.

Bhilwara:

In Bhilwara district jowar and maize are the major kharif crop whereas wheat and barley are principal rabi crop. Among oilseeds sesamum, groundnut and linseed are cultivated and cotton as a cash crop occupies major area. Perusal of table 4.8 clearly indicates that among the cereals crops the equations under considerations could explained 66% (log linear equation) to 70% (quadratic equation) for maize whereas for jowar, equation could explained only 18% (linear equation) to 22% (log linear equation). The R^2 value in case of quadratic and log quadratic equation are not significant for area of jowar crop. Further, table reveals that none of the equation could significantly explained the variation in productivity of maize whereas only 16% variation in productivity of jowar could explained by the linear equation ($Y_t = a + bt$). Likewise only linear equation could explained 17% of the variation in maize crop whereas for the production of jowar different equations could significantly explained 24% (linear equation) to 26% (log quadratic equation) variation. From this we can infer that in case of Bhilwara district kharif cereals crops linear equation ($Y_t = a + bt$) can be considered as relatively better equation capable of significantly explaining the variation in the area, production and productivity of jowar and area and production of maize crop. Not much gain is explained variation in obtained by use of any other equation i.e. log linear, quadratic and log quadratic equation in case of jowar and maize both .

In rabi season, significant R^2 values are obtained in respect of area, production and productivity by all the four equations for wheat and area and productivity for barley crop. In case of production of barley significant R^2 value obtained only by linear equation. A critical view in the table suggest that for wheat, quadratic equation ($Y_t = a + bt+ct^2$) can be considered as a better predictor as compared to rest three equation which is capable of explaining 30%, 63% and 69% variations in the area, production and productivity respectively. In case of barley none of the coefficients of square term ('c' coefficient in equation $Y_t = a + bt +ct^2$ and log $Y_t = a+bt+ct^2$) is significant. Hence, the linear equation ($Y_t = a + bt$) which is capable of explaining 62%, 15% and 52% in area, production and productivity respectively can be considered as better equation.

As regard oilseeds crops are concern no equation could significantly explained the variation in area, production and productivity of sesamum and area and production of groundnut. In case of groundnut 23% variation (linear equation) to 32% variations (quadratic equation) could be explained by the respective R^2 values. However, the quadratic, the coefficient of component still not significant so linear equation ($Y_t = a + bt$) can be considered for the predicting productivity of groundnut crop.

In case of lineseed a choice can be made between quadratic and log quadratic equation as these two equation respectively are capable of explaining 46%and 55% variation in area, 30% and 54% in production and 27 and 29 per cent in productivity. Further as regard productivity is concern neither linear nor quadratic components of these two equations (quadratic and log quadratic) are significant. So it is better to consider one of linear or log linear equation capable of explaining 27% and 29% variation respectively. The gain in considering log linear equation is only of about 2% over linear equation. So for the sake of clearity and ease to understanding linear equation which is explaining slightly more than 27% variation can be considered suitable.

Table 4.8 **Regression Co-efficients, Compound Growth Rates and Coefficient of Determination of Area, Production and Productivity of Selected Crops in Bhilwara District for Various Equations**

Crops	Equation	Period 1970-71 to 1996-97								
		Area			Production			Productivity		
		t	t^2	R^2	t	t^2	R^2	t	t^2	R^2
Jowar	1	0.7295* (0.3077)	-	0.1836*	0.5287** (0.1953)	-	0.2358**	9.1600* (4.1166)	-	0.1653*
	2	3.5658* (1.359)	-	0.2207*	7.4008** (2.671)	-	0.2469**	2.2314 (1.129)	-	0.0493
	3	1.022 (1.3018)	-0.010 (0.045)	0.1854	1.1497 (0.7956)	-0.0222 (0.0276)	0.2559*	19.7981 (17.2912)	-0.3799 (0.5993)	0.1791
	4	0.0118 (0.0242)	1.0276 (£)	0.2213*	0.0639 (0.045)	-$ ($)	0.2640*	0.0384 (0.0351)	-$ ($)	0.0768
Maize	1	1.6175** (0.2206)	-	0.6826**	2.4836* (1.1017)	-	0.1689*	6.6990 (8.1376)	-	0.0264
	2	1.1923** (0.163)	-	0.6595**	1.8146 (0.961)	-	0.1254	0.5985 (0.926)	-	0.0168
	3	0.4813 (0.9032)	0.0406 (0.0313)	0.7034**	2.5543 (4.6659)	-$ (0.1617)	0.1690	13.3029 (34.4377)	-0.2359 (1.1937)	0.0280
	4	$ ($)	£ (£)	0.6750**	$ (0.0174)	£ (£)	0.1308	-£ (0.0168)	£ (£)	0.0188
Wheat	1	1.3016* (0.5048)	-	0.2101*	6.8814** (1.4125)	-	0.4869**	53.1026** (7.5288)	-	0.6655**
	2	1.5009* (0.654)	-	0.1767*	4.9260** (0.918)	-	0.5490**	3.3961** (0.452)	-	0.6911**
	3	-2.1608 (2.0103)	0.1237 (0.0697)	0.3017*	-8.1608 (5.0777)	0.5372** (0.1760)	0.6340**	9.2563 (30.5245)	1.5659 (1.0580)	0.6937**
	4	-0.0106 (0.0113)	£ (£)	0.2523*	-$ (0.0148)	$ (£)	0.6152**	$ ($)	£ (£)	0.7009**

Crops	Equation	Period 1970-71 to 1996-97								
		Area			Production			Productivity		
		t	t^2	R^2	t	t^2	R^2	t	t^2	R^2
Barley	1	-1.0734** (0.1685)	-	0.6189**	-0.5937* (0.2875)	-	0.1456*	28.2497** (5.5837)	-	0.5059**
	2	-3.4526** (0.511)	-	0.6476**	-1.4290 (0.772)	-	0.1183	2.0545** (0.423)	-	0.4871**
	3	-1.8175* (0.6962)	0.0266 (0.0241)	0.6372**	-2.2047 (1.1697)	0.0575 (0.0405)	0.2118	-9.9877 (22.2394)	1.3656 (0.7709)	0.5630**
	4	-0.0207* ($)	£ (£)	0.6526**	-0.0216 (0.0141)	£ (£)	0.1624	-$ ($)	£ (£)	0.5264**
Sesamum	1	0.1065 (0.2398)	-	$	0.0969 (0.0843)	-	0.0502	2.9640 (1.9553)	-	0.0842
	2	0.6348 (1.112)	-	0.0128	2.5022 (2.124)	-	0.0543	1.8777 (1.525)	-	0.0580
	3	-0.4534 (1.0090)	0.0200 (0.0350)	0.0212	0.1283 (0.3570)	-$ (0.0124)	0.0506	5.0701 (8.2695)	-0.0752 (0.2866)	0.0868
	4	-0.0127 (0.0202)	£ (£)	0.0376	-$ (0.0379)	£ ($)	0.0586	0.0107 (0.0276)	-£ ($)	0.0584
Groundnut	1	-0.1630 (0.1396)	-	0.0517	$ ($)	-	0.1120	14.0476* (5.0751)	-	0.2346*
	2	-0.5940 (0.664)	-	0.0303	1.6432 (1.099)	-	0.0833	2.1735* (0.964)	-	0.1746*
	3	-0.3779 (0.5895)	$ (0.0204)	0.0573	-0.5895 (0.4998)	0.0290 (0.0173)	0.2046	-19.2558 (20.3214)	1.1894 (0.7044)	0.3159*
	4	-$ (0.0123)	£ (£)	0.0423	-0.0262 (0.0186)	£ (£)	0.1967	-0.0205 (0.0160)	$ (£)	0.2844*

Crops	Equation	Period 1970-71 to 1996-97								
		Area			Production			Productivity		
		t	t^2	R^2	t	t^2	R^2	t	t^2	R^2
Linseed	1	$ (0.0225)	-	$	0.0189 ($)	-	0.1266	6.2100** (2.0233)	-	0.2737**
	2	0.0535 (1.313)	-	£	83.5489** (21.342)	-	0.5217**	2.6245** (0.827)	-	0.2868**
	3	0.3146** (0.0703)	-0.0109** ($)	0.4590**	0.1085** (0.0375)	-$* ($)	0.3030**	7.1088 (8.5674)	-0.0321 (0.2970)	0.2740*
	4	0.0855** (0.0161)	-$** (£)	0.5528**	0.4661* (0.2097)	-$ ($)	0.5406**	0.0115 (0.015)	-£ (£)	0.2868*
Cotton	1	-0.6615** (0.1397)	-	0.4728**	-0.0303 (0.0372)	-	0.0258	2.9603** (1.0014)	-	0.2590**
	2	-2.8356** (0.604)	-	0.4527**	-0.9311 (1.163)	-	0.0248	1.7722* (0.703)	-	0.2062*
	3	-0.8075 (0.5909)	$ (0.0205)	0.4743**	-0.1511 (0.1556)	$ ($)	0.0511	-4.8300 (3.9121)	0.2782 (0.1356)	0.3696*
	4	-0.0128 (0.0116)	£ (£)	0.4527**	-0.0190 (0.0213)	£ (£)	0.0456	-$ (0.0121)	£ (£)	0.2720*

Figures in brackets are standard errors

1. Linear Equation
2. Exponential Equation
3. Quadratic Equation
4. Second Degree Curve Fitting to logarithms

* Significant at 5 per cent level of significance

** Significant at 1 per cent level of significance

$ Indicates three significant digits after decimal

£ Indicates four or five significant digits after decimal

The units of area and production are thousand hectares and thousand tonnes.

Similarly linear equation, which is explaining 47% variation in area, 26% variation in productivity can be considered suitable for cotton crop.

Chittorgarh:

In Chittorgarh district jowar, maize, sugarcane, soybean, and groundnut are grown in kharif season whereas wheat, gram, rapeseed & mustard and linseed are grown during rabi season. From the table it can be seen that all the four equations significantly explained the variation in the area under the jowar crop whereas none of these could explained variations in production and productivity significantly. Log quadratic equation found to be capable of explaining 80% of the variation but here linear component not significant and the quadratic component have negative coefficient, which indicates reduction at this level. Further, linear and log linear equation both have negative coefficients indicating a reduction in area under the jowar with the advancement of time. No significant pattern in the explained variation in respect of production and productivity is observed. Similarly the variations in area and production both of maize crop was explained by all the four equation. But in case of productivity in this crop also none of the equation found to be capable of explaining significant variation. The explained variation in production of maize about 32% (log linear equation) to 36% (quadratic equation). Perusal of table 4.9 further suggests that the quadratic component in case of quadratic equation is not significant. So linear equation can be considered relatively better for explaining the variations in production of maize. The slope of the equation (b) indicates that every year production is increasing by 4.31 thousand tonnes.

Wheat which is the major rabi crop has significantly different trend as compare to Kharif crop, where all the four equations could significantly explained the variation in production and productivity whereas only linear and log linear equation did so in case of area. The equation explained variation

50% (linear & quadratic equation) to 56% (log linear & log quadratic equation) for productivity. The quadratic component in case of quadratic and log quadratic equation were not found significant, so log linear equation capable of explaining about 56% variation can be preferred to predict the productivity of wheat which indicates an increasing trend in productivity. Similarly the log linear equation can be considered suitable for area as well as production of wheat whereas in case of area and production 18% and 46% of the variation respectively could explained by log linear equation. The values of 'b' coefficient in both the cases were positive and significant indicating a significant increase in area as well as production every year.

Among the pulses no equation could significantly explained the variation in productivity and production of kharif pulses whereas quadratic and log quadratic equation are found to be explained about 64% and 69% variation respectively. Perusal of table further suggest that rate of increase in the area under kharif pulse is decreasing over the years as evident from the negative values of coefficient of quadratic component.

Results pertaining to gram crop shows that all the four equations significantly explained the variation in the productivity ranging from 40% (linear equation) to 48% (log quadratic equation). However log linear equation can be consider suitable for predicting the productivity as the coefficient of quadratic component is not significant in quadratic and log quadratic equation. But in case of production and area of gram log quadratic equation can be considered suitable which is capable of explaining 36% and 24% variation in production and area respectively. The values of coefficient of equation clearly suggest that in case gram also the rate of increase is decreasing over time as indicated by negative values of the coefficient of quadratic component.

Table 4.9 Regression Co-efficients, Compound Growth Rates and Coefficient of Determination of Area, Production and Productivity of Selected Crops in Chittorgarh District for Various Equations

Crops	Equation	Period 1970-71 to 1996-97								
		Area			Production			Productivity		
		t	t^2	R^2	t	t^2	R^2	t	t^2	R^2
Jowar	1	-1.2541** (0.1741)	-	0.6749**	-0.5153 (0.3476)	-	0.0808	3.9676 (6.4960)	-	0.0147
	2	-.3.5865* (0.488)	-	0.6795**	-2.6526 (1.457)	-	0.1148	0.8850 (1.208)	-	0.0211
	3	0.1956 (0.6713)	-0.0518* (0.0233)	0.7305**	2.4328 (1.3352)	-0.1053* (0.0463)	0.2438*	49.2749 (25.8097)	-1.6181 (0.8946)	0.1329
	4	0.0114 ($)	-$** (£)	0.8037**	0.0467 (0.0246)	-$* (£)	0.2917*	0.0338 (0.0211)	-$ (£)	0.1011
Maize	1	1.9581** (0.1569)	-	0.8617**	4.3120** (1.1665)	-	03534**	13.8272 (9.7308)	-	0.0747
	2	1.7261** (0.140)	-	0.8402**	2.8926** (0.853)	-	0.3207**	1.1401 (0.838)	-	0.0683
	3	3.1435* (0.6161)	-0.0423 (0.0214)	0.8811**	6.2705 (4.9235)	-0.0699 (0.1707)	0.3579**	14.8056 (41.2128)	-0.0349 (1.4285)	0.0748
	4	0.0133** ($)	-£* (£)	0.8722**	0.0183 (0.0152)	-£ (£)	0.3253**	$ (0.0154)	-£ (£)	0.0684
Wheat	1	1.1435* (0.4845)	-	0.1822*	6.2175** (1.4079)	-	0.4382**	55.9219** (11.2805)	-	0.4957**
	2	1.2317* (0.536)	-	0.1757*	3.4277** (0.7624)	-	0.4581**	2.9970** (0.545)	-	0.5611**
	3	0.0701 (2.0397)	0.0383 (0.0707)	0.1921	-1.4373 (5.7415)	0.2734 (0.1990)	0.4792**	52.0065 (47.7699)	0.1398 (1.6558)	0.4959**
	4	$ ($)	£ (£)	0.1763	$ (0.0132)	-£ (£)	0.4783**	0.0143 ($)	-£ (£)	0.5616**

Crops	Equation	Period 1970-71 to 1996-97								
		Area			Production			Productivity		
		t	t^2	R^2	t	t^2	R^2	t	t^2	R^2
Gram	1	0.0980 (0.4901)	-	$	0.5976 (0.3980)	-	0.0827	15.3950** (3.7558)	-	0.4019**
	2	0.6051 (1.019)	-	0.0139	3.1167* (1.353)	-	0.1802*	2.7699** (0.615)	-	0.4500**
	3	4.8340* (1.8211)	-0.1691* (0.0631)	0.2315*	4.0104* (1.5254)	-0.1219* (0.0529)	0.2490*	28.3870 (15.6706)	-0.4640 (0.5432)	0.4196**
	4	0.0450* (0.016)	-$* (£)	0.2445*	0.0667** (0.0213)	-$* (£)	0.3584**	0.0235* (0.0105)	-£ (£)	0.4794**
Kharif Pulses	1	0.3232 (0.2470)	-	0.0641	0.1395 (0.1506)	-	0.0332	-0.1441 (3.3599)	-	£
	2	1.1302 (0.675)	-	0.1017	1.1789 (1.095)	-	0.0451	-0.0255 (1.151)	-	£
	3	4.2202** (0.6502)	-0.1392** (0.0225)	0.6385**	0.7843 (0.6231)	0.0330 (0.0216)	0.0769	-25.4333 (13.1991)	0.9032 (0.4575)	0.1398
	4	0.052** ($)	-$** (£)	0.6862**	0.0142 (0.0197)	£ (£)	0.0540	-0.0393 (0.0196)	$ (£)	0.1508
Groundnut	1	0.3673 (02130)	-	0.1064	1.4857** (0.3033)	-	0.4898**	24.3828** (5.2456)	-	0.4636**
	2	0.8642 (0.510)	-	0.1035	3.7881** (0.789)	-	0.4955**	2.8921** (0.592)	-	0.4993**
	3	-0.9953 (0.8552)	0.0487 (0.0296)	0.1966	1.1991 (1.2030)	0.0102 (0.0445)	0.4909**	42.5924 (21.8845)	-0.6503 (0.7586)	0.4795**
	4	-0.0115 ($)	£ (£)	0.2094	0.0113 (0.0138)	£ (£)	0.4983**	0.0234* (0.0102)	-£ (£)	0.5238**

Crops	Equation	Period 1970-71 to 1996-97								
		Area			Production			Productivity		
		t	t^2	R^2	t	t^2	R^2	t	t^2	R^2
Soybean	1	7.5525** (0.6936)	-	0.9081**	8.5491** (0.9786)	-	0.8641**	57.8264* (25.0598)	-	0.3073*
	2	30.9216** (2.502)	-	0.9434**	48.4077** (8.064)	-	0.8152**	12.0751* (0.0202)	-	0.3344*
	3	0.2472 (2.1501)	0.4870** (0.1394)	0.9564**	-1.0369 (3.2529)	0.6391** (0.2109)	0.9259**	181.1746 (106.1400)	-8.2232 (6.8829)	0.3869
	4	0.1366** (0.0367)	-$ ($)	0.9449**	0.2078 (0.1055)	-$ ($)	0.8173**	0.0883 (0.0900)	$ ($)	0.3461
Rape and Mustard	1	2.4152** (0.3408)	-	0.6678**	2.2916** (0.365)	-	0.6115**	20.4335** (4.5343)	-	0.4482**
	2	41.4187** (3.745)	-	0.8727**	44.5589** (4.227)	-	0.8634**	3.1911** (0.712)	-	0.4510*
	3	-0.1204 (1.3411)	0.0906 (0.0465)	0.7132**	-0.0137 (1.4692)	0.0823 (0.0509)	0.6497**	18.2905 (19.1991)	0.0765 (0.6655)	0.4485**
	4	0.2623** (0.0426)	-$* (£)	0.9024**	0.2803** (0.0476)	$* ($)	0.8934**	0.0172 (0.0127)	-£ (£)	0.4530**
Linseed	1	-0.2756** (0.0744)	-	0.3543**	-0.0634* (0.0219)	-	0.2504**	8.3608** (2.1157)	-	0.3845**
	2	-6.9654** (1.413)	-	0.4779**	4.0925 (7.262)	-	0.0130	2.1474** (0.611)	-	0.3408**
	3	0.4078 (0.2805)	-0.0244* ($)	0.4886**	0.1075 (0.0856)	-$ ($)	0.3627*	-18.9699* (6.8739)	0.9761** (0.2381)	0.6378**
	4	0.0399 (0.0234)	-$* (£)	0.6300**	0.1853 (0.1234)	-$ ($)	0.0877	-0.0196* ($)	-$** (£)	0.5455*

Crops	Equation	Period 1970-71 to 1996-97								
		Area			Production			Productivity		
		t	t^2	R^2	t	t^2	R^2	t	t^2	R^2
Sugarcane	1	-0.0678* (0.0295)	-	0.1742*	-2.3404 (1.6981)	-	0.0706	490.8639* (216.9853)	-	0.1699*
	2	-1.9798* (0.857)	-	0.1728*	-13.4002 (7.517)	-	0.0988	1.0044* (0.465)	-	0.1538*
	3	-0.0599 (0.1250)	-£ (£)	0.1743	-3.3184 (7.1890)	0.0349 (0.2492)	0.0714	-1543.2201 (813.3598)	72.6459* (28.1925)	0.3498*
	4	-0.0106 (0.0161)	£ (£)	0.1733	0.1627 (0.1526)	-$ ($)	0.1780	-0.0153 ($)	£* (£)	0.3471*

Figures in brackets are standard errors

1. Linear Equation
2. Exponential Equation
3. Quadratic Equation
4. Second Degree Curve Fitting to logarithms

* Significant at 5 per cent level of significance

** Significant at 1 per cent level of significance

$ Indicates three significant digits after decimal

£ Indicates four or five significant digits after decimal

The units of area and production are thousand hectares and thousand tonnes.

All the four equations were found capable of significantly explaining the variations in rapeseed & mustard and maximum variation explained by the log quadratic equation. Perusal of table shows that 90% 89% and 45% variations in area, production and productivity respectively explained by log quadratic equation. Further, rate of increase in area significantly decrease but rate of increase in production remained increasing. But in case of productivity log linear equation should be considered better as the coefficients in log quadratic are not significant.

The cash crop in Chittorgarh district is sugarcane. Each of the linear and log linear equation significantly explained variations to the tune of about 17% in area under the crop, whereas no equation could explain the variation in production and all the equation significantly explained the variations in productivity. From the table it can be seen that every year about 68 hectare area is decreasing under the crop as revealed by the linear equation. Likewise, about 35% variation in productivity is explained by log quadratic equation. Here coefficient of linear component is not observed to be significant, only quadratic component is significantly suggesting very gradual increase in the rate of increase in productivity.

Dungarpur:

Table 4.10 presents the results of attempt of fitting different equations to the area, production and productivity figures of selected crops in Dungarpur district. From table it can be seen that for kharif cereals none of the equation could significantly explained the variation in any of the area, production and productivity of maize and rice. Similar was the case with tur among the pulses grown in rabi season.

As regard small millets is concerned quadratic equation could explained about 90% variation in the area whereas it could explained about 43% variations in production. But coefficient of quadratic component in case

of production is not significant so linear equation capable of explaining about 39% variation can be considered acceptable. The slope of linear equation clearly indicates that there is retardation of about 316 tonnes per year. In case of productivity linear equation which explain only about 16% variation can be considered suitable as all other equation do not explained significant variation. From table it can be seen that productivity of small millets is also on decreasing trend, where productivity is found to be decreasing at the rate 14 kg/ha per year.

For the kharif pulses about 86% variation is explained by linear equation, which shows that every year 770 hectares of area is increasing under kharif pulses. It corresponds to an increase of 236 tonnes of production per year, which is evident from linear equation capable of significantly explaining about 18% of the variations. No equation could explain the productivity of kharif pulses. In case of gram grown in rabi season, no equation could explain the variations in production whereas linear equation capable of explaining about 19% variation can be considered suitable for area. It is clear from the table that area under the gram is decreasing 419 hectare per year. All the four equations are found to be capable of explaining significant variations in productivity whereas the minimum 37% variation explained by linear equation and maximum 42% variation explained by log quadratic. But both the coefficients i.e. coefficient of linear term and quadratic term are not significant in quadratic and log quadratic equation. Therefore, log linear equation, which explained 40% variation, is considered suitable for explaining the variation in productivity.

In case of wheat all the four equations significantly explained the variation in area, production and productivity. However, linear equation can be considered better when compare to other equation in case of all the three components i.e. area, production and productivity, where it explain 24, 55 and

Table 4.10 **Regression Co-efficients, Compound Growth Rates and Coefficient of Determination of Area, Production and Productivity of Selected Crops in Dungarpur District for Various Equations**

Crops	Equation	Period 1970-71 to 1996-97								
		Area			Production			Productivity		
		t	t^2	R^2	t	t^2	R^2	t	t^2	R^2
Maize	1	-0.0861 (0.1414)	-	0.0146	-0.2181 (0.4512)	-	$	-3.8559 (8.8230)	-	$
	2	-0.1563 (0.298)	-	0.0112	-0.3583 (1.537)	-	$	-0.2508 (1.447)	-	$
	3	-0.3289 (0.5967)	$ (0.020)	0.0218	-1.3894 (1.8952)	0.0418 (0.0657)	0.0257	-22.2328 (37.1680)	0.6563 (1.2883)	0.0182
	4	-$ ($)	£ (£)	0.0202	-0.015 (0.028)	£ (£)	0.0121	-0.0129 (0.0265)	£ (£)	$
Rice	1	0.0502 (0.1949)	-	$	$ (0.4082)	-	0.000	0.6142 (9.5910)	-	$
	2	0.1227 (0.692)	-	$	0.7665 (2.552)	-	$	0.7603 (2.065)	-	$
	3	0.5723 (0.8180)	-0.0186 (0.0284)	0.0203	0.3935 (1.7268)	-0.0140 (0.0599)	$	-10.9732 (40.5480)	0.4138 (1.4055)	$
	4	$ (0.0127)	-£ (£)	$	-0.0201 (0.047)	£ ($)	0.0141	-0.0208 (0.0375)	£ ($)	0.0232
Small Millets	1	-0.4255** (0.0334)	-	0.8666**	-0.3155** (0.0796)	-	0.3861**	-14.3852* (6.6411)	-	0.1580*
	2	-4.3199** (0.286)	-	0.8943**	-10.1204* (3.104)	-	0.2721**	-6.0903 (3.525)	-	0.1012
	3	-0.7720** (0.1212)	0.0124** ($)	0.9020**	-0.7308* (0.3255)	0.0148 (0.0113)	0.4274**	-32.9723 (27.8544)	0.6638 (0.9655)	0.1743
	4	-0.0249** (0.0055)	-£ (£)	0.8991**	-0.1080 (0.062)	$ ($)	0.3018*	-0.1006 (0.0671)	$ ($)	0.1463

Crops	Equation	Period 1970-71 to 1996-97								
		Area			Production			Productivity		
		t	t^2	R^2	t	t^2	R^2	t	t^2	R^2
Wheat	1	0.4029* (0.1432)	-	0.2406*	1.2880** (0.2316)	-	0.5529**	27.9853** (7.3441)	-	0.3674**
	2	1.6932* (0.609)	-	0.2370*	3.5248** (0.715)	-	0.5057**	1.7992* (0.445)	-	0.3892**
	3	0.5477 (0.6056)	-$ (0.0210)	0.2425*	0.0731 (0.9472)	0.0434 (0.0328)	0.5833**	-5.8952 (30.2777)	1.2100 (1.0495)	0.4006**
	4	0.0111 (0.011)	-£ (£)	0.2409*	$ (0.0125)	£ (£)	0.5105**	-$ ($)	£ (£)	0.4288**
Gram	1	-0.4198* (0.1713)	-	0.1936*	0.1463 (0.1401)	-	0.0418	22.9090** (6.0182)	-	0.3669**
	2	-2.0785 (1.084)	-	0.1240	1.2598 (1.212)	-	0.0411	3.0462* (0.712)	-	0.4033**
	3	-1.3805 (0.6969)	0.0343 (0.0242)	0.2561*	0.0551 (0.5930)	$ (0.0206)	0.0428	37.8618 (25.2944)	-0.5340 (0.8768)	0.3766**
	4	-0.0312 (0.02)	£ (£)	0.1687	-$ (0.0222)	£ (£)	0.0450	0.0227 (0.0133)	-£ (£)	0.4168*
Kharif Pulses	1	0.7703** (0.0625)	-	0.8586**	0.2355* (0.1021)	-	0.1754*	-7.5946 (7.3280)	-	0.0412
	2	5.6900** (0.584)	-	0.8058**	12.3770 (11.385)	-	0.0486	-0.8114 (3.197)	-	$
	3	0.7016* (0.2644)	$ ($)	0.8590**	0.3145 (0.4323)	-$ (0.0150)	0.1766	-15.0894 (30.9965)	0.2677 (1.0744)	0.0437
	4	0.0431** ($)	£* (£)	0.8366**	0.0578 (0.1898)	-£ ($)	0.0487	-0.0414 (0.0587)	$ ($)	0.0206

Crops	Equation	Period 1970-71 to 1996-97								
		Area			Production			Productivity		
		t	t^2	R^2	t	t^2	R^2	t	t^2	R^2
Tur	1	0.0319 (0.0459)	-	0.0190	-0.0118 (0.0182)	-	0.0167	-10.0659 (6.0819)	-	0.0987
	2	1.3767 (1.401)	-	0.0326	18.5503 (15.559)	-	0.0623	-3.3870 (2.669)	-	0.0586
	3	0.1485 (0.1930)	-$ ($)	0.0346	-0.0664 (0.0763)	$ ($)	0.0384	-27.3512 (25.5013)	0.6173 (0.8839)	0.1167
	4	$ (0.027)	£ (£)	0.0335	-0.2095 (0.2354)	0.0101 ($)	0.1188	-0.0760 (0.0491)	$ ($)	0.1187

Figures in brackets are standard errors

1. Linear Equation
2. Exponential Equation
3. Quadratic Equation
4. Second Degree Curve Fitting to logarithms

* Significant at 5 per cent level of significance
** Significant at 1 per cent level of significance
$ Indicates three significant digits after decimal
£ Indicates four or five significant digits after decimal

The units of area and production are thousand hectares and thousand tonnes.

37 percent variations respectively. Table further indicates that every year there is an increase of 403 hectare of area under wheat, 1288 tonnes of production and 28 kg/ha productivity can also be seen as annual increase.

Udaipur:

Perusal of table 4.11 clearly indicates that none of the equation explained the variation in all the three components i.e. area, production and productivity in case of jowar, rice and urad crops. However, among the kharif crop in case of maize quadratic and log quadratic equation each explained 33% variation in case of area whereas none of the equation could explain significant variation in production and productivity. Table further indicates that there is an increasing trend as indicated by significant linear coefficients. But the rate of increase is decreasing as evident from negative coefficients of quadratic term of these two equations i.e. quadratic and log quadratic. It is recommended to use quadratic equation for the sake of relative clearity and ease as compared to log quadratic equation.

In case of sugarcane 39% (linear equation) to 51% (log quadratic equation) variation could be explained by the four equations in case of area whereas in case of production this ranged from 27% (log linear equation) to 35% (quadratic equation). But the coefficients of linear as well as quadratic component in respect of both quadratic and log quadratic equation are not significant so it is recommended that linear equation explaining 28% variation be used which shows that every years production of sugarcane is decreasing by 3910 tonnes. None of the equation could significantly explained the variation in the productivity of sugarcane.

Small millets are grown during the Kharif season. In this case variations in area, were explained by these equation in the range 85% (linear equation) to 89% (log quadratic equation). Here also there is not wide range in the explained variation by different equations so it is better to use linear

equation for the sake of ease to understanding. This equation indicates that every year there is reduction about 400 hectares of area under small millets crop. About production quadratic equation capable of explaining 48% variations is recommended. The values of coefficient indicate that there is a decrease in the production and rate of decrease is also of increasing side. No equation could significantly explained the variation in the productivity.

Another important rabi crop grown in Udaipur district is wheat. All the four equations significantly explained the variations in the production and productivity of wheat but none of these explained variations in the area. From the table 4.11 it can be seen that linear equation in case of production and quadratic equation in case of productivity can be select for the crop of wheat. From the linear equation obtained for production 37% variation is explained. The equation suggest that every year production is increasing by 3825 tonnes quadratic equation though explaining little more variations (38%) as none of the coefficient significant. As productivity is concern it is recommended to use quadratic equation which explained 75% variation, the significant coefficient of quadratic components indicative of increasing trend in the rate of productivity.

All the equations significantly explained variation in the area, production and productivity of barley crop. From perusal of table 4.11 on the basis of significance of coefficients of different equations, linear equation is found suitable for area and production whereas quadratic equation can be taken for productivity. In case of area, linear equation explained 64% variation showing a reduction of 1464 hectares of area every year. Whereas in case of production 45% variation explained by this from linear equation which shows a decrease of 1578 tonnes per year. Quadratic equation significantly explained variation in productivity by 56% indicating an increasing trend in the reduction of productivity.

Table 4.11 **Regression Co-efficients, Compound Growth Rates and Coefficient of Determination of Area, Production and Productivity of Selected Crops in Udaipur District for Various Equations**

Crops	Equation	Period 1970-71 to 1996-97								
		Area			Production			Productivity		
		t	t^2	R^2	t	t^2	R^2	t	t^2	R^2
Jowar	1	-0.1556 (0.1588)	-	0.0370	0.1185 (0.1359)	-	0.0295	8.2869 (5.0920)	-	0.0958
	2	-0.9813 (0.866)	-	0.0492	1.4972 (1.635)	-	0.0274	2.6160 (1.418)	-	0.1133
	3	-0.0709 (0.6723)	-$ (0.0233)	0.0376	0.7790 (0.5586)	-0.0236 (0.0194)	0.0860	33.016 (20.9298)	-0.8832 (0.7255)	0.1484
	4	$ (0.015)	-£ (£)	0.0612	0.0504 (0.031)	-$ ($)	0.1057	0.0438 (0.026)	-$ (£)	0.1722
Maize	1	0.1972 (0.5086)	-	$	0.4062 (1.8413)	-	$	0.1013 (8.6537)	-	0.0000
	2	0.0485 (0.276)	-	$	0.0294 (1.152)	-	£	-0.0168 (1.151)	-	0.0000
	3	6.0475** (1.7679)	-0.2089** (0.0613)	0.3304**	4.0425 (7.7608)	-0.1299 (0.2690)	0.0115	-14.9313 (36.5148)	0.5369 (1.2657)	0.0101
	4	0.0136** ($)	-£** (£)	0.3336**	$ (0.021)	-£ (£)	$	-$ (0.0202)	£ (£)	0.0104
Rice	1	-0.1399 (0.0789)	-	0.1118	-0.1190 (0.1646)	-	0.0205	-1.5085 (8.7772)	-	$
	2	-1.1101 (0.660)	-	0.0999	-0.8833 (2.237)	-	0.0161	0.4459 (1.896)	-	$
	3	0.2561 (0.3234)	-0.0141 (0.0112)	0.1671	0.5899 (0.6809)	-0.0253 (0.0236)	0.0653	25.6121 (36.7343)	-0.9686 (1.2733)	0.0247
	4	$ (0.0122)	-£ (£)	0.1193	$ (0.042)	-£ ($)	0.0109	0.0142 (0.0346)	-£ ($)	$

Crops	Equation	Period 1970-71 to 1996-97								
		Area			Production			Productivity		
		t	t^2	R^2	t	t^2	R^2	t	t^2	R^2
Small Millets	1	-0.4010** (0.0337)	-	0.8496**	-0.1572** (0.0408)	-	0.3731**	2.3748 (5.1829)	-	$
	2	-8.4776** (0.632)	-	0.8692**	1.9763 (1.315)	-	£	1.5083 (0.250)	-	0.0145
	3	-0.6108** (0.1359)	$ ($)	0.8639**	-0.5030** (0.1565)	0.0123* ($)	0.4844**	-30.3931 (20.8413)	1.1703 (0.7224)	0.1061
	4	-0.012 (0.011)	-£* (£)	0.8946**	-0.2881 (0.2312)	0.0106 ($)	0.0687	-0.0482 (0.044)	$ ($)	0.0775
Wheat	1	0.2103 (0.4833)	-	$	3.8248** (1.0050)	-	0.3668**	48.6502** (6.9984)	-	0.6591**
	2	0.3025 (0.692)	-	$	3.0040** (0.948)	-	0.3109**	2.7093** (0.473)	-	0.6809**
	3	2.0810 (2.0088)	-0.0668 (0.0696)	0.0442	1.3895 (4.2255)	0.0870 (0.1465)	0.3760**	-24.3982 (25.3481)	2.6089** (0.8786)	0.7507**
	4	0.0128 (0.014)	-£ (£)	0.0375	0.0129 (0.016)	-£ (£)	0.3109*	-£ (£)	£** (£)	0.7293**
Barley	1	-1.4636** (0.2179)	-	0.6435**	-1.5768** (0.3518)	-	0.4455**	27.8400** (6.8061)	-	0.4009**
	2	-4.8440** (0.657)	-	0.6515**	-3.1598** (0.758)	-	0.4085**	1.7536** (0.468)	-	0.3906**
	3	-1.1006 (0.9195)	-0.0130 (0.0319)	0.6460**	-2.4929 (1.4776)	0.0327 (0.0512)	0.4548**	-42.1846 (24.7798)	2.5009** (0.8589)	05573**
	4	-£ (0.013)	-£ (£)	0.6885**	-0.0101 (0.0142)	-£ (£)	0.4104**	-$ ($)	-£* (£)	0.5177**

Crops	Equation	Period 1970-71 to 1996-97								
		Area			Production			Productivity		
		t	t^2	R^2	t	t^2	R^2	t	t^2	R^2
Tur	1	0.551* (0.0198)	-	0.2363*	0.0686** (0.0184)	-	03568**	6.8339 (5.3866)	-	0.0605
	2	2.8880 (0.948)	-	0.2240*	92.1040** (21.542)	-	0.5751**	1.0182 (2.328)	-	0.0176
	3	-0.1894** (0.0664)	$** ($)	0.5228**	-0.0775 (0.0717)	-$* ($)	0.4566**	-43.9817* (20.1560)	1.8148* (0.6986)	0.2667*
	4	-0.0376* (0.0164)	$** ($)	0.4490**	0.3545 (0.2059)	- $ ($)	0.5773**	-0.0671 (0.0397)	$ ($)	0.1321
Urad	1	0.1465 (0.0750)	-	0.1537	0.0361 (0.0852)	-	$	-0.3557 (5.0142)	-	£
	2	0.8117 (0.441)	-	0.1382	1.6432 (2.387)	-	0.0222	0.8831 (2.230)	-	$
	3	0.1358 (0.3213)	£ (0.0130)	0.1537	-0.0131 (0.3646)	$ (0.0148)	0.019	-5.6585 (21.4327)	0.2209 (0.8671)	$
	4	$ ($)	£ (£)	0.1383	-0.0172 (0.0435)	$ ($)	0.0381	-0.0200 (0.0408)	$ ($)	0.0251
Sugarcane	1	-0.1968** (0.0494)	-	0.3882**	-8.007** (2.5393)	-	0.2846**	262.8797 (213.0754)	-	0.0574
	2	-4.2009** (0.993)	-	0.4089**	-3.9110** (1.261)	-	0.2714**	0.8906 (0.627)	-	0.0740
	3	0.2083 (0.1911)	-0.0145* ($)	0.4896**	6.8553 (10.2903)	-0.5308 (0.3567)	0.3450**	452.6206 (901.5668)	-6.7765 (31.2499)	0.0592
	4	0.0178 (0.0174)	-$* (£)	0.5051**	0.0108 (0.0233)	-$ ($)	0.3155**	0.0107 (0.0113)	-£ (£)	0.0891

Figures in brackets are standard errors

1. Linear Equation
2. Exponential Equation
3. Quadratic Equation
4. Second Degree Curve Fitting to logarithms

* Significant at 5 per cent level of significance
** Significant at 1 per cent level of significance
$ Indicates three significant digits after decimal
£ Indicates four or five significant digits after decimal

The units of area and production are thousand hectares and thousand tonnes.

An analysis of observation in respect of tur suggests that all the four equations significantly explained variation in area and production, whereas only quadratic equation could explain variation in productivity. From the perusal of table 4.11 it can be deduced that quadratic equation suitable for area and productivity whereas log linear equation is better for production. These equations explain 52%, 58% and 27% variation in area, production and productivity respectively.

Rajasthan:

In order to examine the suitability of the four equations for studying the trend of different selected crops in individual districts of Udaipur division in comparison to the state of Rajasthan has also been attempted. For this purpose an attempt has been made to fit these equations for state of Rajasthan. Table 4.12 presents the results obtained in respect of area, production and productivity of different major principal crops for the period under consideration.

From the table it can be seen that none of the equation could significantly explain the variations in respect of area, production and productivity of jowar, bajra, gram and kharif pulses. In case of guarseed quadratic and log quadratic equation significantly explained 26 and 29 per cent of the variations in area only. Whereas none of the equation could significantly explained the variation in production and productivity of guarseed. From the values of the coefficient of quadratic term in case of area reveals that the rate of increase in area under gram is decreasing over time.

In case of maize 58% (log linear equation) to 64% (quadratic equation) variation in area explained by these equations. However coefficient of quadratic component is not significant so linear equation capable of explaining 59 per cent variation and showing positive growth of 8.09 thousand hectare per year can be considered suitable. Similarly in case of

Table 4.12 Regression Co-efficients, Compound Growth Rates and Coefficient of Determination of Area, Production and Productivity of Selected Crops in the state of Rajasthan for Various Equations

Crops	Equation	Period 1970-71 to 1996-97								
		Area			Production			Productivity		
		t	t^2	R^2	t	t^2	R^2	t	t^2	R^2
Jowar	1	-3.5970 (7.85)	-	$	-2.8685 (3.1305)	-	0.0325	0.9756 (2.8745)	-	$
	2	0.2454 (1.731)	-	£	-1.1495 (0.978)	-	0.0511	0.0794 (0.829)	-	£
	3	-50.006 (131.813)	1.6575 (1.1027)	0.0936	7.6978 (13.0714)	-0.3774 (0.4531)	0.0597	5.3665 (12.1395)	-0.1568 (0.4208)	0.0103
	4	-0.0536 (0.029)	$ ($)	0.1323	0.0119 (0.018)	-£ (£)	0.0867	$ (0.0150)	-£ (£)	$
Bajra	1	-0.6064 (14.2030)	-	£	26.8896 (18.8098)	-	0.0756	5.5806 (3.4962)	-	0.0925
	2	0.0203 (0.322)	-	$	1.9511 (1.432)	-	0.0700	1.9374 (1.290)	-	0.0843
	3	-38.1253 (59.6351)	1.3400 (2.0671)	0.0173	-97.0905 (75.2779)	4.4279 (2.6093)	0.1746	-18.2644 (13.9327)	0.8516 (0.4829)	0.1966
	4	-$ ($)	£ (£)	0.0181	-0.0309 (0.0246)	$ (£)	0.1644	-0.0273 (0.0220)	$ (£)	0.1792
Maize	1	8.0857** (1.3494)	-	0.5895**	14.3283* (6.3101)	-	0.1710*	7.3797 (7.0646)	-	0.0418
	2	0.9594** (0.163)	-	0.5829**	1.8243* (0.867)	-	0.1498*	0.8561 (0.859)	-	0.0394
	3	17.9187** (5.3277)	-0.3512 (0.1847)	0.6433**	15.6544 (26.724)	-0.0474 (0.9263)	0.1711	-3.0526 (9.8406)	0.3726 (1.0343)	0.0470
	4	$** ($)	-£ (£)	0.6366**	$ (0.0158)	£ (£)	0.1509	-$ (0.0154)	£ (£)	0.0499

Crops	Equation	Period 1970-71 to 1996-97								
		Area			Production			Productivity		
		t	t^2	R^2	t	t^2	R^2	t	t^2	R^2
Wheat	1	23.3525** (5.3066)	-	0.4365**	147.7040** (14.4612)	-	0.8067**	55.8510** (5.0378)	-	0.8310**
	2	1.2639* (0.279)	-	0.4386**	4.5192** (0.361)	-	0.8695**	3.2073** (0.261)	-	0.8513**
	3	11.0438 (22.3259)	0.4396 (0.7739)	0.4440**	17.2193 (54.7560)	4.6602* (1.8979)	0.8455**	30.0919 (20.6374)	0.9200 (0.7153)	0.8419**
	4	$ ($)	£ (£)	0.4395**	0.0167* ($)	-£ (£)	0.8704**	0.0121* ($)	£ (£)	0.8520**
Barley	1	-17.4389** (2.2753)	-	0.7015**	-15.5006** (2.9401)	-	0.5265**	27.6270** (3.9716)	-	06593**
	2	-4.6967** (0.439)	-	0.8173**	-2.9031** (0.492)	-	0.5827**	1.8661** (0.282)	-	0.6570**
	3	-21.5804* (9.5973)	0.1479 (0.3327)	0.7039**	-23.3974 (12.3411)	0.2820 (0.4278)	0.5349**	-0.3696 (1.5756)	0.9999 (0.5462)	0.7011**
	4	-0.0183* ($)	-£ (£)	0.8180**	-0.0162 ($)	-£ (£)	0.5853**	$ ($)	£ (£)	0.6819**
Gram	1	-10.5121 (7.3923)	-	0.0748	-6.3682 (7.8973)	-	0.0254	0.5775 (2.7203)	-	$
	2	-0.7574 (0.548)	-	0.0682	-0.6235 (0.801)	-	0.0237	0.1337 (0.392)	-	$
	3	-3.4294 (3.2725)	-0.2530 (1.0840)	0.0769	7.4540 (33.3215)	-0.4936 (1.1550)	0.0327	4.5297 (11.4915)	-0.1411 (0.3983)	$
	4	-$ (0.0103)	£ (£)	0.0684	-£ (0.0148)	-£ (£)	0.0246	$ ($)	-£ (£)	0.0102

Crops	Equation	Period 1970-71 to 1996-97								
		Area			Production			Productivity		
		t	t^2	R^2	t	t^2	R^2	t	t^2	R^2
Kharif Pulses	1	-8.6802 (6.3137)	-	0.0703	2.3886 (5.0669)	-	$	2.0739 (2.4799)	-	0.0272
	2	-0.4610 (0.367)	-	0.0599	0.4637 (1.966)	-	$	0.9288 (1.743)	-	0.0113
	3	-66.583* (23.806)	2.0680* (0.825)	0.2631*	-35.3290 (19.939)	1.3471 (0.6911)	0.1403	-12.8211 (10.0254)	0.5320 (0.3475)	0.1138
	4	-0.0163* ($)	£* (£)	0.2471*	-0.0623 (0.0332)	$ ($)	0.1443	-0.0462 (0.0300)	$ ($)	0.1203
Groundnut	1	-0.5402 (1.0860)	-	$	3.4077* (1.1431)	-	0.2622**	14.9799** (4.1565)	-	0.3419**
	2	-0.1622 (0.437)	-	$	1.9430* (0.751)	-	0.2132*	2.1003* (0.682)	-	0.2748**
	3	-2.8494 (4.5741)	0.0825 (0.1585)	0.0208	-4.2696 (4.5644)	0.2742 (0.1582)	0.3443**	-8.2066 (16.9152)	0.8284 (0863)	0.3924**
	4	-$ ($)	£ (£)	0.0309	-0.0143 (0.0127)	£ (£)	0.3099*	-$ (0.0119)	-£ (£)	0.3314**
Rape and Mustard	1	97.2925** (8.085)	-	0.8528**	92.0402** (7.9159)	-	0.8439**	17.2045** (3.7539)	-	0.4566**
	2	10.5854** (0.713)	-	0.9044**	13.7278** (1.074)	-	0.8828**	2.8367** (0.639)	-	0.4408**
	3	-44.947* (16.667)	5.080** (0.577)	0.9651**	-44.3096* (17.3680)	4.8696** (0.6020)	0.9581**	10.4262 (15.8352)	0.2421 (0.5489)	0.4609**
	4	0.0185 (0.0108)	£* (£)	0.9230**	0.0322 (0.0165)	£ (£)	0.8926**	0.0135 (0.0116)	-£ (£)	0.4411**

Crops	Equation	Period 1970-71 to 1996-97								
		Area			Production			Productivity		
		t	t^2	R^2	t	t^2	R^2	t	t^2	R^2
Guarseed	1	17.876 (10.4286)	-	0.1052	7.6774 (9.063)	-	0.0279	0.6874 (2.8974)	-	$
	2	1.4142 (0.700)	-	0.1414	1.6522 (2.177)	-	0.0230	-0.1761 (1.586)	-	£
	3	105.510* (40.1393)	-3.1298* (1.3913)	0.2610*	31.6724 (38.0549)	-0.8570 (1.3191)	0.0447	-17.9469 (11.6289)	0.6655 (0.4031)	0.1040
	4	0.0312* (0.0116)	-£* (£)	0.2886*	$ ($0.0393)	$ ($)	0.0230	-0.0469 (0.0274)	$ (£)	0.1120

Figures in brackets are standard errors

1. Linear Equation
2. Exponential Equation
3. Quadratic Equation
4. Second Degree Curve Fitting to logarithms

* Significant at 5 per cent level of significance
** Significant at 1 per cent level of significance
$ Indicates three significant digits after decimal
£ Indicates four or five significant digits after decimal

The units of area and production are thousand hectares and thousand tonnes.

production linear equation, which significantly explained 17 per cent of the variation, showing an increase of 14.33 thousand tonnes of production per year can be considered suitable. No equation could significantly explained the variation in productivity.

Likewise in case of area, production and productivity of wheat linear, log linear and quadratic equation respectively were found suitable, where these equation could explained 44, 87 and 85 per cent of the variation, with an increasing trend in that order.

In case of barley, 82, 58 and 66 per cent variations are significantly explained by the log linear equation for a decrease in area, production and productivity respectively.

Linear equation significantly explaining 26 and 34 per cent variation in production and productivity respectively can be considered suitable for groundnut; where an increase of 3.40 thousand tonnes of production and 14.98 kg/ha of productivity every year can be discerned.

In rapeseed & mustard crop all the four equations are found to capable of significantly explaining the variations in area, production and productivity, but in case of area and production quadratic equation and in case of productivity linear equation found suitable in view of their capacity to explain higher variation with significant coefficients.

4.2.1 Most Suitable Models Identified:

The seasonwise and cropwise summary of equations identified for trend prediction of area, production and productivity of selected crops are presented in (Table 4.13 and 4.14).

Perusal of table clearly indicates that none of the equation is found suitable for area, production and productivity of rice in respect of Banswara, Dungarpur and Udaipur districts. In Bhilwara district, linear equation is found

suitable pertaining to area, production and yield of jowar crop. In case of maize crop linear equation is found suitable for area as well as for production & yield in respect of Banswara district but for Bhilwara district, linear equation (area and production) is found suitable whereas for Chittorgarh district linear equation (production) and for Udaipur district quadratic equation (area) are recommended. Moreover, at state level equation suitable for maize is linear in respect of area as well as production. Linear equation in respect of area, production and yield of small millets is found suitable for Banswara district whereas for Dungarpur district linear equation (production and productivity) and quadratic (area) are found suitable. But in case of Udaipur district linear equation (area) and quadratic equation (production) are found suitable for small millets. The results reveal that for kharif pulses in Banswara district log quadratic equation (area and production) found suitable. Whereas in case of Dungarpur, linear equation (area and production) is recommended. For tur crop in Udaipur district quadratic equation (area and yield) and log linear equation (production) is found suitable. At State level linear equation for production and yield of groundnut is found suitable whereas for Bhilwara district linear equation for yield is suggested. In Chittorgarh district for soybean crop quadratic equation is found suitable for area & production whereas log linear equation is found suitable for yield.

In Banswara district none of the equation is found suitable for yield of wheat but log quadratic equation for production and linear equation for area is suggested. Further, quadratic equation (area, production & yield) for wheat in Bhilwara and for Chittorgarh district log linear (area, production & yield) is recommended. In, Dungarpur district linear equation for area, production and productivity of wheat is recommended but in case of Udaipur district linear equation for production and quadratic equation for productivity of maize is recommended. Moreover at the State level suitability of the equation for wheat crop is linear (area), log linear (production and yield) recorded.

For barley crop in Bhilwara district linear equation (area, production & yield) and for Udaipur district linear (area and production) and quadratic equation for yield is found suitable.

In Banswara district linear equation (production & yield) in respect of gram and for Chittorgarh district log linear (yield) and log quadratic (area & production) is found suitable whereas in Dungarpur district linear equation for area and log linear equation for yield equation is suggested

In case of rapeseed & mustard in Chittorgarh district log linear (yield) and log quadratic equation (area & production) is found suitable. However for the state quadratic equation for area and production and linear equation for yield is suggested.

Another oilseeds crop linseed the suitable equation for this crop in Bhilwara district is linear for (yield) but for Chittorgarh district log quadratic equation (area & yield) and quadratic equation (production) are recommended.

Linear equation for production of sugarcane is found suitable for Udaipur district and for cotton crop in Bhilwara district linear equation for area as well as productivity is recommended. At state level for guarseed quadratic equation for area is suggested.

Thus linear equation ($Y_t = a + bt$) has a wider applicability. This equation has been found suitable in majority of cases for estimating and predicting the area/production/yield of crops in Southern Rajasthan. Further, this has specific advantage of ease of understanding and relatively better prediction capacity. However, the explained variation is not very high in any case. This clearly indicates that such attempts can only provide a preliminary base to study and understand the trends.

Table -4.13 Seasonwise Summary of Equations Identified for Trend Predictions of Area, Production and Yield of Selected Crops

Particular	Banswara	Bhilwara	Chittorgarh	Dungarpur	Udaipur	Rajasthan
Kharif						
Rice	Δ	-	-	Δ	Δ	-
Jowar	-	Linear	Δ	-	Δ	Δ
Bajra	-	-	-	-	-	Δ
Maize	Linear	Linear (A,P)	Linear (P)	Δ	Quadratic (A)	Linear (A,P)
Small millets	Linear	-	-	Linear (P, Y) Quadratic (A)	Linear (A) Quadratic (P)	-
Kharif Pulses	Log quadratic (A,P)	-	Δ	Linear (A,P)	-	Δ
Arhar	Δ	-	-	Δ	Quadratic (A,Y) Log Linear (P)	-
Sesamum	-	Δ	-	-	-	-
Groundnut	-	Linear (Y)	Δ	-	-	Linear (P,Y)
Soybean	-	-	Quadratic (A,P) Log linear (Y)	-	-	-
Rabi						
Wheat	Log quadratic (P) Linear (A)	Quadratic	Log Linear	Linear	Linear (P) Quadratic (Y)	Linear (A) Log linear (P,Y)
Barley	-	Linear	-	-	Linear (A P) Quadratic (Y)	Δ
Gram	Linear (P,Y)	-	Log Linear (Y), Log quadratic (A, P)	Linear (A) Log Linear (Y)	-	Δ
Rapeseed & Mustard	-	-	Log Linear (Y) Log quadratic (A,P)	-	-	Quadratic (A,P) Linear (Y)
Linseed	-	Linear (Y)	Log quadratic (A,Y) Quadratic (P)	-	-	-
Others						
Sugarcane	Δ	-	Δ	-	Linear (P)	-
Cotton	-	Linear (A, Y)	-	-	-	-
Guarseed	-	-	-	-	-	Quadratic (A)

Δ = No equation found suitable - = Crop not select

Table-4.14 Cropwise Summary of Equations Identified for Trend Predictions of Area, Production and Yield of Selected Crops

Particular	Banswara	Bhilwara	Chittorgarh	Dungarpur	Udaipur	Rajastha n
Cereals						
Rice	Δ	-	-	Δ	Δ	-
Jowar	-	Linear	Δ	-	Δ	Δ
Bajra	-	-	-	-	-	Δ
Maize	Linear	Linear (A,P)	Linear (P)	Δ	Quadratic (A)	Linear (A,P)
Small millets	Linear	-	-	Linear (P,Y) Quadratic (A)	Linear (A) Quadratic (P)	-
Wheat	Log Quadratic (P) Linear (A)	Quadratic	Log Linear	Linear	Linear (P) Quadratic (Y)	Liner (A) Log linear (P,Y)
Barley	-	Linear	-	-	Linear (A) Quadratic (Y)	Δ
Pulses						
Kharif Pulses	Log Quadratic (A, P)	-	Δ	Linear (A,P)	-	Δ
Arhar	Δ	-	-	Δ	Quadratic (A, Y) Log Linear (P)	-
Gram	Linear (P,Y)	-	Log Linear (Y) Log Quadratic (A, P)	Linear (Y) Log Linear (P)	-	Δ
Oilseeds						
Sesamum	-	Δ	-	-	-	-
Groundnut	-	Linear (Y)	Δ	-	-	Linear (P,Y)
Soybean	-	-	Quadratic (A,P) Log linear (Y)	-	-	-
Rape & Mustard	-	-	Log Linear (Y) Log Quadratic (A,P)	-	-	Quadratic (A,P) Linear (Y)
Linseed	-	Linear (Y)	Log Quadratic (A,Y) Quadratic (P)	-	-	-
Others						
Sugarcane	Δ	-	Δ	-	Linear (P)	-
Cotton	-	Linear (A,Y)	-	-	-	-
Guarseed	-	-	-	-	-	Quadratic (A)

Δ = No equation found suitable - = Crop not select

4.3 GROWTH RATE ANALYSIS :

Time series of crop output do not reveal, normally, a smooth trend. This is not only true for district level series but holds equally for state level series too. Hence, growth rates based on a selected few observations at the beginning and end of the series or for that matter even those based on their averages too may prove to be misleading (Dandeker, 1980; Sagar 1980, p. 52). That is why, in the present study growth rates have been estimated by using all the observations in the series for the period 1970-71 to 1996-97.

All the growth rates in the present study are compound growth rates (CGRs) estimated by fitting a log linear trend function namely $\log Y_t = a + bt$ to the time period specified. The compound growth rate is capable of providing better idea of overall growth as compared to linear growth rate. The compound growth rates of area, production and productivity of the selected crops in the districts of Udaipur division viz., Banswara, Bhilwara, Chittorgarh Dungarpur and Udaipur vis-à-vis major principal crops in the state of Rajasthan are presented in (Tables 4.15 to 4.20).

Banswara:

From table 4.15 it is clear that the area, production and productivity of rice, tur and sugarcane did not show any significant change during the period under study. The area, production, and productivity of maize increased significantly by 5.34, 8.49 and 3.00 per cent respectively. Whereas in case of wheat there is significant increase in area by 2.02 per cent per annum and production by 7.52 per cent. The production of Kharif pulses increased due to the significant increase in area. The production and productivity of small millets did not show any significant change but significant decrease (3.36%) in area. The rabi crop, gram, there is also significant increase in production and productivity during the period under study.

The results further reveals that the growth rates of area under maize and Kharif pulses in kharif season and wheat in rabi season are positive and statistically significant. The trend of growth rates of production under maize, kharif pulses, wheat and gram are positive and statistically significant except small millets (-14.15 %). Likewise the growth rates of productivity is positive for maize, wheat and gram but negative in case of rice (-0.35%), small millets (-11.36%), kharif pulses (-2.36%), tur (-0.89%) and sugarcane (-0.29 per cent) respectively. Thus growth rates are negative in all the kharif crops except maize in Banswara district.

Table further indicates that the trend of growth rates of area, production and productivity of maize is positive and statistically significant. This analysis clearly indicates that maize grower in Banswara district substituting the area under this crop by some other crops.

Table: 4.15 Compound Growth Rates of Area, Production and Productivity of Selected Crops in Banswara District During 1970-71 to 1996-97

Crops	Area	Production	Productivity
Maize	5.3444** (0.339)	8.4940** (0.7244)	3.0043** (0.6166)
Rice	0.4849 (0.2777)	0.1747 (2.168)	-0.3517 (2.1338)
Small millets	-3.3650** (0.5474)	-14.1548 (8.0256)	-11.3613 (7.8170)
Wheat	2.0208** (0.117)	7.5256** (2.550)	2.2033 (1.929)
Gram	0.7788 (0.6961)	3.9684** (0.9097)	3.1197** (0.5461)
Kharif Pulses	5.5837** (0.7536)	5.3102** (1.8671)	-2.3559 (1.5738)
Tur	0.9062 (1.0688)	-1.7521 (2.2170)	-0.8919 (1.4377)
Sugarcane	0.6348 (0.7878)	0.8252 (1.1608)	-0.2999 (0.5739)

Figures in parenthesis are standard errors.
* Significant at 5 per cent level of probability
** Significant at 1 per cent level of probability

Bhilwara:

It is clear from table 4.16 that the trend of growth rates of area is positive and statistically significant in most of the selected crop except barley (-3.45%), groundnut (-0.59%) and cotton (-2.83%) respectively. This indicates that there is gradual improvement in area under jowar followed by maize, wheat, sesamum and linseed. The growth rates of production are positive and statistically significant in case of jowar, wheat and linseed but negative in case of barley (-1.43%) and cotton (-0.93%). Interestingly the trend of growth in productivity under all the selected crops are positive and statistically significant except jowar, maize and sesamum during the study period.

Table further reveals that there is a positive and statistically significant growth rate in area, production and productivity of wheat crop. But in case of jowar, maize, sesamum and linseed the growth rates of area, production and productivity is also positive but statistically significant only in area and production of jowar and maize whereas production and productivity in case of linseed crop. The important rabi crop i.e. barley exhibited negative growth rates in area and production but positive and statistically significant in productivity during the period under study. Similar trend is noticed in case of cotton crop. The positive growth rates in area, production and productivity of wheat shows that performance of the crop in the district is satisfactory as compare to state level. The negative growth of area and production indicate that substitution of area under cotton crop in other remunerative crops.

Table:4.16 Compound Growth Rates of Area, Production and Productivity of Selected Crops in Bhilwara District During 1970-71 to 1996-97.

Crops	Area	Production	Productivity
Jowar	3.5658**	7.4008**	2.2314
	(1.3592)	(2.6708)	(1.1299)
Maize	1.1923**	1.8146*	0.5985
	(0.1631)	(0.9611)	(0.9265)
Wheat	1.5009*	4.9260**	3.3961**
	(0.6544)	(0.9180)	(0.4523)
Barley	-3.4526**	-1.4290	2.0545**
	(0.5113)	(0.7718)	(0.4230)
Sesamum	0.6348	2.5022	1.8777
	(1.1122)	(2.1241)	(1.5248)
Groundnut	-0.5940	1.6432	2.1735*
	(0.6638)	(1.0999)	(0.9645)
Linseed	0.0535	83.5489**	2.6245**
	(1.3131)	(21.3419)	(0.8270)
Cotton	-2.8346**	-0.9311	1.7722**
	(0.6040)	(1.1634)	(0.7030)

Chittorgarh:

The compound growth rate of area under maize, kharif pulses, wheat, gram, groundnut, soybean and rapeseed & mustard are found positive but statistically significant in case of maize, wheat, soybean and rape & mustard crop only. Whereas the growth rates of area under jowar, linseed and sugarcane found negative and statistically significant only for jowar (-3.58%), linseed (-6.96%) and sugarcane (-1.98%) respectively (Table 4.17).

The trend of growth rates in production most of the selected crops are positive except jowar (-2.65%) and sugarcane (-13.40%). However, the trend of growth rates of productivity under all the kharif and rabi crops found positive and statistically significant except kharif pulses (-0.025%) during the period under consideration.

Table:4.17 Compound Growth Rates of Area, Production and Productivity of Selected Crops in Chittorgarh District During 1970-71 to 1996-97

Crops	Area	Production	Productivity
Jowar	-3.5865*	-2.6526	0.8850
	(0.4884)	(1.4570)	(1.2079)
Maize	1.7261**	2.8926**	1.1401
	(0.1405)	(0.8529)	(0.8384)
Wheat	1.2317*	3.4377**	2.9970**
	(0.5361)	(0.7621)	(0.5455)
Gram	0.6051	3.1167*	2.6999**
	(1.0193)	(1.3534)	(0.6148)
Kharif Pulses	1.1302	1.1789	-0.0255
	(0.6753)	(1.0950)	(1.1510)
Groundnut	0.8642	3.7881**	2.8921**
	(0.5109)	(0.7886)	(0.5923)
Soybean	30.9216**	48.4077**	12.0751**
	(2.5021)	(8.0645)	(5.2128)
Rape & Mustard	41.4187**	44.5589**	3.1911**
	(3.7447)	(4.2273)	(0.7128)
Linseed	-6.9654**	4.0925	2.1474**
	(1.4138)	(7.2623)	(0.6115)
Sugarcane	-1.9798*	-13.4002	1.0044*
	(0.8576)	(7.5174)	(0.4651)

Further, the growth rates of area, production and productivity of maize, wheat, groundnut, soybean and rapeseed & mustard are positive but statistically significant in case of wheat, soybean and rapeseed & mustard crop. This clearly indicates that the growers in chittorgarh districts substituting the area under these crops by some other crops looking to the profitability. The decline in area as well as production of jowar and sugarcane may be also due to substitution in other remunerative crops. The table further reveals that the growth rates in area and production of jowar and sugarcane crops were negative but statistically significant only in area, but for productivities both the crops are positive. The positive growth rates in area, production and productivity of wheat, soybean and rapeseed & mustard indicates gradual improvement in performance of these crops.

Dungarpur:

Table 4.18 indicates that there has been no significant change in area, production and productivity of maize, rice, gram and tur during the period. The area, and production of small millets decreased significantly. Moreover, the area of kharif pulses increased significantly by 5.69 per cent per annum but this increase did not affect the production whereas the rate of growth in productivity is decreasing during the period. The significant increase in area, production & productivity of wheat crop was noticed.

The trend of growth rates of area under rice, kharif pulses, tur and wheat is positive whereas in case of maize, small millets and gram it is negative and statistically, significant in small millets only. The growth rates of production is positive in rice, wheat, gram, kharif pulses and tur but significant in wheat only. The negative growth rates of production in maize (-0.35 %) and small millets (-10.12 %) but significant in small millets observed during the period. Likewise, trend of growth rates of productivity is positive and statistically significant in case of only in rabi crops viz. wheat (1.79 %) and gram (3.04 %) respectively.

An analysis clearly indicates that the growth rates of area, production and productivity is positive in case of wheat and rice but statistically significant in wheat only. Similarly growth rates in all the three component i.e. area, production and productivity are negative in case of maize and small millets but statistically significant in small millets during the period under study. The significant growth rates in area, production and productivity of wheat crop shows that performance of the crop in the district is satisfactory as compare to State level. The negative growth rates in area, production and productivity in respect of small millets clearly indicates that the growers are not taking much of interest in it as compared to other kharif crops.

Table 4.18 : Compound Growth Rates of Area, Production and Productivity of Selected Crops in Dungarpur Districts During 1970-71 to 1996-97

Crops	Area	Production	Productivity
Maize	-0.1563 (0.2989)	-0.3583 (1.5372)	-0.2508 (1.4470)
Rice	0.1227 (0.6916)	0.7665 (2.552)	0.7603 (2.0649)
Small millets	-4.3199** (0.2864)	-10.1204* (3.1043)	-6.0903 (3.5246)
Wheat	1.6932* (0.6088)	3.5248** (0.7151)	1.7992* (0.4454)
Gram	-2.0785 (1.0823)	1.2598 (1.2124)	3.0462* (0.7118)
Kharif Pulses	5.6900** (0.5841)	12.3770 (11.3852)	-0.8114 (3.1974)
Tur	1.3767 (1.4006)	18.5503 (15.5592)	-3.3870 (2.6695)

Udaipur:

It is obvious from table 4.19 that the area, production and productivity of jowar, maize, small millets, rice, wheat and urad did not show any significant change but significant decrease, (8.48 %) in area of small millets and significant increase in production and productivity of wheat by 3.00, 2.71 per cent respectively. The productivity of barley increases significantly by 1.75 per cent per annum although the area and production decreased during the period.

As it can be discernible from table 4.19 the growth rates of area under maize, tur, urad and wheat are positive except jowar (-0.98 %), barley (-4.84%), small millets (-8.48%), rice (-1.11%) and sugarcane (-4.21%) respectively. However, the growth rates of area under tur is positive and statistically significant whereas in case of small millets, barley and sugarcane the growth rates of area is negative and significant. The trend of growth rates of production is positive in jowar, maize, small millets, tur, urad and wheat but statistically significant only in case of wheat and tur crop. Likewise in

case of rice, sugarcane and barley the growth rates of production are negative but statistically significant in sugarcane (-3.91%) and barley (-3.15%) during the period under study. The trend of growth rates of productivity in all the crops were found positive except maize (-0.017%) but statistically significant only in rabi crops i.e. wheat and barley.

Table: 4.19 Compound Growth Rates of Area, Production and Productivity of Selected Crops in Udaipur Districts During 1970-71 to 1996-97

Crops	Area	Production	Productivity
Jowar	-0.9813 (0.8664)	1.4972 (1.6359)	2.6160 (1.4177)
Maize	0.0485 (0.2764)	0.0294 (1.1516)	-0.0168 (1.1511)
Rice	-1.1101 (0.6603)	-0.8833 (2.2366)	0.4459 (1.8965)
Small millets	-8.4776** (0.6322)	1.9763 (1.3150)	1.5083 (0.2501)
Wheat	0.3025 (0.6929)	3.0040** (0.9487)	2.7093** (0.4730)
Barley	-4.8440** (0.6573)	-3.1598** (0.7581)	1.7536* (0.4686)
Tur	2.8880** (0.9476)	92.1040** (21.5415)	1.0182 (2.3281)
Urad	0.8117 (0.4410)	1.6432 (2.3872)	0.8831 (2.2300)
Sugarcane	-4.2009** (0.9926)	-3.9110** (1.2611)	0.8906 (0.6272)

An analysis further reveals that the growth rates in area, production and productivity are positive in tur, urad and wheat crop. The growth rates of production and productivity are positive and significant in wheat whereas in case of tur significant in area and production during the period under consideration. The growth rates in respect of area, production and productivity of wheat, tur and urad are positive clearly indication of the performance of the crop in the district is satisfactory as compare to state level.

Rajasthan:

There is no significant change in growth rates for area, production and productivity of jowar, bajra, grám, kharif pulses, groundnut and guarseed but decrease in area of groundnut by 0.16 per cent, and increased in production

and productivity by 1.94 and 2.10 per cent per annum respectively. The area of wheat and rapeseed & mustard significantly increased by 1.26 and 10.58 per cent per annum respectively however the production is not decreased significantly, although the productivity increased significantly by 3.21 and 2.84 per cent per annum during the period. The area of barley declined significantly by 4.69 per cent per annum. However, the production decreased to certain extent (2.90%) although the productivity of barley significantly increased by 1.87 per cent per annum during the period under consideration (Table 4.20).

Table clearly indicates the trend of growth rates of area under the selected principal crops of Rajasthan State viz., jowar, bajra, maize,wheat, guarseed and rapeseed & mustard are found positive except barley (-4.60%), gram (-0.75%) and groundnut (-0.16%) and kharif pulses (-0.46%) respectively during the period. The growth rates of production under jowar bajra, guarseed and kharif pulses found positive whereas in case of maize, wheat, groundnut and rapeseed & mustard are positive and also statistically significant. However, in case of barley and gram the growth rates of production are negative but statistically significant in barley. Likewise the growth rates of productivity under all the selected crops found positive except guarseed (-0.17%). However, there is positive and statistically significant growth rates in productivity under wheat, groundnut and rapeseed & mustard crops.

An examination of table reveals that the compound growth rates of area, production and productivity of bajra, maize, wheat and rapeseed & mustard are positive but statistically significant in case of wheat and rapeseed & mustard crop only. Whereas in case of maize the growth rates of area and production are positive and statistically significant during the period under consideration.

Table: 4.20 Compound Growth Rates of Area, Production and Productivity of Selected Crops in the State of Rajasthan During 1970-71 to 1996-97

Crops	Area	Production	Productivity
Jowar	0.2454 (1.7312)	1.1495 (0.9787)	0.0794 (0.8296)
Bajra	0.0203 (0.3224)	1.9511 (1.4320)	1.9374 (1.2909)
Maize	0.9594** (0.1627)	1.8243* (0.8675)	0.8561 (0.8592)
Wheat	1.2639* (0.2798)	4.5192** (0.3610)	3.2073** (0.2614)
Barley	-4.6967** (0.4389)	-2.9031** (0.4919)	1.8661** (0.2815)
Gram	-0.7574 (0.5484)	-0.6235 (0.8009)	0.1337 (0.3920)
Kharif Pulses	-0.4610 (0.3667)	0.4687 (1.9663)	0.9288 (1.7430)
Groundnut	-0.1622 (0.4368)	1.9430* (0.7511)	2.1003* (0.6818)
Rape & Mustard	10.5854** (0.7130)	13.7278** (1.0736)	2.8367** (0.6393)
Guarseed	1.4142 (0.7005)	1.6522 (2.1768)	-0.1761 (1.5860)

An analysis further indicates that the growth rates of production and productivity found positive in case of groundnut and kharif pulses but negative growth rates in case of area in both the crops. At state level area, production and productivity in maize, wheat and rapeseed & mustard are positive and significant. Alongwith significant rise in productivity and significant rise in area clearly indicates that there is dependable market support for these crops at state level.

4.3.1 Classification of Growth Rates

Classification of growth rates of area, production and productivity under major selected crops in the districts of Udaipur division viz. Banswara, Bhilwara, Chittorgarh, Dungarpur and Udaipur as well as the state of Rajasthan are presented in (Table 4.21).

The table indicates that the total output in case of maize, wheat and gram crop has increased due to rise in area and productivity of these crops in the district of Banswara. Inspite of decline in productivity of rice, kharif pulses and sugarcane the output has increased due to increased in area of the respective crops. However due to declining in area as well as in productivity of small millets the output exhibited a declining trend.

In Bhilwara district, the production in respect of jowar, maize, wheat, sesamum and linseed increased due to rise in area and productivity. With the decline in area under barley and groundnut, the output has increased due to significant rise in productivity of these crops. The growth of output of cotton has declined in Bhilwara districts due significant decline in area inspite of increase in productivity.

Similarly in Chittorgarh district the total output in case of maize, wheat, gram, groundnut, soybean and rapeseed & mustard crop has increased due to rise in area and productivity of these crops. In case of kharif pulses decrease in productivity the output has increased due to increase in area of the crop. With the decline in area of linseed the production has increased due to significant rise in productivity in the district. The growth of output of jowar and sugarcane has declined in the district due to significant decline in area inspite of increase in productivity.

The growth of output of rice and wheat has increased mainly due to increase in area and productivity in the Dungarpur district. Inspite of decline in productivity of kharif pusles and tur, the output has increased due to increase in area of these crops in the district. The output of gram in Dungarpur district has increased due to significant rise in productivity inspite of decline in area of gram crop. Moreover, with the decline in area and productivity of maize and small millets the output exhibited a declining trend in the district.

Table- 4.21: Classification of Growth Rates of Area, Production and Productivity Under Major Selected Crops of Udaipur Division and Rajasthan State

S. No.	Classification	Banswara	Bhilwara	Chittorgarh	Dungarpur	Udaipur	Rajasthan
1.	(+)A, (+)P, (+) Y	Maize, Wheat, and Gram	Jowar, Maize, Wheat, Sesamum and Linseed	Maize, Wheat, Gram, Groundnut Soybean and Rape & Mustard	Rice and Wheat	Wheat, Tur and Urad	Jowar, Bajra, Maize, Wheat and Rape & Mustard
2.	(+)A, (+)P, (-) Y	Rice, Kharif Pulses and Sugarcane	-	Kharif Pulses	Kharif Pulses and Tur	Maize	Guarseed
3.	(+)A, (-)P, (-) Y	Tur (Arhar)	-	-	-	-	-
4.	(-)A, (+)P, (+) Y	-	Barley and Groundnut	Linseed	Gram	Jowar and Small millets	Kharif Pulses and Groundnut
5.	(-)A, (-)P, (+) Y	-	Cotton	Jowar and Sugarcane	-	Rice, Barley and Sugarcane	Barley and Gram
6.	(-)A, (-)P, (-) Y	Small millets	-	-	Maize and Small millets	-	-

A, P and Y denotes the Area, Production and Productivity
+ Positive Growth Rate
- Negative Growth Rate

Likewise in Udaipur district the total production of wheat, tur and urad has increased mainly due to increase in area and productivity of these crops. Due to decline in productivity of maize, the output has increase due to increase in area in the district. Inspite of decline in area of jowar and small millets, the output has increased due to significant rise in productivity of these crops in the district. In case of rice, barley and sugarcane, the growth of output in these crops is declined in Udaipur district due to significant decline in area inspite of increase in productivity.

As state level, the total output of jowar, bajra, maize, wheat and rapeseed & mustard has increased mainly due to rise in area and productivity of these crops in the state of Rajasthan. A similar trend in these, crop except bajra also observed in the districts of Udaipur division. Inspite of decline in productivity of guarseed, the output has increased due to increase in area of guarseed in the state of Rajasthan. With decline in area under kharif pulses and groundnut the output of these crops has increased due to significant rise in productivity at state level. A similar pattern of growth of trend is observed in case of gram in Bhilwara district. The growth of output in respect of barley and gram crop has declined in the state of Rajasthan due to significant decline in area inspite of increase in productivity.

4.4 DECOMPOSITION ANALYSIS:

The decomposition analysis of the growth of crop output in India was introduced by Minhas and Vaidyanathan (1965), who used for the first time an additive scheme of decomposition. With this scheme the growth of crop output was disaggregated into a set of physical factors viz., area, yield rate and cropping pattern as well as an interaction term between yield rate and cropping pattern. The same model was used by Mishra (1971) for the decomposition of crop output in Gujarat by Sondhi and Singh (1975) for a comparative analysis of the pre-green revolution and the green revolution periods.

In the present study decomposition analysis have been used as the method given by Vidya Sagar (1977, 1980) in order to measure the relative importance in area, yield and their interaction on the total change in production. The word interaction here need not be confounded with the term used in statistical analysis of "experimental design". It shows the impact of joint movements in the two factors on overall production increase. Three years average has been taken on each end i.e. 1970-73 and 1994-97. The effect of yield, area and their interaction in the increase/decrease of total production for all the selected crops in each district of Udaipur division viz., Banswara, Bhilwara, Chittorgarh, Dungarpur and Udaipur vis-à-vis for Rajasthan state have been worked out and presented in (Table 4.22 to 4.27).

Banswara :

An examination of table 4.22 revealed that among cereals the increase in output of wheat and maize is due to acreage expansion. But in case of rice, the output infact declined mainly due to yield expansion. Towards decline in output of rice the effect yield reduction is about 154 per cent. Similarly the reduction in the output of small millets due to sharp decline in yield expansion followed by acreage expansion. The interaction of area and yield effect among cereals for maize and small millets are negative but positive in case of rice and wheat crop. The interaction of yield and area effect showed significant contribution (to the tune of 37 per cent) to output growth in the case of wheat.

Among pulses, the increase in output of gram was due to yield expansion but in case of kharif pulses it is mainly due to area expansion. Towards decline in output of tur, the effect of area reduction is about 72 per cent. The decline in output of tur, a substantial rise in output growth of kharif pulses. This growth came through acreage expansion.

Table : 4.22 Area, Yield and their Interaction Effect on Total Production of Selected Crops in Banswara District.

Crop	Yield Effect (%)	Area Effect (%)	Interaction Effect (%)
Cereals			
Maize	-304.89	594.03	-188.95
Rice	153.95	-96.05	42.11
Small millets	75.30	66.48	-41.75
Wheat	13.78	49.08	37.13
Pulses			
Kharif Pulses	6.06	79.84	13.65
Gram	55.51	22.45	21.13
Tur	43.00	72.50	-15.77

The result further revealed that area effect was the highest in kharif pulses followed by wheat and gram. However, the highest production effect is recorded in gram followed by wheat and kharif pulses respectively in Banswara district. The interaction of area and yield effect is positive in case of rice, wheat, kharif pulses, and gram but in case of maize, small millets and tur it is negative.

Bhilwara :

The results of decomposition analysis revealed that majority of cereal crops the increase in output is due to yield expansion rather than area. This has particularly true with jowar and wheat crop. But in case of maize, the output infact increase due to acreage expansion. However, the decline in output of barley is mainly due to sharp decline in area (Table 4.23).

Among oilseeds crops the increase in output of groundnut and linseed is mainly due to yield expansion. This effect was same as that of cereal crops like jowar and wheat. In case of sesamum the decline in the output is due to acreage expansion.

Table : 4.23 Area, Yield and their Interaction Effect on Total Production of Selected Crops in Bhilwara District.

Crops	Yield Effect (%)	Area Effect (%)	Interaction Effect (%)
Cereals			
Jowar	90.84	2.62	6.73
Maize	0.88	98.86	0.25
Wheat	37.49	28.18	34.21
Barley	-1184.62	770.51	514.10
Oilseeds			
Sesamum	-53.57	127.86	25.71
Groundnut	100	0	0
Linseed	216	-66.67	49.34
Others			
Cotton	-430.66	328.57	204.28

In cotton, the effect of area reduction was so intense that it out weighted the effect of yield expansion and net cumulative effect was decline in output. Towards decline in output of cotton, the effect of area reduction is about 329 per cent. Contrary the decline in output of sesamum a substantial rise in output growth of oilseeds crops like linseed and groundnut.

It was encouraging that production effect was positive for all the cereal crops except barley, which indicates that decrease in production was mainly due to reduction in area.

Among oilseeds the production effect was positive for all except sesamum crop. It again indicates that decrease in production is due to acreage expansion.

The result further reveals that the highest production effect among cereal crops was recorded in jowar followed by wheat. Whereas in case of oilseeds the highest production effect were noticed in linseed. The interaction

effect is also positive for all the selected crops except linseed in Bhilwara district. The result clearly indicate that the production of jowar, wheat and groundnut is dominated over area and interaction effect.

Chittorgarh:

It is clear from table 4.24 that in most of the selected crops the increase in output is due to area expansion rather than yield. But in case of jowar and linseed it is not true. The decline in output of these crops is mainly due to acreage expansion.

Among cereal crops the increase in output of maize and wheat is due to area expansion. But in jowar the output is infact declined, the effect of area is about 111 per cent.

Likewise among pulses the increase in output of kharif pulses is mainly due to yield expansion whereas in case of gram it is acreage expansion.

Table : 4.24 Area, Yield and their Interaction Effect on Total Production of Selected Crops in Chittorgarh District.

Crop	Yield Effect (%)	Area Effect (%)	Interaction Effect (%)
Cereals			
Jowar	-33.18	111.37	21.81
Maize	-66.03	196.76	-30.69
Wheat	27.13	52.62	20.11
Pulses			
Kharif Pulses	62.44	9.86	27.69
Gram	32.76	43.08	24.12
Oilseeds			
Groundnut	98.99	0.60	0.40
Soybean	3.88	40.16	55.95
Rape & Mustard	0.02	74.27	25.70
Linseed	-638.11	370.71	367.39
Others			
Sugarcane	157.35	-41.45	-15.72

In oilseeds crops the increase in output of soybean and rapeseed & mustard is due to area effect. In case of groundnut the increase in output of

groundnut is mainly due to yield expansion rather than area. But in case of linseed that reduction in output is mainly due to acreage expansion.

The result further revealed that area effect was the highest in maize followed by rapeseed & mustard, wheat, gram and soybean respectively. The production effect is positive for all the crops except jowar and linseed, which indicates that the decrease in production is mainly due to reduction in area. The highest production effect was recorded in sugarcane followed by groundnut, kharif pulses and wheat crops in Chittorgarh district.

The interaction of area and yield effect is also positive for all the crops except maize and sugarcane. The interaction of yield and area effect shows significant contribution (to the tune of 20 per cent) to output growth in case of wheat. The results clearly shows that in case of wheat, gram and rapeseed & mustard crop production is dominated over area and interaction effect.

Dungarpur :

It is obvious from table 4.25 that among cereal crops, rice and wheat the increase in output is mainly due to acreage expansion. But in case of maize the decline in output is due to yield effect whereas, in case of small millets it is due to area effect. Towards decline in output of small millets the effect of area reduction is about 74 per cent.

Further, among cereals more or less than fifty two per cent increase in output growth of rice and wheat came through acreage expansion. The contribution of yield expansion in output growth of these two important crops is about 39 and 24 per cent respectively.

The increase in output of gram is mainly due to yield effect whereas, in case of kharif pulses it is due to area effect. But decrease in output of arhar (tur) is mainly due to yield effect.

The result clearly indicated that area effect was the highest in kharif pulses followed by small millets, wheat and rice crops. The highest production effect is recorded in gram followed by arhar, maize and small millets. The interaction of area and yield effect is positive in case of rice, wheat, kharif pulses and arhar but in case of maize, small millets and gram it is negative.

Table :4.25 Area, Yield and their Interaction Effect on Total Production of Selected Crops in Dungarpur District

Crops	Yield Effect (%)	Area Effect (%)	Interaction Effect (%)
Cereals			
Rice	38.82	51.76	9.40
Maize	76.20	34.0	-10.20
Small millets	61.47	74.23	-35.70
Wheat	24.38	52.39	23.23
Pulses			
Gram	178.63	-44.77	-33.86
Kharif Pulses	1.85	96.41	1.74
Arhar	173.78	-98.50	27.77

The results further reveals that the crop like maize and arhar where the production is dominated over area and interaction effect. On the other hand in kharif pulses, small millets, wheat and rice area is responsible for higher production. The yield effect had a least contribution in total production of kharif pulses in Dungarpur district.

Udaipur:

The effect of yield, area and their interaction in increase/decrease of total production of selected crops in Udaipur district are given in table 4.26. The result revealed that among cereals majority of crops, the decrease in output is due to area effect except wheat. In case of wheat, increase in output is due to yield effect. Among pulses, the increase in output of tur and urad is due to acreage expansion. Whereas in sugarcane the decrease in output is mainly due to area effect.

Further among pulses 46 per cent increase in output growth of tur and 78 per cent in urad came through acreage expansion. The contribution of yield expansion in output growth of these two crops is less than 26 per cent. The interaction of yield and area effect showed significant contribution (to the tune of 28 per cent) to output growth in case of tur crop.

Table :4.26 Area, Yield and their Interaction Effect on Total Production of Selected Crops in Udaipur District

Crops	Yield Effect (%)	Area Effect (%)	Interaction Effect (%)
Cereals			
Jowar	-171.12	165.09	106.03
Maize	58.08	50.66	-8.72
Rice	-92.65	177.94	15.58
Small millets	-0.69	100	0.65
Wheat	73.78	13.33	12.96
Barley	-86.69	127.63	59.08
Pulses			
Tur	25.99	46.43	27.86
Urd	18.33	77.5	4.17
Others			
Sugarcane	-28.32	111.80	16.52

The table further reveals that area effect is the highest in rice followed by jowar, barley, urad, maize and tur. The production effect was positive for wheat and maize but negative in case of jowar, rice, barley and small millets crops, which indicated that the decrease in production is mainly due to reduction in area.

The highest production effect is recorded in wheat followed by maize, tur and urad crop. The interaction effect in general positive among cereals except maize. The result clearly showed that in case of maize and wheat where the production is dominated over area and interaction effect. However, the interaction effect is also positive for pulses in general.

Rajasthan:

In order to examine the effect of yield, area and their interaction in the increase/ decrease of total production of selected crops in the individual

district of Udaipur division in comparison to the state of Rajasthan has also been attempted. The results of decomposition analysis pertaining to major principal crops in the State of Rajasthan has been worked out and presented in (Table 4.27).

From table it can be seen that the increase in output of maize is mainly due to area effect but in case of wheat it is due to yield expansion. However, among cereals the decrease in output in respect of jowar, bajra and barley crop is due to reduction in area. The effects of yield increase in these crops are neutralized by heavy acreage reduction and the net cumulative effect caused a decline in output growth for these crops. Among pulses, an increase in output in respect of kharif pulses and gram came through yield expansion rather than area.

Further among pulses, 95 per cent increase in output growth of kharif pulses and 67 per cent in gram came through yield expansion. The contribution of acreage expansion in case of kharif pulses is about 4 per cent and for gram crop it is about 27 per cent.

Table : 4.27 Area, Yield and their Interaction Effect on Total Production of Selected Crops in Rajasthan State

Crops	Yield Effect (%)	Area Effect (%)	Interaction Effect (%)
Cereals			
Jowar	-7.81	104.76	3.02
Maize	-144.84	272.44	-27.65
Bajra	41.61	61.82	-3.44
Wheat	45.83	27.03	27.15
Barley	-151.97	167.28	84.71
Pulses			
Kharif pulses	95.19	3.59	1.25
Gram	69.24	26.69	4.08
Oilseeds			
Groundnut	98.42	1.10	0.49
Rape & Mustard	3.71	69.78	26.49
Others			
Guarseed	25.54	54.35	20.12

Likewise among oilseeds increase in output of groundnut is mainly due to yield expansion whereas in case of rapeseed & mustard the growth in output is due to acreage expansion. Result further revealed that among oilseeds, 98 per cent increase in output growth of groundnut came through yield expansion whereas in case of rapeseed & mustard about 70 per cent increase in output of growth came through acreage expansion. The interaction of yield and area effect showed significant contribution (to the tune of 26 per cent) to output growth in the case of rapeseed & mustard.

The result further revealed that area effect was the highest in maize followed by barley, jowar, rapeseed & mustard, guarseed and gram crop. The production effect ias positive for all the major principal crops except jowar, maize and barley respectively. The highest production effect is recorded in groundnut followed by kharif pulses, gram and wheat crop. The interaction effect in general is positive for all the cereal crops except maize and bajra. However among pulses and oilseeds crops the interaction effect is positive in general.

4.4.1 Factors Responsible for Increase/Decrease Total Output of Selected Crops :

In the state of Rajasthan reduction in total output of bajra is due to acreage expansion. The increase in output growth of maize came through area effect in Banswara, Bhilwara, Chittorgarh district vis-à-vis State. In contrast to this reduction in production of maize in Dungarpur is due to yield expansion whereas in case of Udaipur district it is on account of area effect. Towards decline in output of rice the effect of area in Udaipur but yield effect is observed in Banswara district. Further, the increase in output of rice in Dungarpur is mainly due to acreage expansion. The total output of wheat is increased due to acreage expansion in all the districts of Udaipur division except Bhilwara district. Though the increase in output of wheat in Bhilwara and State is due to yield effect. There is reduction in output of small millets is due to area effect in Dungarpur and Udaipur districts whereas in case of Banswara it is because of yield expansion. Towards decline in the output of jowar is on account of area effect in Dungarpur, Udaipur, and State but in

case of Bhilwara it is due to yield effect. The reduction in total output barley in Bhilwara, Udaipur and at the State is due to acreage expansion. There is increase in the production of kharif pulses due to area effect in Banswara and Dungarpur district whereas in case of Chittorgarh and State of Rajasthan is because of yield expansion. The yield effect is observed to increase the production of gram for State as well as district of Banswara and Dungarpur. Towards decline in the production of tur is due to area effect in Banswara, yield effect in Dungarpur whereas increase in output of tur is on account of area effect in Udaipur district.

Table: 4.28 Relative Contribution of Different Elements to Increase/ Decrease Total Production of the Selected Crops

Crops	Districts of Udaipur Division and State					
	Banswara	Bhilwara	Chittorgarh	Dungarpur	Udaipur	Rajasthan
Cereals						
Bajra	-	-	-	-	-	(-)A
Maize	(+)A	(+)A	(+)A	(-)Y	(-)A	(+)A
Rice	(-)Y	-	-	(+)A	(-)A	-
Wheat	(+)A,I	(+)Y	(+)A, I	(+)A	(+)A	(+)Y
Small millets	(-)Y	-	-	(-)A	(-)A	-
Jowar	-	(+)Y	(-)A	-	(-)A	(-)A
Barley	-	(-)A	-	-	(-)A	(-)A
Pulses						
Kharif Pulses	(+)A	-	(+)Y	(+)A	-	(+)Y
Gram	(+)Y	-	(+)A	(+)Y	-	(+)Y
Tur	(-)A, I	-	-	(-)Y	(+)A, I	-
Urad					(+)A	
Oilseeds						
Sesamum	-	(-) A	-	-	-	-
Groundnut	-	(+)Y	(+)Y	-	-	(+)Y
Linseed	-	(+)Y	(-) A	-	-	-
Soybean	-	-	(+)A	-	-	-
Rape & Mustard	-	-	(+)A	-	-	(+)A, I
Others						
Cotton	-	(-)A	-	-	-	-
Guarseed	-	-	-	-	-	(+)A
Sugarcane	-	-	(+)Y	-	(-)A	-

A = Area, Y = Yield
(+) = Increase in Production
(-) = Decrease in Production
I = Interaction Effect

However, there is also observed the interaction effect in Banswara and Udaipur district to increase decrease the total output of tur.

Among oilseeds, crops reduction in production of sesamum in Bhilwara is due to acreage expansion. Likewise the increase in the output of groundnut is due to yield expansion rather than area in Bhilwara, Chittorgarh as well as State of Rajasthan. Towards decline in output of linseed is due to area effect but increase due to yield effect in Bhilwara district. The area effect is mainly for the increase the production of soybean, rapeseed & mustard in Chittorgarh. Further at State level, the increase in output of rapeseed & mustard is due to area effect followed by interaction effect.

B: PARAMETRIC ANALYSIS OF TIME SERIES

4.5 INTRODUCTION:

Series of observation generated through time on a character under study is termed as time series. Such series require separate econometric analysis to know the different sources of variation effecting the nature of behaviour of the observation. Furthermore, the analysis in meaningful for deeper understanding of the inner behaviour of the character under study as well as for forecasting the future time dependent observed value. The observed value of the time series is affected by four components viz., longtime (or secular) trend, seasonal variation, cyclical and random fluctuation. In general practice, estimated trend by fitting linear or log linear or any other function of time and consider the error (residuals) as a cyclical fluctuations. In this direction a number of authors (Stock and Watson, 1988) shows that the fluctuations that are attributed to cyclical factors may in fact be due to variation in the trend itself. In such a situation, usual practice of running a regression on time and treating the residuals as cyclical component may not be relevant.

While analysing time series the relationship among them are likely to be spurious or dubious (Gujarati, 1995). This happens when one or more of the series in regression equation are non-stationary or contains unit root in their auto regressive representation. In such cases an appropriate strategy is to test, all the series under considerations for stationarity before analysing further, some of them are found to be non-stationary. The relation among them as estimated generally using ordinary least square (OLS) are likely to be spurious.

In time series analysis there are broadly three types of series.

(i) Those series which have, mean reverting fluctuations around level.

(ii) Which have, mean reverting fluctuations around a deterministic trend (increases by some fixed amount every period).

(iii) Those series which having fluctuations, not mean reverting around a deterministic trend.

From the above, the first category represents stationary series. The second category, those series in which deviations from trend are stationary. In the third category, the deviation from trend too are not stationary. This type of series creates problems. In such situation the usual practice of running regression on time stands invalidated and one has to test for variable trend. Estimation of relationship among variables may results in spurious relationship if the nature of the data generating process series under consideration are not taken care of. This chapter attempts to investigate the nature of series under consideration for stationarity and finding their order of integration, which is the first step in further analysis of these series. The following section discusses the introduction followed by basic concepts relating to time series in section 4.6. Section 4.7 contains the test related to unit root and section 4.8 provides the empirical results. Section 4.9 pertaining to cointegration analysis while 4.10 described the conclusions of cointegration.

4.6 BASIC CONCEPTS RELATED TO TIME SERIES:

A time series is a set of observation on the values that a variable takes at different times. Most of the empirical work based on time series data assumed that the under considered time series are stationary. In regression analysis a strong relationship between two variables may obtained due to strong trends. So in this case high R^2 value will be obtained. This high R^2 value may not reflect the true association between the two. This high value is due to presence of strong trend, the relationship between two variables is spurious not true.

When a time series data are considered it can be seen as a realization (a sample) of the stochastic process. The difference between realization and stochastic process is like the difference between sample and its population in cross-sectional data.

A time series X_t is said to be stationary if its mean, variance and auto covariances (at various lags) are independent of time.

Symbolically, a stationary time series must satisfy the following conditions for all values of t.

$$E(X_t) = \mu \text{ (mean)}$$

$$Var(X_t) = E[(X_t-\mu)^2] = \sigma^2$$

$$Cov(X_t, X_{t+r}) = E[(X_t-\mu)(X_{t+r}-\mu)]$$

If we shift the origin of X from X_t to X_{t+r}, the mean, variance and autocovariance of X_{t+r} must remain the same.

As stated above if a time series is not stationary if its mean, variance and autocovariances are constant over time is termed as non stationarity time series. One of the basic assumption made in modeling and forecasting that the series must be stationary. If series is not stationary, then its mean, variance and covariances are changing so that models which assumes these are constants will be misleading. This is the basic concepts behind the stationarity.

The standard classical methods of estimation are based on the assumption that the mean and variances of the variables are independent of time. But applications of unit root test have shown that these assumptions are not satisfied in number of macro economic time series. Variables where mean and variances are changes over time are called non-stationary or unit root variables. Furthermore, the unit root has also shown that using classical estimation method like OLS, to estimate relationship with unit root variable gives misleading inferences. This is the problem of spurious regression. If the

mean and variances of the unit root variables changes over time, all the computed statistics in a regression model, are also time dependent and fair to converge to their true value as the sample size increases. Further, conventional test of hypothesis will be biased towards rejecting the null hypothesis of no relationship between dependent and independent variables. This is the basic theme behind the 'unit root'.

A general model for a variable X_t may be as

$$X_t = \alpha+\beta t+U_t$$

Where, U_t is the stochastic error terms and has zero mean, constant variance σ^2, and is unautocorrelated.

In the above model, there may be three types of structures for disturbance term U_t and accordingly three different types of series.

- U_t is white noise series. Here X_t will be stationary about trend (if $\beta = 0$, it is about level)
- U_t is stationary possibly auto regressive process

Since, the disturbances are generated as follows

$$U_t = \rho U_{t-1} + \varepsilon_t$$

$$\text{Where } -1 < \rho < 1$$

then in this case X_t may be ρ represented as

$$X_t = [\alpha(1-\rho) + \beta\rho] + \rho X_{t-1} + \beta (1-\rho)t+\varepsilon_t$$

and again it has a trend stationary process (level stationary if $\beta=0$)

If $\rho=1$ in the above equation becomes

$$X_t = \beta+ X_{t-1}+\varepsilon_t$$

and it is represented as a random walk with drift (if $\beta=0$, then without drift) if the residual is white noise. Hence this situation is also called unit root.

If ε_t in the above equation is stationary, X_t will be stationary and in that case X_t is said to be integrated of order 1. However, if ε_t itself is integrated of order 1, then $\Delta^2 X_t$, rather than ΔX_t will be stationary. In such a case X_t is said to be integrated of order 2. In general, if a series has to be differences 'd' times before it becomes stationary, it is said to be integrated of order 'd' and is denoted as I(d).

4.7 TESTS RELATING UNIT ROOTS:

4.7.1 Dickey and Fuller Test:

Various attempts have been suggest to test the unit root. One of them most popular test provided for the hypothesis difference stationarity against the alternative hypothesis of trend stationarity has been proposed by Dickey and Fuller (the DF test). This involves running the following regression, equation.

$$\Delta X_t = \alpha + \beta.t + \gamma x_{t-1} + \varepsilon_t$$

Here, null hypothesis, is expressed as $\gamma = 0$

This hypothesis is tested using the critical values provided by Fuller (1976). The significance of trend is tested using the usual t-test. As already stated, if the coefficient of β is significant, then under the null hypothesis the series is random walk with drift, otherwise it is random without drift.

If the error (disturbance) term is found auto correlated, then the above equation modified as

$$\Delta X_t = \alpha + \beta.t + \gamma x_{t-1} + \delta_i \sum_{i=1}^{m} \Delta X_{t-1} + \varepsilon_i$$

Here again the null hypothesis is expressed as $\gamma=0$

When DF test is applied to above model, it is called augmented dickey fuller (the ADF test). The ADF test statistic has the same asymptotic distribution as the DF test statistic, so the same critical value can be used.

Finally, confirming the non-stationarity of the series, the trend is found using the regression.

$$\Delta X_t = \alpha + \varepsilon_t$$

4.8 EMPIRICAL RESULTS:

After the introduction of the variables (series) used, results of the nature of time series under considerations for stationarity are presented.

4.8.1 Selection of Variables:

As already stated regarding selection of major crops in the districts of Udaipur division as well as major principal crops in the state of Rajasthan in chapter-3. This section aims at finding the nature of the time series to be used in subsequent empirical analysis. From each districts vis-à-vis state of Rajasthan, selection of two crops which are common, have been considered here maize and wheat, keeping in view the fact that one belongs to kharif and other to rabi season. However, these two important crops are used as the main staple foods for the state of Rajasthan particularly southern Rajasthan. In all 36 variables have been considered in the present study. Out of these 18 variables pertains to area, production and productivity of maize crops and another 18 variables related to area, production and productivity of wheat crop. The former category includes the area under maize of Banswara district (MBA), production of maize in Banswara district (MBP) and yield of maize in Banswara district (MBY). For other variables of area under wheat in Banswara district (WBA), production of wheat in Banswara district (WBP) and yield of wheat in Banswara district (WBY) have been designated.

The variables assigned for Bhilwara district pertaining to the production of maize in Bhilwara (MWP), productivity (MWY) and area under maize (MWA). For second crop, wheat the variable for area under wheat in Bhilwara (WWA), production of wheat (WWP) and yield of wheat (WWY).

Likewise the variables relating to Chittorgarh district, area under maize (MCA), production of maize (MCP) and yield of maize (MCY). Whereas, the variables for wheat crop as regards to area under wheat (WCA), production of wheat (WCP) and yield of wheat (WCY) have been designated.

In Dungarpur district the variables assigned to area under maize (MDA), production of maize (MDP) and yield of maize (MDY). The variables for wheat crop in Dungarpur districts for area, production and yield are designated as (WDA), (WDP) and (WDY) respectively.

Similarly for Udaipur district, the variables designated for area under maize in Udaipur district (MUA), production of maize in Udaipur district (MUP) and yield of maize in Udaipur district (MUY). For another crop wheat, the variables of area under wheat in Udaipur district (WUA), production of wheat in Udaipur district (WUP) and yield of wheat in Udaipur district (WUY) have been designated.

At state level, same patterns have been adopted for the designation of the variables. The variables relating to area under maize in Rajasthan state (MRA), production of maize in Rajasthan state (MRP) and yield of maize in Rajasthan state (MRY) are designated. While the area under wheat in Rajasthan state (WRA), production of wheat in Rajasthan state (WRP) and yield of wheat in Rajasthan state (WRY) have been designated. All the 36 variables have been taken in log form.

4.8.2 Nature of Time Series:

The results for ADF test are presented in Tables. Looking at the result of Banswara district among six variables the production of maize (MBP) and yield of maize (MBY) are found stationary about the level (Table 4.29). It

shows that there is no unit root. In contrast to this area under maize (MBA) found non-stationary. This variable is not found to be stationary even when a deterministic linear trend included in the regression (Tables 4.30). Thus indicating that it has a unit root. However, it is significant in first difference (Table 4.31) indicating that it is integrated of order 1 i.e. I (1). Further, the variables for another crop area under wheat (WBA), production of wheat (WBP) and yield of wheat (WBY) are not stationary about the levels but its deviations from fitted linear deterministic trend are stationary. This suggests trend stationary nature and these variables do not contain unit root. The result further reveals that variables for production and yield of maize in Banswara district are stationary about level whereas area of maize is non-stationary. In case of wheat all the three variables namely area, production and yield are not stationary about level but trend stationary.

Among the variables in Bhilwara district production of maize (MWP), yield of maize (MWY) are found to be stationary about the level (Table 4.29) whereas area under maize (MWA) is not found stationary about the level. However, its deviations from fitted linear deterministic trend is stationary. Thus, none of the variables viz. (MWA), (MWP) and (MWY) contain unit root. Further, the variables of area under wheat (WWA) have been found stationary about the level. Whereas the production of wheat (WWP) and yield of wheat (WWY) are not stationary about the level, though they are found to be trend stationary. Thus all the three variables are stationary. Interestingly, none of the variables are found to be contain a unit root in case of Bhilwara district.

In Chittorgarh district, two variables pertaining to maize namely production of maize (MCP) and yield of maize (MCY) are found stationary about the level (Table 4.29). It indicates that these two variables do not contain unit root. In contrast to this, the variable of area under maize (MCA) is found non-stationary even about a linear deterministic trend. Indicating that

it has a unit root. However, it is significant in first difference (Table 4.31) indicating that it is integrated of order 1 i.e. I(1). The production of wheat (WCP) and yield of wheat (WCY) are not stationary about the level but their deviations from fitted deterministic trend are stationary. In contrast to this, the variable of area under wheat (WCA) found stationary about the level. This indicates that these variables too do not have unit root. Overall these results reveals that among six variables, three variables pertains to production of maize (MCP), yield of maize (MCY) and area of wheat (WCA) are found stationary about the level, while two variables namely production of wheat (WCP) and yield of wheat (WCY) are though not stationary about the level, but are trend stationary. Thus five out of six do not contain the unit roots.

Looking at the results of Dungarpur district the variables of area under maize (MDA), production of maize (MDP) and yield of maize (MDY) all the three are found to be stationary about the level (Table 4.29). Hence, these variables do not contain the unit roots. For second crop the production of wheat (WDP) is not found to be stationary about the level but trend stationary (Table 4.30). Further, the variable yield of wheat (WDY) found stationary about the level. In contrast to this, area under wheat (WDA) have been found non-stationary even when a deterministic linear trend is included in the regression. This indicates that it has a unit root. However, it is significant in first difference (Table 4.31) indicating that it is I(1). Thus among six variables, four are stationary about the level namely (MDA), (MDP) (MDY) and (WDY) whereas one variable (WDA) found not stationary about the level but is trend stationary nature. Hence only one variable remained is area of wheat (WDA) found to be non-stationary, indicating that it has a unit root.

Of the variables pertaining to maize in Udaipur districts the production of maize (MUP) and yield of maize (MUY) are found stationary about the level (Table 4.29). It indicating that it does not have unit root. But in contrast to this in case of area under maize (MUA), even the deviations about a fitted

Table 4.29: Augmented Dickey-Fuller Test-Level of Series

S. No.	Variable	n	ADF	Coefficient	τ
	Banswara				
1.	MBA	26	0	-0.0525	-0.8307
2.	MBP	26	0	-0.8174	-4.0684*
3.	MBY	26	0	-0.9473	-4.7113*
4.	WBA	26	0	-0.0966	-1.1615
5.	WBP	26	0	-0.1051	-1.0136
6.	WBY	26	0	-0.3506	-2.1203
	Bhilwara				
7.	MWA	26	0	-0.2923	-1.9712
8.	MWP	26	0	-0.9993	-4.7690*
9.	MWY	26	0	-1.0636	-5.1603*
10.	WWA	26	0	-0.8193	-3.7364*
11.	WWP	25	1	-0.2056	-0.8825
12.	WWY	25	1	-0.1062	-0.6083
	Chittorgarh				
13.	MCA	26	0	-0.1315	-1.6846
14.	MCP	26	0	-0.6073	-3.2041*
15.	MCY	26	0	-0.8639	-4.3544*
16.	WCA	26	0	-0.9113	-4.2253*
17.	WCP	25	1	-0.3915	-1.6454
18.	WCY	26	0	-0.4627	-2.6498
	Dungarpur				
19.	MDA	26	0	-0.5665	-3.1232*
20.	MDP	26	0	-0.8807	-4.3551*
21.	MDY	26	0	-0.9505	-4.6714*
22.	WDA	26	0	-0.4757	-2.6020
23.	WDP	26	0	-0.3991	-2.2648
24.	WDY	26	0	-0.5966	-3.1305*
	Udaipur				
25.	MUA	26	0	-0.3380	-2.0082
26.	MUP	26	0	-0.8512	-4.2297*
27.	MUY	26	0	-0.8800	-4.3222*
28.	WUA	26	0	-0.7614	-3.8420*
29.	WUP	26	0	-0.6290	-3.1540*
30.	WUY	26	0	-0.1511	-0.9404
	Rajasthan				
31.	MRA	26	0	-0.2486	-1.9691
32.	MRP	26	0	-0.7326	-3.6933*
33.	MRY	26	0	-0.8448	-4.2354*
34.	WRA	25	1	-0.2284	-1.1494
35.	WRP	25	1	-0.0179	-0.1554
36.	WRY	26	0	-0.1075	-0.9646

ADF critical value at 5 per cent for (n=25) = - 2.9850 ; (n=26) = -2.9798

Table 4.30: Augmented Dickey-Fuller Test-Trend of Series

S. No.	Variable	n	ADF	Coefficient	τ
	Banswara				
1.	MBA	26	0	-0.6826	-3.4375
2.	WBA	26	0	-0.9650	-4.6271*
3.	WBP	26	0	-0.8967	-4.4729*
4.	WBY	26	0	-0.7455	-3.8669*
	Bhilwara				
5.	MWA	26	0	-0.8548	-4.1857*
6.	WWP	26	0	-1.0956	-5.0068*
7.	WWY	26	0	-1.0824	-5.2838*
	Chittorgarh				
8.	MCA	26	0	-0.5048	-2.8967
9.	WCP	26	0	-1.2153	-5.9814*
10.	WCY	26	0	-1.0795	-5.3046*
	Dungarpur				
11.	WDA	26	0	-0.6105	-3.1149
12.	WDP	26	0	-0.8330	-4.0735*
	Udaipur				
13.	MUA	26	0	-0.3147	-1.8262
14.	WUY	26	0	-0.8824	-4.2819*
	Rajasthan				
15.	MRA	26	0	-0.5212	-2.7890
16.	WRA	26	0	-0.6630	-3.2496
17.	WRP	26	0	-1.0935	-5.0656*
18.	WRY	26	0	-0.9598	-4.7998*

ADF critical value at 5 per cent for (n=25) = - 3.6027 ; (n=26) = -3.5943

Table 4. 31: Augmented Dickey-Fuller Test-First Difference

S. No.	Variable	n	ADF	Coefficient	τ
	Banswara				
1.	MBA	25	0	-1.1906	-5.7954*
	Chittorgarh				
2.	MCA	25	0	-1.1669	-5.9031*
	Dungarpur				
3	WDA	25	0	-1.3467	-6.6878*
	Udaipur				
4	MUA	25	0	-1.1341	-5.5196*
	Rajasthan				
5.	MRA	25	0	-1.1132	-5.3705*
6.	WRA	25	0	-1.5154	-8.3429*

ADF critical value at 5 per cent for (n=25) = - 2.9850 ; (n=26) = -2.9798

linear deterministic trend are not stationary, this implies that the variable is non-stationary. This shows that it contains a unit root. However, it is significant in first difference (Table 4.31), indicating that it is I(1). Further, the production of wheat (WUP) and area of wheat (WUA) are found stationary about the level but the yield of wheat (WUY) is not stationary about the level though it is trend stationary. Thus none of the three variables contains unit root. The result further reveals that among six variables in Udaipur district four are found to be stationary about the level i.e. (MUP), (MUY), (WUA) and (WUP) whereas one variable (WUY) found not stationary about the level but trend stationary nature (Table 4.30). Thus in all five out of six variables do not contain unit root. Only remaining variable (MUA) found non-stationary indicating that it has a unit root in case of Udaipur district.

As far as the results for the state of Rajasthan are concerned the production of maize (MRP) and yield of maize (MRY) are found stationary about the level (Table 4.29), indicating no unit root in these variables. In contrast to this, the area under maize (MRA) is not found to be stationary even when a deterministic linear trend included in the regression. This implies that it has a unit root. However, it is significant in first difference (Table 4.31) indicating that it is I(1). Further, the variable production of wheat (WRP) and yield of wheat (WRY) are found non-stationary about the level but deviation from fitted linear deterministic trend are stationary. This implies trend stationarity and no unit root. In contrast to this, the variable area under wheat (WRA) is found to be non-stationary even the deviations about a fitted linear deterministic trend are not stationary. This implies that it has a unit root. However, it is significant in first difference indicating that it is I(1). The result further reveals that among six variables, two are stationary about the level namely (MRP) and (MRY) whereas two are non-stationary about the level i.e. (WRP) and (WRY). The remaining two variables namely (MRA) and (WRA)

are not found to be stationary even when a deterministic linear trend included in the regression. Thus out of six, four variables do not contain unit roots whereas two variables contain unit root i.e. (MRA) and (WRA). However, these two variables are significant in first difference indicating that it is integrating of order 1 i.e. I(1).

To sum up classification of series according to nature with respect to stationarity are presented in (Table 4.33). Looking at the results, the production and yield of maize in all the districts of Udaipur division as well as the state of Rajasthan are found stationary about the level. This clearly implies that these variable do not have unit root. However, in Dungarpur district all the three variables pertaining to maize i.e. area, production and yield are found to be stationary about the level. Further, the area of maize in Bhilwara district is not found stationary about the level but deviations from fitted linear deterministic trend are stationary.

Table-4.32: Classification of Time Series According to Nature of Stationarity

S. No.	Crop	Nature of Stationarity			Distt./ State
		Stationary	Trend Stationary	Non-Stationary	
1.	Maize	P,Y	-	A	Banswara
		P,Y	A	-	Bhilwara
		P,Y	-	A	Chittorgarh
		A, P,Y	-	-	Dungarpur
		P,Y	-	A	Udaipur
		P,Y	-	A	Rajasthan
2.	Wheat	-	A,P,Y	-	Banswara
		A	P,Y	-	Bhilwara
		A	P,Y	-	Chittorgarh
		Y	P	A	Dungarpur
		A, P	Y	-	Udaipur
		-	P,Y	A	Rajasthan

A= Area, P = Production and Y = Yield

Except Dungarpur and Bhilwara district the variable area under maize was found non-stationary even when a deterministic linear trend was included in the regressions. This shows that in case of area under maize the hypothesis of unit root can not be rejected in any case except Bhilwara and Dungarpur district.

Coming to the second crop, production and yield are not found to contain unit root. In all cases except Dungarpur and Udaipur, these variables are stationary about linear deterministic trend. In Dungarpur the yield is stationary in level while in Udaipur production is stationary in level. Area is stationary about level in Bhilwara, Chittorgarh and Udaipur while in Banswara it is stationary about a linear deterministic trend. In Dungarpur and all Rajasthan it is not found to be stationary even when the regression equation includes a linear deterministic trend indicating that it contains a unit root.

It is only the variable related to area which are found to contain unit root. However, these variables too are stationary in first difference (Table 4.31) implying that they have only one unit root each i.e. they all are of integrated of order 1 i.e. I(1).

4.9 COINTEGRATION ANALYSIS :

Generally it is assumed that a time series is stationary but infact it may not be true. Stationarity of a time series is very essential on using of non-stationary time series in regression analysis can give rise to dubious and spurious relationship. Cointegration analysis is to get away from such problem. This technique is used to evaluate econometric models purporating to describe long-run relationship. If the variables selected are not cointegrated, the resulting model can not represent such relationship. In other words, cointegration between two or more variables is taken to imply the existence of a long-run equilibrium relationship between them.

Normally, most of the econometric models were based on equilibrium relationship suggested by a theory, such as

$$X_t = AY_t + \varepsilon_t$$

Without any consideration of the levels of integration of the observed variables X_t, Y_t or of the residual series e_t. For example if X_t is I(0) but Y_t is I (1), the value of A in the resulting regression is forced to be near zero. If the residual e_t is I(1), standard estimation techniques are not appropriate. This was shown for the first time by Granger and New Bold (1974). If two series are integrated of same order, say d, which is greater than zero (d>0), though the regression will not give A insignificant, the authors shows that the regression is spurious. Therefore in first step, the variables should be checked with respect to their order of integration and only after ensuring that they are integrated of same order, attempt to estimate any relationship among them should be made. Therefore, in a long run relationship between two variables both must be integrated of the same order if the error term is to be I(0), Deadman and Charemza (1992).

For cointegration we run the cointegration regression.

$$X_t = a + \alpha Y_t + \varepsilon_t$$

If the errors ε_t are stationary i.e. I(0) then the two series x_t and y_t are said two be cointegrated. This is the basic concept behind the cointegration technique.

4.10 SUMMING UP:

Keeping in view this fact, attempt has been made here to estimate the relationship among the variables under consideration. Looking at the result in table 4.31, it is only the variables related to area which are found to contains unit root. Further, these variables too are stationary in first difference implying that they have only one unit root each i.e. they are all of integrated of order 1 i.e. I(1). The orders of integration of selected variables, are hence found and given in table 4.33. Out of 36 variables only 6 variables viz., MBA, MCA, WDA, MUA, MRA and MRP are of order 1 i.e. I(1) and rest are of order zero i.e. I(0).

Further the non-stationary is found to be in very few variables considered here. Estimation of relationships among them as simple regression (with deterministic linear trend include) gives valid results. Hence there is no need of separate cointegration analysis for the variables considered here.

Table 4.33: Order of integration of Various Variables

S. No.	Variable	I(d)
	Banswara	
1.	MBA	1
2.	MBP	0
3.	MBY	0
4.	WBA	0
5.	WBP	0
6.	WBY	0
	Bhilwara	
7.	MWA	0
8.	MWP	0
9.	MWY	0
10.	WWA	0
11.	WWP	0
12.	WWY	0
	Chittorgarh	
13.	MCA	1
14.	MCP	0
15.	MCY	0
16.	WCA	0
17.	WCP	0
18.	WCY	0
	Dungarpur	
19.	MDA	0
20.	MDP	0
21.	MDY	0
22.	WDA	1
23.	WDP	0
24.	WDY	0
	Udaipur	
25.	MUA	1
26.	MUP	0
27.	MUY	0
28.	WUA	0
29.	WUP	0
30.	WUY	0
	Rajasthan	
31.	MRA	1
32.	MRP	0
33.	MRY	0
34.	WRA	1
35.	WRP	0
36.	WRY	0

5. SUMMARY AND CONCLUSIONS

The present investigation entitled "*Statistical Analysis of Agricultural Time Series Data*" was undertaken with specific objectives, which are as under:

(i) To study the performance of Agriculture.

(ii) To identify the factors responsible for its growth.

(iii) To examine the data generation process of the agricultural time series.

(iv) To study the nature of area, production and productivity.

(v) To study the long term equilibrium in area, production and productivity in agriculture.

The study was delimited to all the districts of Udaipur division and Rajasthan State as a whole. Secondary data pertaining to area, production and yield of major crops in the districts of Udaipur division viz., Banswara, Bhilwara, Chittorgarh, Dungarpur and Udaipur and also State of Rajasthan were collected for the period 1970-71 to 1996-97 from the different publications viz.. Vital Agricultural Statistics, Districtwise trends of agricultural production, Directorate of Agriculture, Government of Rajasthan, Jaipur and reports and records of Directorate of Economics and Statistics, Jaipur. In order to achieve the above objectives the data were statistically analysed. Here first of all statistical summary of area, production and productivity of different selected crops in the districts of Udaipur division and also State of Rajasthan were prepared by working out average, standard deviation, coefficient of variation, skewness and kurtosis. The trends in area, production and yield were examined by fitting linear, log linear, quadratic and log quadratic equations to identify best fit among these equations. Growth studies for area, production and yield were undertaking by working out compound growth rate in respect of each crop for each district of Udaipur

division and for the State of Rajasthan. The analysis in order to measure the relative importance in area, yield and their interaction on the total change in production of selected crops were estimated by using decomposition model given by Vidya Sagar (1977, 1980). The stationarity of area, production and yield was examined for non-stationarity by employing unit root test. Augmented Dickey Fuller test was used for ascertaining level of series, trend of series and order differences for the two most important crops by taking one each from rabi and kharif season from each district and State of Rajasthan. In present study maize from kharif season and wheat from rabi season were identified for the analysis. The results are summarized here as under.

The statistical summary of the observations revealed that in all the districts of Udaipur division and Rajasthan state, maize is the principal kharif cereal crops whereas wheat is principal rabi cereal crops when viewed in terms of area and production. In Dungarpur, Banswara and Udaipur rice whereas in Chittorgarh and Bhilwara groundnut occupied next position during kharif season. As regards rabi season is concern gram is the second important crop in Banswara, Chittorgarh and Dungarpur district whereas in Bhilwara and Udaipur district barley occupied the second position. Variability as indicated by coefficient of variation ranged for different crops from about 11% (rice in Banswara) to 126% (rapeseed & mustard in Chittorgarh) in case of area, 31.10% (barley in Bhilwara) to 175.98% (maize in Banswara) when viewed for production and 18.5% (Sugarcane in Udaipur) to 86.25% (small millets in Banswara) for yield. The shape of the curves in all the cases whether for area or for production or for yield were skewed. However, extent of skewness varied from moderate i.e. 0.005 (rapeseed & mustard in Chittorgarh) for area to severe i.e. 3.26 (maize in Banswara) for production. Likewise the curve are recorded highly platykurtic i.e. - 1.58 (soybean in Chittorgarh) for area to severe leptokurtic i.e. 18.04 (tur in Dungarpur) for area.

As regards to State as a whole is concerned maize occupied an average area, average production and average yield of 869.55 thousand hectares, 799.00 thousand tonnes and 915.48 kg/ha respectively with their corresponding CV as 9.61, 34.38 and 31.28 per cent. In rabi season the most important crop wheat with 1839.79 thousand hectares of average area, 3339.97 thousand tonnes of average production and 1774.11 kg/ha of average productivity. The variability of wheat in respect of area, production and yield was recorded to be 9.96, 39.08 and 27.41 per cent respectively. Further in the State of Rajasthan most important crop bajra occupied highest average area of 4696.67 thousand hectares, 1477.02 thousand tonnes of average production and 308.85 kg/ha of average yield.

The results of the trend analysis of the selected crops in the districts as well as State reveals that none of the equation is found suitable for area, production and productivity of rice in respect of Banswara, Dungarpur and Udaipur districts. In Bhilwara district, linear equation is found suitable pertaining to area, production and yield of jowar crop. In case of maize crop linear equation is found suitable for area as well as for production and yield in respect of Banswara district but for Bhilwara district, linear equation (area and production) was found suitable whereas for Chittorgarh district linear equation (production) and for Udaipur district quadratic equation (area) are recommended. Moreover, at State level equation suitable for maize is linear in respect of area as well as production. Linear equation in respect of area, production and yield of small millets is found suitable for Banswara district whereas for Dungarpur district linear equation (production and productivity) and quadratic equation (area) are found suitable. But in case of Udaipur district linear equation (area) and quadratic equation (production) are found suitable for small millets. The results reveal that for kharif pulses in Banswara district log quadratic equation (area and production) found suitable. Whereas in case of Dungarpur, linear equation (area and production) is recommended.

For tur crop in Udaipur district quadratic equation (area and yield) and log linear equation (production) is found suitable. At State level linear equation for production and yield of groundnut is found suitable whereas for Bhilwara district linear equation for yield is suggested. In Chittorgarh district for soybean crop quadratic equation is found suitable for area and production whereas log linear equation is found suitable for yield.

No equation is found suitable for yield of wheat in Banswara district but for production (log quadratic equation) and for area (linear equation) is suggested. Further quadratic equation (area, production & yield) for wheat in Bhilwara and for Chittorgarh district log linear is recommended for area, production and productivity of wheat crop. In Dungarpur district linear equation (area, production and yield) for wheat is suggested, but in case of Udaipur district linear equation (production) and quadratic equation (yield) is recommended. Moreover at State level suitability of the equation for wheat is linear (area), log linear (production and yield) is recorded.

For barley crop in Bhilwara district, linear equation (area, production and yield) and Udaipur district linear (area and production) and quadratic equation (yield) is found suitable.

In Banswara district linear equation (production and yield) in respect of gram and log linear (yield) and log quadratic (area and production) in Chittorgarh district is found suitable. Whereas for this crop in Dungarpur district linear equation (area) and log linear equation (yield) is suggested.

In case rapeseed and mustard in Chittorgarh district linear equation (yield) and log quadratic equation (area and production) are found suitable. However for the State of Rajasthan, quadratic equation (area and production) and linear equation (yield) have been found suitable.

In Bhilwara district linear equation is recommended for linseed crop for yield and in case of Chittorgarh district log quadratic equation (area and yield) and quadratic equation (production) are found suitable.

Linear equation for production of sugarcane is found suitable for Udaipur district and for cotton crop in Bhilwara district linear equation (area and yield) is recommended. At State level for guarseed quadratic equation (area) is suggested.

Thus linear equation ($Y_t = a+bt$) has a wider applicability in the districts of Udaipur division as well as for the State. This equation has been found suitable in majority of cases for estimating and predicting the area/production/ productivity of crops in Southern Rajasthan. Moreover, this has specific advantage of ease of understanding and relatively better prediction capacity.

The analysis of compound growth rates reveals that the increase in total output in case of maize, wheat and gram is because of rise in area and productivity of these crops in Banswara district. Inspite of decline in productivity of rice, kharif pulses and sugarcane, the output has increased due to acreage expansion in the respective crops. The trend of growth rates in respect of area, production and productivity of maize is found positive and statistically significant in Banswara district. In Bhilwara district the production in respect of jowar, maize, wheat, sesamum and linseed increased due to rise in area and yield. With the decline in area under barely and groundnut, the output has increased due to significant enhancement in productivity of the said crops in the district. The compound growth rates in area, production and productivity of wheat is found positive and statistically significant. However, for this district in case of jowar, maize, sesamum and linseed the growth rates of area, production and yield are also positive but significant only in case of area and production for jowar and maize whereas production and productivity of linseed crop.

In case of Chittorgarh district the total production in respect of maize, wheat, gram, groundnut, soybean and rapeseed & mustard crops has increased due to area and productivity of these crops. With the decline in area of linseed the production has increased due to significant rise in productivity in the district. Inspite of increase in productivity the growth of output in jowar and sugarcane has declined due to reduction in area. The growth rates of area, production and productivity in respect of wheat, soybean and rapeseed & mustard are found positive and statistically significant. Further, growth rates in area and production of jowar and sugarcane are negative. This reduction may be due to substitution of area in other remunerative crop.

The growth of output of rice and wheat has increased mainly due to increase in area and productivity in Dungarpur district. Inspite of decline in productivity of kharif pulses and tur, the output has increased due to increase in area under these crops in the district. Moreover, with the decline in area and productivity of maize and small millets the output exhibited a declining trend. There are positive growth rates of area, production and productivity in respect of wheat and rice crop. In contrast to this negative growth rates are recorded in area, production and productivity of maize and small millets but statistically significant only in small millets. In this district the growth rates in area, production and productivity are found positive for tur and urd crops.

In Udaipur district the total production of wheat, tur and urd has increased mainly due to increase in area and productivity. In case of maize, there is a decline in yield level but the output has increased due to increase in the area. Though there is a reduction in the area of jowar and small millets yet, the output has increased due to rise in productivity of these crops. In case of rice, barley and sugarcane the growth of output in these crops has declined due to significant declined in their respective area. However, there is an increase in the yield level.

At State level, the total output of jowar, bajra, maize, wheat and rapeseed & mustard have increased mainly due to rise in area and productivity of these crops. A similar trend is also observed in these crops (except bajra) in Udaipur division. Inspite of decline in productivity of guarseed the output has increased due to increase in area of the crop in the State. The growths of output in respect of barley and gram crops have declined mainly due to significant reduction in area inspite of increase in productivity of these crops. With decline in area under kharif pulses and groundnut the output of these crops have increased due to significant rise in productivity at State level. A similar pattern of growth of trend is also observed in case of gram in Bhilwara district. A positive and significant growth rate is obtained in area, production and productivity of maize, wheat and rapeseed & mustard crops for the State.

The decomposition analysis reveals that the reduction of production in bajra is due to area effect in the State. The increase in output of maize in Banswara, Bhilwara and Chittorgarh vis-à-vis that of State is due to area effect. Whereas reduction in output of this crop in case of Dungarpur district is due to yield effect but in case of Udaipur it is acreage expansion.

Reduction in output of rice is observed in two districts viz., Banswara and Udaipur but the output increased in case of Dungarpur district. The yield effect in case of Banswara and area effect in case of Udaipur district are observed for the reduction of total production of rice. In contrast to this increase in total output of rice in Dungarpur district is mainly due to area effect.

Increase in total output of wheat in respect of Banswara, Chittorgarh, Dungarpur and Udaipur district are mainly due to acreage expansion whereas in case of Bhilwara and State of Rajasthan it is due to yield effect. Further, interaction effect of yield and area also significantly contributions in increasing the total production in wheat in Banswara and Chittorgarh districts.

The interaction effect of yield and area shows significant contribution (to the tune of 37 per cent) to growth of output in wheat for Banswara district. In Chittorgarh district the interaction effect of yield and area shows significant contribution (to the tune of 20 per cent) to growth of output in wheat.

The reduction in output of small millets in Dungarpur and Udaipur is due to area effect whereas in case of Banswara it is due to yield effect.

The increase in output of jowar in Bhilwara district is due to yield effect. But in case of Chittorgarh, Udaipur and State of Rajasthan, reduction in production of jowar is because of area effect.

In barely the total output is decreased due to acreage expansion in the districts of Bhilwara and Udaipur as well as for the State.

Among pulses, the increases in output of kharif pulses are mainly due to area effect in case of Banswara and Dungarpur districts whereas in case of Chittorgarh and of State it is on account of yield effect.

Yield effect is the main factor to increase the output of gram in Banswara, Dungarpur and State of Rajasthan whereas area effect the causative factor in case of Chittorgarh district.

The reduction in production of tur in Banswara is due to area effect but in case of Dungarpur it is due to yield effect. In contrast to this increase in production of tur in Udaipur district is mainly due to area effect. The interaction effect is also observed in case of Banswara for reduction of production in tur. Further, the reduction of output of urd in Udaipur district is mainly due to area effect.

Among oilseed crops, the increase in the total output of groundnut in Bhilwara, Chittorgarh and State of Rajasthan is due to yield effect. The decline in production of linseed in Chittorgarh is due to area effect whereas increase in output of linseed in Bhilwara is due to yield effect.

In Chittorgarh and for the State of Rajasthan, the increase in production of rapeseed & mustard is mainly because of acreage expansion. At the State level the interaction effect shows significant contribution to the tune of 25 per cent to growth output of rapeseed & mustard.

Among cash crops, the reduction of production in cotton in Bhilwara is on account of area effect. But in case of sugarcane, the increase in output is due to yield expansion in Chittorgarh district. In contrast to this, reduction of production of sugarcane in Udaipur district is due to area effect.

Likewise, increase in the production of guarseed in the State is on account of area effect.

In Banswara district the interaction effect of area and yield are positive for rice, wheat, kharif pulses and gram but in case of maize, small millets and tur it is negative. Further interaction effect is positive for all the selected crops (except linseed) in Bhilwara. Likewise in Chittorgarh the interaction effect is positive for all the selected crops except for linseed and sugarcane. However, in case of Dungarpur district interaction effect is positive in respect of rice, wheat, kharif pulses and tur whereas negative for maize, small millets and gram crops. Similarly for the State of Rajasthan, interaction of area and yield effect is found to be positive for all the cereal crops except for maize and bajra. However, in case of State the interaction effect is positive for pulses and oilseed crops.

The stationarity of the time series is examined by unit root test i.e. Augmented Dickey Fuller test which, reveals that the series of production and productivity of maize in all the districts of Udaipur division as well as in the State of Rajasthan are found stationary about the level. This implies that these variables do not have unit root. In case of Dungarpur district all the three variables viz., area, production and yield of maize is found to be stationary about the level. Further, the area of maize in Bhilwara district is not found

stationary about the level but deviations from fitted linear deterministic trend are stationary. Except Dungarpur and Bhilwara district the area under maize is found non-stationary even when a deterministic linear trend is included in the regression. This shows that in case of area under maize the hypothesis of unit root can not be rejected in any case except Bhilwara and Dungarpur district.

In case of wheat crop, production and yield are not found to contain unit root in any of the district as well as in the State of Rajasthan. In all cases except Dungarpur and Udaipur district, production and yield are stationary about linear deterministic trend. In Dungarpur district the yield is stationary in level while in Udaipur district production is stationary in level. The variables (area) are found to be stationary about level in Bhilwara, Chittorgarh and Udaipur district, while, in Banswara it is stationary about a linear deterministic trend. In case of Dungarpur and the State of Rajasthan the variable (area under wheat) is not found to be stationary even when the regression equation includes a linear deterministic trend this shows that it contains a unit root.

Thus area is the only variable for both the crops i.e. maize and wheat, which is found to contain unit root. Moreover, this variable too is stationary in first difference. This implies that area has only one unit root each in wheat as well as maize. Hence the order of integration is one in case of both the area under maize and area under wheat. Further among 36 variable defined for the area, production and yield for maize and wheat for five districts and State as a whole. Only 6 variables are of order 1 i.e. I(1) and rest are of order zero i.e I(0). Therefore, it was not found necessary to go for second order difference because for the application of cointegration techniques there should be at least two different variables of the same order of difference. Hence non-stationarity is found in very few variables considered here. So for estimating relationship among them simple regression can provide valid results.

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ABSTRACT

STATISTICAL ANALYSIS OF AGRICULTURAL TIME SERIES DATA

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Statistical evaluation of area, production and yield figures in respect of all the districts of Udaipur division and the State of Rajasthan pertaining to the years 1970-71 to 1996-97 revealed that maize and wheat are the most important cereal crops in *kharif* and *rabi* season respectively for all the districts as well as for the state. The coefficient of variation for area in respect of different crops in the districts of Udaipur division and the State ranged from about 11% (rice in Banswara) to 126% (rapeseed & mustard in Chittorgarh) whereas for production it ranged from 31.10% (barley in Bhilwara) to 175.98% (maize in Banswara) and in case of yield it ranged from 18.5% (sugarcane in Udaipur) to 86.25% (small millets in Banswara). The distribution of curves for above parameters were skewed and leptokurtic/ platykurtic.

The trend analysis revealed that for most of the crops studied linear equation ($Y_t = a + bt$) was observed to be appropriate describing the trend for area, production and yield.

The compound growth rates were worked out for all the crops for these parameters separately for each district of Udaipur division and State of Rajasthan revealed in case of principal crops maize and wheat the growth of these parameters is positive. In case of small millets in Banswara district the compound growth rate indicated that all the three i.e. area, production and yield are declined.

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Through decomposition analysis an attempt was made to ascertain whether changes in production are due to area effect, yield effect or interaction of area and yield effect. It was observed that in most of the cases change in the production was brought out by area effect. In some cases like wheat in Banswara and Chittorgarh district interaction effect of yield and area was contributing.

Level of series, trend of series and first difference of series was worked out in this order by Augmented Dickey Fuller (ADF) test. Non-stationarity was observed in only one variable i.e. area under maize and wheat in all the districts (except Bhilwara) and State of Rajasthan.

सारांश

कृषि काल–श्रेणी समंको का सांख्यिकीय विश्लेषण

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यह अनुसंधान उदयपुर संभाग के सभी जिलों एवं राजस्थान राज्य के लिए 1970–71 से 1996–97 तक कृषि के क्षेत्रफल, उत्पादन एवं उत्पादकता संबंधी आकड़ों के सांख्यिकी विश्लेषण से ज्ञात हुआ कि मक्का तथा गेहूँ क्रमशः खरीफ एवं रबी ऋतु की इन सभी जिलों तथा राज्य के लिए प्रमुख फसलें है। विभिन्न फसलों के अन्तर्गत क्षेत्रफल के समंको का विचरण गुणांक प्रसार लगभग 11 प्रतिशत (चांवल, बांसवाड़ा जिला) से 126 प्रतिशत (तारामीरा एवं सरसों, चित्तोड़गढ जिला) पाया गया जबकि उत्पादन के लिए इसका मान 31.10 प्रतिशत (जौ, भीलवाड़ा जिला) से 175.98 प्रतिशत (मक्का, बांसवाड़ा जिला) रहा। उत्पादकता के संबंध में विचलन गुणांक की प्रसार सीमा 18.5 प्रतिशत (गन्ना, उदयपुर जिला) से 86.25 प्रतिशत (छोटे धान, बांसवाड़ा जिला) रही। उपरोक्त प्राचल के बंटन वक्रो का आकार असामान्य एवं कुदुकता लिए हुआ था।

प्रवृति विश्लेषण से ज्ञात हुआ कि अधिकांश फसलों के अध्ययन में रेखीय समीकरण ($Y_t = a + bt$), क्षेत्रफल, उत्पादन एवं उत्पादकता तीनो का समुचित प्रवृति प्रदर्शित करता है।

उदयपुर संभाग के सभी जिलों एवं राज्य के लिए चयनित फसलों के क्षेत्रफल, उत्पादन एवं उत्पादकता संबंधी चक्र वृद्धि दर से ज्ञात हुआ कि प्रमुख फसलों में मक्का एवं गेहूँ के लिए वृद्धि दर धनात्मक थी। बांसवाड़ा जिले में इन तीनों अर्थात् क्षेत्रफल, उत्पादन एवं उत्पादकता में वृद्धि दर ऋणात्मक थी।

* शोधकर्ता एवं सहायक आचार्य, कृषि सांख्यिकीय विभाग, राजस्थान कृषि महाविद्यालय, उदयपुर
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विघटन विश्लेषण के द्वारा इस बात को जानने का प्रयत्न किया गया कि उत्पादन में परिवर्तन क्षैत्रफल प्रभाव के द्वारा अथवा उत्पादकता प्रभाव के द्वारा अथवा इनके अन्तःक्रिया के प्रभाव द्वारा होता है। यह ज्ञात हुआ कि अधिकाशं परिस्थितियों में फसलों के उत्पादन में परिवर्तन क्षैत्रफल प्रभाव के कारण हुआ। बांसवाड़ा एवं चित्तोड़गढ़ जिलों में गेहूँ जैसी स्थितियों में अन्तःक्रिया प्रभाव का योगदान था।

श्रेणी का स्तर, श्रेणी की प्रवृति एवं श्रेणी का प्रथम अन्तर इसी क्रम में आग्यूमेंटेड डिक्की फूलर जांच द्वारा ज्ञात किया गया। भीलवाड़ा जिले के अलावा सभी जिलों एवं राजस्थान राज्य में केवल एक ही चर अर्थात् गेहूँ एवं मक्का के अन्तर्गत क्षैत्रफल में अस्थिरता पायी गयी।