

**GROWTH PERFORMANCE AND
PRICE BEHAVIOUR OF ONION IN
MAJOR STATES OF INDIA**

By

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B. Sc. (Agri.)



**DEPARTMENT OF AGRICULTURAL ECONOMICS
COLLEGE OF AGRICULTURE
JUNAGADH AGRICULTURAL UNIVERSITY
JUNAGADH – 362 001**

SEPTEMBER - 2021

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PRICE BEHAVIOUR OF ONION IN
MAJOR STATES OF INDIA**

**A THESIS SUBMITTED TO
JUNAGADH AGRICULTURAL UNIVERSITY
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE OF**

MASTER OF SCIENCE

(Agriculture)

IN

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C E R T I F I C A T E – I

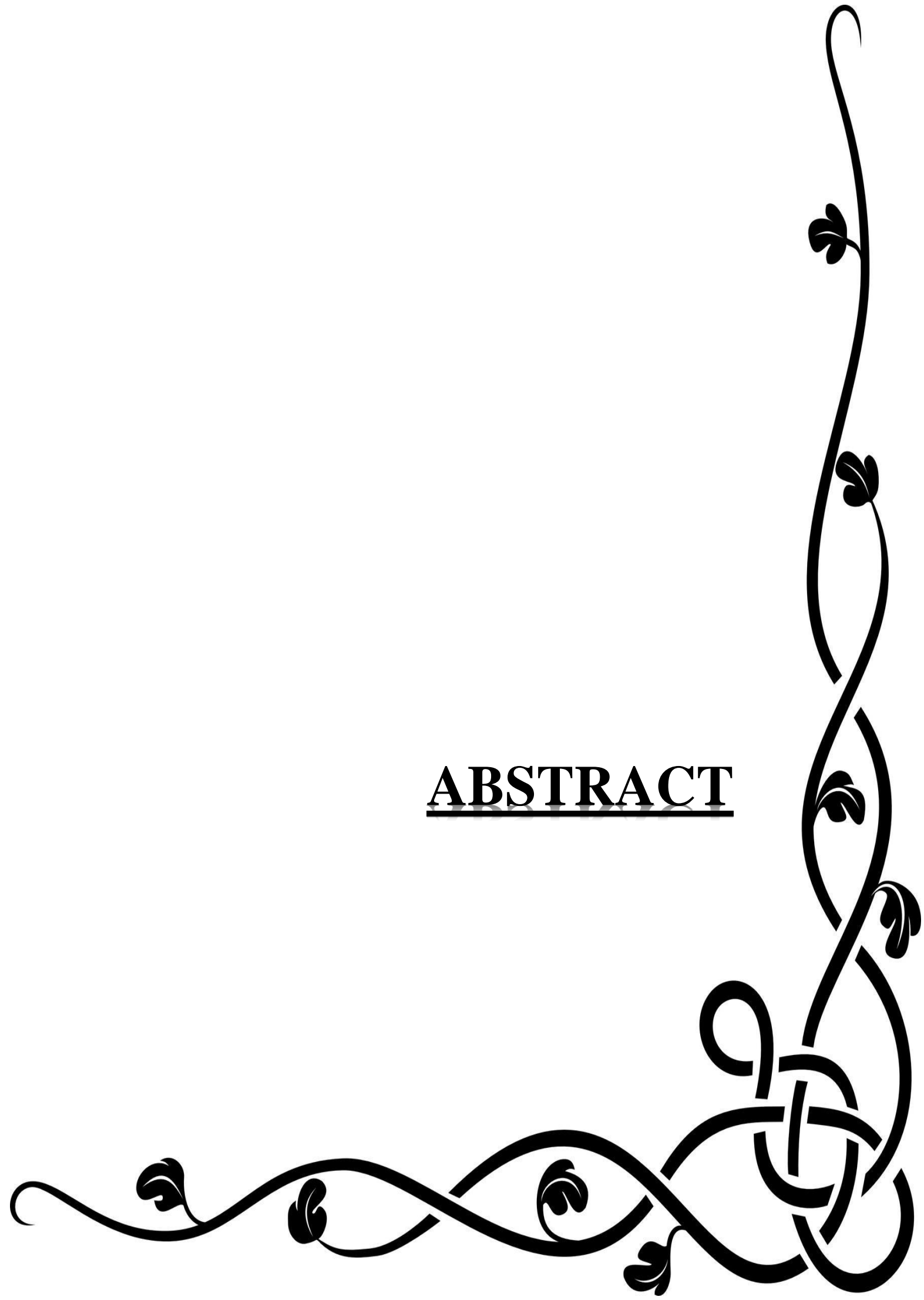
This is to certify that the thesis entitled “**GROWTH PERFORMANCE AND PRICE BEHAVIOUR OF ONION IN MAJOR STATES OF INDIA**” submitted by **Miss. PARMAR HETAL BHIKHABHAI (Reg. No. 2010119080)** in partial fulfilment of the requirements for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in the subject of **AGRICULTURAL ECONOMICS** to the Junagadh Agricultural University is a record of bonafide research work carried out by her under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma or other similar title. The candidate had fulfilled all prescribed requirements. The assistance and help received during the course of investigation have been fully acknowledged. She has successfully completed the comprehensive/preliminary examination held on **June 07, 2021** as required under the regulation for post-graduate studies. She has submitted *kachha* bound thesis on **30th July, 2021**.

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ABSTRACT



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**“GROWTH PERFORMANCE AND PRICE BEHAVIOR OF ONION IN
MAJOR STATES OF INDIA”**

ABSTRACT

Key words: Onion, growth rate, instability, contribution, price behavior

Onion is one of the important vegetable crop widely used in all households all the year round in India and throughout world. It is commonly known as “Queen of the kitchen” due to its highly valued flavour, aroma, and unique taste, and the medicinal properties of its flavour compounds. Onion is an important commercial crop earning sizable foreign currencies and it has received greater attention because of extreme price volatility. Keeping in view of this potentialities, the present study, “Growth performance and price behaviour of onion in major states of India” was undertaken with the main objectives to assess the growth dimensions, instability, sources of growth, price variability and interrelation among the major markets in India.

The secondary data on area, production and productivity of onion in seven major producing states of India were collected for the period from 1990-91 to 2019-20. Besides, nine wholesale market prices of onion, one each from major states, representing consumption and two major producing locations markets were also collected for the period from 2001-02 to 2019-20 from various public sources. The data was analyzed using techniques of compound growth rate, linear and quadratic trends, Cuddy Della Valle index, decomposition analysis, seasonal and irregular variations, and inter-relationship by correlations co-efficient and co-integration analysis.

The investigation revealed that, among the major onion growing states, Madhya Pradesh recorded the highest increase in onion area about 9.23 per cent per annum followed by Maharashtra (8.04%), Rajasthan (6.31%) during 1990-91 to

2019-20. Madhya Pradesh also registered significantly the highest growth rate of onion production about 12.69 per cent per annum, while Bihar registered significantly the highest growth rate of productivity about 4.59 per cent per annum. During 2000s, significantly the highest increase in area (19.89%) and production (20.96) of onion was reported in Gujarat. At all India level shown significantly positive growth in onion area (5.89%), production (8.33) and yield (2.30) during overall period.

At country level as well as in all the major states, the yield effect was found as the main component of production growth followed by area and interaction effects. Rajasthan noticed the highest instability in onion area (39.27%), Madhya Pradesh production (52.33%) and Karnataka in yield (40.93%).

The co-efficient of quadratic trend (T^2) found non-significant in all markets noticed that there was no change in growth pattern of onion price in last two decades, which indicates that farmers were not benefited by rise in price, it is the effect of inflation factors only. On an average the onion prices in major markets of India was increased annually at the rate of 8.50 per cent during last two decades.

The seasonal indices indicated the minimum onion price in the months of April-May and the maximum in the months of October-November in most of the markets, besides revealed high seasonal and irregular fluctuations. The monthly (>0.87) and yearly (>0.90) onion prices were found highly correlated among all the markets. The Augmented Dickey-Fuller (ADF) unit root test for onion showed the data are level stationary I (0). Moreover, all the onion markets were shown spatially integrated, that is there is a co-movement in prices across markets in long run and the short-run disequilibrium was found existing, but it found get corrected at larger speed. Most of the markets found bidirectional influence on prices.

This study suggest that there is large scope for achieving higher production of onion in India, development of irrigations facilities and proper agronomical practices to stabilize onion acreage. As onion price are highly volatile, the Government should take immediate action to enhance export, when price falls drastically and allow the import, when price increase beyond certain level.

ACKNOWLEDGEMENT

It is by the grace and will of the almighty that I have this great privilege to convey my regards and thanks to those, who helped me to complete my research. These words are small acknowledgement, but never fully recompensed for their great help and cooperation. First of all, I bestow myself to “The almighty” who gave me strength and fortitude to complete this strenuous work.

*I wish to express my heartfelt thanks, sincere regards, indebtedness, deep sense of gratitude and esteemed reverence to my major guide **Dr. M. G. Dhandhalya**, Associate Research Scientist, Department of Agricultural Economics, College of Agriculture, Junagadh Agricultural University, Junagadh for his scholastic guidance, valuable support, constant encouragement, unceasing interest, constructive criticism, constant painstaking efforts, innovative scientific orientation, judicious supervision and amicable behavior throughout the course of my study and research.*

*I have great pleasure in recording my gratefulness to the member of my advisory committee, **Dr. N. J. Rankja**, Minor guide, Associate Professor, Department of Agricultural Statistics, College of Agriculture, Junagadh Agricultural University, Junagadh, **Dr. N. J. Ardeshna**, Associate Research Scientist, Department of Agricultural Economics, JAU, Junagadh, and **Dr. B. N. Kalsariya**, Associate Professor, Polytechnic in Agriculture, JAU, Sidsar, Junagadh for valuable guidance, regular encouragement and academic support during my Post Graduate Programme.*

*I acknowledge with thanks for the facilities provided by **Dr. V. P. Chovatia**, Honourable Vice Chancellor and Director of Research and P. G. Dean, J.A.U., Junagadh, **Dr. K. A. Khunt**, Principal and Dean, College of Agriculture, J.A.U., Junagadh, **Dr. H. M. Gajipara**, Professor and Head, Department of Agricultural Economics, J. A. U., Junagadh and all the staff members of academic branch for their ever willing co-operation and encouragement.*

*My sincere thanks are also flawlessly moving toward **Dr. S. B. Vekariya**, **Dr. V. D. Tarpara**, **Dr. B. Swaminathan**, late **Dr. B. K. Gadhavi** and also thank to **Trupti D. Pansara** and all other technical and administrative staff members of*

Department of Agricultural Economics, Junagadh Agricultural University, Junagadh for their continuous and ultimate support, guidance and help during period of study.

Words are not enough to express my genuflect love, unbound gratitude and sense of affection to my parents Sri Bhikhabhai A. Parmar and Smt. Baghiben B. Parmar for their everlasting love, inestimable encouragement and dedicated efforts to educate me this level and whose unparalleled affection and persistent encouragement in keeping my career go a long throughout my life.

I am really grateful to my seniors Upasana, Nikita, Sneha, Dhara, Anjali, Hemagandhi and also thank full to my juniors for their support and generous help rendered during the course of study.

No word could justice to express my deepest sense of gratitude and love towards my friends Nita K., Mansi p., Varshini M., Abhishek virani, Vivek Donga and Bharat Makvana for their excellent company, inspiration, moral support, boost up, healthy friendship and helped me in all aspects during my PG programme to whom, I remain indebted forever.

There are number of well wishers whom I can't forget, and I thank to one and all associated with me directly and indirectly.

Place: Junagadh

Date: 30/07/2021

(Hetal B. Parmar)

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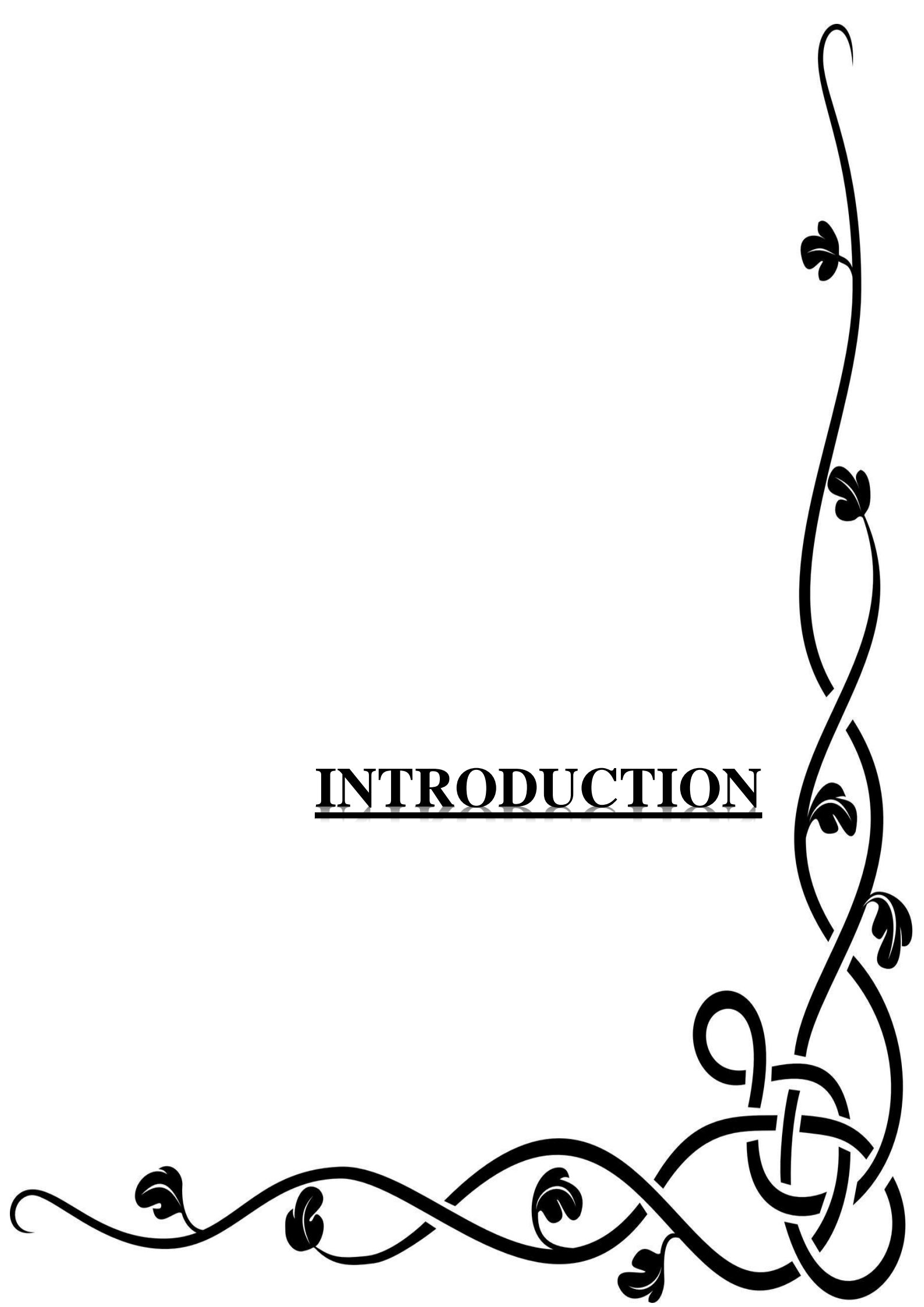
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INTRODUCTION



CHAPTER I

INTRODUCTION

1.1. Introduction

Agriculture is the largest sector of the economic activity in India. This sector has a crucial role to play in the country's economic development by providing food and raw materials, employment to a very large proportion of population, capital for its own development and surpluses for national economic development. The growth of agriculture largely depends on monsoon condition cause year to year variation in farm products. The demand of agricultural goods is inelastic and prices of these agricultural goods fluctuate more than those of industrial goods, hence they have enormous human and political implications, especially in developing country like India, so price play a more important role in agricultural sector. Agricultural production in India is getting increasingly commercialized with diversification towards horticultural crops, livestock and dairy products, along with other high value commodities.

Onion (*Allium cepa* L.) is one of the most important spice and commercial crop in India. Onion is consumed round the year by all sections of people throughout the world. In India, onion is being used in almost in every kitchen for seasoning a variety of food stuffs and as spice in vegetarian and non-vegetarian curries during preparation. It is valued for its distinct pungent flavour and is an essential ingredient of cuisine of many regions. Onion is used either in raw form or in dehydrated form to add flavour and taste to Indian cuisine.

The history of onion can be traced back to at least 5000 years. It is probably a native of Asia comprising North West India, Baluchistan and Afghanistan, from where it spread across entire world. In India onion has been grown from ancient times as mentioned in a famous early medicine treatise *Charaka Samhita* (200 B. C.). Onions were also used by the Greeks and the Romans. Onions were easy to grow on any kind of soil, any type of weather ecosystem and are easy to store, dry and preserve during monsoon.

Usually three types of onions are grown commercially in India like white, yellow and red. Onion is belonging to *Liliaceae* family. Its closest relatives are shallots, garlic and leeks. It is a bulbous plant with the bulbs being produced seasonally. The leaves are semi-cylindrical or tubular in structure. They have a waxy coating on

the surface and emerge from a subterranean bulb that bears short, thin branched roots. The stem grows upto 200 cm in height. Flowers appear at the tip of the stem and are greenish-white in colour. The bulb has several layers of overlapping surfaces around a central core and it can expand upto 10 cm in diameter. Generally, three species of onions are grown in India: (1) Common onion (*Allium cepa*, var. *cepa*) with large bulbs borne singly and propagated through seeds. It is mainly used as salad or in curries, (2) Multiplier onion or potato onion (*Allium cepa*, var. *aggregatum*) producing small bulbs borne in clusters and generally propagated through small bulbs. Mainly used for seasoning curries, and (3) Shallot (*Allium cepa*, var. *ascalonicum*) produces bulbs in clusters on surface of soil. This perennial onion rarely produces seeds and is propagated through bulbs. The term "dry onion" is used to distinguish them from green onions, which are pulled while the tops are still green and usually before a large bulb has formed.

1.1.1 Economic importance of onion

Onion is called as "*Kasturi*" of poor people in India as it is one of the important condiments widely used in all households all the year round and also earns sizable foreign currencies. The green leaves and immature and mature bulbs are eaten raw or used in preparation of vegetables. Onion has been used in soups, sauces and for seasoning foods. Onion has medicinal value, it is used in some pharmaceutical preparation also. The pungency in onion is due to a volatile oil known as allyl-propyl disulphide. It rejuvenates the body, remove toxins, revitalizes the blood and stimulates blood circulation in the body. Freshly extracted juice has antiseptic and moderate anti-bactericidal properties due to the presence of several sulphur compounds and is used as inhaler in faintness on hysterical fits and used to relive store throat too. Recent reports suggested that onion play a part in preventing heart diseases and other ailments. Indian onions are famous for their pungency and are available round the year. At least 175 countries grow onions in the world. In India, onion an important commercial crop contributed about 204 Arab rupees in the Indian economy in the year 2018-19. This value was the highest gross value of output recorded in recent years.

In agricultural sector, the various high value products, like onion has emerged among the fastest growing crops in recent years, throughout the world. Onion is the largest vegetable produced and consumed not only in India, but also in the world. Onion has become an almost indispensable part of the Indian diet. Per capita onion consumption among rural households witnessed increase of 121 per cent during

1987-88 and 2011-12. Due to differences in lifestyle and dietary patterns, onion consumption among urban households is usually higher than rural households. Onion consumption in urban households experienced 90 per cent increase during 1987-88 to 2011-12. Of the various periods, the highest growth in onion consumption has been observed during 2004-05 to 2011-12 (Saxena and Chand, 2017). India produces a range of fresh, semi-processed and processed onion products including: whole peeled onions, diced, sliced, onion powder, granulated, ground, minced, chopped, kibbled, toasted, agglomerated, custom blends. Besides, specialty products like, onion puree, dehydrated onions fried in vegetable oils, grilled, char-grilled and flame-grilled, caramelized, smoked, marinated, cooked and boiled, canned and frozen. Our main export products are dehydrated red and white onions in various forms like slices, flakes, kibbled, chopped, minced, granules and powder. Moreover, onion powder is used in ready-to-eat food products, like packaged soups, sauces, oats, noodles, pasta, frozen food and instant mixes. The demand for the processed products is increasing day by day due to its convenience to handle and use.

1.1.2 Global scenario

Onion is famous all over the world for its ability to improve the taste of food. People all over the world not only use onion in their day-to-day cooking, but it is also eaten raw and contains medicinal properties. Although every country relishes it, very few countries produce it and India is one of them. Onion is an important vegetable crop grown and consumed widely across the world. India is the second largest producer of onion in the world after China (Table 1.1). Other important onion producing countries are Egypt, Iran, Turkey, Bangladesh *etc.*

Global production of dry onion in 2019 was 999.68 lakh tonnes, with China producing 24.97 per cent of the world total, India producing 22.82 per cent of the world total and Egypt producing 3.08 per cent of the world total production. At world level, onion occupied 29.19 lakh area in 2000, which was increased to 51.93 lakh ha in 2019. Whereas, world production of onion was increased to 999.68 lakh tonnes in 2019 as against 501.41 lakh tonnes in 2000. The average productivity of onion at global was 19.25 t/ha in 2019 and Iran recorded the highest yield about 39.36 t/ha, however its area was declined to 0.45 lakh ha, as against 0.47 lakh ha in 2000.

Table 1.1: World production of onion

Country	Area (lakh ha)		Production (lakh tonnes)		Yield (t/ha)	
	2000	2019	2000	2019	2000	2019
China	7.21	11.29	150.22	249.66	20.84	22.11
India	4.95	12.20	52.52	228.19	10.59	18.70
Egypt	0.23	0.88	6.28	30.81	27.70	35.03
Iran	0.47	0.45	14.19	17.79	30.07	39.53
Turkey	0.99	0.69	21.50	22.00	21.68	32.02
Pakistan	1.06	1.48	15.63	20.80	14.80	14.03
Bangladesh	0.34	1.72	1.27	18.03	3.73	10.45
Others	13.94	23.22	239.80	412.40	17.20	17.76
World	29.19	51.93	501.41	999.68	18.44	19.25

Source: FAO, 2021.

In last decades the area under onion in India increased to more than double and production to more than fourfold due to notable increased in productivity from 10.59 t/ha in 2000 to 18.70 t/ha in 2019. In the FAO series, the data available is as per calendar year. Whereas, in India, the crops production data are given as per agricultural year from July to June. Hence, the data mentioned in FAO series for the year 2019 for India, is related to the agricultural year 2018-19.

1.1.3 National scenario

In India, onion is cultivated in both seasons as kharif and rabi-summer crop. This is because onion is grown in almost all the Indian states. The time and season of onion cultivation depends on the geographical location and weather at particular place. In India total acreage under onion cultivation constitutes about 10 per cent of total acreage under vegetables. Around 45 percent of total onion produce takes place in the three Agricultural Export Zones, which comprises three states, namely, Maharashtra, Karnataka and Madhya Pradesh (Table 1.2). Lasalgaon in Maharashtra is Asia's largest wholesale onion market. Which supplies about 80 per cent of the Maharashtra's supply. In country, onion is produced in the major states viz, Maharashtra, Madhya Pradesh, Karnataka, Bihar, Rajasthan, Gujarat and Andhra Pradesh.

Table 1.2: Major Onion producing states in India, 2019-20

States	Area (lakh ha)	% share in area	Production (lakh tonnes)	% share production	Yield t/ha
Maharashtra	6.18	43.18	106.83	40.94	17.29
Madhya Pradesh	1.74	12.15	42.70	16.36	24.54
Karnataka	1.60	11.18	22.75	8.71	14.22
Rajasthan	0.75	5.24	12.42	4.76	16.56
Gujarat	0.57	4.00	14.22	5.45	24.84
Bihar	0.58	4.05	13.13	5.03	22.63
Andhra Pradesh	0.43	3.00	9.81	3.75	22.81
Others	2.46	17.22	59.05	15.00	24.00
All India	14.31	100.00	260.91	100.00	18.23

Source: DES, 2021.

Maharashtra is the major onion growing state covering about 6.18 lakh ha area with production of 106.83 lakh tonnes, followed by Madhya Pradesh (42.70 lakh tonnes), Karnataka (22.75 lakh tonnes), Gujarat (14.22 lakh tonnes), Bihar (13.13 lakh tonnes), Rajasthan (12.42 lakh tonnes) and Andhra Pradesh (9.81 lakh tonnes) in 2019-20. Gujarat achieved the highest productivity of onion in the country ranging from 24 t/ha to 31 t/ha, since last three decades or more. Gujarat is the 4th largest producer of onions after Maharashtra, Madhya Pradesh and Karnataka in India with a production share of 5.45 per cent in 2019-20 (Table 1.2).

1.1.4 Scenario in Gujarat

The major onion growing districts in Gujarat are Bhavnagar, Amreli, Gir Somnath, Rajkot, Junagadh, Dahod, Surendranagar and Morbi. In Gujarat, Bhavnagar is major onion growing district covering about 27.18 thousand ha area with the production of 699.94 thousand tonnes (Table1.3), followed by, Amreli (225 thousand tonnes), Rajkot (173.96 thousand tonnes), Gir Somnath (98.25 thousand tonnes), Junagadh (61.26 thousand tonnes) and Jamnagar (34.70 thousand tonnes). In Gujarat, during 2019-20 onion occupied about 57.26 thousand ha area and obtained the production of 1422.26 thousand tonnes.

Table 1.3: Major onion producing districts in Gujarat, 2019-20

District	Area (000' ha)	Production (000' tonnes)	Yield (t/ha)
Bhavnagar	27.18	699.94	25.75
Amreli	9.00	225.00	25.00
Gir Somnath	4.00	98.25	24.56
Rajkot	6.90	173.93	25.21
Surendrangar	0.21	5.04	24.00
Morbi	0.55	13.75	25.00
Junagadh	2.48	61.26	24.70
Jamnagar	1.74	34.70	19.94
Dahod	1.61	31.78	19.73
Others	3.59	78.61	189.05
Gujarat state	57.26	1422.26	24.84

Source: DHG, 2020.

1.1.5 Export and import of onion in India

Onion is a pride item of agricultural exports earning valuable foreign exchange to the country. India is the second largest exporter of onion in the world after China. It is sought after due to its spiciness and zingy flavor and its availability throughout the year. Of the total fresh vegetable exports 67 per cent share is of onion. Perusal of Table 1.4 reveals the top five destinations for the export of Indian fresh onion in terms of quantity and value during 2019-20. It is interesting to note that the Bangladesh topped the list among all the five fresh onion importing countries from India, both in terms of quantity and value during 2019-20, followed by Malaysia, UAE, Sri Lanka and Nepal. The total export of onion during 2019-20 was 11.53 lakh tonnes worth Rs. 2340.26 crores and import about 1.41 lakh tonnes valued to Rs. 567.41 crores during the same year.

Table 1.4: Export-import of onion in India (2019-20)

Country	Onion export from India			Country	Onion import in India		
	Quantity (lakh tonnes)	Value (Rs. crores)	Unit value (Rs/Kg)		Quantity (lakh tonnes)	Value (Rs. crores)	Unit value (Rs/Kg)
Bangladesh	2.59	550.14	21.21	Afghanistan	0.64	224.26	35.20
Malaysia	1.91	438.46	22.87	Turkey	0.36	170.79	47.31
UAE	1.53	301.46	19.63	Egypt	0.24	95.16	39.86
Sri Lanka	1.266	297.34	23.45	UAE	0.11	46.61	42.71
Nepal	0.75	94.40	12.55	Netherland	0.04	16.41	43.18
Total	11.53	2340.26	20.30	Total	1.41	567.41	40.24

Source: DGCI & S, 2020.

1.1.6 Nutritional value of onion

Apart from its medicinal properties, onion is simply delicious. Onion is processed in various products such as ketchup, chutney, sauce, puree, dry soup mixture *etc.* The composition of onion varies according to variety, agronomic and environmental conditions of growth. Onion is a rich source of amino acids, anthocyanins, flavonols and phenolic. Onion bulb is rich in minerals like phosphorous, calcium and carbohydrate. Common onion ranks medium in supply of proteins, caloric value and vitamin B and C. In addition, onion are a good source of folic acid. The nutritional compositions of onion are given below Table 1.5. Onion has both glucose and sucrose. The special quality of onion is its smell (flavour) on account of which it is commonly used in food and masala preparations.

Table 1.5: Nutritional value of onion (per 100 g edible portion)

Energy (Calories)	166 kJ (40 kcal)	Magnesium (mg)	10 (3 %)
Carbohydrates (g)	9.34	Manganese (mg)	0.129 (6 %)
Sugars (g)	4.24	Phosphorus (mg)	29 (4 %)
Dietary fiber (g)	1.7	Potassium (mg)	146 (3 %)
Fat (g)	0.1	Vitamin B1 (Thiamine) (mg)	0.046 (4 %)
Protein (g)	1.1	Vitamin B2 (Riboflavin) (mg)	0.027 (2 %)
Calcium (mg)	23 (2 %)	Vitamin B3 (Niacin) (mg)	0.116 (1 %)
Iron (mg)	0.21 (2 %)	Vitamin C (mg)	7.4 (9 %)

Source: Butnariu and Butu, 2014.

Note: Percentage in brackets indicates daily dietary requirements as per as recommendations for adults.

1.2 Practical utility of the research problem

The production pattern of onion also changes considerably over years due to change in resource use pattern, production technology and price of input and output. The variation in the output of the onion leads to wild fluctuations in its prices, exposing the vegetable growers to more risk as compare to the growers of other crops. The prices of onion fluctuate widely and farmers' response to price change causes bumper production, which tends to decrease prices of onion drastically. Such a situation is not only creating domestic disturbances in the food economy, but also causing hardship to the farmers.

An analysis of price and market arrivals over time is important for formulating a sound agricultural price policy. Fluctuations in market arrivals largely contribute to the price instability of the produce. In order to devise appropriate ways and means for reducing price fluctuations of agricultural commodities, there is a need to have a thorough understanding of price behavior over time and over space. Such an analysis is also useful for farmers in order to decide the optimum time for disposing of their produce to their best advantage. Gujarat being one of the important onion growing states in India, the relationship of onion prices movement in consumption and producing local markets will helpful to farmers for better price realization.

Onion price shocks are hitting India frequently and they are getting severe due to climate change. It is ironical that sharp price spikes are experienced almost every third year despite impressive growth in onion production in the country, which has risen from below 55 lakh tonnes till 2002-03 to above 261 lakh tonnes in the recent year. The country experienced annual growth rate of above 13 per cent in onion production during the last 13 year since 2000-01. Per capita availability of onion has increased from 4.0 Kg in year 2002-03 to more than 13 Kg in recent years, showing an increase of 12 per cent every year (*NITI Aayog*, 2017).

Hence, this study on, "Growth Performance and Price Behavior of Onion in Major States of India" has been taken up with the following specific objectives.

1.3 Objectives

1. To measure the temporal changes in area, production and productivity of onion in major states of India
2. To analyse the relative contribution of area and productivity towards the change in total onion production
3. To measure the onion production instability in major states of India

4. To measure trend and estimate rates of change in onion price in major states of India
5. To measure the variability of onion prices in major states in India
6. To analyse the seasonal and irregular fluctuations in onion prices
7. To determine interrelation of onion prices among the states

1.4 Hypothesis of the study

In order to attain the set objectives, the following hypotheses have been formulated.

1. H_0 : There is no variation in production of onion over time.
2. H_0 : There no seasonal variability in the prices of onion.

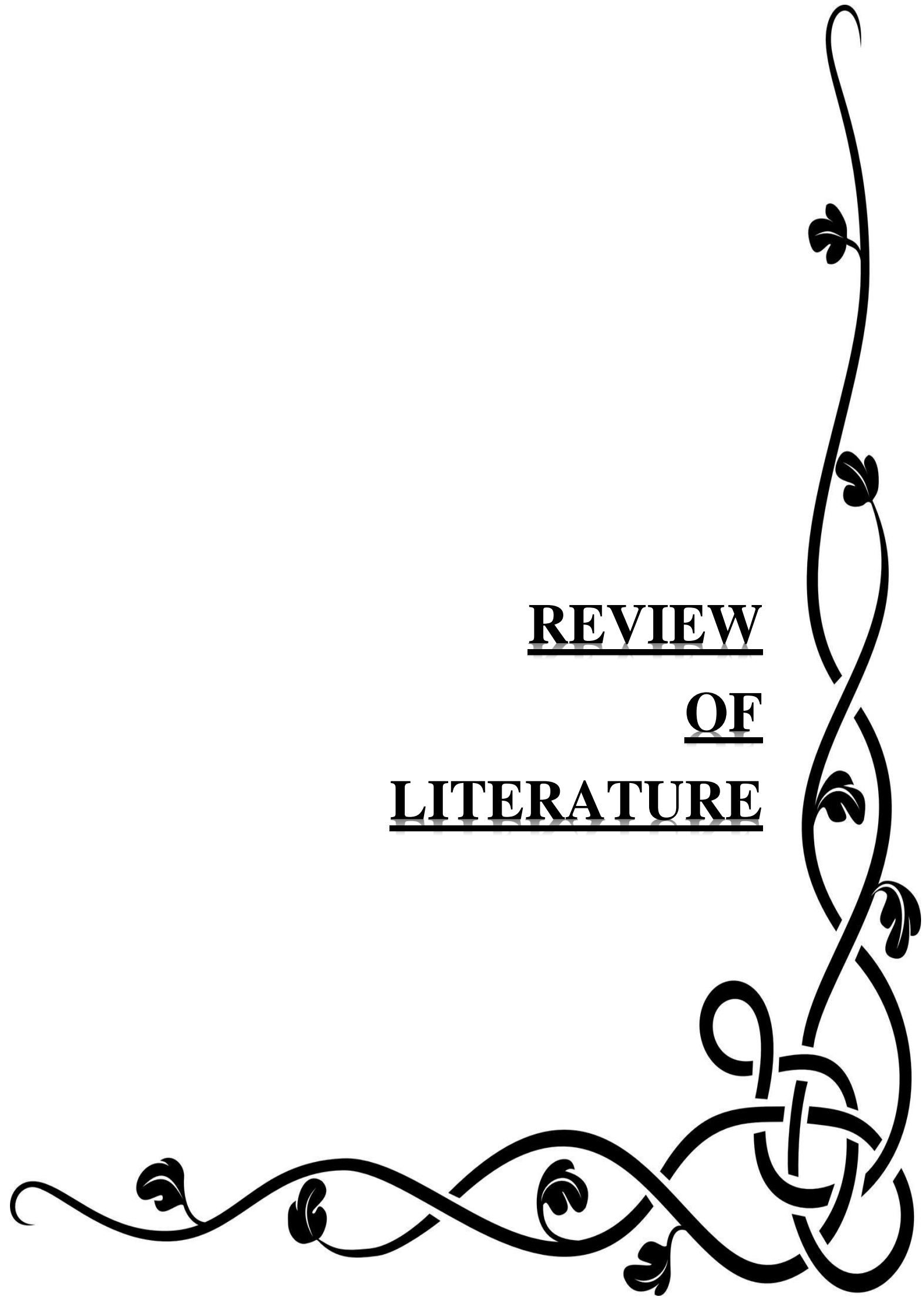
1.5 Scope of the study

The study provides information on how the prices of onion would be in different months of the year. Such information gives clues to the farmers to read the price behaviour so as to make necessary sowing and selling decisions. This information is definitely helpful to conceptualize development framework for the onion in state.

1.6 Organization of the study

The thesis has been divided into five chapter. The first chapter deals with introduction, Practical utility of the research problem, objectives, hypothesis and scope of the study. A brief resume of earlier research work carried out by various researchers in concerned field has been discussed in the second chapter. The details of study area, data collection and its sources and the tools of analysis used to achieve the objectives of the study are present in third chapter. The fourth chapter is related to results and discussion part of this investigation. A brief summary, important conclusion and policy implication of the study are present in the last chapter.

REVIEW
OF
LITERATURE



CHAPTER-II

REVIEW OF LITERATURE

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In order to have a healthy growth in agriculture sector, it is necessary to keep a watch on the price movement of agriculture commodities. This also ensure the economic interests of a nation and assures the food security to its people. Detailed studies are required from time to time to assess the current situations and assist in the formation of price policy that affects the future of the market. Although few such studies were conducted in India, rarely we find such study been carried out in Gujarat.

The literature reviewed provides a theoretical framework, which will be very useful in executing the research, starting from raising an issue to the final conclusion. Thereby, a comprehensive survey of the earlier work done is very much essential in framing the objectives of a research problem. The related review of literature concerned with the objectives of the study is presented in this section. As literature on the specific onion crop is limited, the literature pertaining to other crops has been included in the present review, related to the objective of this study. Reviews of a few of such studies were carried out under following heads.

2.1 Growth rate and instability in area, production and yield

2.2 Price variability

2.3 Price behavior

2.1 Growth rate and instability in area, production and yield

Veena (1996) studied the growth and instability of vegetables in Karnataka by employing Hazell's decomposition analysis. The findings of the study revealed that changes in mean yield were the major sources of increase in mean production of vegetables in the state during second period (1985-1994). However, increase in mean area accounted for larger share in brinjal (48.70%) and tomato (43.26%) crops. The use of high yielding varieties, increased irrigation facilities especially tube-well irrigation and increased use of chemical fertilisers have contributed to increased yield in the state. The components of change in variance of individual vegetable crops showed that change in yield variance has contributed more towards increased variability in the state followed by change in the mean area under these vegetables.

Singh and Srivastava (2003) analyzed the growth rate and instabilities in sugarcane production in different regions of Uttar Pradesh, India. The study has used

time series data on area, production and productivity of sugarcane for Western, Eastern and Central (including Bundelkhand) regions as well as for the state as a whole with reference to the period 1980-81 to 1998-99. Semi-log equations were fitted to estimate compound growth rates in area, production and productivity of cane. Instability in area, production and productivity was measured through coefficient of variation analysis using detrended data. The production instability was also decomposed to examine the magnitude of various components of regional sugarcane production variability. Though, significant and positive growth in the production of sugarcane has emerged as a common feature in all three regions of the state, its magnitude was not uniform across the regions. The study suggested adequate measures to improve location-specific production technology through research, development and extension efforts and also through ensured input supply mechanism.

Kumawat and Meena (2005) studied the growth and instability trends in area, production and yield of spice crops such as coriander, cumin, fenugreek, fennel, garlic and chilli in Rajasthan vis-à-vis India during 1986-87 to 2000-01. The authors reported that all the spices taken under study registered significant growth rates in their production in Rajasthan as well as in India. Besides, the production instability, using detrended coefficient of variation was found to be highest for fennel (54.03 %) followed by cumin (52.89 %), coriander (35.58 %) and fenugreek (24.45 %) in India during the same period.

Kulkarni *et al.* (2012) studied the growth trends in area, production and export of onion from India -An economic analysis from 1978-79 to 2010-11. Result revealed that the quantity of onion exported from India to different countries has increased from 106.89 million kg in 1960-61 to 1163.47 million kg in 2010-11 with an increase in the export value from Rs. 26.53 crores to Rs. 1741.55 crores. The share of export in the production has also increased from 7.27 per cent (343.26 thousand tones) during 2000 to 12.45 per cent (1664.92 thousand tones) in 2010. India is presently exporting onion to mainly Gulf countries, far East countries, Bangladesh and Sri Lanka where there is not much scope to increase the quantity, as some countries have also started their own production.

Rani and Theenathayalan (2013) studied the performance of onion production in India from 2001- 2010. They reported that onion is one of the sensitive crops, both in terms average area of onion cultivation and production. India occupies an important place in case of onion production in world. But from the point of view of productivity

per hectare India's productivity is not satisfactory. The reason attributed for due to unseasonal rains and high temperature at the time of harvesting during April – may the quality of onion has been affected.

Soumya *et al.* (2014) studied the instability in coriander in major producing states of India during 2001-02 to 2012-13. The authors observed that the area under coriander cultivation had shown instability of 25.18 per cent, whereas the coriander production and productivity showed instability of 33.61 and 13.18 per cent, respectively at national level. Similarly, instability of 22.20, 35.79 and 20.20 per cent in area, production and productivity of coriander were noticed in case of Madhya Pradesh, respectively. Coming to Rajasthan, area, production and productivity had showed instability of 26.66, 29.41 and 5.16 per cent, respectively.

Sajesh *et al.* (2014) analyzed Maharashtra's onion growth and instability. Erratic weather, volatile market price and lack of adequate storage and market infrastructure caused instability in production, through preventing the farmers in taking the optimal decision on allocation of area and raising farm productivity. Study revealed that onion production in Maharashtra is mainly driven by acreage allocation. But in the long run increasing area under onion may not be feasible without reducing the area of other important crops. The major reason for the instability of onion production was due to area instability and partly due to yields instability.

Dinesha and Sriramappa (2015) in the studied the growth in area, production and productivity of vegetables and fruits in India with special reference to Karnataka, calculated compound growth rate for the period from 2001-02 to 2010-11. They indicated that area and production under fruits registered significant positive growth rates at 5.80 per cent and 6.70 per cent, respectively during study period. Whereas, the growth of productivity was 0.80 per cent, which was positive but not significant.

Jhajhria (2015) studied the instability trends of coriander cultivation in India for three different decadal periods starting from 1981-82 to 2009-10 using Cuddy-Della Valle index. The author reported that the coriander crop registered declining instability levels in terms of area from 20.51 per cent in 1981-1990 to 16.93 per cent in 1991-2000, but again increasing instability index of 18.66 per cent in 2001-2010. At the same time, the yield of coriander in India registered high rate of instability with a declining trend in instability in yield from 15.80 per cent in 1981-1990 to 10.72 per cent in 1991-2000 and 9.84 per cent in 2001-10. This was primarily because of better irrigation facilities, quality seed and better management of diseases and pests.

Meena *et al.* (2016) studied the performance of onion in Bihar. The study period has been divided into five periods: 1975-1984, 1985- 1994, 1995-2004, 2005-2014 and 1975-2014. Results of the study showed that in the first decade onion gain the area at the compound growth rate of 1.7 per cent per annum. The production of onion registered highest growth rate during this decade about 2.9 per cent, despite an increase in productivity was at slow pace. During the second decade performance of the onion in area and production was much better than first decade but onion lost the productivity at the compound growth rate of 0.3 per cent per annum. Onion in the third decade showed very poor performance and lost the area and production. Performance of onion was recorded much better and gained area, production and productivity with the highest growth rate in the fourth decade. Finally during the whole study period best performance of onion was found in production followed by area and productivity.

Patil and Kerur (2016) carried out the growth and instability analysis of onion and garlic in India from 1995-96 to 2014-15. This study was mainly based on secondary data, revealed that for onion area, production and productivity CAGR was the highest in the last ten year. There was a positive growth in area and productivity of onion in India and Karnataka. At india level variation was much observed in cost of production of onion, which was mainly due to farmers changing the varieties of onion in production. Attempt has to be made in order to see that popularization of improved varieties, quality seed production and distribution, expansion of area in nontraditional pockets and contract production for export.

Patil and Yeledhalli (2016) analyzed growth and instability in area, production and productivity of different crops in Bengaluru division, Karnataka state. This has a typical composition having a large share of its area under highly diversified agricultural crops, higher growth in agriculture assumes great importance and is a matter of concern for policy planners and research scholars in recent times. The results revealed that Bengaluru urban had significantly the highest CAGR about 24.26 per cent in productivity of avare. In Bengaluru rural also the highest CAGR was 22.26 per cent in productivity of avare. Production of chrysanthemum had growth of 22.36 per cent, which was the highest annual growth and 4 per cent (area of tamarind) was found to be lowest instability for selected crops in Chitradurga. In Davanagere district, the highest CAGR was observed in productivity of tomato (9.12%). In Kolar district, 19.65 per cent instability was observed in production of avare. In Shivamogga district the highest

CAGR observed in production of sunflower to an extent 29.57 per cent. In Tumkuru district, area under green chillies was growing at rate of 34.46 per cent per annum.

Hemant *et al.* (2017) analyzed the trends in area, production and yield of onion in Rajasthan state of India by using component analysis model. The study data period has been divided into three periods: period one, 1984-95, 1996-2005 and 2006-2015. The comparison of area, production and yield growth rates in all periods revealed that onion showed better performance in state as well as national level. The decomposition analysis of growth suggests that for onion yield effect is the major source of growth in period 1984-95 and 1996-2005, except for period 2006-2015 for which area effect was the major source in Rajasthan. At national level, source of output growth for onion was the yield effect. The sources of output for the overall study period revealed that in case of onion crop, the main output source was the yield effect. The results of decomposition analysis have important policy implications because each growth component alone has a limited scope to expand overtime.

Ankush and Utkarsh (2018) analyzed instability in APMC market, export, area, production and yield of onion in Maharashtra. The present study commenced on secondary data on arrival and prices of onion in APMC, Pune, Solapur, Pimpalgaon, Mumbai, Lasalgaon, Kolhapur and Nagpur for the period 2000 to 2015. Study reveal that price of onion ascertained the highest during lean and the lowest during peak arrival period. Instability in onion export noticed higher during August-January. After globalization, high growth rate with high instability observed in area, production and yield.

Bhopala (2019) studied the growth of total factor productivity of sugarcane in Gujarat and production instability in major states of India during 1980-2018. The growth of total input and total output indices of sugarcane in Gujarat decreased at the rate of -0.77 and -0.34 per cent per annum during 1990-91 to 2018-19, respectively. Whereas, TFP indices increased slightly at the rate of 0.43 per cent per annum. But, such type of positive growth is not meaningful as it is associated with negative input-output growth. In case of decade-wise results, only during 2000s, the input, output and TFP indices growth were found positive, but it was stagnant (*i. e.* < 0.5%) indicating mainly input-based output growth, might not sustained in future, in absence of input saving varieties and technologies. Also, the sugarcane ratoon and planted crop system by and large revealed similar results regarding TFP growth rates.

Mahmadajaruiddin and Mamani (2020) Studied that growth and export performance of onion in India. The data collected from 2006-07 to 2017-18. The results revealed that Gujarat recorded negative and significant growth rates of -6.11, -6.28 and -0.18 per cent per annum in area, production and productivity of onion, respectively. Rajasthan exhibited high variability in area (43.30%), production (46.70%) and productivity (36.76%). Quantity of onion production in India exhibited a positive growth rate of 6.34 per cent per annum and was statistically non-significant at five per cent level of significance. Quantity of onion production in India has shown variability of (24.33%). Whereas, quantity of onion exports registered a growth rate of 3.14 per cent per annum and in terms of value 9.09 per cent per annum, which is non-significant. With reference to the variability of onion exports, the value of onion exports exhibited a highest variability (35.01%) than that of quantity (25.22%). The positive growth rate in quantity of onion production attributed to increase in area under the onion cultivation coupled with use of improved cultivars and with increase in demand for India's onions in the international market.

Nalegaonkar *et al.* (2020) studied the growth and instability in area, production and yield of onion in India from 1995-96 to 2018-19. They reported that, compound growth rate of area, production and yield of onion were statistically significant and positive. The highest instability was observed in production of onion followed by area and yield.

Nivetha and Uma (2020) studied the performance of fresh onions in India from 1999 to 2019. Study revealed that the growth rate in first decade were higher, which was statistically significant at 1 per cent. While the export value recorded comparatively higher annual growth rates at 20.99 per cent in first decade, which was statistically significant at 1 percent level. In supply response analysis, among the price and non-price factors, lagged yield only positively influences farmer's decision on acreage allocation in current year. The direction of trade in Indian onion export showed that UAE and Nepal are the highest stable onion market with the probability of retention 0.52 and 0.45, respectively from 1999-2019. It shows that there is a need to create our onion demand and maintain good relations with other countries to retain the market share.

Parimalarangan (2020) calculated the area, production and yield growth rates and reported that, onion showed better performance in Tamil Nadu as well as at national level. Area, production and productivity of onion in Tamil Nadu was found to be stable.

In India, even though there was decline in area, increasing trend in production was noticed. Production was increased because of increase in productivity, use of technologies including high yielding varieties, better irrigation and management practices.

2.2 Price variability

Singh and Rai (1980) in their study in Hariyana observed that from 1965-66 to 1975-76 the price variability was lowest for wheat and rapeseed-mustard being 27.57 and 32.46 per cent, respectively. During the period under study, it was higher for moong *i.e.* 49.84 per cent. Almost all the crops exhibited high price variability in the state, except wheat, which has support price.

Kumar *et al.* (2005) studied the variability pattern of market arrivals and prices of selected vegetable crops in four metropolitan markets (Delhi, Bangalore, Mumbai and Kolkata) for the period from 1990 to 2001. The results showed that the extent of variability in the arrivals of cabbage was lower in Bangalore and the highest in Mumbai. The prices were relatively stable in Mumbai, but were more volatile in Bangalore. In the case of cauliflower, the variability in the market arrivals was more pronounced in the Kolkata than the remaining markets. The extent of variability in the market arrivals of tomato across different months was very high in all the four markets. While the maximum variability in the prices of peas was noticed in Delhi market, these were relatively less in Bangalore market.

Sharma *et al.* (2011) studied that prices of onion in India. They revealed that there was substantial increase in onion production until 2008-09, resulting in a rise in market arrivals. The rise in prices of onion can be attributed to a decline in kharif production on account of unseasonal rains at harvest time in the major onion producing states, a reduction in the minimum export price and constant increase in exports during 2010.

Chaudhari and Tingre (2012) studied price movement of pigeon pea, *i.e.* seasonal variation, price variability among the major pigeon pea markets in India. The results of the study showed that the prices of pigeon pea were higher in the months from June to August in all selected markets. Akola, Latur and Thandur markets showed high price volatility.

Reddy *et al.* (2012) revealed that there was high variability in the arrival of onion in the month of March and April in selected markets in India. Among the markets, the coefficient of variation in both, arrivals and prices were found to be higher in

Ahmadabad and Kolkata. The zero order correlation matrix between two markets, average wholesale prices of onion indicated the high integration among the selected markets, except Ahmadabad and Mumbai market. This might be due to the movement of produce from one market area to another depending upon price prevailed in the markets. The competitive conditions prevailing in the selected markets might have influenced the movement of prices in the same direction.

Burark *et al.* (2013) studied the price variability in domestic markets of coriander in Rajasthan during 2009-10 through GARCH estimation. The result revealed that price variability of coriander prices in Baran market was relatively more than Kota and Ramganj markets.

Hemant (2013) carried out ARCH-GARCH analysis for the price series of gram in different markets *i.e.*, Anupgarh, Bikaner, Hanumangarh, Padampur, Pilibangar, Sri Ganganagar and Sangaria. The sum of Alpha and Beta values indicated the presence of persistent fluctuation. The value close to 1 indicates the persistence of volatility in the market. The result confirmed that there was no volatility in price of gram in these market, since the entire sum Alpha and Beta values were less than 0.34.

Jharjhria *et al.* (2013) examined persistence and asymmetry in prices of coriander through GARCH model by using time series data for the period between 2008-09 to 2010-11. The empirical results revealed the variation in coriander prices generally fluctuate over time and there is an evidence of long term persistence and volatility clustering in prices.

Khatkar *et al.* (2013) studied the monthly wholesale price fluctuation in mustard prices in Hisar, Rewari, Sirsa and Sri Ganganagar markets and carried out ARCH-GARCH analysis. The sum of Alpha and Beta values indicated the presence of persistent fluctuation. The value close to 1 indicates the persistence of variability in the market. The result confirmed that there was no volatility in price of mustard in these market with the exception of Sirsa market where there was a presence of variability in the prices of mustard.

Patil *et al.* (2014) carried out ARCH-GARCH analysis to assess the presence of price fluctuation in the prices of green gram in Akola, Latur, Amravati and Jalagaon markets of Maharashtra during 2004-2013. It was observed that among the markets, the sum of Alpha and Beta was not nearer to 1 *i.e.*, 0.34. 0.35. 0.33 and 0.35 for Akola, Latur, Amravati and Jalagaon markets, respectively indicating that the variability shocks were not quite persistent in these markets.

Bhavani *et al.* (2015) examined the price variability of chilli in major markets of India using ARCH-GARCH analysis. For the study *viz.*, Guntur, Khammam, Virudnagar and Nagpur markets were purposively chosen. The secondary data on monthly modal prices (Rs/qtl) were emanated from the records maintained by the respective market committees. Chilli prices in Guntur market for the period from 1997 to 2011 has indicated wide variations in prices ranging from Rs. 1000 per quintal (1997) to Rs. 8800 per quintal (2011). The coefficient of variation of the prices was 32.4 per cent in Virudnagar market. The price behaviour of selected crop in Nagpur compared to Guntur and Virudnagar presented on altogether new dimension till 2000 commencing from 1997. Chilli prices in all the markets indicated persistent fluctuation over a period of time and these were maximum in Nagpur market.

Darekar *et al.* (2015) studied the growth rate in area, production, productivity and instability of onion in Maharashtra. Study categorized period as follows; Period I: 1975-76 to 1984-85, Period II: 1985-86 to 1994-95, Period III: 1995-96 to 2004-05, Period IV: 2005-06 to 2012-13 and overall period 1975-76 to 2012-13 revealed that onion production in Maharashtra is mainly driven by acreage allocation. But in the long-run increasing area under onion may not be feasible without reducing the area of other important crops. Hence, solution lies in by bridging the yield gap or increasing the yield potential. The major reason for the instability of onion production after period II was mainly due to area instability and partly due to yield instability. Although, productivity of onion has improved from last decade, still onion production is mainly driven by acreage allocation. As onion is irrigated crop and Maharashtra is endowed with relatively less irrigation potential, increasing production through scaling up area may not be feasible without reducing the acreage under other important high value crops.

Kumar *et al.* (2015) Examined export volatility structural breaks in price volatility and linkages between domestic and export prices of onion in India. The study is based on the monthly arrival data of five major regulated markets from three major onion-producing states of India, namely Azadpur from Delhi, Lasalgaon, Pune and Solapur from Maharashtra, Bangalore and Hubli from Karnataka along with the export price. The ARCH-LM test has been applied to find the presence of conditional heteroscedasticity. To model the conditional heteroscedasticity as well as asymmetry in volatility, exponential GARCH model has been applied. The analysis of structural breaks in volatility has revealed the situations of price shocks in the years

2007, 2010, 2011 and 2013, when onion prices went abnormally high and created disturbances in the markets. The application of Johansen method of cointegration has revealed that prices in all the markets share stable long-run relationship. The Granger causality test has shown that all the major domestic markets of onion Granger cause export prices on one hand and export prices Granger cause prices in Delhi, Bangalore, Hubli and Solapur markets. These results have been supported by the impulse response function.

Navadkar *et al.* (2016) carried out econometric analysis of arrivals and prices of black gram in Western Maharashtra, observed that the arrivals of black gram in the post-harvest period were the maximum and during the lean period were the least. Whereas, in the case of prices, opposite trend was observed. At the Barshi market, the prices of black gram increased rapidly over the period of 11 years ending 2011-12 and at a faster rate. It was seen that the seasonal indices for black gram arrival was more during the month of September followed by October, while it was lowest during the month of May followed by March.

Basavaraj *et al.* (2019) studied the demand and supply dynamics of onion in Karnataka: Price instability and stabilization measures from 2000 to 2015. Onion prices have become quite volatile in India, affecting both producers and consumers. This paper examines dynamics of demand for and supply of onion in Karnataka, one of the leading onion producing state, and their implications on price volatility. Although the supply of onion has increased substantially, its total consumption has remained almost stagnant, which is around 20 per cent of the total supply. About 60 per cent of the onion produced in the state is exported within and outside the country. Measure on price volatility indicates high inter year variability as compared to intra year volatility.

Birthal and Negi (2019) analysed the variability in onion prices in India. Three important finding emerge from these analysis. First, despite no significant production shocks there is strong element of uncertainty in market arrivals of onion. Demand for onion is price inelastic, and even a small shortfall in their production. Two, onion market are spatially integrated, that is there is a co-movement in prices across markets. Three, the policies such as raising ceiling on minimum export price and banning of exports also do not seem to have any immediate cooling effect on the price volatility.

Gummagolmath *et al.* (2020) carried out a study on analysis of price instability of onion in India *viz.* Maharashtra, Karnataka, Rajasthan and Tamil Nadu from 2000 to 2019. They observed that the there is a deficit of about 40 per cent in onion supply and

hence supply is unable to cope up with the demand, which resulted in the skyrocketing of prices. It is learnt that the prices of onion were hovering around Rs. 100 per kg in the year 2012. The sudden rise in prices of onion can be attributed to reduced sowings on account of delayed monsoons followed by excessive rainfall, mainly during harvesting season.

2.3 Price behavior

Shiyani and Kakadia (1999) in their study on time series analysis of marketing pattern of onion in selected markets of Saurashtra region of Gujarat state noticed that the prices of onion were found higher in the lean and mid period, than that of in the peak period. The price difference also varied considerably in different years. The price indices were above hundred during the month of lean period and they were below hundred in the months of post harvest period in all the markets.

Singh *et al.* (2000) carried out a study on analysis of prices and arrivals of rapeseed and mustard in Haryana during 1991-92 to 2007-08. They observed that the indices of prices of rapeseed and mustard has the general tendency of raising. They also found seasonality in the arrivals and prices of rapeseed and mustard. The price indices were below hundred from February to June when the arrivals were the maximum.

Sharma and Sharma (2001) studied the levels and variation in wholesale prices and export of selected vegetables from India. They observed that the wholesale prices of onion are most consistent across four metro cities followed by potato and tomato, respectively. Potato wholesale prices were lower during February-March, the main harvest season in the Indo Gangetic plain. In case of onion, lower wholesale prices were reported during March-April, the main harvest season.

Balappa and Hugar (2002) analysed the trends in prices of six principal vegetable markets of Northern Karnataka for onion and potato. In case of onion, there was marginal increase in prices over the period with mild in fluctuation in all markets, except Belgaum, Hubli and Dharwad, where in upward trend was noticed in 1997-98.

Wadhvani and Bhogal (2003) studied on vegetables in Uttar Pradesh (Western and hill region) observed a high degree of seasonality in the wholesale prices of potato, onion, tomato, green pea, cabbage, bottle gourd, okra and pumpkin during 1987 to 1996. The trend coefficient were found significantly positive in most of the vegetables. No definite cyclical movement was observed in vegetable price in both the regions. However, in plains, ginger and green pea, and in hills onion, cabbage, bottle gourd showed a relatively more regular cycle.

Sangeeta (2004) analyzed the arrivals and prices of onion in Lasalgaon and Pune markets from 1999-2002. She observed that in Lasalgaon market the arrivals were more in January and February, where as in Pune market the arrivals begun increasing in February and March. The prices showed an upward trend from the month of June and continue to rise up to November, after which decline was observed.

Thumar (2004) in his study on economic analysis of price behavior and acreage response of garlic in Saurashtra region of Gujarat state, observed that the behavior of prices and arrivals were found seasonal, but trend free in all the selected markets. In long run, cyclical variation in price and arrivals of garlic were observed in all the selected markets.

Bhatt (2005) analyzed the price behaviour of major oilseeds in Gujarat state during 1988 to 2003. Result reveals that prices of groundnut, mustard, castor and sesamum exhibited moderately high degree of inter-year variability and high degree of intera-year variability. There was moderately high fluctuations in year to year price change. All the oilseeds under study showed high increase in yearly prices.

Khunt *et al.* (2006) analysed the seasonality in arrivals and prices of all the major vegetables produced in Gujarat and observed inverse relationship between prices and arrivals of most of the vegetables. Arrivals and prices of major vegetables have increased over the period in most of the regulated markets showing the scope for expansion of vegetable cultivation.

Singh and Ranghi (2008) studied the seasonal variations of potato arrivals and prices in Jalandhar and Hoshiarpur markets of Punjab during 1984-85 to 2004-05. The result showed that the seasonal indices of arrivals in both the markets were the highest in the month of December and the lowest in September. The prices were the lowest in January and the highest in the month of August in both the markets.

Kumar *et al.* (2009) conducted a study in Bangalore market for the period 1999-2008 using secondary data pertaining to monthly arrivals and prices of green-chilly, onion, potato and tomato. For evaluation of seasonality in arrivals and prices, the multiplicative time series analysis and 12 month centered moving average were used and the study concluded that, there was presence of seasonality within a year and seasonal pattern did not change over years in the market except in onion prices.

Sidhu *et al.* (2010) studied the supply chain analysis of onion and cauliflower in Punjab during 2002 to 2006. They reported that wholesale markets of Pune, Ludhiana and Patiala for onion and that of Shimla, Ludhiana and Patiala for cauliflower have

been found integrated with price of onion and cauliflower transmitting quickly from the independent to the dependent markets. The highest elasticity of price transmission in onion has been observed between Ludhiana and Patiala markets with almost 90 per cent of the price change in Ludhiana getting transmitted to the Patiala market. Such transmission has been 100 per cent for cauliflower between Shimla and Patiala markets. The price transmission has been observed faster in cauliflower than onion.

Upadhyay and Zala (2010) analyzed the price behavior of pigeon pea in Middle Gujarat state and noticed that seasonal price indices of pigeon pea were the lowest in January-February in majority of the markets, except in Karjan, Padra and Naswadi markets. Prices were increased by more than Rs.100/quintal from January-February to September-October in majority of markets and decreased there after till the arrival of the next crop.

Sharma (2011) studies the behavior of market arrivals and prices of tomato in selected markets over the years (1991-2003). The results revealed that both market arrivals as well as prices of tomato showed an increasing trend in all the markets during the study period. The seasonality in prices was higher than the seasonality in market arrivals in all the selected markets, emphasizing the improvement in the production and protection technology and imperfection in markets and marketing system of tomato.

Mishra and Kumar (2012) studied the price behaviour of major vegetables in hill region of Nepal during 2000-01 to 2009-10. The seasonality in wholesale prices was analysed and found that during the post-harvest period, the wholesale prices ruled very low, while during the lean period, the prices were quite high, which is due to seasonal and perishable nature of the vegetables. The entire vegetables registered the positive and increasing trend and periodicities of 2 to 3 years in the wholesale prices of vegetables.

Verma *et al.* (2013) analyzed that the pattern of market arrivals of cumin in different seasons during 2005-06 to 2009-10 and indicated that the arrivals of cumin have been 63.51 per cent in first peak season of total. Arrivals were low in the second, third and fourth seasons. Prices of cumin were higher in second season by 10.36 per cent, over the first season. Prices were negative by 4.28 per cent in the fourth season over the third season. The monthly arrivals data showed that there has been continuous decrease from June to February months and increase from March till May month. Arrivals were higher in April to May due to arrivals of new crops.

Diwaker and Rai (2014) studied the behaviour of market arrivals and prices of onion, garlic and turmeric in selected markets of Uttar Pradesh from 2001-2010. The study revealed that the extent of variability in market arrival of onion was lower in Lucknow market, but higher in Kanpur market. Its prices variability was lower in Kanpur market and higher in Lucknow market. In case of garlic, the variability in market arrivals and prices was lower in Kanpur market, but higher in Lucknow market. In case of turmeric, the variability in market arrivals and prices was lower in Lucknow market, but higher in Kanpur market. The study has confirmed the negative relationship between market arrivals prices of onion, garlic and turmeric over the years in all two markets. However, across different months, there have been several instances of positive relationship between market arrivals and prices in Lucknow and Kanpur markets.

Darekar *et al.* (2015) examined the behavior of market arrivals and prices of onion in Western Maharashtra during 2004-2013. They concluded that the extent of variability in market arrivals and prices of onion was lower in Pune, Lasalgaon and Yeola markets, but it was higher in Ahmednagar, Pimpalgaon, Lonad, Kolhapur, Solapur, Dhule and Jalgaon markets. Its indicate that, the arrivals of onion were more consistent in Pune, Pimpalgaon and Yeola markets due to more consistency in prices of onion. These three markets are the important markets of onion in Western Maharashtra.

Nirmala *et al.* (2015) examined price behaviour of tomato, brinjal and bhendi in selected markets of united Andhra Pradesh for a period of 2002-2013. The result revealed that there was an increasing tread in the prices of tomato in all markets and also in Gadsianaram and Gudimalkapur markets for brinjal and bhendi.

Dave and Tarpara (2016) studied the price behavior of major pluses in Gujarat state during 2003 to 2013. They found that, there was a lower fluctuation in the period 2003, 2004 and 2013, while remaining years showed moderate to very high fluctuations of intra-year variability in all the markets under study period. The linear model is a better fitted in pigeon pea and green gram crops, while in case of chickpea in Dhandhuka and Dahod markets quadratic model is a better fitted. The compound rates of increase in prices of crops under study were statistically significant during the period under study. The prices of all the four pulses under study indicated downward trend in post-harvest period, while, upward trend in pre-harvest period. The maximum value of the coefficient in seasonal variation was found in case of green gram in Gondal market

(22.47%). The prices of pigeon pea and green gram revealed less degree of irregular fluctuations, while the prices of chickpea and black gram showed comparatively high and violent type of irregular fluctuations. The values of correlation coefficient of monthly and yearly prices of pulses under study were more than 0.90 and were highly significant.

Sinha *et al.* (2016) studied the price transmission and causality in major onion markets of India *viz.* Mumbai, Nashik and Delhi from 2003 to 2015. The finding of the study revealed that there was a significant difference between average price of Nashik and other markets prices. In case of Nashik market the price ranges in between 8 to 9 Rs. per kg, whereas, it is 10 to 11 Rs. per kg in other markets. High instability/ volatility of prices has been remained in case of Nashik market (C.V. 87%) followed by Mumbai and Delhi market. Among these three markets the lowest and the highest price occurred in Nashik (Rs. 2.16 per kg during March, 2003) and Delhi (Rs. 49.22 per kg during September, 2013) in the entire duration of March, 2003 to September, 2013, respectively.

Srikala *et al.* (2016) studied the price behaviour of chillies in Guntur market of Andhra Pradesh, India using time series data on monthly prices (Rs/qtl) for the years 1997-2014. There was an increasing trend in the prices of chillies in the selected market and was found to be statistically significant at 5 per cent level of significance. The seasonal index was maximum in December with 108.52 and the price indices ranged from 92.52 to 102.94, only one cycle was observed, which had lasted for four years. Chilli prices were subjected to high irregular variation during the period of 1997-2014.

Ahmed and Singla (2017) studied the market integration and price transmission in selected onion markets using Johansen cointegration, Granger causality and impulse response function. The outcomes of the study strongly buttressed to the co-integration and interdependence of onion markets in India. The impulse response function supported that, except Mumbai and Kozhikode, all other selected markets were responded well to standard deviation shock given to any of the markets. One of the possible reasons might be that Mumbai is the largest supplier of onion and Kozhikode is geographically dispersed and is a sea port, where foreign produce may be arriving in a larger quantity. The overall regional markets of onion were strongly cointegrated that allows the private traders and restricts the role of government intervention.

Saxena and Chand (2017) indicated that during the last 12 years period from 2005-06 to 2016-17, the major onion markets in India are highly co-integrated with

each other and thus prices are transmitted from one market to the other quickly. There should be continuous monitoring of prices and market arrivals by some agency of the Central Government, which should also provide advance information to the Government about implications of production fluctuation on prices.

Agrwal *et al.* (2019) studied the dynamics of prices and arrivals of major vegetables: A case of Haldwani and Dehradun markets, Uttarakhand from 2001 to 2017. The study revealed that the behavior and relationship between arrivals and prices of potato in Dehradun market and tomato and onion in Haldwani market of Uttarakhand. The statistical tools employed includes, exponential function, coefficient of variation, seasonal indices and linear regression analysis. The empirical analysis showed that the area and production of these vegetables are significantly increasing. The arrival of potato and tomato negatively and significantly influenced their prices while the lagged prices had a significant and positive effect on current prices of all selected vegetables. The variability in price of onion was the highest amongst all the vegetables and 92 per cent of this was caused by factors other than market arrivals and lagged year prices.

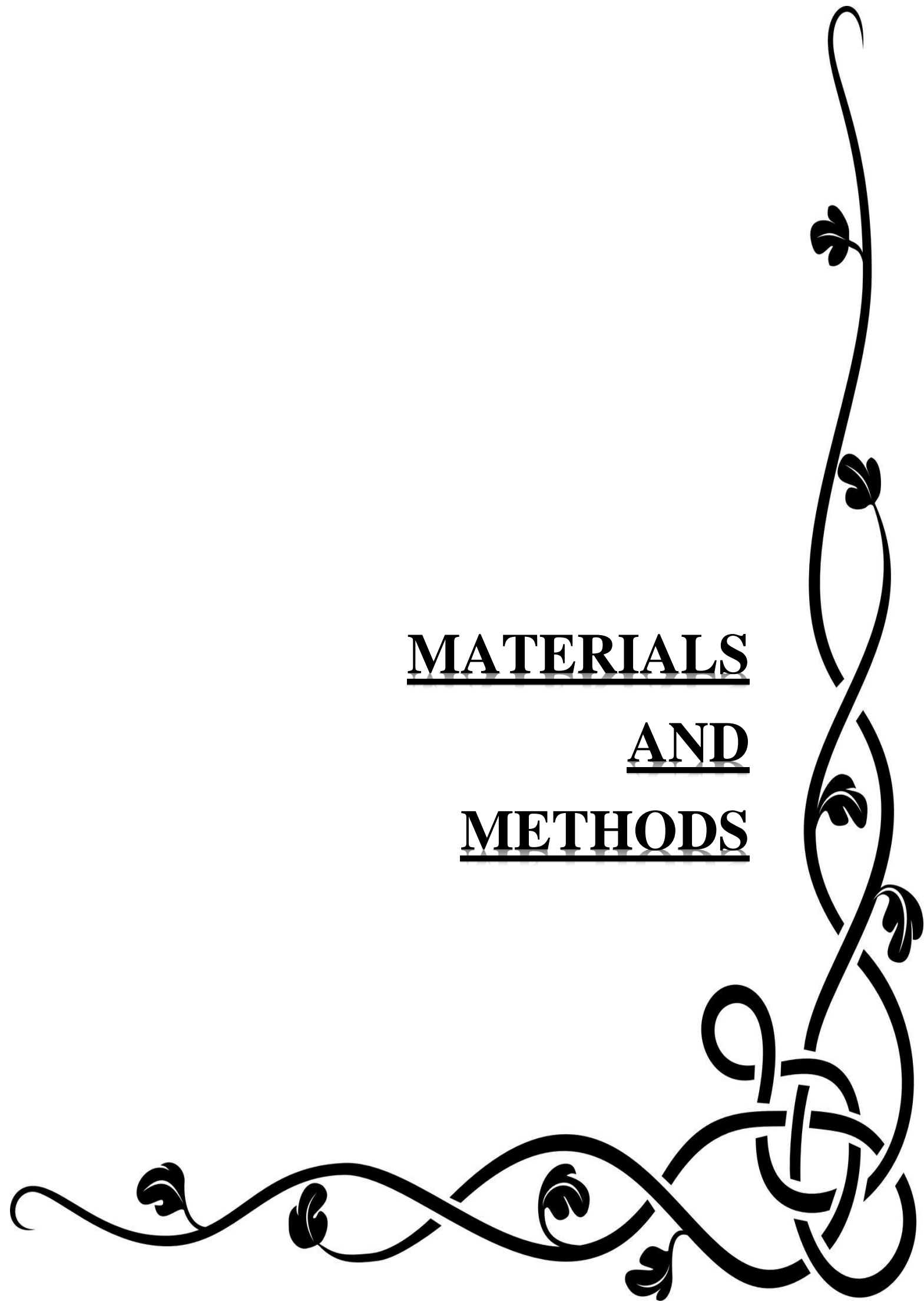
Amand and Gummagolmath (2019) studied the temporal analysis of onion prices in major onion producing states and marketing centres located in Maharashtra, Karnataka, Madhya Pradesh, Rajasthan, Tamil Nadu, West Bengal and Bihar in India from 2002 to 2017. The study revealed that, in the last two decades, area and production of onion has increased considerably in non-traditional areas under onion cultivation coupled with marginal increase in productivity in Madhya Pradesh, Maharashtra, Punjab, Karnataka, Haryana and Rajasthan taking cues from rising wholesale prices in domestic markets. Time series analysis of prices revealed that wholesale prices have exorbitantly increased and touched a historical high of Rs. 5000-6000 per quintal.

Sharma and Singh (2019) studied the performance of onion in Rajasthan during 2006 to 2016. The result revealed that price fluctuation are almost following a uniform trend by reaching peak level in September as majority of districts witnessed peak prices of onion in the month of September only. Price trend noticed from the study has shown erratic behavior, peaking in a particular month and the year. As stated earlier, price shooting occurred in the month of September and this particular month created new high average price of the that particular year.

Mulla *et al.* (2020) analysed the behaviour of onion prices in Kurnool market of Andhra Pradesh and made forecasting the prices for the future. Based on secondary


data from January 2003 to December 2017, it was found that annual increase in prices of onion in Kurnool market was observed to be Rs. 6.22 per quintal per annum. The highest seasonal index was observed in the month of August and the lowest seasonal index was recorded in May. Price cycles were not identified in onion prices.

MATERIALS
AND
METHODS



CHAPTER III

MATERIALS AND METHODS



Agriculture is a major sector of the economy of our country. In a country like India, it become even more important as it provides employment and livelihood to a larger part of the population. Thus, the development of agricultural sector directly affects the development of our country.

Scientific study of any problem requires a systematic investigation using appropriate method and procedures in order to arrive at reliable, unbiased and practical conclusion. This chapter deals with the methodology adopted for achieving the objectives of the study. Characteristics, selection of the study area, database and analytical methods are discussed in this chapter under the following heads.

3.1 Selection of the study area

3.2 Sources and collection of data

3.3 Analytical tools and techniques employed

3.1 Selection of the study area

India also known as the Republic of India is a country in South Asia. It is the seventh largest country by area and with more than 1.3 billion people, it is the second most populous country as well as the most populous democracy in the world. India lies to the North of the equator between 8°4' and 37°06' North latitude and 68°07' and 97°25' East Longitude. India's coastline measures 7,517 km in length. It has achieved all-round socio-economic progress during the last 72 years of its independence. India has become self-sufficient in agricultural production and is now the tenth industrialized country in the world and the sixth nation to have gone into outer space to conquer nature for the benefit of the people. India has the largest area under cultivation of onion in the world followed by China. In terms of production, India is second after China.

Based on annual average production in recent decade, major seven states, *viz.*, Maharashtra, Madhya Pradesh, Karnataka, Gujarat, Bihar, Rajasthan and Andhra Pradesh were selected for this study purpose (Fig. 3.1).

In order to select the markets, one major market from each selected major states was chosen to study the price behaviour. Major nine markets, *viz.* Ahmedabad, Bhopal, Bengaluru, Hyderabad, Jaipur, Mumbai, Patna (*i.e.* consumption markets),

Lasalgaon and Mahuva (*i.e.* production markets) were selected for this study purpose; representing both, consumption and major producing locations markets.

3.2 Sources and collection of data

The study had used the secondary data to measure growth and instability in area, production and productivity, price variability and price trends.

The analysis of growth and instability in area, production and productivity was carried out from the year 1990-91 to 2019-20, which in turn, splitted into four periods *viz.*, Period- I (1990-91 to 1999-2000), Period- II (2000-01 to 2009-10) and Period-III (2010-11 to 2019-20) and overall Period-IV (1990-91 to 2019-20).

As per the availability of data the price trend and variability analysis was carried out from the year 2001-02 to 2019-20.

The required data were collected from National Horticulture Board, Directorate of Economics and Statistics, Government of India, Director of Horticulture, respective states and Directorate General of Commercial Intelligence and Statistics, Government of India, and other public sources.

3.3 Analytical tools and techniques employed

As per the objectives of the study, the following different statistical techniques has been applied.

3.3.1 Growth rate analysis

Growth rate can be defined as the rate of change per unit time. It is used to measure the past performance of the economic variables in question and describe the trends in those variables over time. The normal statistical procedure to obtain a measure of growth dynamics of crops over a period is to postulate a hypothetical function which would adequately describe the series of economic variables over time and estimate their parameters. Growth rate is generally expressed in two forms, *viz.*, linear and compound. The linear form is obtained by fitting a straight line to the yearly data and estimating the parameters. The compound growth rate is obtained by fitting a straight line to the logarithms of the data and estimating the slope of the line (Acharya *et al.*, 2012).

Compound growth rate

The compound growth rates (CGRs) of onion was calculated by using the exponential function of the following specification:

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

Where,

- Y_t = Dependent variable (area, production and productivity and price of onion crop in the year 't'),
- t = Time variable in years taking the value of 1, 2, 3,..., n,
- a = Intercept;
- b = Regression coefficient (1+r),
- r = Compound growth rate,
- u_t = Error term

For the purpose of estimation, the equation has been expressed in logarithmic form.

$$\mathbf{Log Y_t = Log a + t log b + log e} \quad (2)$$

The value of log b in equation (2) was computed using the formula,

$$\mathbf{Log b} = \frac{(\sum t \mathbf{Log Y} - (\sum t \cdot \sum \mathbf{Log Y} / N))}{\sum t^2 - \left(\frac{\sum t^2}{N}\right)} \quad (3)$$

Where,

N = Number of years.

Subsequently, the compound growth rate (%) was computed using the formulation,

$$\mathbf{Compound growth rate (r) = [(Antilog of log b) - 1] * 100} \quad (4)$$

Student 't' test was used to determine the significance of the growth rates obtained for which the following formulation was employed,

$$\mathbf{t = Log b / SE (Log b)} \quad (5)$$

$$\mathbf{SE} = \sqrt{\frac{\sum(Y-\bar{Y})^2 - \mathbf{Log b} * (\sum(Y*t) - \sum(Y)*\bar{t})}{(N-2) \sum(t-\bar{t})^2}} \quad (6)$$

The calculated 't' values, from equation (5), was compared with the table 't' values and the significance were tested at 1, 5 and 10 per cent probability levels.

3.3.2 Instability analysis

Instability is the one of the important decision parameter in development dynamics, more so in the context of agriculture production. Wide fluctuation in crop output, not only affects prices and bring about sharp fluctuations in them, but also result in wide variation in the disposable income of the farmer. The magnitude of fluctuation depends on the nature of product technology, its sensitivity to weather, economic, environment, availability of material input and many other factors. High growth in

production accompanied by low level of instability for any crop is desired for sustainable development of agriculture

Cuddy-Della index is most commonly used measures of instability of time series data and is universally acceptable. The original formulation of the index is given as follows:

$$\text{Instability index (Ix)} = \text{CV} \sqrt{(1 - \bar{R}^2)} \quad (7)$$

$$\text{CV (\%)} = S / \bar{X} * 100 \quad (8)$$

Where,

- Ix = Instability index,
- CV = Coefficient of variation,
- \bar{R}^2 = Adjusted coefficient of multiple determination,
- \bar{X} = Mean value,
- S = Standard deviation.

3.3.3 Decomposition analysis

The relative contribution of area and yield to the total output change (growth) of an individual crop was first estimated by Minhas and Vaidyanathan (1965) using a component analysis model. Sharma (1977) redeveloped the model into the decomposition of output growth of an individual crop. The relative contribution of area, productivity and their interaction effect to the total output change in the study crops could be worked out by two methods viz. (i) Simple decomposition model and (ii) Modified decomposition model.

Following Singh & Sissodia (1989); Bastine and Palanisami (1994); Singh & Ranjan (1998) and Siju and Kombairaju (2001), the Simple Decomposition Model has been worked out as:

$$\text{Let } P = A * Y$$

Where,

- ‘P’ is the production of onion,
- ‘A’ is the area under onion, and
- ‘Y’ is the yield of onion.

$$\text{Then, } P_o = A_o * Y_o \text{ and } P_n = A_n * Y_n$$

Accordingly, the simple decomposition model has been specified as:

$$P_n - P_o = (Y_n - Y_o)A_o + (A_n - A_o)Y_o + (Y_n - Y_o)(A_n - A_o) \quad (9)$$

$$\Delta P = (\Delta Y)A_o + (\Delta A)Y_o + (\Delta Y)(\Delta A)$$

(Yield effect) (Area effect) (Interaction effect)

Where:

‘n’ refers to current year and ‘0’ refers to base year of the study period.

Thereby, the percentage contribution of each effect will be estimated by:

$$P = \frac{A_o \Delta Y}{\Delta P} \times 100 + \frac{Y_o \Delta A}{\Delta P} \times 100 + \frac{\Delta Y \Delta A}{\Delta P} \times 100 \quad (10)$$

The triennium average of the start and end of the study period has been taken as base year and current year, respectively in the simple decomposition model (Equation 9). However, this method has a flaw as it considers only the discrete data and does not take all the years into consideration. Thereby, another method for decomposition analysis suggested by Palanisamiet *al.* (2002) and Laitonjamet *al.* (2018) was used in the present study.

The method to be used to rectify the flaw in the model can be called as the Modified Decomposition analysis as given below:

$$P_t - P_o = A_o(Y_t - Y_o) + Y_o(A_t - A_o) + (A_t - A_o)(Y_t - Y_o) \quad (11)$$

$$\Delta P_t = A_o \Delta Y_t + Y_o \Delta A_t + \Delta A_t * \Delta Y_t \quad (12)$$

(Yield effect) (Area effect) (Interaction effect)

Where, P, A and Y represents production, area and yield; ‘0’ and ‘t’ represents time periods such that ‘t’ > ‘0’ by an accounting period, which is usually a single year. The result obtained from this method will be more reliable as the analysis is done for the continuous data without any omission as the case of simple decomposition model.

This way, the percentage contribution of the effects to the change in total production of an individual crop was arrived by:

$$\Delta P (\%) = \frac{A_o \Delta Y_t}{\Delta P_t} \times 100 + \frac{Y_o \Delta A_t}{\Delta P_t} \times 100 + \frac{\Delta A_t * \Delta Y_t}{\Delta P_t} \times 100 \quad (13)$$

Change in production (%) = Yield effect + Area effect + Interaction effect.

In the present study, the modified decomposition model was used.

3.3.4 Trend in yearly prices

Initially, a trend diagram of yearly index numbers of major state wise wholesale prices of onion were drawn for the period from 2001-02 to 2019-20. The trend in annual prices has been analyzed with the help of following models.

3.3.4.1 Linear and quadratic models

Following two models were employed.

$$P_t = \beta_0 + \beta_1 T + U \quad (14)$$

$$P_t = \beta_0 + \beta_1 T + \beta_2 T^2 + U \quad (15)$$

Where,

P_t = Yearly index numbers of wholesale prices,

T = Time (1,2,3,..., t),

U = Disturbance term with usual assumptions, and, $\beta_0, \beta_1, \beta_2$ are parameters to be estimated.

Adjusted coefficients of multiple determination was worked out using the following formula for above models for onion price under study.

$$\bar{R}^2 = 1 - \frac{(1-R^2)(T-1)}{T-K-1}$$

Where,

\bar{R}^2 = Adjusted coefficients of multiple determination,

T = Number of observations,

K = Number of independent variables.

3.3.4.2 Compound growth rate

It was calculated using the formula as given in equation (1) of this section.

3.3.4.3 Seasonal variation in prices

A trend diagram of monthly wholesale prices of onion was drawn for the study period to see the fluctuations. This was confirmed by calculating range and coefficients of variation also. The seasonal variation for the entire period was calculated using the following empirical approaches.

3.3.4.3.1 Computation of seasonal variation

The seasonal variations are short term fluctuations that occur within a year, which could be isolated from the original composite series and to study them separately, the decomposition of the time series data was done by assuming a multiplicative model of the following form.

$$P = T \times C \times S \times I \quad (16)$$

Where,

P = Monthly Price,

T = Trend values,

- C = Cyclical variations,
- S = Seasonal variation,
- I = Irregular variations.

This multiplicative model assumes the interaction among the different components.

Taking the whole period together seasonal indices were worked out. To remove the effect of trend and cyclical variations, twelve months moving averages were calculated and centered. A further ratio of original price indices to centered moving average was calculated to obtain the combined effect of S x I. In order to remove the effect of I, these ratios were averaged and adjusted seasonal indices has been obtained.

3.3.4.3.2 Coefficient of average seasonal variations

Highest and lowest values were compared by plotting the seasonal indices on a graph. Then the coefficients of the average seasonal price index variation were worked out using following formula.

$$\text{Coefficient of av. seasonal price index variation} = \frac{\text{Highest index} - \text{Lowest index}}{(\text{Highest Index} + \text{Lowest index})/2} \times 100$$

3.3.4.4 Irregular fluctuations in Prices

The irregular component in an annual series of process does not have a definite pattern. It was estimated by following formula.

$$\text{Index of irregular variation} = \frac{\text{Ratio to moving average in a month}}{\text{Adjusted seasonal index in that month}} * 100$$

3.3.5. Inter-relationship between prices of different states

Correlations co-efficient between yearly prices of crop under study would be worked out to determine inter-relationship between them.

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}} \quad (17)$$

Where,

- r = Co-efficient of correlation,
- x and y = Two variables under study,
- n = Total number of observations.

3.3.6 Cointegration analysis

The cointegration depicts long-term relationship between the variables. It means even if two or more series are non-stationary, they are said to be co-integrated, if there

exists a stationary linear combination of them. Cointegration tests starts with the premise that for a long-run equilibrium relationship to exist between two variables, it is necessary that they should have the same inter temporal characteristics. Thus, the first step involves testing for stationarity for variables.

It is very important to test whether the time series is stationary or not because if a time series is not-stationary then one can study its behavior only for the time period under consideration, it is not possible to generalize it to other periods and therefore one can't able to forecast such a time series data. In econometrics, a time series that has a unit root is known as a random walk which is an example of a non-stationary time series. So in order to test stationary or unit root, the most widely used, famous test known as Augmented Dickey-Fuller (ADF) test was carried as given below.

$$\Delta Y_{it} = \alpha + \beta_i T + \delta_i Y_{it-1} + b_i \sum_{i=1}^p \Delta Y_{it-1} + e_t \quad (18)$$

Where,

- Y_{it} = Price of a commodity in a given market 'i' at a time 't',
- ΔY_{it-1} = $Y_{t-1} - Y_{t-2}$ (t-i – lagged prices and Δ – differenced series),
- T = Time trend,
- α = Drift parameter,
- β_i, δ_i and b_i = Coefficients, and
- e_t = Pure white noise error-term.

p is the optimal lag value which is selected on the basis of Schwartz information criterion (SIC). The null hypothesis is that the coefficient of Y_{t-1} is zero. The alternative hypothesis is: $\delta < 0$.

If the original series under study are found to be level stationary, then the analysis of cointegration could be carried out using Engle and Granger (1987), which is basic relationship that is commonly used to test for the existence of integration between two markets. This test was undertaken by running the ordinary regression of the following form:

$$Y_t = \beta_0 + \beta_1 X_t + e_t \quad (19)$$

Where,

- Y_t = Price of a commodity in the dependent market at time 't',
- X_t = Price of a commodity in the independent market at time 't',
- β_0 = Constant term,
- β_1 = Long-run elasticity of price transmission,
- e_t = Error-term.

If the series under study are found to be non-stationary, the first differenced of the series are tested for stationarity. Then the analysis of cointegration could be carried out using Johansen's cointegration technique.

3.3.6.1 Estimating error correction model for short-run disequilibrium

Even after confirming the existence of a long-term equilibrium in the market pairs (*i.e.* the series are found to be co-integrated), there is a possibility of short-run disequilibrium, due to which, the price change in one market may not get transmitted immediately to the other market and takes some time for such transmission. The short-run relationship along with the speed of adjustment towards equilibrium could be found out using error correction model. For example, discontinuities in trade correspond to slow speed of short-run adjustment to the long-run equilibrium were estimated by using the Error Correction Model (ECM), which is given below in the following specification:

$$\Delta Y_{t-i} = \alpha_0 + \alpha_1 \Delta X_{t-i} + \alpha_2 e_{t-1} + \varepsilon_t \quad (20)$$

Where,

- $\Delta Y_{t-i} = Y_{t-1} - Y_{t-2}$,
- α_0 = Constant term,
- α_1, α_2 = Speed of price transmission (expected to be negative in sign),
- $\Delta X_{t-i} = X_{t-1} - X_{t-2}$,
- e_{t-1} = Lagged error-term of the co-integration model, and
- ε_t = Pure white noise error-term.

Negative and statistically significant values of α_2 depict the speed of adjustment in restoring equilibrium after disequilibria. The presence of e_{t-1} reflects the presumption that dependent variable does not adjust instantaneously to its long-run determinants. Therefore, in the short-run an adjustment is made to correct any disequilibrium in the

long-run. Hence, the error correction model shows how system converges to the long-run equilibrium.

3.3.6.2 Granger causality test for long-run causal price relationship

The standard Granger causality test (Granger, 1988) examines how one variable explains the latest value of another variable. It says that if a variable Y is Granger caused by another variable X, then the variable X can be used in predicting the values of Y variable and vice-versa. The null hypothesis (H_0) tested in this case was that the X variable did not Granger cause variable Y and variable Y did not Granger cause variable X. If a variable Granger causes another variable, it means that the lagged value of one variable helps in forecasting the value of another variable and vice-versa.

$$\Delta Y_{it} = \beta_0 + \beta_1 Y_{i(t-1)} + \beta_2 Y_{i(t-2)} + \sum_{k=1}^m \delta_k \Delta y_{i(t-k)} + \sum_{h=1}^n \alpha_h \Delta y_{j(t-h)} + \varepsilon_{it} \quad (21)$$

Where,

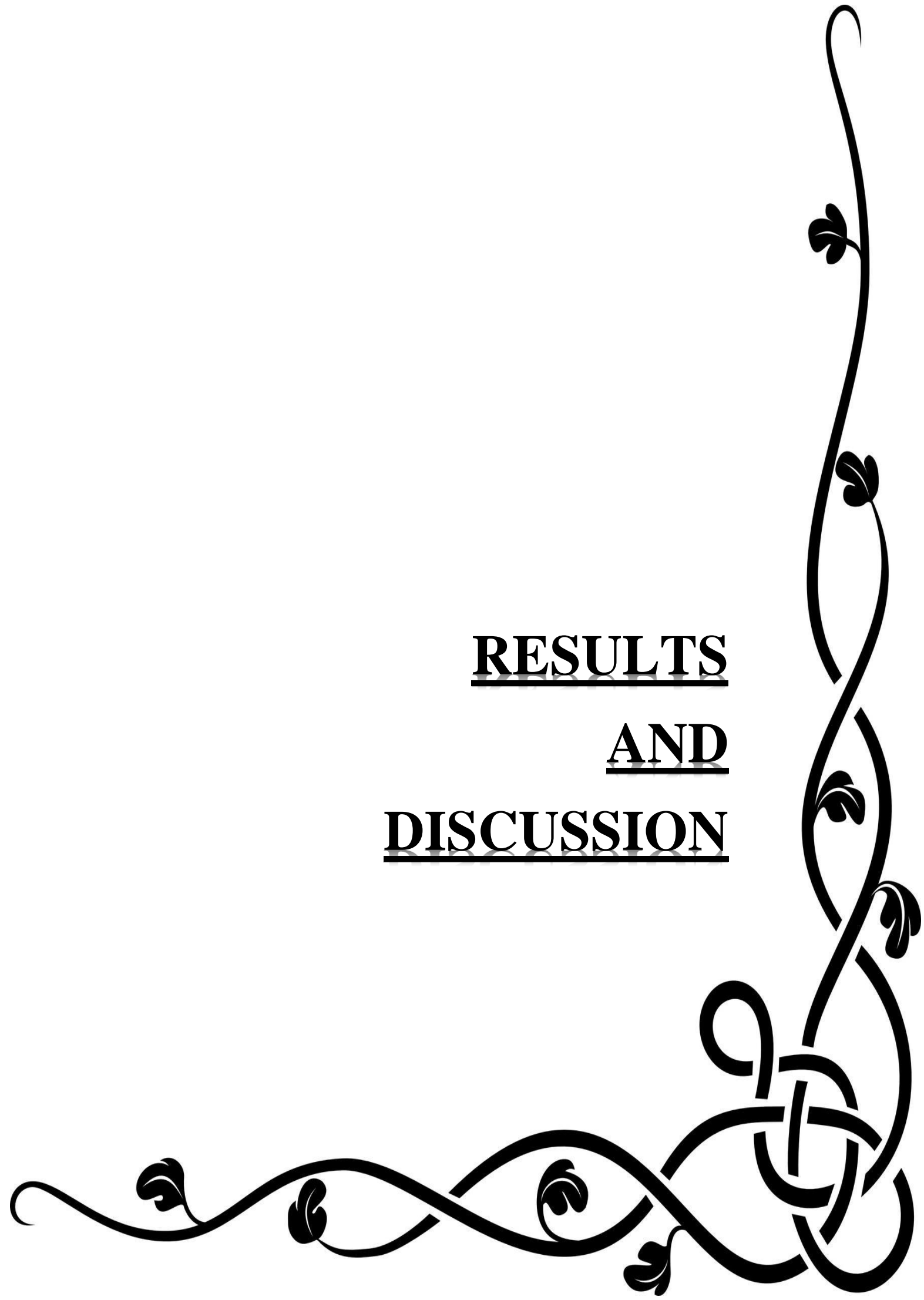
Y_{it} = Market 'i' at time 't',

Y_{jt} = Market 'j' at time 't', and

m and n = Number of lags determined by SIC.

The null hypothesis is that X does not Granger- cause Y. Rejection of the null hypothesis that $\alpha_h = 0$, where $h = 1, 2, 3, \dots, n$ indicates that prices in market "j" Granger-cause prices in market "i". If prices in market "i" also Granger-cause prices in market "j", then prices are determined by a simultaneous feed-back mechanism (SFM). This is the phenomenon of bi-directional causality. If the Granger causality runs one way, it is called unidirectional Granger-causality and the market which Granger-causes the other is lagged the exogenous market.

RESULTS
AND
DISCUSSION



CHAPTER IV

RESULTS AND DISCUSSION

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The results derived from the analysis of the data pertaining to various objectives of the study are presented and critically discussed in this chapter. The chapter is presented under the following broad heads:

- 4.1 Temporal change in area, production and productivity of onion crop in major states of India
- 4.2 Instability in area, production and productivity of onion in major states of India
- 4.3 Sources of contribution in onion production
- 4.4 Trends in onion prices
- 4.5 Seasonal variation in onion prices
- 4.6 Irregular fluctuations in onion prices and inter-relationship between the prices
- 4.7 Co-integration among onion prices

4.1 Temporal changes in area, production and productivity of onion in major states of India

To comprehend the trends in area, production and productivity of onion, state wise growth rates were computed for the three periods as discussed previously. The exponential growth functions were employed to find out growth rates. The results of estimated growth rates of onion area, production and productivity are presented in Table 4.1 for the Period-I (1990-91 to 1999-00), Period-II (2000-01 to 2009-10), Period III (2010-11 to 2019-20) and overall period (1990-91 to 2019-20), separately.

The ranges of growth rates given by Das *et al.* (2016) are as follows:

Low growth rate = between 0 to 5

Medium growth rate = greater than 5 and up to 10

High growth rate = greater than 10

The growth rate results and its discussion has been proceeded state wise for each period. Besides, at all India level the onion area, production and productivity discussed thoroughly and results are presented in Table 4.1.

During 1990s, Maharashtra occupied the highest mean area among all the states in India about 92.11 thousand ha which steadily increased to 454.06 thousand h

in 2010s. Whereas, Karnataka was on second position, occupied mean area of about 78.6 thousand ha in 1990s, increased considerably to 182.2 thousand ha in 2010s. Besides, Madhya Pradesh covered 20.75 thousand ha in Period-I, which was also increased to 123.69 thousand ha in Period-III. The mean area under onion in Gujarat was 22.86 thousand ha in 1990s, increased to 53.01 thousand in 2010s.

Maharashtra achieved the highest mean production about 1109.1 thousand tonnes, followed by Gujarat and Karnataka in Period-I, which showed increasing trend in subsequent periods. Whereas, Gujarat achieved the highest mean productivity about 25.40 t/ha in 1990s, which by and large remains stable in all later periods.

At all India level, the mean area, production and productivity of onion recorded 385.3 thousand ha, 4045.29 thousand tonnes and 10.52 t/ha, respectively in 1990s, which increased steadily in all later periods.

It can be revealed from the table that significantly the highest increase in area under onion was reported in Karnataka (9.78%) in Period-I. Whereas, Maharashtra, Gujarat, Rajasthan and Bihar recorded low but significant growth rate of area about 4.63, 4.56, 4.24 and 3.82 per cent per annum, respectively. While, at all India level in Period-I, the growth rate in onion area was increased significantly at the rate of 5.20 per cent per annum. Similar results were noted by Kumawat and Meena (2005) for spices crop, in Rajasthan during 1987-87 to 2000-01.

In case of onion production in Period-I, Andhra Pradesh registered significantly the highest growth rate of 12.68 per cent per annum followed by Madhya Pradesh (8.07%) and Gujarat (5.52%). Besides, Bihar, Maharashtra and Rajasthan shown significantly low growth rate of 4.05, 3.36 and 2.93 per cent per annum in Period-I, respectively. Whereas, Karnataka recorded negative growth at the rate of -1.00 per cent per annum in Period-I. At all India level, the onion production was annually increased significantly at the rate of 4.24 per cent, during 1990-91 to 1999-00.

During Period-I, the growth rate of productivity of onion was recorded the highest in Andhra Pradesh about 6.28 per cent per annum. Besides, Madhya Pradesh witnessed low, but significant growth rate in onion yield by the rate of 1.47. While, Gujarat and Bihar witnessed non-significant growth rate in onion yield by the rate of 0.92 and 0.22 per cent per annum, respectively. Whereas, in Karnataka, Rajasthan and Maharashtra onion yield was decreased annually at the rate of -9.81, -1.26 and -1.21

per cent in Period-I, respectively. At all India level, the onion yield was decreased at the rate of -0.91 per cent per annum in Period-I.

In Period-II, significantly the highest increase in area under onion was reported in Gujarat (19.89%). Besides, Bihar (12.29%), Madhya Pradesh (11.85%) witnessed high growth, Maharashtra (9.61%) and Rajasthan (6.24%) shown the medium growth in area of onion in Period-II. While, Karnataka (4.31%) and Andhra Pradesh (3.40%) shown the low, but significant positive growth in area of onion in Period-II. At all India level in Period-II, the growth rate in area was increased significantly at the rate of 8.29 per cent per annum.

In case of onion production in Period-II, Gujarat registered significantly the highest growth rate of 20.96 per cent per annum, followed by Bihar (19.00%), Karnataka (18.02%), Rajasthan (15.12%), Madhya Pradesh (14.25%) and Maharashtra (11.90%). Besides, Andhra Pradesh shown low growth rate of 3.83 per cent per annum in Period-II. At all India level, onion production was annually increased at a significant rate of 13.66 per cent. In the study of performance of onion in Bihar, Meena *et al.* (2016) revealed similar results for onion area and production, stating that prices of onion during 2007 to 2010 touched high about Rs. 6000 per quintal in major markets of India, lead to high increase in area and production in Bihar, The average area under onion in Bihar was in the range of 15 to 20 thousand ha till 2007-08, increased to 51.6 thousand ha in 2008-09. But the price factor alone could not cause this much of rise in area; there may be some mistake in data recording, as it seen different in various sources.

During Period II, the growth rate of productivity of onion was reported the highest in Karnataka at the rate of 13.14 per cent per annum, followed by Rajasthan (8.36%) and Bihar (5.98%). Besides, Madhya Pradesh (2.15%) and Maharashtra (2.08%) shown low but significant positive growth in area of onion in Period-II. While, Gujarat (0.89%) and Andhra Pradesh (0.41%) witnessed positive, but non-significant growth in productivity in Period-II. At all India level, the onion yield was increased at the rate of 4.98 per cent per annum in Period-II.

In Period-III, Madhya Pradesh obtained significantly the highest growth rate of onion area about 10.06 per cent per annum, followed by Maharashtra (5.12%), Karnataka (1.22%) and Bihar (0.70%). Whereas, Gujarat, Rajasthan and Andhra

Pradesh registered negative growth in area of onion in Period-III. The negative growth rate of area in Gujarat and Rajasthan during 2010-11 to 2019-20 is might be due to the poor monsoon in the year 2012-13, 2014-15, 2015-16 and 2018-19, as onion required more irrigation, which was shortfall in main onion growing regions like Saurashtra and West Rajasthan. At all India level, growth rate in area was increased at the rate of 2.98 per cent per annum during Period-III. Sajesh *et al.* (2014) noted similar results for onion area in Maharashtra during 2010s.

In Period-III, significantly the highest increase in onion production was reported in Madhya Pradesh (12.70%) followed by Rajasthan (10.71%), Maharashtra (8.41%), Karnataka (2.02%) and Bihar (1.58%). While, Andhra Pradesh (0.67%) shown the low, but significant positive growth in area of onion in Period-III. Whereas, Gujarat registered negative growth in production of onion in period-III. At all India level, onion production increased at the rate of 5.56 per cent per annum.

During Period-III, Rajasthan shown significantly the highest increase in onion yield by 11.06 per cent per annum. While, Andhra Pradesh, Maharashtra, Madhya Pradesh, Bihar, Karnataka and Gujarat recorded very low growth rate of 3.67, 3.12, 2.40, 0.87, 0.80 and 0.19 per cent per annum in Period-III, respectively. At all India level also shown low, but significant positive growth in onion yield (2.51%) during Period-III.

In overall period from 1990-91 to 2019-20, Madhya Pradesh recorded the highest significant increase in onion area at the rate of 9.23 per cent per annum followed by Maharashtra (8.04%), Rajasthan (6.31%) and Bihar (5.84%). While, Gujarat (4.82%), Karnataka (4.52%) and Andhra Pradesh (3.55%) shown the low, but significant positive growth in area of onion during overall period. All India level shown significantly positive growth in onion area (5.89%) during overall period.

In case of onion production in overall period, Madhya Pradesh registered significantly the highest growth rate of 12.69 per cent per annum followed by Bihar (10.69%), Rajasthan (9.80%), Maharashtra (9.16%), Karnataka (8.12%) and Andhra Pradesh (5.64%). While, Gujarat (4.87%) shown the low, but significant positive growth in production of onion during overall period. At all India level, onion production increased significantly at the rate of 8.33 per cent per annum during overall period.

Thus, during last three decades, Maharashtra contributed considerably for increasing onion production in India.

Table 4.1: Period wise growth rates of onion area, production and productivity of major states in India

Periods	State/ Item	Andhra Pradesh			Bihar		
		A	P	Y	A	P	Y
Period-I (1990-91 to 1999-00)	Mean	23.84	332.74	13.75	17.49	153.95	8.79
	CGR%	6.03***	12.68***	6.28***	3.82***	4.05***	0.22
	SE	0.12	0.23	0.24	0.04	0.14	0.13
Period-II (2000-01 to 2009-10)	Mean	33.4	593.2	17.7	37.6	651.6	15.4
	CGR%	3.40***	3.83***	0.41	12.29***	19.00***	5.98***
	SE	0.081	0.12	0.070	0.34	0.60	0.26
Period-III (2010-11 to 2019-20)	Mean	49.86	953.67	19.24	54.50	1233.95	22.62
	CGR%	-2.90**	0.67	3.67***	0.70	1.58*	0.87
	SE	0.22	0.26	0.088	0.019	0.047	0.26
Overall Period (1990-91 to 2019-20)	Mean	35.70	626.52	16.90	36.53	679.84	15.60
	CGR%	3.55***	5.64***	2.02**	5.84***	10.69***	4.59***
	SE	0.19	0.25	0.17	0.34	0.58	0.26

Periods	State/ Item	Gujarat			Karnataka		
		A	P	Y	A	P	Y
Period-I (1990-91 to 1999-00)	Mean	22.86	589.06	25.40	78.6	570.96	7.79
	CGR%	4.56***	5.52***	0.92	9.78***	-1.00	-9.82***
	SE	0.31	0.35	0.09	0.09	0.37	0.30
Period-II (2000-01 to 2009-10)	Mean	46.7	1299.4	27.1	138.9	1127.3	7.8
	CGR%	19.89***	20.96***	0.89	4.31***	18.02***	13.14***
	SE	0.54	0.65	0.12	0.13	0.41	0.38
Period-III (2010-11 to 2019-20)	Mean	53.01	1335.4	25.15	182.2	2718.9	14.90
	CGR%	-0.40	-0.21	0.19	1.22*	2.02*	0.80
	SE	0.26	0.27	0.02	0.14	0.16	0.079
Overall Period (1990-91 to 2019-20)	Mean	40.84	1074.6	25.87	133.2	1472.3	10.15
	CGR%	4.82***	4.87***	0.05	4.52***	8.12***	3.45***
	SE	0.45	0.51	0.094	0.17	0.41	0.44

Table 4.1 Cont....

Periods	State/ Item	Madhya Pradesh			Maharashtra		
		A	P	Y	A	P	Y
Period-I (1990-91 to 1999-00)	Mean	20.75	255.38	12.20	92.11	1109.1	12.09
	CGR%	6.50***	8.07***	1.47	4.63***	3.36***	-1.21
	SE	0.04	0.07	0.06	0.08	0.15	0.13
Period-II (2000-01 to 2009-10)	Mean	35.8	549.0	15.0	167.7	2278.5	13.4
	CGR%	11.85***	14.25***	2.15**	9.61***	11.90***	2.08**
	SE	0.07	0.10	0.05	0.13	0.16	0.094
Period-III (2010-11 to 2019-20)	Mean	123.69	2956.2	23.45	454.06	6727.6	14.84
	CGR%	10.06***	12.70***	2.40**	5.12***	8.41***	3.12***
	SE	0.14	0.22	0.08	0.18	0.12	0.16
Overall Period (1990-91 to 2019-20)	Mean	60.06	1253.5	16.89	237.94	3371.76	13.43
	CGR%	9.23***	12.69***	3.16***	8.04***	9.16***	1.03
	SE	0.21	0.28	0.09	0.61	0.20	0.13

Periods	Item	Rajasthan			All India		
		A	P	Y	A	P	Y
Period-I (1990-91 to 1999-00)	Mean	19.53	134.97	6.88	385.3	4045.29	10.52
	CGR%	4.24***	2.93**	-1.26	5.20***	4.24***	-0.91
	SE	0.12	0.25	0.16	0.04	0.09	0.06
Period-II (2000-01 to 2009-10)	Mean	36.1	339.7	9.0	602.0	7867.4	12.6
	CGR%	6.24***	15.12***	8.36***	8.29***	13.66***	4.98***
	SE	0.13	0.22	0.16	0.07	0.11	0.06
Period-III (2010-11 to 2019-20)	Mean	73.17	911.15	13.32	1214.2	20330.1	16.66
	CGR%	-0.31	10.71***	11.06***	2.98***	5.56***	2.51**
	SE	0.30	0.24	0.42	0.05	0.04	0.03
Overall Period (1990-91 to 2019-20)	Mean	42.93	461.92	9.74	733.85	10747.6	13.27
	CGR%	6.31***	9.80***	3.28***	5.89***	8.33***	2.30**
	SE	0.22	0.26	0.30	0.11	0.17	0.09

Note: 1. *, ** and *** indicate significance at 10%, 5% and 1% levels, respectively.

2. CGR = Compound Growth Rate and SE = Standard Error

3. A = Area (000'ha), P = Production (000' tonnes) and Y = Yield (t/ha)

In case of onion productivity during overall period, Bihar registered significantly the highest growth rate of 4.59 per cent per annum followed by Karnataka (3.45%), Rajasthan (3.28%), Madhya Pradesh (3.16%), Andhra Pradesh (2.02%) and Maharashtra (1.03%). While, Gujarat (0.05%) shown the positive, but non-significant

growth in productivity of onion during overall period. At all India level, onion productivity increased significantly at the rate of 2.30 per cent per annum during overall period. Thus, during last three decades, Bihar, Karnataka, Rajasthan and Maharashtra contributed considerably for increasing onion productivity in India. However, the initial productivity in these states were very low. Besides, the Gujarat registered the highest mean productivity of onion above 25 t/ha in all periods. Andhra Pradesh has also obtained good productivity, but still it is far behind the Gujarat.

Meena *et al.* (2016) in their study revealed that during the second decade performance of the onion in area and production was much better than first. Finally during the whole study period best performance of onion was found in production followed by area and productivity. Hemant *et al.* (2017) also reported similar results at state as well as national level for onion in India. Besides, Dinesha and Sriramappa (2015) in their study revealed that area and production under fruits registered significant positive growth rates at 5.80 per cent and 6.70 per cent, respectively during study period. Whereas, the growth of productivity was 0.80 per cent, which was positive but non-significant.

Thus, in last three decades India has achieved remarkable growth in area, production and productivity of onion. The growth in area and production was mainly contributed by Madhya Pradesh, Maharashtra and Rajasthan. Whereas, growth in productivity was largely contributed by Bihar, Karnataka, Rajasthan and Madhya Pradesh. Besides, high yield was sustained by Gujarat in last 30 years, overcoming the problems of high volatility in prices and shortfall of irrigations.

4.2 Instability in area, production and yield of onion in major states of India

The agricultural instability can be measured by different methods, such as the coefficient of variation (CV), dispersion, Cuddy Della Valle index (CDV), *etc.* The present study applies the Cuddy Della Valle index and coefficient of variation for measuring the instability. This index first de-trends the given series and gives a clear direction about instability. The use of coefficient of variation as a measure to show the instability in any time series data has some limitation. If the time series data exhibit any trend, the variation measured by CV can be over-estimated, *i.e.* the region which has growing production are at constant rate will score high in instability of production if CV is applied for measuring instability. As against that, Cuddy- Della Valle index

attempts detrended the CV by using adjusted coefficient of determination (\bar{R}^2). Thus, it is better measure to capture instability in farm production and vice-versa. Here C. V. adjusts \bar{R}^2 to de-trend the production series, because it is statistically sound. The present study divides the CDV values into three categories, which represent the different range of instability (Sihmar, 2014). The ranges of instability are as follows:

Low instability = between 0 to 15

Medium instability = between 15 to 30

High instability = greater than 30

Non-significant value of Cuddy Della Valle index was calculated on the basis of compound growth rate. The country where compound growth rate is non-significant at all probability level, the value of Cuddy Della Valle index is also non-significant and in such case, co-efficient of variation is used instead of Cuddy Della Valle index, which implies that data exhibited no trend.

State wise instability in area, production and productivity of onion crop were measured for four periods, viz., Period-I (1990-91 to 1999-00), Period-II (2000-01 to 2009-10), Period-III (2010-11 to 2019-20) and overall period (1990-91 to 2019-20) and results are presented in Table 4.2.

Among all the states, Gujarat (44.23%) showed the highest instability in onion area during Period-I. Besides, Andhra Pradesh (14.08%), Rajasthan (13.14%), Karnataka (9.96%), Maharashtra (7.39%), Madhya Pradesh (4.12%), Bihar (3.44%) and All India (4.51%) had shown low instability in Period-I, in case of onion area. This reveals that during 1990s, the area under onion remained by and large stable in all the states, except Gujarat. This is mainly, as onion area in Gujarat increase to about 52 thousand ha in 1998-99 following good monsoon and high price in previous year. But due to severe drought in 2000-01 the area under onion decrease drastically to 9.6 thousand ha lacking irrigations and production also dropped accordingly resulted in high instability.

In case of onion production, the states of Gujarat (50.79%) and Karnataka (42.15%) had shown high instability in Period-I. Besides, Rajasthan (25.78%) and Andhra Pradesh (20.23%) had shown medium instability in period-I. whereas, all other states under study and at all India level showed low instability in production in Period-I. Looking to the onion productivity, Karnataka state recorded high instability (41.67%)

during Period-I. Besides, Andhra Pradesh (25.08%) and Rajasthan (15.67%) had shown medium instability in period-I. whereas, remaining other states under study and at all India level showed low instability in production in Period-I. Similar results were also reported by Kumawar and Meena (2005) for spices crops in Rajasthan and at all India level during 1986-87 to 2000-01.

In Period-II, onion area in Gujarat (37.51%) showed the highest instability. Among all the states, only Bihar (28.41%) showed medium instability in onion area during Period-II. whereas, all other states under study and at all India level showed low instability in area in Period-II. In Period-II, onion production in Karnataka (52.02%), Bihar (43.65%) and Gujarat (43.17%) had shown high instability. Besides, Rajasthan (28.97%) had shown medium instability in period-II. Whereas, remaining other states under study and at all India level showed low instability in production in Period-II. While, in case of onion productivity, Karnataka recorded the highest instability (48.63%) in Period-II. Besides, Bihar (24.14%) and Rajasthan (21.01%) had shown medium instability in period-II. All other states and at all India level showed low instability in onion productivity in Period-II. Similar result for onion production growth and instability in Maharashtra was reported by Sajesh *et al.* (2014) stated that erratic weather, volatile market price and lack of storage and market infrastructure caused instability in production.

In Period-III, onion area in Rajasthan (36.43%) showed the highest instability. Besides, the states of Andhra Pradesh (27.19%) and Gujarat (23.78%) showed medium instability in onion area during Period-III. Whereas, all other states under study and at all India level showed low instability in area in Period-III. In case of onion production, Andhra Pradesh (27.97%), Gujarat (24.37%) and Rajasthan (23.87%) experienced medium instability during Period-III. While, all other states and at all India level recorded low instability in onion production in Period-III. This indicates that during 2010s the onion production has been reported medium variations in all the states under study.

In overall period from 1990-91 to 2019-20, Rajasthan (39.27%), Gujarat (37.56%) and Madhya Pradesh (37.05%) showed high instability in onion area and it was medium at all India level. Whereas, Karnataka (13.87%) showed low instability in onion area during last three decades. Whereas, all other states under study showed

medium instability in area during overall period including at all India level. In overall study period, Bihar (29.95%), at all India level (23.86%) and Andhra Pradesh (25.92%) had recorded having medium instability in production. Whereas, all other states under study showed high instability in production during overall period. In overall study period, Rajasthan (28.53%) and Bihar (17.16%) had recorded having medium instability in productivity. Whereas, all other states and at all India level under study showed low instability in productivity during overall period, except Karnataka (40.93%). Bihar and Rajasthan had recorded the medium instability in onion area, production and productivity in overall period.

Looking to the state-wise scenario, Andhra Pradesh state recorded the low instability in case of onion area, production and productivity during Period-II. Bihar state recorded the low instability in case of onion area, production and productivity during Period-I & Period-III. Gujarat state recorded the high instability in case of onion area and production during Period-I & Period-III.

Karnataka state recorded the high instability in case of onion production and productivity during Period-I and Period-II. Hence, our null hypothesis is rejected and concluded that there was variation of onion production in all the states.

Madhya Pradesh indicated the lower instability in case of area and production and productivity in all periods under study. Moreover, in overall period, Maharashtra state recorded the medium instability in case of onion area and production, and low in case of productivity, except period-II. Sajesh *et al.* (2014) in their study on analysis of Maharashtra's onion growth and instability recorded the similar results. They also, revealed that major reason for the instability of onion production was due to area instability and partly due to yields instability. Besides, Ankush and Utkarsh (2018) in their study of instability in area, production and yield of onion in Maharashtra, reported the similar results.

Rajasthan state recorded the high instability in case of onion area and production during all over period. At all Indian level recorded the medium instability in case of onion area and production, and low instability in case of productivity during all three decades. Nalegaonkar *et al.* (2020) reported similar results for the period 1995-96 to 2018-19 for onion area, production and yield. They further stated that the highest instability was observed in production of onion followed by area and yield.

Table 4.2: Instability analysis of onion area, production and productivity

Sr. No.	Instability in sugarcane (APY)	Period-I (1990-91 to 1999-20)		Period-II (2000-01 to 2009-10)		Period-III (2010-11 to 2019-20)		Over All Period (1990-91 to 2019-20)	
		CV (%)	CDV (%)	CV (%)	CDV (%)	CV (%)	CDV (%)	CV (%)	CDV (%)
1	Andhra Pradesh								
	Area	23.14	14.08	12.60	7.82	27.67	27.19	38.96	26.05 [^]
	Production	37.76	20.23	15.31	11.26	26.37	27.97	48.97	25.92
	Productivity	27.97	25.08	6.60	6.88 [^]	13.48	8.23 [^]	21.03	14.47 [^]
2	Bihar								
	Area	11.61	3.44 [^]	45.11	28.41	2.82	1.94	149.58	22.08
	Production	18.52	14.31 [^]	62.56	43.65	6.44	4.46 [^]	74.32	29.95
	Productivity	12.56	13.28 [^]	31.49	24.14	5.011	4.60 [^]	41.08	17.16 [^]
3	Gujarat								
	Area	45.83	44.23	49.46	37.51	22.63	23.78	50.07	37.56
	Production	53.20	50.79	52.49	43.17	23.12	24.37	53.18	42.84
	Productivity	9.57	9.66 [^]	11.73	12.19 [^]	2.04	2.08 [^]	9.29	9.45 [^]
4	Karnataka								
	Area	29.19	9.96 [^]	17.58	12.85	13.43	13.68	36.79	13.87 [^]
	Production	40.72	42.15	75.11	52.02	16.36	15.97 [^]	73.08	38.23
	Productivity	52.22	41.67	65.14	48.63	8.06	8.16 [^]	49.43	40.93
5	Madhya Pradesh								
	Area	19.27	4.12 [^]	34.27	9.74	27.57	8.96	83.99	37.05
	Production	25.21	8.74 [^]	41.45	13.97	32.38	11.68	107.51	52.33
	Productivity	7.06	5.73 [^]	8.19	5.30 [^]	9.37	7.10	30.04	11.09 [^]
6	Maharashtra								
	Area	14.84	7.39	30.54	14.86	20.76	15.61	71.28	29.45
	Production	16.79	14.64 [^]	38.20	18.40	28.61	13.69	80.98	34.61
	Productivity	12.91	13.08 [^]	11.18	9.66	17.51	15.76	16.40	13.65 [^]
7	Rajasthan								
	Area	17.83	13.14	20.97	12.92 [^]	34.62	36.43	63.39	39.27
	Production	26.18	25.78	50.29	28.97	35.32	23.87	84.73	39.80
	Productivity	15.22	15.67 [^]	32.94	21.01	34.72	24.88	42.53	28.53
8	All India								
	Area	15.97	4.51 [^]	24.58	7.33 [^]	10.22	5.42	51.02	15.38
	Production	16.02	10.04 [^]	40.53	14.30	16.64	4.15 [^]	70.15	23.86
	Productivity	6.17	5.92 [^]	16.62	7.31	8.25	3.64	22.33	9.18 [^]

Note: CV- Coefficient of Variation (%), CDV – Cuddy Della Valle Index (%),

[^] Non-Significant.

4.3 Sources of contribution in onion production

A quantitative assessment of contribution of the various factors to output growth of onion crop in major onion producing states of India would be helpful for understanding which factor is relatively lagging behind and to identify the reasons or constraints for that. It has been also help us to understand the drivers for the enhancement of onion production. There are many factors which affect the growth of crop output. The major factors that are assumed to affect the production of crop are area effect, yield effect and their interaction effect. These three factors for onion production are discussed throughly. The decomposition analysis was done for four periods, *viz.*, Period-I (1990-91 to 1999-00), Period-II (2000-01 to 2009-10), Period-III (2010-11 to 2019-20) and overall period (1990-91 to 2019-20). The decomposition of onion production in terms of area, yield and interaction effects are presented in Table 4.3. The results shows the per cent contribution of all the effects for increasing production of onion in all the major onion growing states of India.

During, Period-I, Bihar recorded the highest area effect (45.72%) followed by Andhra Pradesh (30.78%), Madhya Pradesh (16.84%) and Maharashtra (5.57%). Whereas, the area effect of -751.23, -153.01 and -27.03 per cent were responsible for decreasing the production of onion in Gujarat, Karnataka and Rajasthan, respectively. This might be due to high fluctuation in area in these states due to drought condition. Whereas, the yield effect was found to be positive in all the states during Period-I. Among all the states, Gujarat recorded highest yield effect (400%) followed by Karnataka (200.62%) in Period-I. Besides, lowest yield effect was found in Bihar, which contributed positively for onion production. While, Interaction effect contributed negatively to onion production in Maharashtra (-16.64%) and Andhra Pradesh (-3.31%) in Period-I. Whereas, Interaction effect was found to be positive for the states of Gujarat (451.22%) followed by Karnataka, Rajasthan, Madhya Pradesh and Bihar. At all India level yield effect and interaction effect contributed positively in onion production during Period-I. Moreover, During Period-I, in all states under study and at all India level, yield effect was found to contribute more to production as compared to area effect and interaction effect, except in Gujarat, where interaction effect contributed more than yield effect. Similar results were noted for vegetable crops in Karnataka during

1985-1994 by Veena (1996), revealed that the change in mean yield were the major source of increase in mean production of vegetables in the state.

In Period-II, the area effect was found to be negative in Andhra Pradesh (-35.08%), Gujarat (-15.23%) and Bihar (-9.00%), as it was responsible for decreasing onion production in these states. The highest area effect was reported in Karnataka (116.62%) followed by Rajasthan (67.43%) during Period-II. Besides, in Maharashtra and Madhya Pradesh the area effect was also found to be positive. Whereas, yield effect contributed positively to onion production in all the states under study during Period-II, except Karnataka. Among all the states, Andhra Pradesh recorded the highest yield effect (119.88%) in Period-II. Moreover, the interaction effect recorded positive and responsible for increasing onion production in Bihar (90.18%), Gujarat (17.75%), Andhra Pradesh (15.20%), Rajasthan (8.27%), Maharashtra (6.32%) and Madhya Pradesh (4.76%) during Period-II. Whereas, Karnataka shown negative yield effect in Period-II. During Period-II, in all the states under study and at all India level, yield effect was found to contribute more to onion production as compared to area effect and interaction effect, except Karnataka and Rajasthan. At all India level reported positive area effect, yield effect and Interaction effect during Period-II.

During Period-III, the area effect was found to be positive to onion production in all the states under study. The highest area effect was recorded in Rajasthan (142.98%) as compared to all the other states under study during Period-III. Similar results were obtained by Hemant *et al.* (2017) for onion crop production during 2006-2015, stated that area effect was the major source in Rajasthan. Moreover, yield effect contributed positively to onion production in all the states under study during Period-III, except Andhra Pradesh. The highest yield effect was recorded in Gujarat (195.81%) as compared to all the other states under study during Period-III. The interaction effect reported positive in Andhra Pradesh (45.68%), Madhya Pradesh (6.23%) and Bihar (2.80%) during Period-III. Whereas, the interaction effect recorded negative in Rajasthan, Gujarat, Karnataka, and Maharashtra in Period-III. During Period-III, in all the states under study and at all India level, yield effect was found to contribute more to onion production as compared to area effect and interaction effect, except in Andhra Pradesh, Bihar and Rajasthan. At all India level reported positive area

effect and yield effect during Period-III. While, interaction effect was responsible for decreasing onion production at all India level in Period-III.

During overall period from 1990-91 to 2019-20, the highest area effect was recorded in Rajasthan (102.94%) followed by Karnataka (62.72%). Whereas, the area effect was found to be positive in Andhra Pradesh (36.98%), Maharashtra (33.62%), Madhya Pradesh (16.81%) and Bihar (15.50%) during overall period. On the contrary, in Gujarat, the area effect was responsible for decreasing onion production in overall period. Whereas, yield effect contributed positively to onion production in all the states under study during overall period. The highest yield effect was recorded in Gujarat (100.75%) as compared to all other states under study during overall period.

This analysis is evident that onion production in Gujarat state is mainly driven by yield effect, as the area fluctuated largely depending upon irrigation condition owing to erratic rainfall. But high yield around 25t/ha or more has been obtained during last two decades.

In case of interaction effect, Bihar recorded the highest interaction effect (63.62%) as compared to all other states under study in overall period. Moreover, the interaction effect reported positive in Gujarat (40.10%), Andhra Pradesh (12.17%), Karnataka (7.76%) and Madhya Pradesh (5.80%) during overall period. Whereas, the interaction effect recorded negative in Maharashtra and Rajasthan in overall period. At all India level, all three effects were found to be positive. Besides, yield and area effect were found to have contributed about 70 and 30 per cent, respectively towards the increase in total production and interaction effect slightly about 0.09 per cent. Parimalaranjan (2020) noted similar results for onion performance in India, stated that onion production was increased because of increase in productivity, use of technologies of high yield varieties, better irrigations and management practical.

Looking to the state-wise scenario, Andhra Pradesh showed the highest yield effect as compared to all other states under study and at all India level during Period-II. Besides, Andhra Pradesh showed the highest interaction effect as compared to all other states under study and at all India level during Period-III. Except, period-II in Andhra Pradesh, area effect was found to be positive in three periods. Yield effect was negative in period-III in Andhra Pradesh. Besides, interaction effect was negative in period-I. While, in overall period, area, yield and interaction effect contributed

positively in onion production in Andhra Pradesh. In all decades, yield effect contributed more to onion production as compared to area and interaction effect in Andhra Pradesh.

Among all the states, Bihar recorded the highest area effect of about 45.72 per cent in Period-I. The highest interaction effect was also recorded in Bihar as compared to all the states under study and at all India level during Period-II and overall period. Besides, in Bihar, yield effect contributed positively in onion production in all periods. Whereas, area effect was also found positive in all periods in Bihar, except period-II. In overall period, interaction effect was found dominant factor for higher onion production in Bihar.

Gujarat recorded the highest yield effect in all period as compared to all states under study and at all India level, except period-II. Gujarat reported negative area effect as it was responsible for decreasing the onion production during period-I, period-II and over all period. Whereas, yield effect was found to be positive in all periods in Gujarat. The highest interaction effect was also recorded in Gujarat as compared to all the states under study and at all India level during Period-I. Moreover, in Gujarat, interaction effect was found to be positive in Period-I, II, and in overall period. In all periods, yield effect contributed more to onion production as compared to area and interaction effect in Gujarat, except period-I, in which interaction effect contributed more.

The highest area effect was also recorded in Karnataka as compared to all the states under study and at all India level during Period-II. Karnataka shown positive area effect in Period-II, III and in overall period. Whereas, yield effect was found to be negative in period-II in Karnataka. Whereas, interaction effect was found to be positive in Period-I. In overall period, area, yield and interaction effect was found to be positive in Karnataka.

In Madhya Pradesh area, yield and interaction effect was found positive in all periods and in overall period. The contribution of yield effect recorded more in all the periods, followed by area effect and interaction effect.

Maharashtra recorded the highest yield effect in Period-I. Whereas, in Maharashtra, area and yield effect was found to be positive in all periods. Moreover, Interaction effect was found to be negative in all periods, except Period-II. In all periods, yield effect contributed more to onion production as compared to area and

interaction effect in Maharashtra. Moreover, yield effect was found to be dominant as compared to interaction and area effect in overall period in Maharashtra.

Rajasthan recorded the highest area effect (142.98%) in Period-III and in overall period (102.94%) as compared to all states under study and at all India level. Whereas, area effect was found to be positive in all periods, except Period-I in Rajasthan. Besides, yield effect was found to be positive in all periods in Rajasthan. Interaction effect was also found to be positive Period-I and Period-II. Moreover, area effect contributed more to onion production as compared to yield and interaction effect in all periods in Rajasthan, except period-I.

Hemant *et al.* (2017) in their study revealed similar the results and indicated that decomposition analysis have important policy implications because each growth component alone has a limited scope to expand overtime.

At all India level, yield effect was found to be positive in all periods. While, interaction effect was reported positive in Period-I, II and in overall period. While, area effect was reported positive in Period-II, III and in overall period. Moreover, yield effect contributed more to onion production as compared to area and interaction effect in all periods at all India level.

Table 4.3: Decomposition of growth in onion production

Sr. No.	State/Period	Per cent contribution		
		Area	Yield	Interaction
1.	Andhra Pradesh			
	Period-I	30.78	72.53	-3.31
	Period-II	-35.08	119.88	15.20
	Period-III	66.69	-12.38	45.68
	Overall Period	36.98	50.84	12.17
2.	Bihar			
	Period-I	45.72	45.72	4.01
	Period-II	-9.00	18.82	90.18
	Period-III	51.96	45.23	2.80
	Overall Period	15.50	20.86	63.62

Table 4.3 Cont....

3.	Gujarat			
	Period-I	-751.23	400.01	451.22
	Period-II	-15.23	97.47	17.75
	Period-III	4.69	195.81	-100.50
	Overall Period	-40.85	100.75	40.10
4.	Karnataka			
	Period-I	-153.01	200.62	52.38
	Period-II	116.62	-15.06	-1.55
	Period-III	1.81	149.46	-51.27
	Overall Period	62.72	29.51	7.76
5.	Madhya Pradesh			
	Period-I	16.84	79.12	4.02
	Period-II	13.82	81.41	4.76
	Period-III	15.10	78.66	6.23
	Overall Period	16.81	77.37	5.80
6.	Maharashtra			
	Period-I	5.57	111.07	-16.64
	Period-II	29.38	64.29	6.32
	Period-III	59.11	70.66	-29.77
	Overall Period	33.62	92.29	-25.91
7.	Rajasthan			
	Period-I	-27.03	76.88	50.15
	Period-II	67.43	24.28	8.27
	Period-III	142.98	107.76	-150.74
	Overall Period	102.94	93.39	-96.34
8.	All India			
	Period-I	-25.11	116.92	8.19
	Period-II	42.83	48.38	8.98
	Period-III	44.43	57.08	-1.40
	Overall Period	29.29	70.61	0.089

4.4 Trends in onion prices

The long term trend in the agricultural prices in India has been of continuous rise. This occurs due to slow change in demand and supply condition over a long period

of time. For example, a steady growth in population, changing customers habits, purchasing power and other factors. Some of these factors may tend to push prices up, while others may be a pull in opposite direction. As a result, prices may move slowly, either upward or downward or remain stationary. Trend or secular trend does not include short range oscillation, but rather steady movements over a long period of time. To know the trend in yearly prices of onion under study, following three approaches were tried.

1. Estimation of linear trend
2. Estimation of quadratic trend
3. Estimation of compound rate of increase in annual prices

4.4.1 Estimation of linear trend

Linear model as per specification given in methodology chapter fitted in order to estimate the linear trend during twenty years period, *i.e.* 2001 to 2020 using yearly index numbers of wholesale prices of onion in selected markets. The estimates obtained are presented in Table 4.4.

It could be observed from the result that all regression coefficients were highly significant for the price series of selected markets. This clearly indicated that a considerable amount of variation in the price could be explained by the linear trend. Among the selected markets, the annual rate of increase was the highest *i.e.* 24.95 per cent in Lasalgaon market and the lowest was 14.18 per cent in Bhopal market.

Co-efficient of multiple determination (R^2) was more than 52 per cent for all markets, indicating that more than 50 per cent of variation in price of onion could be explain through linear trend.

Similar result was noted by Balappa and Hugar (2002) in their study of trends in prices of onion in Northern Karnataka markets, there was marginal increase in prices over the period with mild in fluctuation in all markets, except Belgaum, Hubli and Dharwad, where in upward trend was noticed in 1997-98.

Table 4.4: Estimation of linear trend in yearly prices of onion in major markets of India

Markets	Intercept β_0	Co-efficient for Time β_1	R ²	Adjusted R ²
Ahmedabad	35.35	21.07* (5.44)	0.62	0.6
Bengaluru	65.45	18.14*** (5.77)	0.65	0.63
Bhopal	45.63	14.18*** (4.43)	0.52	0.49
Hyderabad	41.2	15.38* (7.12)	0.74	0.72
Jaipur	55.86	23.56* (3.81)	0.68	0.64
Mumbai	46.85	19.18* (3.47)	0.63	0.6
Patna	47.42	16.01* (5.71)	0.64	0.62
Lasalgaon	38.71	24.95* (5.60)	0.64	0.62
Mahuva	39.23	16.77*** (3.24)	0.57	0.55

Note: Figures in the parentheses are standard errors.

***, * Significant at 1 and 10 per cent probability level

4.4.2 Estimation of quadratic trend

It is also important to check the assumption of constant rate of increase in the prices over twenty years. Hence, a quadratic model was also tried which indicates the change in growth pattern of prices over time.

The estimates obtained are present in Table 4.5 for each selected market. It could be seen that the regression co-efficient associated with time variable (*i.e.* T) was maximum in Bengaluru market and minimum in Mahuva market. These co-efficient were non-significant in case of Mumbai and Ahmedabad markets. Whereas, the coefficients of quadratic term (*i.e.* T²) found to be non-significant in all markets.

The co-efficient of multiple determination (R²) showed higher variations *i.e.* more than 52 per cent in all the markets could be explained by quadratic trend. Adjusted co-efficient of multiple determination was also worked out to know the better fit.

The co-efficient of multiple determination (R^2) was similar in Bengaluru, Bhopal, Mumbai and Lasalgaon market suggesting absence of quadratic trend. Thus, quadratic trend results revealed that onion price in all the markets under study have not shown increasing growth pattern, but indicated almost constant growth pattern during 2001 to 2020. Hence, the rise in onion price was only due to inflation and farmers were not benefited at all.

The estimation of adjusted co-efficient of multiple determination was carried out to know, which of the model fits better from linear and quadratic models. The value of adjusted co-efficient of multiple determination were found to be same in quadratic model and linear model in Hyderabad market. While in case of onion in Bhopal market value of adjusted co-efficient of multiple determination were found to be lower, revealed that the linear model is a better fit than quadratic model.

Table 4.5: Estimation of quadratic trend in yearly prices of onion in major markets of India

Markets	Intercept β_0	Co-efficient for Time β_1	Co-efficient for $T^2 \beta_2$	R^2	Adjusted R^2
Ahmedabad	69.32	11.81 (16.59)	0.44 (0.76)	0.63	0.59
Bengaluru	47.56	23.02* (13.55)	-0.23 (0.62)	0.65	0.61
Bhopal	57.22	11.02* (13.81)	0.15 (0.63)	0.52	0.47
Hyderabad	64.63	8.99* (9.20)	0.3 (0.42)	0.75	0.72
Jaipur	55.85	18.77* (16.47)	0.23 (0.76)	0.68	0.64
Mumbai	65.97	13.96 (14.99)	0.25 (0.69)	0.63	0.58
Patna	64.22	11.43* (12.08)	0.22 (0.55)	0.65	0.6
Lasalgaon	56.32	20.14* (19.23)	0.23 (0.88)	0.64	0.59
Mahuva	73.32	6.70* (13.83)	0.44 (0.64)	0.58	0.54

Note: Figures in the parentheses are standard errors.

* Significant at 10 per cent probability level.

The original price indices and estimates obtained through linear and quadratic equations for all markets are present in Tables 4.6 to 4.10. The results reveals that the original price indices showed a continuous increase from 2001 to 2005 for all markets and linear, and quadratic trend values has been found continuously increasing from year to year for all markets.

Table 4.6: Original and estimated linear and quadratic trend values of wholesale price index number of onion in Ahmedabad and Bengaluru market

years	Ahmedabad			Bengaluru		
	Original price indices	Linear trend values	Quadratic trend values	Original price indices	Linear trend values	Quadratic trend values
2001	100.00	56.42	81.57	100.00	83.58	70.34
2002	84.67	77.50	94.70	82.5	101.73	92.67
2003	114.39	98.57	108.72	120.39	119.87	114.52
2004	114.80	119.65	123.62	124.38	138.01	135.92
2005	145.92	140.72	139.40	154.60	156.15	156.84
2006	93.48	161.80	156.06	101.32	174.29	177.31
2007	222.32	182.87	173.61	210.91	192.43	197.31
2008	143.04	203.95	192.04	169.029	210.57	216.84
2009	238.48	225.02	211.35	272.36	228.71	235.91
2010	276.45	246.10	231.5	330.41	246.85	254.52
2011	196.72	267.17	252.6	269.27	264.99	272.66
2012	149.93	288.25	274.57	203.13	283.13	290.33
2013	526.86	309.32	297.41	470.46	301.27	307.55
2014	312.38	330.40	321.13	327.07	319.42	324.29
2015	524.07	351.47	345.74	457.31	337.56	340.58
2016	192.25	372.55	371.22	218.67	355.70	356.39
2017	345.22	393.62	397.59	304.47	373.84	371.75
2018	291.23	414.70	424.84	246.66	391.98	386.64
2019	508.89	435.77	452.98	460.39	410.12	401.06
2020	551.61	456.85	482	495.14	428.26	415.02

Table 4.7: Original and estimated linear and quadratic trend values of wholesale price index number of onion in Bhopal and Hyderabad market (2001 to 2020)

Years	Bhopal			Hyderabad		
	Original price indices	Linear trend values	Quadratic trend values	Original price indices	Linear trend values	Quadratic trend values
2001	100.00	59.81	68.39	100.00	56.57	73.91
2002	76.97	73.99	79.86	73.15	71.95	83.81
2003	87.43	88.18	91.64	95.81	87.33	94.32
2004	89.86	102.36	103.71	97.75	102.70	105.44
2005	108.14	116.54	116.09	115.66	118.08	117.17
2006	71.87	130.72	128.77	67.48	133.46	129.50
2007	175.85	144.91	141.75	173.02	148.83	142.44
2008	113.73	159.09	155.03	126.35	164.21	156.00
2009	193.00	173.27	168.61	199.56	179.59	170.16
2010	197.56	187.45	182.49	235.87	194.96	184.92
2011	189.03	201.64	196.67	177.44	210.34	200.30
2012	116.53	215.82	211.15	137.27	225.72	216.29
2013	404.42	230.00	225.94	358.18	241.09	232.88
2014	256.54	244.18	241.02	233.60	256.47	250.08
2015	414.56	258.37	256.41	337.38	271.85	267.89
2016	115.26	272.55	272.10	186.07	287.22	286.31
2017	194.69	286.73	288.09	294.26	302.60	305.34
2018	216.61	300.91	304.37	273.10	317.98	324.97
2019	390.03	315.10	320.96	405.88	333.35	345.22
2020	378.80	329.28	337.86	365.20	348.73	366.07

Table 4.8: Original and estimated linear and quadratic trend values of wholesale price index number of onion in Jaipur and Mumbai market (2001 to 2020)

Years	Jaipur			Mumbai		
	Original price indices	Linear trend values	Quadratic trend values	Original price indices	Linear trend values	Quadratic trend values
2001	100.00	61.84	74.85	100.00	66.02	80.17
2002	101.18	85.40	94.30	83.27	85.19	94.88
2003	121.91	108.96	114.21	111.39	104.37	110.08
2004	119.29	132.52	134.57	130.64	123.54	125.78
2005	144.39	156.08	155.40	143.18	142.72	141.98
2006	106.17	179.64	176.67	96.36	161.90	158.67
2007	246.90	203.20	198.41	210.02	181.07	175.86
2008	167.17	226.76	220.60	139.91	200.25	193.54
2009	240.11	250.32	243.25	238.99	219.42	211.72
2010	302.39	273.88	266.35	282.10	238.60	230.40
2011	268.74	297.44	289.91	223.73	257.78	249.58
2012	208.38	321.00	313.93	157.69	276.95	269.25
2013	572.55	344.56	338.40	490.16	296.13	289.42
2014	349.70	368.12	363.33	308.64	315.30	310.09
2015	556.12	391.68	388.72	474.04	334.48	331.25
2016	248.83	415.24	414.56	175.78	353.66	352.91
2017	353.09	438.80	440.86	317.23	372.83	375.07
2018	357.22	462.37	467.61	283.77	392.01	397.72
2019	631.64	485.93	494.83	514.54	411.18	420.87
2020	517.49	509.49	522.50	482.32	430.36	444.52

Table 4.9: Original and estimated linear and quadratic trend values of wholesale price index number of onion in Patna and Lasalgaon market (2001 to 2020)

Years	Patna			Lasalgaon		
	Original price indices	Linear trend values	Quadratic trend values	Original price indices	Linear trend values	Quadratic trend values
2001	100.00	63.43	75.87	100.00	63.65	76.69
2002	86.09	79.45	87.95	94.97	88.60	97.52
2003	104.30	95.46	100.48	128.49	113.5	118.80
2004	107.55	111.48	113.44	130.90	138.49	140.55
2005	120.85	127.49	126.84	166.55	163.44	162.75
2006	92.20	143.51	140.67	107.44	188.38	185.41
2007	183.59	159.52	154.94	249.37	213.33	208.53
2008	123.66	175.54	169.65	169.46	238.27	232.10
2009	195.34	191.55	184.79	264.72	263.22	256.13
2010	216.25	207.57	200.37	323.81	288.16	280.62
2011	193.51	223.59	216.39	286.54	313.1	305.56
2012	144.21	239.60	232.84	198.74	338.05	330.97
2013	433.75	255.62	249.73	640.20	363.00	356.83
2014	274.18	271.63	267.05	366.97	387.94	383.14
2015	403.36	287.65	284.81	589.86	412.82	409.92
2016	177.25	303.66	303.01	217.08	437.84	437.15
2017	283.77	319.68	321.64	407.04	462.78	464.84
2018	249.11	335.69	340.71	341.06	487.73	492.98
2019	428.72	351.71	360.22	643.70	512.67	521.59
2020	393.87	367.73	380.16	585.85	537.62	550.65

Table 4.10: Original and estimated linear and quadratic trend values of wholesale price index number of onion in Mahuva market (2001 to 2020)

Years	Mahuva		
	Original price indices	Linear trend values	Quadratic trend values
2001	100.00	55.22	80.46
2002	90.17	71.23	88.49
2003	84.52	87.23	97.41
2004	89.078	103.23	107.22
2005	106.95	119.23	117.91
2006	113.08	135.24	129.48
2007	178.93	151.24	141.94
2008	110.33	167.24	155.29
2009	200.84	183.24	169.52
2010	266.91	199.20	184.64
2011	176.08	215.25	200.64
2012	149.19	231.25	217.53
2013	399.17	247.26	235.30
2014	244.50	263.26	253.96
2015	415.90	279.26	273.50
2016	166.63	295.26	293.30
2017	211.39	311.27	315.25
2018	202.02	327.27	227.45
2019	446.23	343.27	360.54
2020	513.87	359.27	384.51

The original prices were noticed large declined by and large in the years 2006, 2008, 2011, 2012, 2014, 2016 and 2018 *i.e.* in 7 years, out of 20 years period under the study. This might be due to the fact that onion can be cultivated only in the irrigation conditions in winter and summer season. When there is a normal to good monsoon, the irrigation feasibilities expands, which contributes to increase in onion area and production ultimately results in price decline as demand remains constants. Besides,

high price of onion in previous year also induce the farmers to allocate more acreage in current years enhance the simply, acridier in low prices. Darekar *et al.* (2015) noted similar results in case of growth rate in onion area, production and yield. They stated that although, productivity of onion has improved from last decade, still onion production is mainly driven by acreage allocation. As onion is irrigated crop and Maharashtra is endowed with relatively less irrigation potential, increasing production through scaling up area may not be feasible without reducing the acreage under other important high value crops.

4.4.3. Estimation of compound rate of increase in annual prices

The estimates of the compound annual growth rates of prices of onion were determined for each market covered under study. For this, exponential function of the form specified in section 3.3.1 was used for all markets covered under study. The decade-wise and overall period results obtained from this estimation are given in Table 4.11, 4.12 and 4.13.

Table 4.11: Estimation of compound rate of increase in onion prices (2001 to 2010)

Markets	Estimates of β	Compound rate of increase (%)	R ²
Ahmedabad	1.12***	12.24	0.70
Bengaluru	1.14***	14.24	0.78
Bhopal	1.10***	9.84	0.56
Hyderabad	1.11***	11.06	0.58
Jaipur	1.12***	12.52	0.11
Mumbai	1.13***	12.12	0.71
Patna	1.09***	9.43	0.67
Lasalgaon	1.13***	13.32	0.76
Mahuva	1.12***	11.60	0.69

Note: *** Indicates significance at 1 per cent probability level.

The result revealed that the compound rates of increase in prices in onion for all markets were statistically significant during the period 2001 to 2010. The prices of onion in Bengaluru market registered the highest increasing rate of 14.24 per cent per annum, whereas, it was the lowest in Patna market about 9.43 per cent per annum.

Table 4.12: Estimation of compound rate of increase in onion prices (2011 to 2020)

Markets	Estimates of β	Compound rate of increase (%)	R ²
Ahmedabad	1.09***	8.97	0.29
Bengaluru	1.04**	4.35	0.14
Bhopal	1.06**	5.92	0.12
Hyderabad	1.08***	8.08	0.42
Jaipur	1.07***	6.59	0.24
Mumbai	1.07***	7.25	0.23
Patna	1.07**	6.59	0.23
Lasalgaon	1.07***	6.78	0.20
Mahuva	1.08***	7.90	0.24

Note: **, *** Indicates significance at 5 and 1 per cent probability level, respectively.

It can be seen from the table 4.12 that the compound rates of increase in prices of onion for all markets were statistically significant during the period 2011 to 2020. The price of onion in Ahmedabad market registered the highest increasing rate of 8.96 per cent per annum, while it was the lowest in Bengaluru market about 4.35 per cent per annum. This, further indicates that onion prices were increased at a larger rate during 2000s as compared to 2010s.

Table 4.13: Estimation of compound rate of increase in onion prices (2001 to 2020)

Markets	Estimates of β	Compound Rate of Increase (%)	R ²
Ahmedabad	1.09***	9.19	0.71
Bengaluru	1.08***	8.33	0.72
Bhopal	1.07***	7.84	0.60
Hyderabad	1.08***	8.57	0.76
Jaipur	1.09***	9.56	0.78
Mumbai	1.08***	8.66	0.71
Patna	1.08***	8.17	0.74
Lasalgaon	1.09***	9.61	0.74
Mahuva	1.08***	8.33	0.69

Note: *** Indicates significance at 1 per cent probability level.

From the year 2001 to 2020 the compound rates of increase in prices of onion for all markets under study were statistically significant. The prices of onion in Ahmedabad, Bengaluru, Bhopal, Hyderabad, Jaipur, Mumbai, Patna, Lasalgaon and Mahuva markets increased at the rate of 9.19, 8.33, 7.84, 8.57, 9.56, 8.66, 8.17, 9.61 and 8.33 per cent per annum, respectively. Thus, on an average the onion prices in major markets of India was significantly increased annually at the rate of 8.50 per cent per annum during last two decades.

Similar results were reported by Dave and Tarpara (2016) in case of pulses price in Gujrat. They stated that the compound rates of increase in prices of major pulses crop under study were statistically significant during 2003 to 2013, in Gujarat. Besides, Mulla *et al.* (2020) also noted that onion price in Kurnool market of Karnataka was increased at the rate of 6.22 per cent per annum during 2003 to 2017.

4.5 Seasonal variations in onion prices

Seasonality in prices are such changes that occur regularly every year as a result of changes in season. These variation may be primarily due to the seasonal production, poor storage facilities and lack of retention power of growers. Prices of agricultural commodities are the lowest during the post-harvest months and higher during the pre-harvest months. Seasonal variation are caused by the both the natural and the man made factors. The behaviour and magnitude of seasonal price variations are important for farmers and traders on one hand, and policy makers on the other.

The seasonality in supply of agricultural commodities mainly arises from the seasonality in production as the crops can grow only under particular weather conditions. It is important to study the magnitude of the change and seasonal variation during the period under study. So, this section of seasonal variation is divided into two parts, which are presented below.

4.5.1 Indices of seasonal variations

4.5.2 Coefficient of average seasonal variations

4.5.1 Indices of seasonal variations

A multiplicative model of the form specified in methodology section was applied in order to isolate seasonal variation from the original composite series. centered twelve months moving average and ratio of original price indices to these centered average worked out for each twenty years period. These ratios were averaged

for each of the twelve month for the whole period and were adjusted to make the twelve month's total as 1200 points.

The adjusted monthly seasonal indices of onion price in Ahmedabad, Bengaluru and Bhopal are presented in Table 4.14. In Ahmedabad and Bengaluru markets the seasonal index reached its maximum level in November *i.e.* 134.57 points and 135.87 points, respectively and falls to its minimum level in May and April *i.e.* 58.40 points and 64.60 points, respectively during the period 2001 to 2020 (Table 4.14). In Bhopal market the seasonal index reached its maximum level in October (135.77 points) and falls to its minimum level in May (54.30 points).

Table 4.14: Index of seasonal variation in wholesale prices of onion in Ahmedabad, Bengaluru and Bhopal markets (2001 to 2020)

Month	Ahmedabad	Bengaluru	Bhopal
January	117.23	117.78	115.50
February	92.75	91.30	97.03
March	74.64	71.13	80.03
April	64.19	64.60	66.55
May	58.40	66.36	54.30
June	73.99	84.54	67.30
July	91.68	96.62	102.50
August	110.43	111.44	109.95
September	125.56	110.76	126.19
October	132.33	121.27	135.77
November	134.57	135.87	129.86
December	124.24	128.01	115.02
Total	1200	1200	1200

The results of adjusted monthly price indices of onion in Hyderabad and Jaipur markets the seasonal index reached its maximum level in December and October *i.e.* 121.77 points and 143.08 points, respectively and falls to its minimum level in May *i.e.* 70.24 points and 60.73 points, respectively (Table 4.15). In Mumbai markets the seasonal index reached its maximum level in November (138.64 points) and falls to its minimum level in April (63.43 points).

Similar results for pigeon pea price variation in Akola, Latur and Thandum markets of Maharashtra were noted by Chaudhari and Tingre (2012). They indicated that prices of pigeon pea were higher from June to August in all selected markets.

Table 4.15: Index of seasonal variation in wholesale prices of onion in Hyderabad, Jaipur and Mumbai markets (2001 to 2020)

Month	Hyderabad	Jaipur	Mumbai
January	117.14	110.25	107.95
February	94.38	95.78	83.97
March	78.96	80.69	68.46
April	74.26	70.35	63.43
May	70.24	60.73	67.78
June	82.00	69.78	82.19
July	89.72	83.58	91.44
August	114.31	109.26	108.80
September	116.78	126.59	120.19
October	120.31	143.08	131.68
November	120.12	130.32	138.64
December	121.77	119.61	135.46
Total	1200	1200	1200

The adjusted monthly price indices of onion in Patna and Mahuva markets the seasonal index reached its maximum level in November *i.e.* 135.30 points and 123.07 points, respectively and falls to its minimum level in May about 62.31 points and 74.10 points, respectively. In Lasalgaon markets the seasonal index reached its maximum level in October (137.02 points) and falls to its minimum level in April (58.72 points).

Sharma and Sharma (2001) in their study of levels and variation in wholesale prices and export of onion, revealed that the prices were lower during March-April, in the main harvest season.

Sangeeta (2004) in their study revealed that in Lasalgaon market the arrivals were more in January and February, where as in Pune market the arrivals began increasing in February and March. The prices showed an upward trend from the month of June and continue to rise up to November, after which decline was observed.

Table 4.16: Index of seasonal variation in wholesale prices of onion in Hyderabad, Jaipur and Mumbai markets (2001 to 2020)

Month	Patna	Lasalgaon	Mahuva
January	114.51	110.05	106.90
February	97.34	87.47	92.81
March	74.80	67.00	83.09
April	70.33	58.72	77.67
May	62.31	65.83	74.10
June	75.27	82.56	81.21
July	87.97	100.22	87.92
August	107.96	114.51	109.80
September	115.07	134.84	119.93
October	129.81	137.02	123.06
November	135.30	130.66	123.07
December	129.34	111.13	120.44
Total	1200	1200	1200

In all 9 onion markets under study comprised of 7 consumption and 2 producing location markets *i.e.* Lasalgaon and Mahuva, 3 markets *i.e.* Bhopal, Jaipur and Lasalgaon had the maximum level of seasonal index in October, 5 markets *i.e.* Ahmedabad, Bengaluru, Mumbai, Patna and Mahuva in November and 1 Hyderabad market in December, Whereas, minimum level of seasonal index were noticed for 3 markets in April and 6 markets in May. Thus, the seasonal indices were indicated the minimum onion price in the months of April-May and the maximum in the months of October-November. Moreover, the analysis of seasonal variation also indicates the higher inter-year variability in case of onion prices in all selected markets. Hence, our null hypothesis is rejected and concluded that their exist seasonal variation in onion prices.

This is in line with findings of Basavaraj (2019), for onion price in Karnataka, Shiyani and Kakalia (1999) durings 1980s and 1990s for onion price in Gujarat, Sharma and Sharma (2001) for selected vegetables in India, Singh and Ragi (2008) foe potato price in India, Sinha *et al.* (2016) for onion markets in India and Mulla *et al.* (2020) for onion price in Kurnal market of Andhra Pradesh.

4.5.2 Coefficient of average seasonal variations

In order to find out the differences in the magnitude of seasonal variation for peak and through period, the coefficient of average seasonal prices index were calculated for onion for their respective markets for the period under study i.e. 2001 to 2020. The result obtained are present in the Table 4.17.

It can be seen from Table that the maximum value of the coefficient in seasonal variation was found in Bhopal market (85.73%) and minimum value of the coefficient in seasonal variation was found in Mahuva market (49.67%). Thus, it can be revealed that during the period 2001 to 2020, onion crop under study had showed high coefficient of average seasonal variation, except Mahuva market.

Reddy *et al.* (2012) in their study revealed the similar results and stated that there was high variability in the arrival of onion in the month of March and April in selected markets in India. Among the markets, the coefficient of variation in both, arrivals and prices were found to be higher in Ahmadabad and Kolkata.

This might be due to the fact that onion is the vegetable crop and cannot be stored for longer period. On the other had its demand is constant and throughout the year. Hence, after harvesting season its price are mostly tends to go down, which results in wide seasonal variability. Besides, in many years unseasonal rain cause large damage to stored quantity and hoarding by big traders takes benefit of price increase in lean season.

Table 4.17: Coefficients of average seasonal prices index variation (2001 to 2020)

Markets	Coefficients of average seasonal variation (%)
Ahmedabad	78.17
Bengaluru	71.11
Bhopal	85.73
Hyderabad	53.67
Jaipur	80.81
Mumbai	74.44
Patna	73.88
Lasalgaon	80.00
Mahuva	49.67

4.6 Irregular fluctuations in onion prices and inter-relationship between the prices

The movement of price shows irregular behaviour, which is not systematic. This type of price movement termed as irregular price variation. These irregular price variations are random in nature. The index of irregular fluctuation was calculated for the middle year 2010 of the entire period under study using the formula given in methodology section.

The irregular indices of onion and their respective markets under study are presented in Table 4.18. The index of irregular fluctuation of onion prices was maximum in the month of May (513.48 points) and minimum in the month of December (57.42 points) in Ahmedabad market. In Bengaluru index of irregular fluctuation of onion prices was maximum in the month of April (446.97 points) and minimum in the month of December (49.61 points). In Bhopal index of irregular fluctuation of onion prices was maximum in the month of December (103.04 points) and minimum in the month of July (42.64 points).

Table 4.18: Index of irregular fluctuation in wholesale prices of onion in Ahmedabad, Bengaluru and Bhopal (2001 to 2020)

Month	Ahmedabad	Bengaluru	Bhopal
January	96.20	92.33	76.59
February	139.75	158.22	88.32
March	248.09	328.92	68.56
April	427.66	446.97	56.87
May	513.48	373.30	48.31
June	359.25	273.25	53.24
July	263.51	257.39	42.64
August	191.18	222.88	43.91
September	109.26	153.31	53.07
October	85.61	129.35	61.21
November	73.43	66.03	75.60
December	57.42	49.61	103.04

In case of Hyderabad index of irregular fluctuation of onion prices was maximum in the month of May (263.20 points) and minimum in the month of December

(67.74 points). In Jaipur index of irregular fluctuation of onion prices was maximum in the month of May (435.04 points) and minimum in the month of December (61.39 points). In Mumbai index of irregular fluctuation of onion prices was maximum in the month of April (441.34 points) and minimum in the month of December (49.24 points).

Table 4.19: Index of irregular fluctuation in wholesale prices of onion in Hyderabad, Jaipur and Mumbai (2001 to 2020)

Month	Hyderabad	Jaipur	Mumbai
January	145.00	105.85	97.89
February	208.91	125.69	163.24
March	182.01	196.20	327.22
April	146.85	301.43	441.34
May	263.20	435.04	387.50
June	169.24	429.87	299.42
July	253.95	336.55	278.39
August	164.04	197.15	208.56
September	171.61	109.13	119.84
October	133.34	77.80	97.79
November	108.37	81.65	62.48
December	67.74	61.39	49.24

In case of Patna index of irregular fluctuation of onion prices was maximum in the month of May (495.31 points) and minimum in the month of December (60.06 points). In Lasalgaon index of irregular fluctuation of onion prices was maximum in the month of December (209.10 points) and minimum in the month of July (56.63 points). In Mahuva index of irregular fluctuation of onion prices was maximum in the month of July (375.43 points) and minimum in the month of December (59.28 points). Similar results for the prices of chickpea and black gram in Gujarat during 2003-2013 were noted by Dave and Tarpara (2016). They noted vary high inter-year variability in all selected markets under study.

Table 4.20: Index of irregular fluctuation in wholesale prices of onion in Patna, Lasalgaon, and Mahuva (2001 to 2020)

Month	Patna	Lasalgaon	Mahuva
January	92.02	144.78	104.33
February	119.58	129.21	144.99
March	298.99	90.93	201.33
April	334.48	90.28	279.44
May	495.31	86.60	358.47
June	346.10	69.61	374.78
July	269.99	56.63	375.43
August	206.84	63.45	184.56
September	127.32	81.93	119.67
October	98.40	84.92	90.49
November	69.65	93.18	60.84
December	60.03	209.10	59.28

4.6.1 Inter-relationship between prices of different markets of onion

It is important to determine the inter-relation between prices of onion in their respective markets. To estimate this relationship, simple correlation coefficient were worked out for yearly and monthly prices for the period under study.

4.6.1.1 Inter-relationship between monthly prices

The result of simple correlation coefficients of the monthly prices of onion in its respective markets under study are present in Table 4.21.

It can be seen from the table that the values of correlation coefficients of onion price movement in selected market under study were more than 0.87. They are also found to be highly significant indicating high correlations in in monthly prices of onion among all the consumption and production markets.

Table 4.21: Simple correlation coefficients of monthly prices of onion

Onion									
Markets	Ahmedabad	Bengaluru	Bhopal	Hyderabad	Jaipur	Mumbai	Patna	Lasalgaon	Mahuva
Ahmedabad	1	0.934***	0.960***	0.931***	0.937***	0.982***	0.977***	0.951***	0.940***
Bengaluru		1	0.899***	0.916***	0.875***	0.954***	0.932***	0.897***	0.908***
Bhopal			1	0.893***	0.916***	0.955***	0.958***	0.911***	0.898***
Hyderabad				1	0.897***	0.926***	0.933***	0.876***	0.889***
Jaipur					1	0.929***	0.937***	0.904***	0.908***
Mumbai						1	0.979***	0.949***	0.933***
Patna							1	0.941***	0.913***
Lasalgaon								1	0.909***
Mahuva									1

Note: *** Significant at 1 per cent probability level.

4.6.1.2 Inter-relationship between yearly prices

Correlation matrix showing the correlations among the yearly prices of onion in selected market has been present in Table 4.22.

From the results, it could be seen that the values of correlation coefficients of onion markets under study were more than 0.90. They are also found to be highly significant. Similar results were noted by Dave and Tarpara (2016) in their study on price behavior of major pulses in Gujarat state during 2003 to 2013. They revealed that the values of correlation coefficient of monthly and yearly prices of pulses under study were more than 0.90 and were highly significant.

Table 4.22: Simple correlation coefficients of yearly prices of onion

Onion									
Markets	Ahmedabad	Bengaluru	Bhopal	Hyderabad	Jaipur	Mumbai	Patna	Lasalgaon	Mahuva
Ahmedabad	1	0.975***	0.980***	0.973***	0.980***	0.993***	0.991***	0.991***	0.972***
Bengaluru		1	0.966***	0.961***	0.967***	0.981***	0.972***	0.978***	0.967***
Bhopal			1	0.943***	0.974***	0.984***	0.981***	0.981***	0.962***
Hyderabad				1	0.980***	0.980***	0.980***	0.979***	0.935***
Jaipur					1	0.990***	0.993***	0.993***	0.952***
Mumbai						1	0.995***	0.997***	0.968***
Patna							1	0.997***	0.956***
Lasalgaon								1	0.959***
Mahuva									1

Note: *** Significant at 1 per cent probability level

4.6.1.3 Inter-relationship between arrivals and prices of different markets of onion

It is important to determine the inter-relation between arrivals of onion in their respective markets. To estimate this relationship, simple correlation coefficient were worked out for monthly arrivals and prices for the period under study.

Table 4.23: Simple correlation coefficient of monthly arrivals and prices of onion

Markets	Item	Arrival	Price
Ahmedabad	Arrival	1	0.15
	Price		1
Bengaluru	Arrival	1	0.19
	Price		1
Bhopal	Arrival	1	-0.07
	Price		1
Hyderabad	Arrival	1	0.19
	Price		1
Jaipur	Arrival	1	0.03
	Price		
Mumbai	Arrival	1	0.16
	Price		
Patna	Arrival	1	0.22
	Price		
Lasalgaon	Arrival	1	-0.35
	Price		
Mahuva	Arrival	1	-0.10
	Price		

From the results, it could be seen that the values of correlation coefficients of onion markets under study were range from -0.35 to 0.22. Bhopal, Lasalgaon and Mahuva markets shown negative correlation between the prices and arrivals. Whereas, Ahmedabad, Bengaluru, Hyderabad, Jaipur, Mumbai and Patna shown positive but poor correlation between the prices and arrivals. The main reason behind this is that the price fluctuation in pre and post-harvest periods of the crops. This results are in line with the Diwaker and Rai (2014) studied the behaviour of market arrivals and prices of onion, garlic and turmeric in selected markets of Uttar Pradesh from 2001-2010. They

reported that, across different months, there have been several instances of positive relationship between market arrivals and prices in Lucknow and Kanpur markets.

4.7 Co-integration among onion prices in selected markets

Before starting the co-integration and error correlation analysis, the descriptive statistics were obtained for onion price series in selected markets. After this, the unit root test for the price series was done using the Augmented Dickey-Fuller (ADF) test. Then, the co-integration and error correction analysis were conducted.

4.7.1 ADF unit-root test for stationarity of onion wholesale market prices

The Augmented Dickey Fuller based unit root test procedure was done to check whether the monthly price series of onion crop were stationary or not. From Table 4.24 it could be inferred that Augmented Dickey Fuller test values are above the critical (1%) given by MacKinnon statistical table at levels implying that the series are stationary, which means that the calculated values for all the markets are less than the critical value (1%) and free from the consequence of unit root. The results of the Augmented Dickey-Fuller (ADF) unit root test for onion showed the data are level stationary. Hence, all market price series were integrated of the order zero ($I = 0$).

Table 4.24: ADF unit root test for onion prices in selected markets

Markets	Augmented Dickey-Fuller (ADF)	Critical value (1%)	Probability value
	t-Statistic Level		
Ahmedabad	-6.1679***	-3.4577	0.0000
Bengaluru	-6.3134***	-3.4577	0.0000
Bhopal	-6.2998***	-3.4577	0.0000
Hyderabad	-5.6711***	-3.4577	0.0000
Jaipur	-5.1376***	-3.4576	0.0000
Mumbai	-6.5519***	-3.4577	0.0000
Patna	-6.2850***	-3.4577	0.0000
Lasalgaon	-5.6052***	-3.4577	0.0000
Mahuva	-4.5178***	-3.4576	0.0000

*Note: *** significant at 1% level*

4.7.2. Augmented Engle-Granger test

From Table 4.25 it could be inferred that the elasticity of price transmission of onion was 0.06, 0.16, 0.11, 0.01, 0.34, 0.20, 0.12, 0.15, 0.10, 0.26, 0.15, 0.82, 0.01, 0.07, 0.19, 0.10, 0.12, 0.26, 0.63, 0.06, 0.05, 0.09, 0.17, 0.57, 0.14, 0.17, 0.07, 0.68, 0.06, 0.32, 0.70, 0.15, 0.70, 0.57, 0.42 and 1.00 between Ahmedabad-Bengaluru, Ahmedabad-Bhopal, Ahmedabad-Hyderabad, Ahmedabad-Jaipur, Ahmedabad-Mumbai, Ahmedabad- Patna, Ahmedabad-Lasalgaon, Ahmedabad-Mahuva, Bengaluru-Bhopal, Bengaluru-Hyderabad, Bengaluru-Jaipur, Bengaluru-Mumbai, Bengaluru-Patna, Bengaluru-lasalgaon, Bengaluru-Mahuva, Bhopal-Hyderabad, Bhopal-Jaipur, Bhopal-Mumbai, Bhopal-Patna, Bhopal-Lasalgaon, Bhopal-Mahuva, Hyderabad-Jaipur, Hyderabad-Mumbai, Hyderabad-Patna, Hyderabad-Lasalgaon, Hyderabad-Mahuva, Jaipur-Mumbai, Jaipur-Patna, Jaipur-Lasalgaon, Jaipur-Mahuva, Mumbai-Patna, Mumbai-Lasalgaon, Mumbai-Mahuva, Patna-Lasalgaon, Patna-Mahuva and Lasalgaon-Mahuva, respectively. The highest price transmission in onion was observed between Patna and Lasalgaon, markets with more than 90 per cent of the price change in Patna getting transmitted to Lasalgaon. Such transmission was 100 per cent for onion between Lasalgaon and Mahuva markets.

Table 4.25: Elasticity of price transmission of onion between different markets

Dependent/ independent	Ahmedabad	Bengaluru	Bhopal	Hyderabad	Jaipur	Mumbai	Patna	Lasalgaon
Ahmedabad	-	-	-	-	-	-	-	-
Bengaluru	0.06	-	-	-	-	-	-	-
Bhopal	0.16	0.10**	-	-	-	-	-	-
Hyderabad	0.11	0.26	0.10**	-	-	-	-	-
Jaipur	0.01***	0.15	0.12	0.09	-	-	-	-
Mumbai	0.34	0.82	0.26	0.17	0.07	-	-	-
Patna	0.20	0.01***	0.63	0.57	0.68	0.70	-	-
Lasalgaon	0.12	0.07	0.06	0.14	0.06	0.15	0.57	
Mahuva	0.15	0.19	0.05*	0.17	0.32	0.70	0.42	1.00

Note: *, ** and *** indicate significance at 5%, 10% and 1% levels, respectively.

4.7.3. Vector error correction model

The error correction model was applied to determine the effects of shocks in the short run and long run equilibrium among the markets. This model also allows for the short run shocks and estimates the degree of convergence towards the long run relationship. The results presented in Table 4.26 for onion markets.

For Ahmedabad onion market the short-run disequilibrium was found exist at one month leg period with the speed of convergence at 69 per cent, 41 per cent, 86 per cent, 65 per cent, 42 per cent, 65 per cent and 79 per cent with relationship to Bhopal, Hyderabad, Jaipur, Mumbai, Patna, Lasalgaon and Mahuva markets, respectively.

For Ahmedabad onion market the short-run disequilibrium was found exist at two month leg period with the speed of convergence at 45 per cent, 49 per cent, 54 per cent and 36 per cent with relationship to Jaipur, Mumbai, Patna and Mahuva markets, respectively.

For Bengaluru onion market the short-run disequilibrium was found exist at one month leg period with the speed of convergence at 36 per cent with relationship to Lasalgaon market.

For Bhopal onion market the short-run disequilibrium was found exist at one month leg period with the speed of convergence at 63 per cent, 64 per cent, 29 per cent, 34 per cent, 38 per cent, 37 per cent. 41 per cent and 18 per cent with relationship to Bengaluru, Bhopal, Hyderabad, Jaipur, Mumbai, Patna, Lasalgaon and Mahuva markets, respectively.

For Bhopal onion market the short-run disequilibrium was found exist at two month leg period with the speed of convergence at 41 per cent and 32 per cent with relationship to Bhopal and Patna markets, respectively.

For Hyderabad onion market the short-run disequilibrium was found exist at one month leg period with the speed of convergence at 27 per cent, 29 per cent and 29 per cent with relationship to Bengaluru, Bhopal and Hyderabad markets, respectively.

For Hyderabad onion market the short-run disequilibrium was found exist at two month leg period with the speed of convergence at 21 per cent with relationship to Jaipur market.

For Jaipur onion market the short-run disequilibrium was found exist at one month leg period with the speed of convergence at 27 per cent, 31 per cent, 37 per cent

and 54 per cent with relationship to Bengaluru, Mumbai, Patna and Lasalgaon markets, respectively.

For Jaipur onion market the short-run disequilibrium was found exist at two month leg period with the speed of convergence at 27 per cent and 62 per cent with relationship to Patna and Lasalgaon markets, respectively.

For Mumbai onion market the short-run disequilibrium was found exist at one month leg period with the speed of convergence at 32 per cent, 60 per cent, 34 per cent, 49 per cent, 50 per cent, 57 per cent and 26 per cent with relationship to Ahmedabad, Bengaluru, Bhopal, Hyderabad, Jaipur, Patna and Mahuva markets, respectively.

For Mumbai onion market the short-run disequilibrium was found exist at two month leg period with the speed of convergence at 34 per cent with relationship to Bhopal market.

For Patna onion market the short-run disequilibrium was found exist at one month leg period with the speed of convergence at 35 per cent, 31 per cent and 45 per cent with relationship to Hyderabad, Patna and Lasalgaon markets, respectively.

For Patna onion market the short-run disequilibrium was found exist at two month leg period with the speed of convergence at 34 per cent with relationship to Lasalgaon market.

For Lasalgaon onion market the short-run disequilibrium was found exist at one month leg period with the speed of convergence at 46 per cent, 67 per cent, 57 per cent, 39 per cent, 77 per cent, 84 per cent, 44 per cent and 36 per cent with relationship to Ahmedabad, Bengaluru, Bhopal, Hyderabad, Mumbai, Patna, Lasalgaon and mahuva markets, respectively.

For Lasalgaon onion market the short-run disequilibrium was found exist at two month leg period with the speed of convergence at 23 per cent, 24 per cent and 24 per cent with relationship to Bengaluru, Jaipur and Mahuva markets, respectively.

For Mahuva onion market the short-run disequilibrium was found exist at one month leg period with the speed of convergence at 36 per cent, 44 per cent, 37 per cent, and 50 per cent with relationship to Bengaluru, Jaipur, Mumbai and Lasalgaon markets, respectively.

For Mahuva onion market the short-run disequilibrium was found exist at two month leg period with the speed of convergence at 53 per cent, 31 per cent, 22 per cent

37 per cent and 25 per cent with relationship to Bengaluru, Mumbai, Patna, Lasalgaon and Mahuva markets, respectively.

Similar results were noted by Sidhu *et al.* (2010) in Panjab stated that in Patiala-Ludhiana market, 21 per cent of the short-term fluctuations in onion prices were found to get corrected within a week.

Table 4.26: Vector error correction model (VECM) estimates for onion markets.

Error Correction	D(AHM)	D(BEN)	D(BHO)	D(HYD)	D(JAI)	D(MUM)	D(PAT)	D(LAS)	D(MAH)
ECM	0.038 (0.593)	0.071 (0.992)	0.054 (0.810)	-0.088 (-1.508)	-0.297 (-4.269)	0.118 (1.554)	0.189 (2.673)	0.477 (6.333)	0.043 (0.844)
D[AHM(-1)]	0.141 (0.727)	0.351 (1.602)	0.692* (3.385)	0.414* (2.343)	0.863* (4.103)	0.650* (2.819)	0.427* (1.990)	0.658* (2.887)	0.779* (4.953)
D[AHM(-2)]	0.118 (0.587)	0.097 (0.428)	0.310 (1.460)	0.030 (0.1667)	0.456* (2.083)	0.494* (2.060)	0.542* (2.424)	0.376 (1.584)	0.361* (2.206)
D[BEN(-1)]	-0.073 (-0.591)	-0.207 (-1.485)	-0.139 (-1.070)	0.068 (0.607)	-0.063 (-0.476)	-0.150 (-1.021)	-0.308 (-2.257)	-0.366* (-2.520)	0.014 (0.139)
D[BEN(-2)]	0.037 (0.335)	-0.223 (-1.762)	0.205 (1.734)	0.128 (1.256)	-0.003 (-0.025)	-0.121 (-0.906)	-0.055 (-0.442)	-0.037 (-0.286)	-0.058 (-0.638)
D[BHO(-1)]	-0.175 (-1.594)	-0.63* (-5.091)	-0.644* (-5.557)	-0.290* (-2.897)	-0.343* (-2.877)	-0.385* (-2.952)	-0.374* (-3.072)	-0.410* (-3.173)	-0.179* (-2.014)
D[BHO(-2)]	-0.203 (-1.700)	-0.115 (-0.852)	-0.411* (-3.267)	-0.147 (-1.354)	-0.042 (-0.330)	-0.157 (-1.109)	-0.327* (-2.478)	-0.163 (-1.164)	-0.086 (-0.887)
D[HYD(-1)]	-0.176 (-1.411)	-0.271* (-1.923)	-0.295* (-2.237)	-0.292* (-2.566)	-0.248 (-1.832)	-0.246 (-1.655)	-0.095 (-0.692)	-0.036 (-0.246)	-0.123 (-1.212)

Table 4.26 Cont...

D[HYD(-2)]	0.034 (0.282)	-0.117 (-0.859)	0.035 (0.278)	-0.211* (-1.919)	-0.0895 (-0.683)	-0.039 (-0.273)	0.084 (0.632)	-0.001 (-0.013)	-0.087 (-0.891)
D[JAI(-1)]	-0.114 (-0.941)	-0.274* (-2.005)	-0.139 (-1.0930)	-0.049 (-0.446)	0.029 (0.224)	-0.315* (-2.193)	-0.371* (-2.765)	-0.546* (-3.841)	-0.086 (-0.881)
D[JAI(-2)]	-0.058 (-0.630)	-0.098 (-0.931)	-0.100 (-1.019)	-0.023 (-0.272)	0.040 (0.398)	-0.204 (-1.845)	-0.276* (-2.677)	-0.621* (-5.671)	0.062 (0.830)
D[MUM(-1)]	0.326* (1.993)	0.608* (3.296)	0.347* (2.016)	0.496* (3.335)	0.501* (2.830)	0.074 (0.385)	0.578* (3.195)	0.241 (1.257)	0.269* (2.033)
D[MUM(-2)]	-0.138 (-0.839)	0.078 (0.422)	-0.345* (-1.989)	-0.039 (-0.261)	-0.226 (-1.266)	-0.310 (-1.583)	-0.026 (-0.146)	-0.184 (-0.954)	-0.230 (-1.724)
D[PAT(-1)]	-0.189 (-1.303)	-0.281 (-1.716)	-0.018 (-0.119)	-0.359* (-2.717)	-0.197 (-1.253)	-0.217 (-1.259)	-0.312* (-1.942)	0.176 (1.035)	0.045* (-3.561)
D[PAT(-2)]	-0.010 (-0.072)	-0.140 (-0.884)	0.082 (0.559)	0.011 (0.0897)	-0.036 (-0.241)	-0.049 (-0.296)	-0.195 (-1.252)	0.341* (2.067)	0.045 (0.403)
D[LAS(-1)]	0.467* (4.120)	0.672* (5.254)	0.574* (4.801)	0.394* (3.815)	0.225 (1.832)	0.775* (5.754)	0.845* (6.734)	0.449* (3.367)	0.366* (3.983)
D[LAS(-2)]	0.094 (0.980)	0.230* (2.104)	0.014 (0.137)	0.074 (0.843)	-0.247* (-2.351)	0.243* (2.118)	0.190 (1.779)	0.029 (0.257)	0.115 (1.466)

Table 4.25 Cont....

D[MAH(-1)]	0.226 (1.731)	0.361* (2.446)	0.211 (1.529)	0.045 (0.380)	-0.449* (-3.160)	0.375* (2.411)	0.164 (1.133)	0.119 (0.777)	-0.500* (-4.710)
D[MAH(-2)]	0.145 (1.078)	0.537* (3.539)	0.187 (1.324)	0.066 (0.544)	-0.155 (-1.065)	0.312* (1.955)	0.221* (1.490)	0.373* (2.363)	-0.254* (-2.329)
C	2.324 (0.095)	1.589 (0.057)	-3.249 (-0.126)	1.674 (0.075)	3.622 (0.136)	1.068 (0.036)	-1.517 (-0.056)	-1.473 (-0.051)	4.171 (0.210)

Note: AHM = Ahmedabad, Ben= Bengaluru, BHO = Bhopal, HYD = Hyderabad, JAI = Jaipur, MUM = Mumbai, PAT = Patna, LAS =

Lasalgaon, MAH= Mahuva

*Indicates of significance of values at $p = 0.1$

4.7.4 Granger Causality test:

Granger Causality test was employed to know the direction between the markets. Theoretically, a variable, if the current value is conditional on the past data. The results of Pairewise Granger Causality test (Table 4.27) showed for onion markets that there was a bidirectional influence on prices of Bhopal and Ahmedabad, Hyderabad and Ahmedabad, Jaipur and Ahmedabad, Mumbai and Ahmedabad, Patna and Ahmedabad, Lasalgaon and Ahmedabad, Mahuva and Bengaluru, Hyderabad and Bengaluru, Jaipur and Bengaluru, Mumbai and Bengaluru, Lasalgaon and Bengaluru, Mahuva and Bengaluru, Hyderabad and Bhopal, Jaipur and Bhopal, Mumbai and Bhopal, Patna and Bhopal, Mahuva and Bhopal, Mumbai and Hyderabad, Patna and Hyderabad, Mumbai and Jaipur, Patna and Jaipur, Lasalgaon and Jaipur, Patna and Mumbai, Lasalgaon and Mumbai, Mahuva and Mumbai, Lasalgaon and Patna and Lasalgaon and Mahuva markets. There was a unidirectional influence on prices of Ahmedabad and Bengaluru i.e. price increase in Ahmedabad market has been transmitted to Bengaluru market, but Bengaluru market price does not influence Ahmedabad market. Likewise Bhopal and Bengaluru, Patna and Bengaluru, Lasalgaon and Bhopal, Jaipur and Hyderabad, Lasalgaon and Hyderabad, Mahuva and Hyderabad, Mahuva and Jaipur and Mahuva and Patna markets has unidirectional relationship.

Besides, India's main onion production market Lasalgaon has cause bidirectional relationship with Ahmedabad, Bengaluru, Jaipur, Mumbai, Patna and Mahuva. Whereas, Gujarat main onion production market Mahuva has bidirection relations with Ahmedabad, Bengaluru, Bhopal, Mumbai and Lasalgaon.

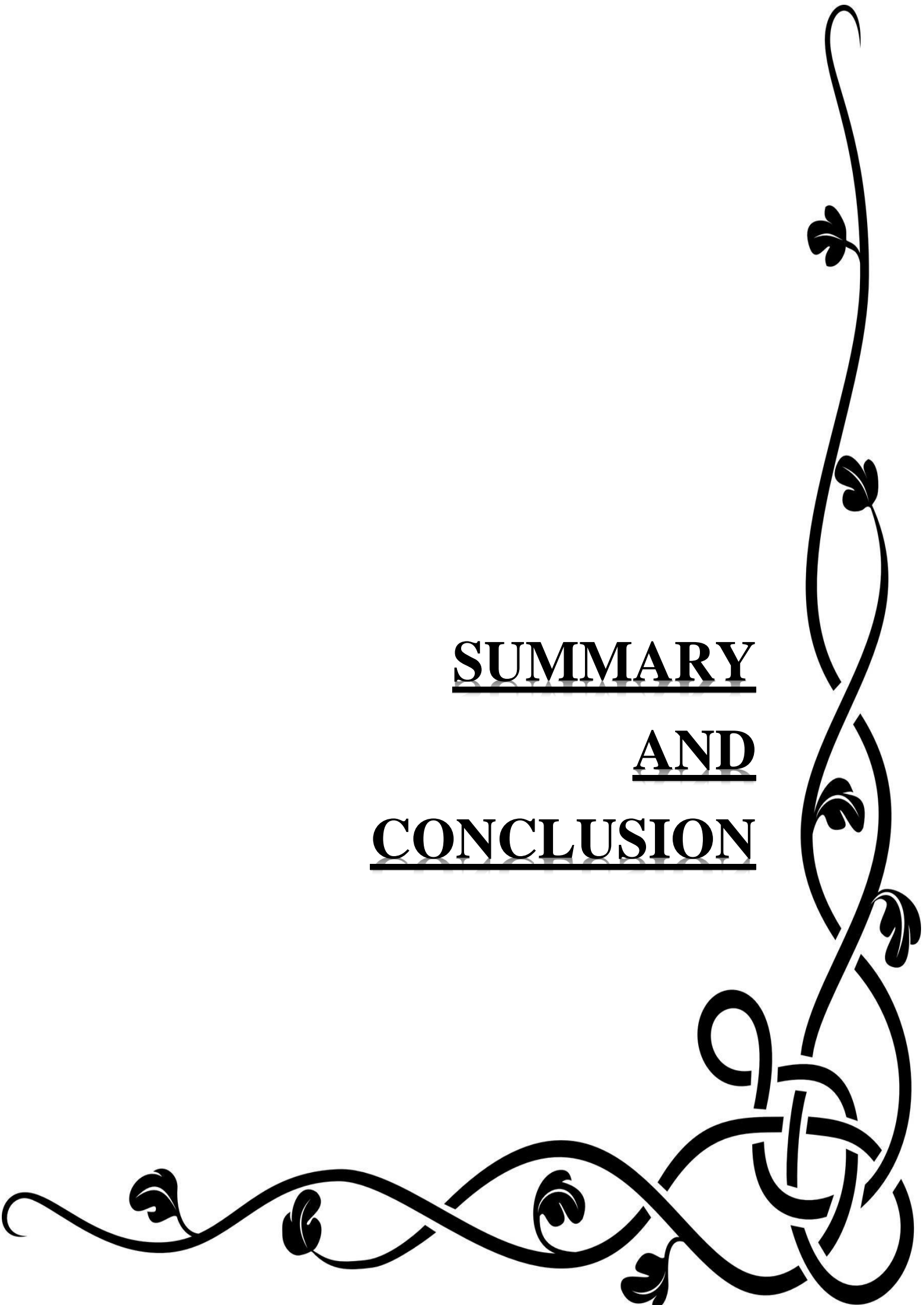
The similar results were obtain by Chudhari and Tinge (2012) in case of pigeonpea price movement noted across major markets of India. Besides, BIRTHAL and Negi (2019) revealed that onion markets were spatially integrated, that is there is a co-movement in prices across markets. Also Saxena and Chand (2017) reported that Lasalgaon prices major cause prices in all the markets under study, except Hubli and Solapur, Delhi shares bidirectional caused relationship with Bengaluru and Hubli.

Table 4.27: Pairwise granger causality tests for onion markets

Null Hypothesis	F-statistic	Prob.	Direction
BENGALURU does not Granger Cause AHMEDABAD AHMEDAVAD does not Granger Cause BENGALURU	0.967 13.416	0.381 3.E-06	Unidirectional
BHOPAL does not Granger Cause AHMEDAVAD AHMEDAVAD does not Granger Cause BHOPAL	7.666 49.867	0.0006 9.E-19	Bidirectional
HYDERABAD does not Granger Cause AHMEDAVAD AHMEDAVAD does not Granger Cause HYDERABAD	5.586 32.640	0.004 3.E-13	Bidirectional
JAIPUR does not Granger Cause AHMEDAVAD AHMEDAVAD does not Granger Cause JAIPUR	3.553 33.8560	0.030 1.E-13	Bidirectional
MUMBAI does not Granger Cause AHMEDAVAD AHMEDAVAD does not Granger Cause MUMBAI	6.750 15.5112	0.001 5.E-07	Bidirectional
PATNA does not Granger Cause AHMEDAVAD AHMEADAVAD does not Granger Cause PATNA	2.472 28.2303	0.086 1.E-11	Bidirectional
LASALGAON does not Granger Cause AHMEDAVAD AHMEDAVAD does not Granger Cause LASALGAON	29.687 13.4488	3E-12 3.E-06	Bidirectional
MAHUVA does not Granger Cause AHMEDAVAD AHMEDAVAD does not Granger Cause MAHUVA	4.817 17.2595	0.008 1.E-07	Bidirectional
BHOPAL does not Granger Cause BENGALURU BENGALURU does not Granger Cause BHOPAL	2.368 9.09866	0.095 0.0002	Unidirectional
HYDERABAD does not Granger Cause BENGALURU BENGALURU does not Granger Cause HYDERABAD	5.060 20.7566	0.0071 5.E-09	Bidirectional
JAIPUR does not Granger Cause BENGALURU BENGALURU does not Granger Cause JAIPUR	12.558 10.0913	E-06 6.E-05	Bidirectional
MUMBAI does not Granger Cause BENGALURU BENGALURU does not Granger Cause MUMBAI	14.924 3.16385	5E- 0.0441	Bidirectional
PATNA does not Granger Cause BENGALURU BENGALURU does not Granger Cause PATNA	2.142 0.90273	0.119 0.4069	Unidirectional
LASALGAON does not Granger Cause BENGALURU BENGALURU does not Granger Cause LASALGAON	49.154 1.57255	2.E-18 0.2097	Bidirectional
MAHUVA does not Granger Cause BENGALURU BENGALURU does not Granger Cause MAHUVA	19.697 5.69053	1.E-08 0.0039	Bidirectional
HYDERABAD does not Granger Cause BHOPAL BHOPAL does not Granger Cause HYDERABAD	4.375 4.07473	0.013 0.0182	Bidirectional
JAIPUR does not Granger Cause BHOPAL BHOPAL does not Granger Cause JAIPUR	10.112 4.98639	6.E-05 0.0076	Bidirectional


MUMBAI does not Granger Cause BHOPAL	35.359	4.E-14	
BHOPAL does not Granger Cause MUMBAI	3.81765	0.0234	Bidirectional
PATNA does not Granger Cause BHOPAL	14.658	1.E-06	
BHOPAL does not Granger Cause PATNA	0.14049	0.8690	Bidirectional
LASALGAON does not Granger Cause BHOPAL	82.982	6.E-28	
BHOPAL does not Granger Cause LASALGAON	1.31396	0.2707	Unidirectional
MAHUVA does not Granger Cause BHOPAL	23.172	7.E-10	
BHOPAL does not Granger Cause MAHUVA	3.37229	0.0360	Bidirectional
JAIPUR does not Granger Cause HYDERABAD	2.823	0.061	
HYDERABAD does not Granger Cause JAIPUR	1.74937	0.1762	Unidirectional
MUMBAI does not Granger Cause HYDERABAD	39.213	2.E-15	
HYDERABAD does not Granger Cause MUMBAI	10.0073	7.E-05	Bidirectional
PATNA does not Granger Cause HYDERABAD	11.840	1.E-05	
HYDERABAD does not Granger Cause PATNA	3.03661	0.0499	Bidirectional
LASALGAON does not Granger Cause HYDERABAD	68.589	4.E-24	
HYDERABAD does not Granger Cause LASALGAON	2.21357	0.1116	Unidirectional
MAHUVA does not Granger Cause HYDERABAD	13.688	2.E-06	
HYDERABAD does not Granger Cause MAHUVA	0.23625	0.7898	Unidirectional
MUMBAI does not Granger Cause JAIPUR	29.463	4.E-12	
JAIPUR does not Granger Cause MUMBAI	13.7542	2.E-06	Bidirectional
PATNA does not Granger Cause JAIPUR	16.982	1.E-07	
JAIPUR does not Granger Cause PATNA	10.4883	4.E-05	Bidirectional
LASALGAON does not Granger Cause JAIPUR	79.654	4.E-27	
JAIPUR does not Granger Cause LASALGAON	8.15858	0.0004	Bidirectional
MAHUVA does not Granger Cause JAIPUR	6.785	0.001	
JAIPUR does not Granger Cause MAHUVA	0.68767	0.5038	Unidirectional
PATNA does not Granger Cause MUMBAI	3.334	0.037	Bidirectional
MUMBAI does not Granger Cause PATNA	21.7831	2.E-09	
LASALGAON does not Granger Cause MUMBAI	55.241	2.E-20	Bidirectional
MUMBAI does not Granger Cause LASALGAON	7.90399	0.0005	
MAHUVA does not Granger Cause MUMBAI	9.886	8.E-05	Bidirectional
MUMBAI does not Granger Cause MAHUVA	15.0208	7.E-07	
LASALGAON does not Granger Cause PATNA	77.823	1.E-26	
PATNA does not Granger Cause LASALGAON	2.06988	0.1285	Bidirectional
MAHUVA does not Granger Cause PATNA	13.547	3.E-06	
PATNA does not Granger Cause MAHUVA	1.87427	0.1558	Unidirectional
MAHUVA does not Granger Cause LASALGAON	6.198	0.002	
LASALGAON does not Granger Cause MAHUVA	33.1828	2.E-13	Bidirectional

SUMMARY
AND
CONCLUSION



CHAPTER V

SUMMARY AND CONCLUSION



Onion is an important vegetable crop grown and consumed widely across the world. India is the second largest producer of onion in the world after China. Other important onion producing countries are Egypt, Iran, Turkey, Bangladesh *etc.* In India total acreage under onion cultivation constitutes about 10 per cent of total acreage under vegetables. Around 45 per cent of total onion produce takes place in the three Agricultural Export Zones, which comprises three states, namely, Maharashtra, Karnataka and Madhya Pradesh. Lasalgaon in Maharashtra is Asia's largest wholesale onion market. Which supplies about 80 per cent of the Maharashtra's supply. In country onion is produced in the major states *viz.*, Maharashtra, Madhya Pradesh, Karnataka, Bihar, Rajasthan, Gujarat and Andhra Pradesh.

In India Onion is an important commercial crop earning sizable foreign currencies, has received greater attention because of extreme price volatility. In case of extreme price rise, the farmers shift the area under cultivation of onion from other competing crops. Such decisions lead to glut in the next season and farmers sometimes are not able to recover even the cost of production.

It is well known that agricultural prices have a tendency to display wider inter and intra year fluctuations. Three main factors responsible for such wide fluctuations are: (a) relatively low price elasticity of demand for agricultural commodities, (b) biological nature of the agricultural productions and (c) seasonal nature of the agricultural industry. Thus, the marketing and price scenario needs to be effectively examined and monitored to understand the linkages among markets and nature of volatility in onion prices. This study is an attempt in this direction. Hence, its production growth, marketing and price scenario needs to be effectively examined.

Agricultural price policy is a potent tool for reshaping allocation of resources and distribution of income both within agriculture and between agricultural and non-agricultural sectors. Agricultural price stabilization and support policies are one of the major constituents of incentive policies. The knowledge of price behavior helps to take decision regarding price policy. Hence, the present investigation on "Growth

performance and price behavior of onion in major states of India” was taken with the following objectives:

1. To measure the temporal changes in area, production and productivity of onion in major states of India
2. To analyse the relative contribution of area and productivity towards the change in total onion production
3. To measure the onion production instability in major states of India
4. To measure trend and estimate rates of change in onion price in major states of India
5. To measure the variability of onion prices in major states in India
6. To analyse the seasonal and irregular fluctuations in onion prices
7. To determine interrelation of onion prices among the states

5.1 Methodology

The study had use the secondary data to measure growth and instability in area, production and productivity, price variability and price trends. The analysis of growth and instability in area, production and productivity was carried out from the year 1990-91 to 2019-20, which in turn, splitted into four periods *viz.*, Period- I (1990-91 to 1999-2000), Period- II (2000-01 to 2009-10) and Period-III (2010-11 to 2019-20) and overall Period-IV (1990-91 to 2019-20). As per the availability of data the price trend and variability analysis was carried out from the year 2001-02 to 2019-20.

Based on annual average production, major seven states, *viz.*, Maharashtra, Madhya Pradesh, Karnataka, Gujarat, Bihar, Rajasthan and Andhra Pradesh were selected for this study purpose. In order to select the markets, one major market from each selected major states was chosen to study the price behaviour. Major nine markets, *viz.* Ahmedabad, Bhopal, Bengaluru, Hyderabad, Jaipur, Mumbai, Patna (*i.e.* consumption markets), Lasalgaon and Mahuva (*i.e.* production markets) were selected for this study purpose; representing both, consumption and major producing locations markets.

The compound growth rates of area, production, yield and prices were worked out with the help of semi log trend equation. For the estimation of instability in area, production and productivity of onion Cuddy Della Valle index for each period was calculated. Modified decomposition model was employed to analyse relative contribution of area and yield to the total output change of onion. To find out the variability in the price of onion under study, coefficient of variation were worked out

for monthly and yearly prices. To estimate trend. The linear and quadratic models were fitted. The seasonal variations in the prices were worked out by assuming a multiplicative model. Irregular variation and inter relationship between price of onion were also worked out for the period from 2001 to 2020. To examine the co-integration and subsequently, the causal relationship and its direction (s) between the prices of selected markets were analysed using the ADF unit root test, Vector Error Correction Model (VECM) and Granger causality test. The major findings that emerged from the study are summarized below:

5.2 Temporal changes in area, production and productivity of onion

During 1990-91 to 2000-01 *i.e.* Period-I the highest increase in area under onion was reported in Karnataka (9.78%). In case of onion production in Period-I, Andhra Pradesh registered significantly the highest growth rate of 12.68 per cent per annum followed by Madhya Pradesh (8.07%) and Gujarat (5.52%). During Period-I, the growth rate of productivity of onion was recorded the highest in Andhra Pradesh about 6.28 per cent per annum. In Period-II, significantly the highest increase in area production of onion was reported in Gujarat at the rate of 19.89 and 20.96 per cent per annum, respectively. During Period II, the growth rate of productivity of onion was reported the highest in Karnataka at the rate of 13.14 per cent per annum.

In Period-III, Madhya Pradesh obtained significantly the highest growth rate of onion area about 10.06 per cent per annum, followed by Maharashtra (5.12%), Karnataka (1.22%) and Bihar (0.70%). In Period-III, significantly the highest increase in onion production was reported in Madhya Pradesh (12.70%). Whereas, Rajasthan shown significantly the highest increase in onion yield by 11.06 per cent per annum.

In overall period from 1990-91 to 2019-20, Madhya Pradesh recorded the highest significant increase in onion area at the rate of 9.23 per cent per annum followed by Maharashtra (8.04%) and Rajasthan (6.31%). While, Gujarat (4.82%), Karnataka (4.52%) and Andhra Pradesh (3.55%) shown the low, but significant positive growth in area of onion during overall period. At all India level shown significantly positive growth in onion area (5.89%) during overall period.

The growth rate in onion production noticed the highest in Madhya Pradesh at the rate of 12.69 per cent per annum followed by Bihar (10.69%) and Rajasthan (9.80%) during overall period. While, Gujarat (4.87%) shown the low, but significant positive growth in production of onion during overall period. At all India level, onion production increased significantly at the rate of 8.33 per cent per annum during overall period.

Thus, during last three decades, Maharashtra contributed considerably for increasing onion production in India.

In case of onion productivity during overall period, Bihar registered significantly the highest growth rate of 4.59 per cent per annum followed by Karnataka (3.45%) and Rajasthan (3.28%). While, Gujarat noticed stagnant productivity growth of onion during overall period. At all India level, onion productivity increased significantly at the rate of 2.30 per cent per annum during overall period. Thus, during last three decades, Rajasthan and Maharashtra contributed considerably for increasing onion productivity in India.

5.3 Instability in area, production and yield of onion in major states of India

Among all the states, Gujarat (44.23%) showed the highest instability in onion area during Period-I. In case of onion production, the Gujarat (50.79%) and Karnataka (42.15%) had shown high instability in Period-I, and in case of productivity, Karnataka state recorded high instability (41.67%) during Period-I. In Period-II, onion area in Gujarat (37.51%) showed the highest instability. Among all the states, only Bihar (28.41%) showed medium instability in onion area during Period-II. whereas, all other states under study and at all India level showed low instability in area in Period-II. In Period-II, onion production in Karnataka (52.02%), Bihar (43.65%) and Gujarat (43.17%) had shown high instability. While, in case of onion productivity, Karnataka recorded the highest instability (48.63%) in Period-II. In Period-III, onion area in Rajasthan (36.43%) showed the highest instability. Besides, the states of Andhra Pradesh (27.19%) and Gujarat (23.78%) showed medium instability in onion area during Period-III. In case of onion production, Andhra Pradesh (27.97%), Gujarat (24.37%) and Rajasthan (23.87%) experienced medium instability during Period-III.

In overall period from 1990-91 to 2019-20, Rajasthan (39.27%), Gujarat (37.56%) and Madhya Pradesh (37.05%) showed high instability in onion area and it was medium at all India level. Whereas, Karnataka (13.87%) showed low instability in onion area during last three decades. The medium instability was noticed in overall study period in Bihar, all India and Andhra Pradesh. In overall study period, Rajasthan (28.53%) and Bihar (17.16%) had recorded having medium instability in productivity. Whereas, at all India level under study showed low instability in area during overall period. Bihar and Rajasthan had recorded the medium instability in onion area, production and productivity in overall period.

5.4 Decomposition of growth in onion production

During, 1990s, Bihar recorded the highest area effect (45.72%) followed by Andhra Pradesh (30.78%) and Madhya Pradesh (16.84%). Whereas, the yield effect was found to be positive in all the states during 1990-91 to 2000-01. Among all the states, Gujarat recorded highest yield effect (400%) in period-I. While, Interaction effect contributed negatively to onion production in Maharashtra (-16.64%) and Andhra Pradesh (-3.31%) in Period-I. Whereas, Interaction effect was found to be positive for the states of Gujarat (451.22%) followed by Karnataka, Rajasthan, Madhya Pradesh and Bihar.

The highest area effect was reported in Karnataka (116.62%) followed by Rajasthan (67.43%) during 2000s. Among all the states, Andhra Pradesh recorded the highest yield effect (119.88%) in Period-II. Whereas, in all the states under study and at all India level, yield effect was found to contribute more to onion production as compared to area effect and interaction effect, except Karnataka and Rajasthan. The highest area effect was recorded in Rajasthan (142.98%) as compared to all the other states under study during 2010s. The highest yield effect was recorded in Gujarat (195.81%) as compared to all the other states under study during Period-III. Whereas, highest Interaction effect was recorded in Andhra Pradesh (45.68%).

During overall period from 1990-91 to 2019-20, the highest area effect was recorded in Rajasthan (102.94%) followed by Karnataka (62.72). On the contrary, in Gujarat, the area effect was responsible for decreasing onion production in overall period. Whereas, yield effect contributed positively to onion production in all the states under study during overall period. The highest yield effect was recorded in Gujarat (100.75%) as compared to all other states under study during overall period. In case of interaction effect, Bihar recorded the highest interaction effect (63.62%) as compared to all other states under study in overall period. At all India level, all three effects were found to be positive. Beside, yield and area effect were found to have contributed about 70 and 30 per cent, respectively towards the increase in total production and interaction effect slightly about 0.09 per cent.

5.5 Trend in onion price

Among the nine onion markets under study, during 2001 to 2020 the annual rate of increase was the highest i.e. 24.95 per cent in Lasalgaon market and the lowest was 14.18 per cent in Bhopal market. Co-efficient of multiple determination (R^2) was more than 52 per cent for all markets, indicating more than 50 per cent of variation in

price of onion could be explain through linear trend. Whereas, in case of quadratic growth trend analysis indicated that the value of adjusted co-efficient of multiple determination were found to be same in quadratic model and linear model in Hyderabad market. While in case of onion in Bhopal market value of adjusted co-efficient of multiple determination were found to be lower, revealed that the linear model is a better fit than quadratic model. Quadratic model showed constant growth pattern in onion prices.

The compound rates of increase in prices in onion for all markets were statistically significant during the period under study. The prices of onion in all selected markets increased at the rate ranging from 7.84 to 9.61 per cent per annum. This indicates that on an average onion prices increased annually at the rate of 8.50 per cent during last two decades.

5.6 Seasonal and irregular variation

The seasonal variations in onion price were analysed by assuming a multiplicative model using secondary data of monthly prices for the period from 2001 to 2020. The prices of onion for all markets under study indicated that the maximum value of seasonal index was found in Mumbai market in November (138.64 points) and minimum value of seasonal index was found in Bhopal market in May (54.30 points). The maximum value of the coefficient in seasonal variation was found in Bhopal market (85.73%) and minimum value of the coefficient in seasonal variation was found in Mahuva market (49.67%). Thus, it can be revealed that during the period 2001 to 2020, onion crop under study had showed high coefficient of average seasonal variation in most of markets.

The Ahmedabad market revealed high degree of irregular fluctuations, while Bhopal market showed less degree of irregular fluctuations.

5.7 Inter-relationship between prices of different markets of onion

The values of correlation coefficient of monthly prices of onion under study were more than 0.87 and values of correlation coefficient of yearly prices of onion under study were more than 0.90 and were highly significant. The result indicated that yearly and monthly prices of onion moved in the same direction.

Looking to the stationality of market price series, the results of the Augmented Dickey-Fuller (ADF) unit root test for onion showed that the data are level stationary, indicated that, all market price series were integrated of the order 1 *i.e.* I(0).

For short-run transfer of price between the markets, the analysis of vector error correction model (VECM) revealed that for Ahmedabad onion market the short-run disequilibrium was found exist at one month lag period with the speed of convergence at 69 per cent, 41 per cent, 86 per cent, 65 per cent, 42 per cent, 65 per cent and 79 per cent with relationship to Bhopal, Hyderabad, Jaipur, Mumbai, Patna, Lasalgaon and Mahuva markets, respectively. For Bengaluru onion market the short-run disequilibrium was found exist at one month lag period with the speed of convergence at 36 per cent with relationship to Lasalgaon market. For Mahuva onion market the short-run disequilibrium was found exist at two month lag period with the speed of convergence at 53 per cent, 31 per cent, 22 per cent 37 per cent and 25 per cent with relationship to Bengaluru, Mumbai, Patna, Lasalgaon and Mahuva markets, respectively. This shown considerable price transmission in a short time.

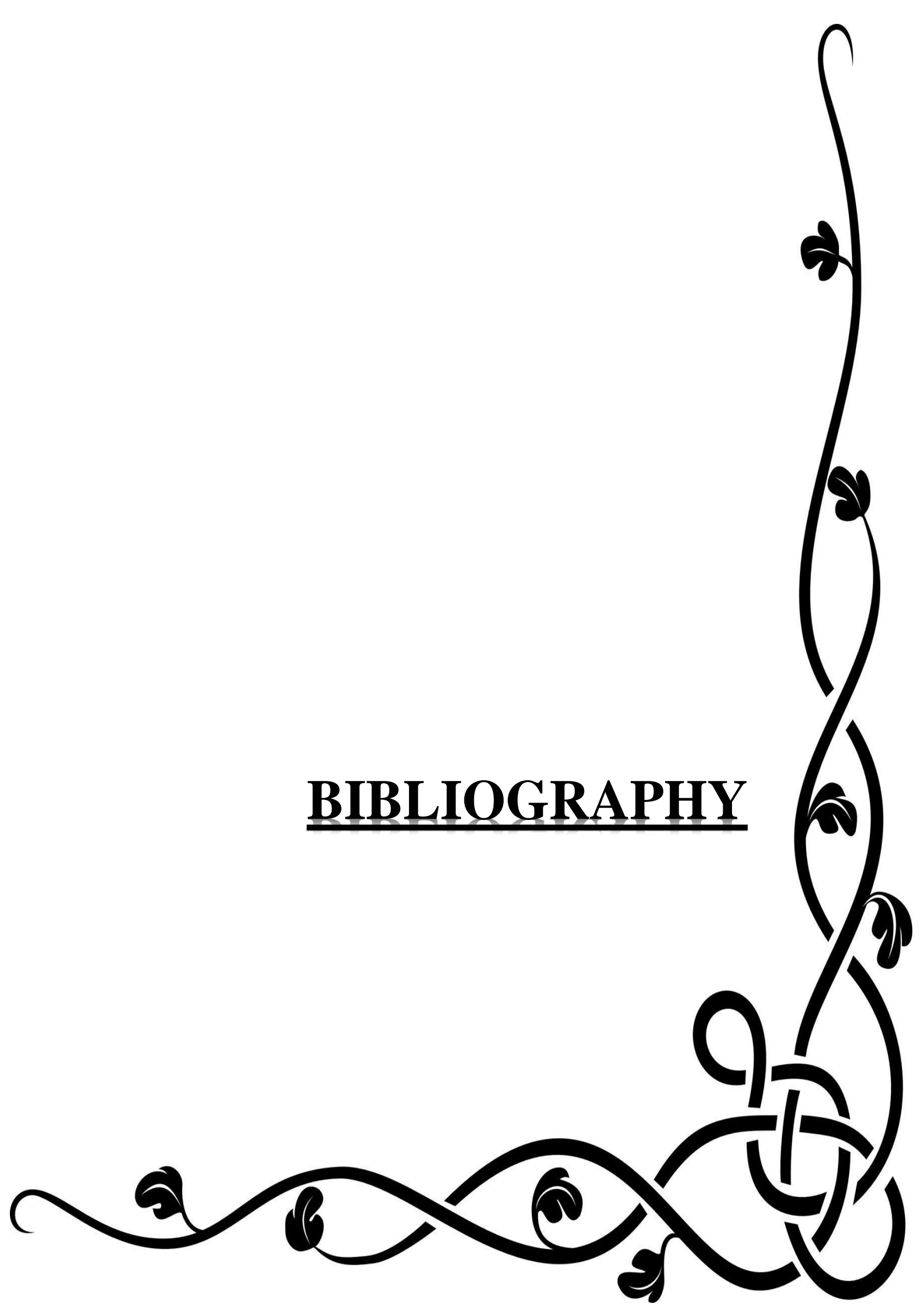
The results of pairwise granger causality test indicated that there was a bidirectional influence on prices of Bhopal and Ahmedabad, Hyderabad and Ahmedabad, Jaipur and Ahmedabad, Mumbai and Ahmedabad, Patna and Ahmedabad, Lasalgaon and Ahmedabad, Mahuva and Bengaluru, Hyderabad and Bengaluru, Jaipur and Bengaluru, Mumbai and Bengaluru, Lasalgaon and Bengaluru, *etc.* This showed that most of the markets have bidirectional relationship for price transmission among, the selected markets under study. Beside, in few markets there was a unidirectional influence on prices *viz.*, Bengaluru and Ahmedabad, Bhopal and Bengaluru, Patna and Bengaluru, Lasalgaon and Bhopal, Jaipur and Hyderabad, Lasalgaon and Hyderabad, Mahuva and Hyderabad, Mahuva and Jaipur and Mahuva and Patna markets. Thus, most of the markets have bidirectional relationship for price transmission.

Policy implications

- Onion production in India increased considerably in last three decades and it has vast scope to increase further having large domestic as well as export demand. The technological innovations should be provided to farmers by extension agents.
- The high instability in onion area and production in Gujarat, Madhya Pradesh and Rajasthan is mainly due to shortage of irrigations in poor monsoon years, needs to develop more irrigation infrastructure in these states.

- Very low productivity of onion in Karnataka and Rajasthan indicates that there exists a vast untapped yield potential, which can be achieved by taking proper agronomical practices that can be easily adopted by farmers.
- High seasonal variations in onion prices in major producing markets reveals that farmers have very poor infrastructural facilities for storage, which needs to be enhanced by the government on large scale basis providing subsidy for construction of storage godowns.
- Onion price experienced vulnerable to violent fluctuations throughout country, needs immediate action by the government to allow more export when price is decline in the country and curb the export when price increasing extremely in the domestic markets.
- The growers should be given training to update knowledge base regarding new marketing strategies, export price fluctuations, export trends and competitive advantage available in international market through FPO's (Farmer Producer Organizations) or through other organizations/ epic resources.
- The advance estimates of area and production of onion in country in rabi and summer seasons should be made timely, backed with sound market intelligence about price in major producing markets and likely effect of supply shocks, which is prime important for farmers to take selling decision.

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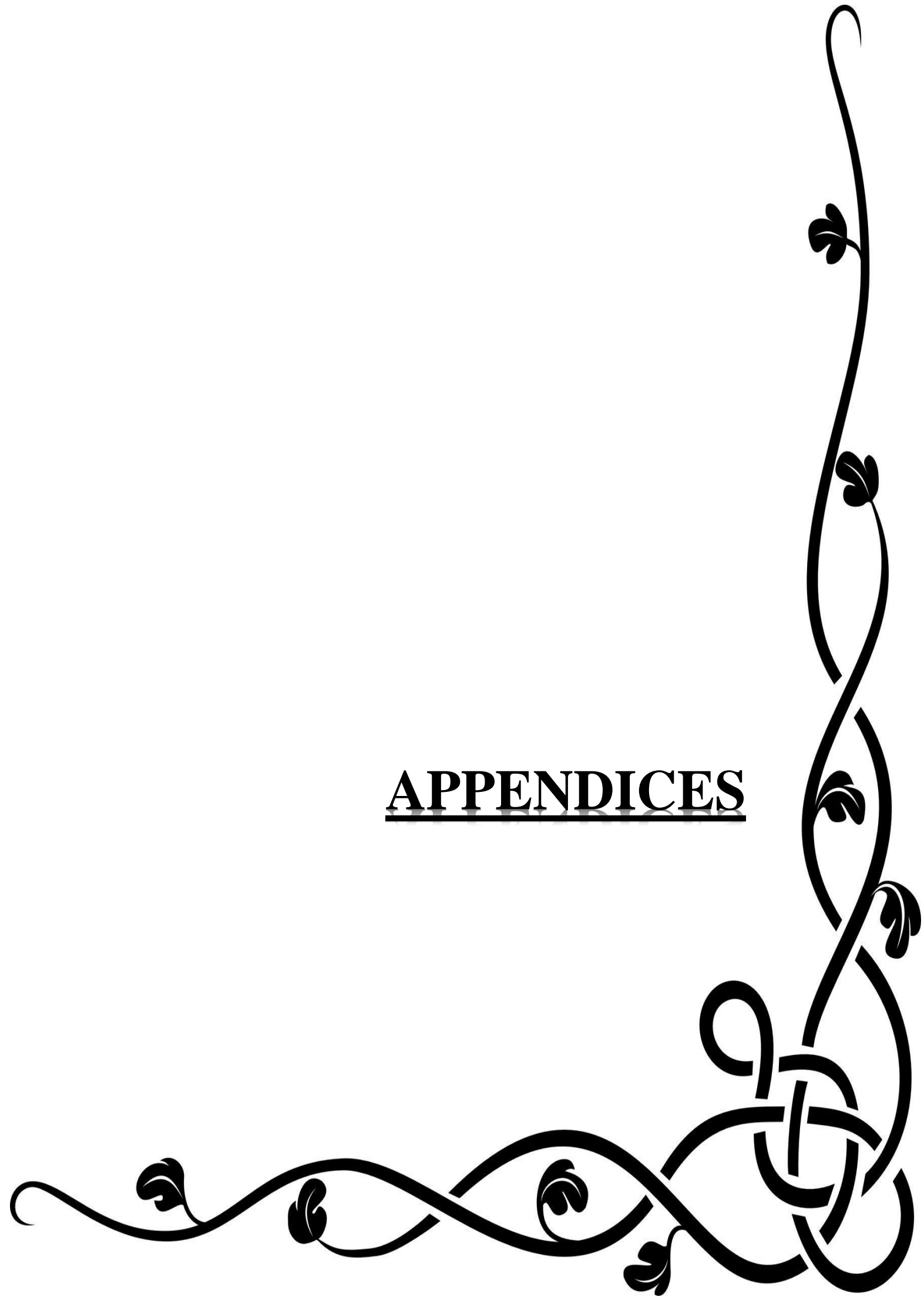
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APPENDICES



Appendix – I

Area, production and productivity of onion in major states of India

Sr. No.	Year	Andhra Pradesh			Bihar			Gujarat		
		A	P	Y	A	P	Y	A	P	Y
		000' ha	000 tons	t/ha	000 ha	000 tons	t/ha	000 ha	000 tons	t/ha
1	1990-91	19.8	176.2	8.9	14.1	113.6	8.1	17.9	424.4	23.7
2	1991-92	20.6	185.5	9.0	15.3	152.7	10.0	17.9	463.6	25.9
3	1992-93	18.8	164.0	8.7	15.8	155.5	9.8	21.0	483.0	23.0
4	1993-94	20.0	415.2	20.8	17.0	149.2	8.8	23.0	549.3	23.9
5	1994-95	20.8	314.7	15.1	17.6	142.8	8.1	20.3	561.5	27.7
6	1995-96	24.0	373.6	15.6	17.5	137.3	7.8	19.0	444.0	23.4
7	1996-97	27.2	369.2	13.6	19.1	145.2	7.6	16.5	433.0	26.2
8	1997-98	21.0	328.0	15.6	18.1	137.9	7.6	20.9	619.0	29.6
9	1998-99	31.1	478.3	15.4	20.4	193.0	9.5	52.2	1462.1	28.0
10	1999-00	35.1	522.7	14.9	20.0	212.3	10.6	19.9	450.7	22.6
11	2000-01	30.3	536.5	17.7	13.8	140.8	10.2	6.4	131.2	20.5
12	2001-02	31.8	559.4	17.6	17.1	163.0	9.5	24.2	640.2	26.5
13	2002-03	27.1	412.6	15.2	17.7	152.0	8.6	25.0	717.4	28.7
14	2003-04	29.0	520.0	17.9	48.3	918.0	19.0	49.1	1479.3	30.1
15	2004-05	34.0	603.0	17.7	48.8	975.0	20.0	44.0	1223.0	27.8
16	2005-06	36.0	696.0	19.3	24.1	266.0	11.0	76.0	2128.0	28.0
17	2006-07	31.0	579.0	18.7	50.5	963.0	19.1	76.0	2128.0	28.0
18	2007-08	37.0	700.0	18.9	51.3	1020.0	19.9	65.0	2059.0	31.7
19	2008-09	39.0	662.6	17.0	51.6	946.6	18.3	57.6	1409.6	24.5
20	2009-10	39.0	662.6	17.0	53.0	972.0	18.3	43.4	1078.6	24.9
21	2010-11	47.8	812.6	17.0	53.3	1082.0	20.3	62.0	1514.1	24.4
22	2011-12	48.5	824.8	17.0	53.8	1236.7	23.0	61.3	1562.2	25.5
23	2012-13	86.7	1560.1	18.0	53.0	1107.8	20.9	28.9	704.4	24.4
24	2013-14	55.8	1004.6	18.0	54.3	1304.2	24.0	72.8	1851.2	25.4
25	2014-15	38.4	575.6	15.0	54.3	1247.3	23.0	44.3	1126.6	25.4
26	2015-16	45.0	885.4	19.7	54.0	1247.3	23.1	53.2	1355.8	25.5
27	2016-17	41.7	916.4	22.0	54.1	1249.0	23.1	51.6	1290.2	25.0
28	2017-18	42.0	915.7	21.8	53.8	1240.6	23.1	54.5	1416.6	26.0
29	2018-19	44.6	980.6	22.0	56.5	1311.5	23.2	44.3	1111.1	25.1
30	2019-20	48.2	1060.9	22.0	58.0	1313.2	22.6	57.3	1422.3	24.8

Appendix – II

Area, production and productivity of onion in major states of India

Sr. No.	year	karnataka			Madhya Padesh			Maharashtra		
		A	P	Y	A	P	Y	A	P	Y
		000 ha	000 tons	t/ha	000 ha	000 tons	t/ha	000 ha	000 tons	t/ha
1	1990-91	43.2	333.1	7.7	15.5	185.2	11.9	66.5	840.1	12.6
2	1991-92	60.0	875.9	14.6	15.5	184.0	11.9	79.1	831.6	10.5
3	1992-93	67.4	1085.5	16.1	17.9	212.8	11.9	78.9	1210.0	15.3
4	1993-94	63.1	414.1	6.6	19.1	227.1	11.9	101.6	1210.0	11.9
5	1994-95	72.7	431.5	5.9	19.7	214.7	10.9	93.7	1206.7	12.9
6	1995-96	78.8	440.3	5.6	21.1	235.4	11.2	92.6	1120.5	12.1
7	1996-97	90.5	508.7	5.6	23.6	308.9	13.1	95.5	1189.1	12.5
8	1997-98	91.0	517.4	5.7	22.3	281.8	12.6	96.7	907.7	9.4
9	1998-99	93.6	508.4	5.4	25.3	337.6	13.3	103.9	1183.6	11.4
10	1999-00	125.7	594.7	4.7	27.5	366.3	13.3	112.6	1392.6	12.4
11	2000-01	120.3	665.4	5.5	19.4	272.7	14.1	118.1	1687.5	14.3
12	2001-02	125.8	721.0	5.7	23.1	324.6	14.1	108.0	1307.0	12.1
13	2002-03	115.0	535.8	4.7	24.7	345.0	14.0	121.0	1427.0	11.8
14	2003-04	101.2	360.5	3.6	31.0	416.2	13.4	134.0	1645.0	12.3
15	2004-05	136.0	856.0	6.3	34.8	535.6	15.4	134.0	1645.0	12.3
16	2005-06	151.0	870.0	5.8	37.8	572.0	15.1	177.0	2469.0	13.9
17	2006-07	151.3	859.1	5.7	37.9	629.7	16.6	229.8	2812.4	12.2
18	2007-08	182.0	1107.0	6.1	38.6	559.7	14.5	204.7	2713.3	13.3
19	2008-09	165.1	3031.8	18.4	53.0	881.8	16.6	250.0	3932.5	15.7
20	2009-10	141.3	2266.2	16.0	57.3	952.3	16.6	200.0	3146.0	15.7
21	2010-11	190.5	2592.2	13.6	58.3	1021.5	17.5	415.0	4905.0	11.8
22	2011-12	177.2	2451.2	13.8	88.1	1957.0	22.2	382.0	5638.0	14.8
23	2012-13	159.6	2395.9	15.0	111.7	2691.0	24.1	260.0	4660.0	17.9
24	2013-14	136.6	2065.2	15.1	117.3	2826.0	24.1	468.0	5864.0	12.5
25	2014-15	187.0	3227.0	17.3	117.9	2842.0	24.1	441.9	5361.0	12.1
26	2015-16	190.2	2696.0	14.2	118.2	2848.0	24.1	522.4	6529.3	12.5
27	2016-17	217.8	3049.5	14.0	150.8	3721.6	24.7	481.1	6734.7	14.0
28	2017-18	195.3	2996.5	15.3	150.9	3701.9	24.5	508.0	8854.0	17.4
29	2018-19	208.5	3440.7	16.5	149.8	3683.1	24.6	444.4	8047.4	18.1
30	2019-20	160.0	2275	14.2	173.9	4270.7	24.6	618.0	10683.0	17.3

Appendix – III

Area, production and productivity of onion in major states of India

Sr. No.	year	Rajasthan			All india		
		A	P	Y	A	P	Y
		000 ha	000 tons	t/ha	000 ha	000 tons	t/ha
1	1990-91	17.0	121.9	7.2	301.9	3226.2	10.7
2	1991-92	19.0	127.9	6.7	323.3	3584.7	11.1
3	1992-93	15.2	118.9	7.8	323.5	3490.0	10.8
4	1993-94	16.1	122.4	7.6	367.5	4006.4	10.9
5	1994-95	16.6	83.2	5.0	378.6	4036.1	10.7
6	1995-96	21.7	161.7	7.5	395.5	4080	10.3
7	1996-97	24.4	206.2	8.5	403.4	4180.7	10.4
8	1997-98	19.7	113.5	5.8	397.9	3617.4	9.1
9	1998-99	20.2	120.7	6.0	468.1	5331.9	11.4
10	1999-00	25.4	173.3	6.8	493.3	4899.5	9.9
11	2000-01	24.6	165.1	6.7	421.9	4550.5	10.8
12	2001-02	28.4	206.3	7.3	452.1	4831.0	10.7
13	2002-03	26.5	155.7	5.9	435.4	4506.1	10.3
14	2003-04	33.6	249.1	7.4	502.6	5922.5	11.8
15	2004-05	42.9	347.9	8.1	549.1	6434.6	11.7
16	2005-06	44.5	427.2	9.6	661.9	8682.6	13.1
17	2006-07	38.6	370.3	9.6	702.1	8885.1	12.7
18	2007-08	36.0	363.4	10.1	704.4	9138.0	13.0
19	2008-09	41.0	369.1	9.0	834.2	13564.5	16.3
20	2009-10	45.0	742.5	16.5	756.2	12158.8	16.1
21	2010-11	49.0	494.2	10.1	1063.8	15117.7	14.2
22	2011-12	73.5	664.2	9.0	1087.2	17511.1	16.1
23	2012-13	139.1	467.2	3.4	1051.5	16813	16.0
24	2013-14	57.5	705.0	12.3	1203.6	19401.7	16.1
25	2014-15	61.4	960.8	15.7	1174.8	18927.0	16.1
26	2015-16	86.3	1435.1	16.6	1320.0	20931.2	15.9
27	2016-17	62.5	1149.3	18.4	1305.6	22427.4	17.2
28	2017-18	64.8	996.7	15.4	1285.0	23262.3	18.1
29	2018-19	63.1	997.3	15.8	1220.0	22819.0	18.7
30	2019-20	74.6	1241.8	16.65	1431.4	26091.4	18.2

Appendix –IV

Monthly price of onion in Ahmedabad (Rs./qtl.)

Ahmedabad (Gujarat)																				
Year / M	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
January	454	310	287	831	330	385	806	411	1241	1188	2232	404	1280	1083	1359	942	717	3035	593	3577
February	305	258	241	744	306	252	892	371	1050	1041	915	341	1301	728	1569	741	650	1823	533	2139
March	280	243	195	398	300	239	728	425	814	748	457	415	958	808	1389	748	662	926	651	1759
April	261	228	278	294	319	212	492	340	545	525	416	435	834	785	1099	768	578	686	713	1287
May	214	210	308	254	269	210	461	262	455	486	385	378	719	860	1140	618	496	592	804	1051
June	279	281	394	283	273	271	659	374	683	565	463	468	1206	1162	1582	753	591	840	997	816
July	332	327	595	325	378	321	896	579	626	674	621	588	2044	1732	1957	782	659	1121	1190	782
August	420	358	498	413	508	362	1055	650	675	810	740	678	3430	1459	3838	680	1899	922	1709	1552
September	522	450	525	390	1337	348	1350	577	645	1230	793	629	4349	1360	4180	507	1403	784	2889	2323
October	499	517	719	483	986	421	1382	500	1288	1464	734	740	3450	1460	2757	697	2238	1090	2881	3898
November	570	420	552	464	1035	513	864	988	1627	1665	731	856	3061	1436	1881	832	2890	879	4344	3733
December	450	281	654	386	651	753	611	1083	1288	2282	535	944	1530	1453	1283	749	3049	658	6034	2380

Appendix –V

Monthly price of onion in Bengaluru (Rs./qtl.)

Bengaluru (Karnataka)																				
Year / M	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
January	425	330	406	912	506	512	806	551	1574	1721	3854	650	1658	1118	1758	1494	738	2859	545	3280
February	334	273	304	818	512	366	806	559	1310	1296	1258	574	1770	794	1815	1236	754	1526	491	1966
March	265	259	283	590	320	429	650	470	860	808	690	604	1250	747	1576	875	685	882	646	1494
April	243	237	402	473	343	383	558	431	636	673	646	628	1087	743	1455	800	622	608	740	1108
May	281	249	409	457	440	329	677	416	632	790	675	594	1196	1015	1725	791	581	638	796	757
June	367	343	436	500	430	482	1000	564	854	902	820	750	1673	2038	2182	815	713	824	1123	850
July	443	487	517	533	575	529	1050	848	820	923	1070	826	2319	2554	2357	931	740	1036	1113	825
August	567	478	549	532	800	505	1283	923	1144	998	1300	946	3090	2241	2727	818	1987	1059	1577	1250
September	567	461	541	530	974	534	1493	795	724	1455	1230	905	3192	1754	2536	870	1511	967	2620	2360
October	601	410	909	457	1529	474	1257	775	1767	1568	1067	1050	3493	1643	2223	931	1987	1112	2463	4719
November	777	509	867	418	1145	444	965	1253	1998	2734	1030	1604	2909	1507	2664	1243	3011	1071	4771	5062
December	490	386	830	447	713	444	760	1475	2280	3842	793	1757	1580	1377	1494	917	2991	639	7792	2869

Appendix –VI

Monthly price of onion in Bhopal (Rs./qtl.)

Bhopal																				
Year / M	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
January	525	415	221	874	343	407	963	390	1323	1140	2562	458	796	746	1287	570	584	2519	738	3600
February	414	300	229	706	264	332	1169	363	1076	1095	1019	425	1790	713	1359	452	537	1614	604	2316
March	355	210	291	538	283	316	750	363	882	713	569	594	1202	708	1539	475	517	1219	625	1713
April	402	254	297	304	294	244	525	338	614	503	496	455	835	650	1278	411	739	812	660	1201
May	338	221	226	234	240	193	349	395	536	349	426	304	611	781	958	397	584	666	635	690
June	367	251	233	243	244	236	623	411	884	491	527	352	1014	1176	1383	492	523	830	933	711
July	587	705	436	385	594	418	887	506	841	663	740	654	1924	2177	1978	746	575	1056	1042	1075
August	391	424	400	391	450	384	1015	647	694	788	924	662	3734	1871	4057	674	943	938	1465	852
September	650	429	533	357	775	388	1452	670	751	1085	1412	717	3596	1386	5543	548	828	822	2681	1383
October	593	480	870	546	1110	429	1405	738	1298	1336	1081	742	3738	1667	2536	686	1292	848	2816	3508
November	706	516	833	416	1037	382	802	723	1623	1581	789	776	3137	1833	1628	711	1892	841	3950	3318
December	575	339	592	311	750	514	441	1170	871	1918	614	740	1496	1436	926	642	2479	622	6875	1994

Appendix –VII

Monthly price of onion in Hyderabad (Rs./qtl.)

Hyderabad																				
Year / M	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
January	475	329	293	842	486	437	959	517	1341	1034	2875	654	1253	844	2029	1629	858	3292	823	4315
February	280	291	258	747	472	302	925	449	1200	895	1267	629	1976	609	1724	1210	836	2026	773	2168
March	250	283	279	510	390	258	995	373	954	1248	586	690	1448	635	1352	896	796	1098	856	1644
April	375	238	373	413	358	250	550	357	993	1663	461	756	1248	547	1433	898	755	883	1007	1272
May	469	254	431	410	357	225	605	344	814	982	400	764	1256	600	1640	871	668	848	1124	1086
June	513	347	493	513	464	300	840	336	678	1331	515	756	1145	890	1717	987	826	1160	1677	901
July	550	395	535	477	549	350	900	640	882	869	752	688	1675	1360	1750	1191	865	1483	1559	764
August	677	499	533	561	687	436	1150	1087	918	1146	1243	678	3004	1914	2368	980	1787	1464	1913	850
September	786	504	564	492	1004	395	1450	854	837	1074	1066	663	3564	1833	2527	770	1836	1333	2980	1760
October	710	601	880	503	1106	429	1275	815	1272	1276	924	748	2768	1821	2026	725	2383	1442	2824	3275
November	812	567	793	421	876	461	895	1243	1436	1477	842	871	2296	1868	1410	889	3528	1526	3620	3011
December	558	414	753	421	717	513	625	1141	1557	2231	523	964	1488	2158	1802	965	3857	1074	7044	2528

Appendix –VIII

Monthly price of onion in Jaipur (Rs./qtl.)

Jaipur (Rajasthan)																				
Year / M	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
January	343	337	233	765	372	457	960	482	1181	1139	2226	583	1172	1081	1310	1155	761	3128	642	2674
February	275	294	207	794	316	357	1123	384	1019	1106	1288	548	1535	919	1586	958	704	2135	594	1396
March	275	290	297	454	341	323	843	420	981	859	629	599	1090	960	1483	1036	738	1094	662	1529
April	242	262	324	357	354	272	584	381	588	665	550	622	1030	935	1252	807	732	821	717	1881
May	240	228	339	215	272	271	483	369	441	553	499	542	930	911	1384	727	581	786	765	950
June	247	339	376	228	227	305	532	490	528	520	589	597	1061	1017	1628	733	617	995	970	1470
July	248	380	441	294	295	348	772	547	640	606	780	713	1570	1735	1897	813	717	1149	2219	1267
August	333	459	446	341	513	356	1266	665	717	837	905	722	2712	1581	3602	791	1944	1104	3953	1600
September	465	479	620	455	882	370	1457	678	865	1309	1168	713	4088	1573	4072	942	1488	1175	3200	3250
October	575	645	789	545	1054	479	1414	773	1286	1603	1372	1029	4509	1669	2782	1017	1723	1303	3468	2701
November	667	454	627	454	1037	479	853	1025	1079	1666	1089	1351	3895	1500	2076	1076	2444	1217	3220	2000
December	480	275	653	335	676	644	552	1125	1216	2412	703	1129	1543	1471	1342	869	3052	775	7319	2000

Appendix –IX

Monthly price of onion in Mumbai (Rs./qtl.)

Mumbai																				
Year / M	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
January	441	339	332	852	416	400	987	417	1303	1558	2660	549	1480	1140	1449	1233	704	2987	658	3793
February	363	279	262	620	375	325	1103	388	1110	1208	994	495	1503	736	1509	1104	698	1895	533	2059
March	250	251	286	668	350	312	684	376	777	758	614	483	1039	847	1364	851	650	1148	676	1797
April	280	200	373	400	331	313	624	412	591	628	596	546	976	952	1120	855	630	1028	850	1496
May	280	237	376	485	332	341	618	595	858	682	663	528	961	1146	1279	782	620	915	1011	810
June	400	327	481	487	435	342	867	569	1293	769	802	595	1422	1800	1814	709	743	1093	1391	880
July	550	468	556	541	631	404	925	688	771	800	874	716	2206	2178	2148	875	824	1253	1393	827
August	550	418	575	494	631	404	1402	817	767	934	1178	764	3809	1878	3904	774	2154	1226	1988	1125
September	533	601	597	494	1262	422	1526	754	777	1455	1305	722	4568	1573	4600	566	1632	919	3221	2410
October	554	610	855	550	1263	596	1444	712	1532	1617	1137	921	4494	1562	3462	638	2459	1535	3400	4822
November	756	596	757	402	1382	759	1036	1015	1773	2400	1078	1264	3569	1831	2645	763	3234	1220	5866	4489
December	688	375	838	1382	675	822	640	1155	1939	3116	729	1319	1643	1780	1466	773	3560	800	8059	2719

Appendix –X

Monthly price of onion in Patna (Rs./qtl.)

Patna																				
Year / M	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
January	453	415	346	1096	490	514	1085	473	1556	1598	2841	686	1701	1396	1659	1499	1071	3496	933	4489
February	526	402	332	1061	429	414	1373	419	1379	1444	1313	719	1980	1144	1918	1123	932	2374	858	2400
March	527	356	483	665	415	348	952	495	1077	765	712	596	1309	1149	1489	1047	874	1224	825	1831
April	429	384	491	521	465	400	711	531	806	746	632	687	1191	1193	1681	1061	899	972	910	910
May	449	342	437	444	398	328	529	432	670	573	636	610	1023	1325	1400	838	883	948	1032	990
June	486	463	576	477	390	401	867	525	789	708	578	680	1322	1588	1909	973	848	1305	1370	1405
July	604	534	696	510	481	486	1070	781	913	834	871	816	2113	2190	2332	1066	865	1528	1622	1955
August	704	685	675	561	765	536	1363	966	846	931	1184	835	3865	2002	4050	975	2243	1392	2038	1175
September	704	652	709	574	1060	461	1574	828	860	1410	1248	745	5012	1883	4614	991	1821	983	3477	1470
October	744	778	875	696	1384	450	1704	780	1651	1610	1355	1008	5315	1733	3686	838	2700	1334	3577	4138
November	883	696	917	531	1481	651	1143	1248	1771	2175	1354	1345	4196	1924	2433	1139	3492	1244	5640	4324
December	627	437	906	539	866	1591	730	1347	1622	2638	1085	1564	1926	2039	1613	1099	3622	977	8312	3020

Appendix –XI

Monthly price of onion in Lasalgaon (Rs./qtl.)

Lasalgaon																				
Year / M	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
January	202	270	162	827	262	271	875	251	1238	1425	2679	623	1341	985	1265	1145	606	2874	417	3377
February	225	225	140	760	243	210	825	290	1119	1022	975	625	1995	736	1403	780	500	1602	398	1928
March	180	180	318	404	233	200	640	341	720	573	520	387	915	819	1189	693	650	808	825	1397
April	180	181	317	300	233	260	461	265	441	513	518	445	778	865	1077	754	450	645	825	844
May	181	174	338	312	343	225	450	291	528	552	583	433	923	984	1172	770	550	1015	1232	823
June	271	339	459	387	343	331	651	431	650	593	672	455	1336	1341	1497	829	1000	1015	1232	783
July	339	340	459	372	671	315	870	821	631	651	835	563	2092	1868	1923	809	1750	1147	1878	1108
August	437	446	512	395	643	410	1461	770	652	870	1015	653	3357	1577	3809	702	1450	957	1679	1067
September	455	448	513	396	1175	530	1771	838	666	1318	1097	694	4364	1336	4159	375	2250	1239	3108	3559
October	584	584	697	481	1114	375	1201	609	1386	1386	836	779	4600	1422	3079	500	3200	1239	3045	3313
November	584	419	610	351	1016	551	561	905	1437	1452	993	1204	2957	1439	2103	800	2800	759	6207	3230
December	419	247	688	326	481	681	351	1063	1272	2782	902	1202	1315	1516	1255	650	1308	537	5269	2339

Appendix –XII

Monthly price of onion in Mahuva (Rs./qtl.)

Mahuva																				
Year / M	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
January	366	266	194	459	264	277	730	331	895	1029	1720	448	1288	611	1067	1021	409	1978	697	2555
February	265	196	166	480	256	302	895	312	837	856	835	471	1074	1025	1330	862	320	1085	636	1727
March	195	184	215	408	252	444	716	284	721	714	598	446	1015	616	1273	701	367	595	846	1670
April	185	185	280	336	248	587	616	251	605	579	413	452	1017	639	1195	598	355	533	846	1499
May	282	282	312	288	258	285	525	280	602	503	443	382	833	857	1194	545	351	574	1041	1328
June	382	380	345	264	214	285	637	310	600	480	453	693	1001	966	1242	574	444	574	1041	1328
July	432	478	395	241	225	642	678	352	552	477	701	504	1445	1020	1371	565	421	646	1306	1321
August	591	575	459	325	451	500	864	460	554	805	744	579	2500	1047	2709	510	972	638	1306	917
September	585	672	491	334	690	500	1038	391	614	1132	496	577	2893	1075	2621	569	869	728	2319	3569
October	400	569	524	381	874	446	1064	471	984	1444	497	648	2124	822	2514	385	1347	728	2545	3593
November	583	195	401	296	765	392	743	563	1138	2126	647	727	2049	1356	1467	715	2119	681	3019	2587
December	367	196	134	315	458	579	533	1027	1203	2221	611	985	1255	1294	1286	675	1820	600	5075	1714

Map of Top 10 Onion Producing States in India

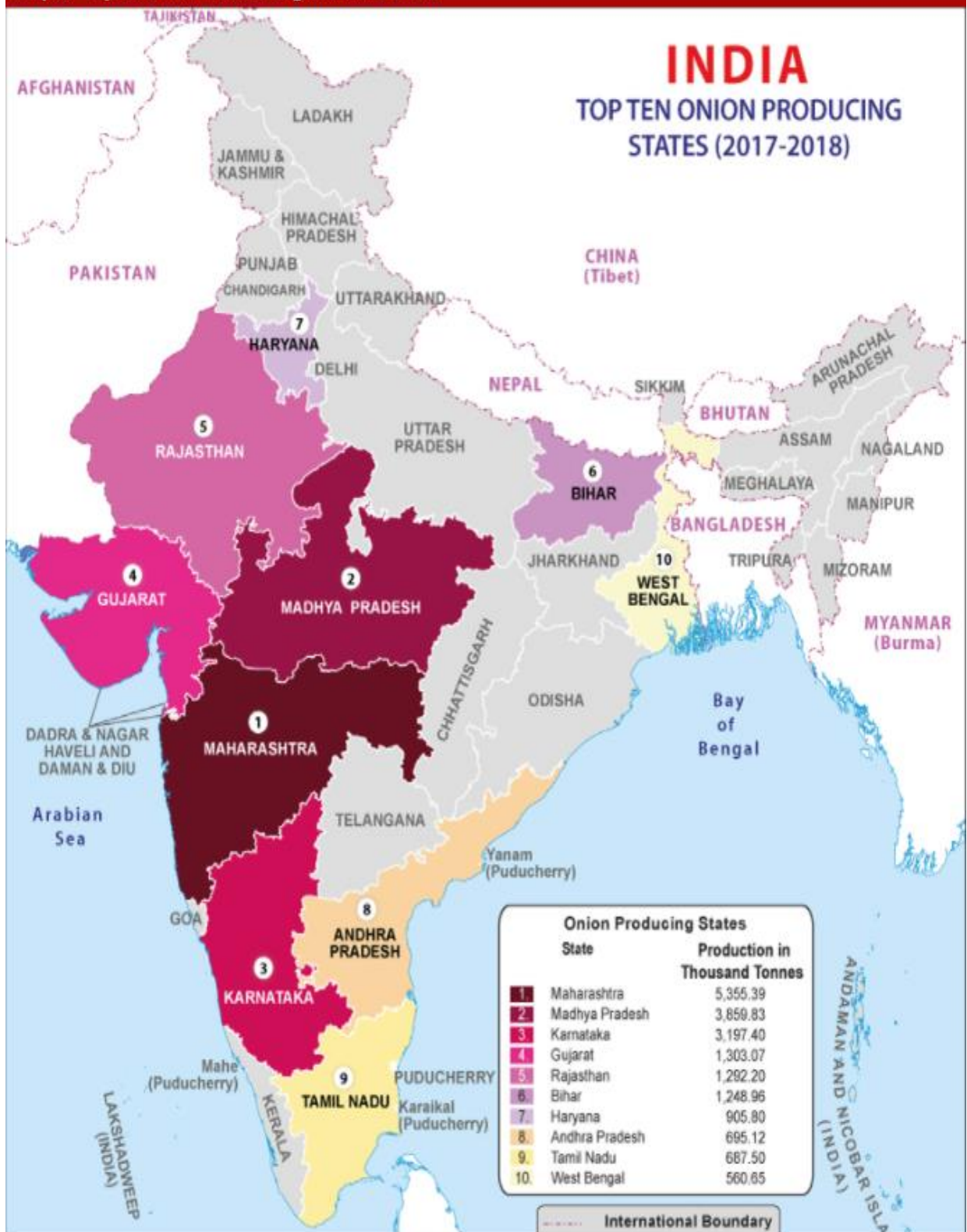


Fig. 3.1: Map of India Showing top 10 onion producing states in India.

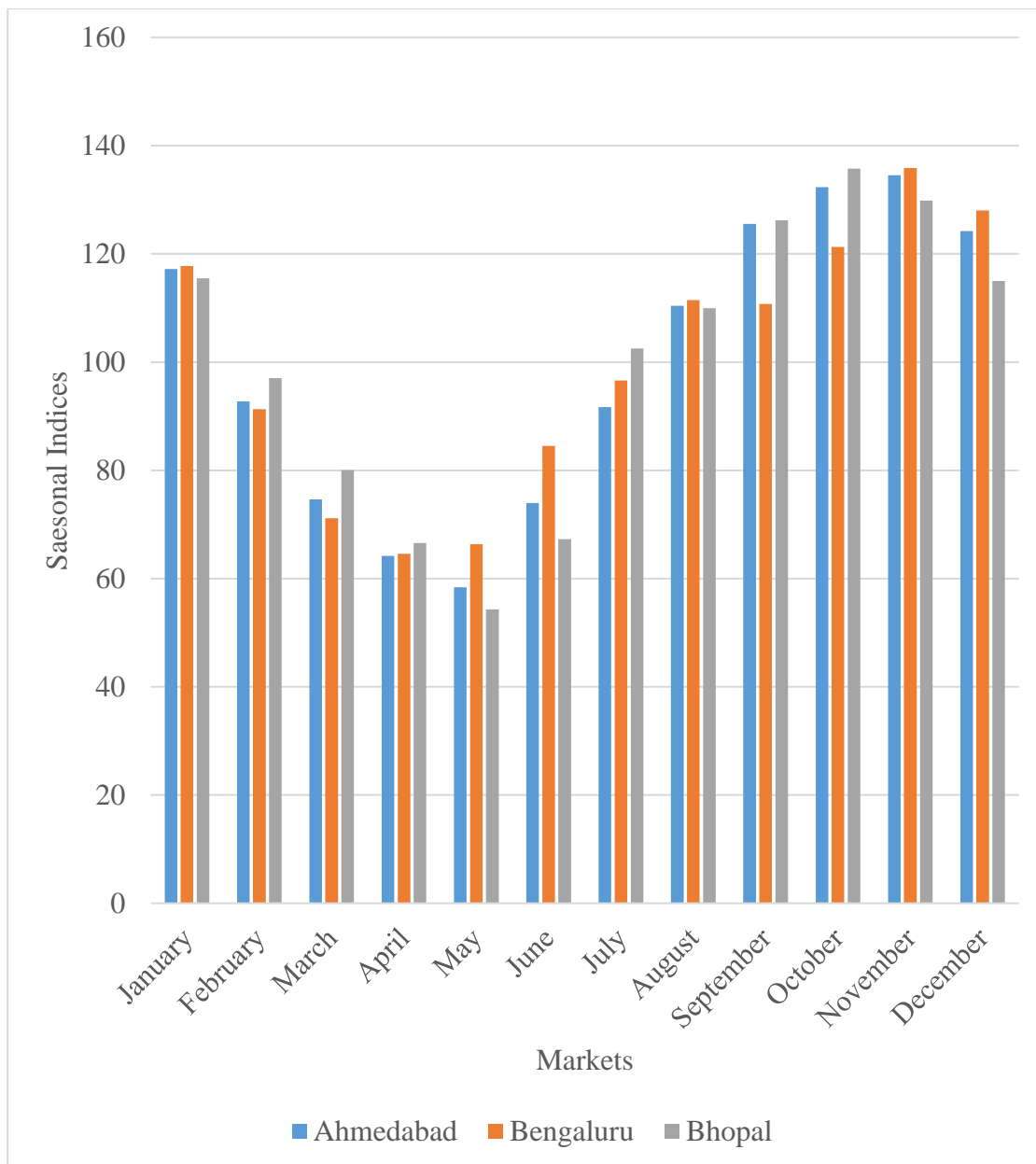


Fig. 4.3 Average seasonal variation in wholesale prices of onion in Ahmedabad, Bengaluru and Bhopal markets (2001 to 2020).

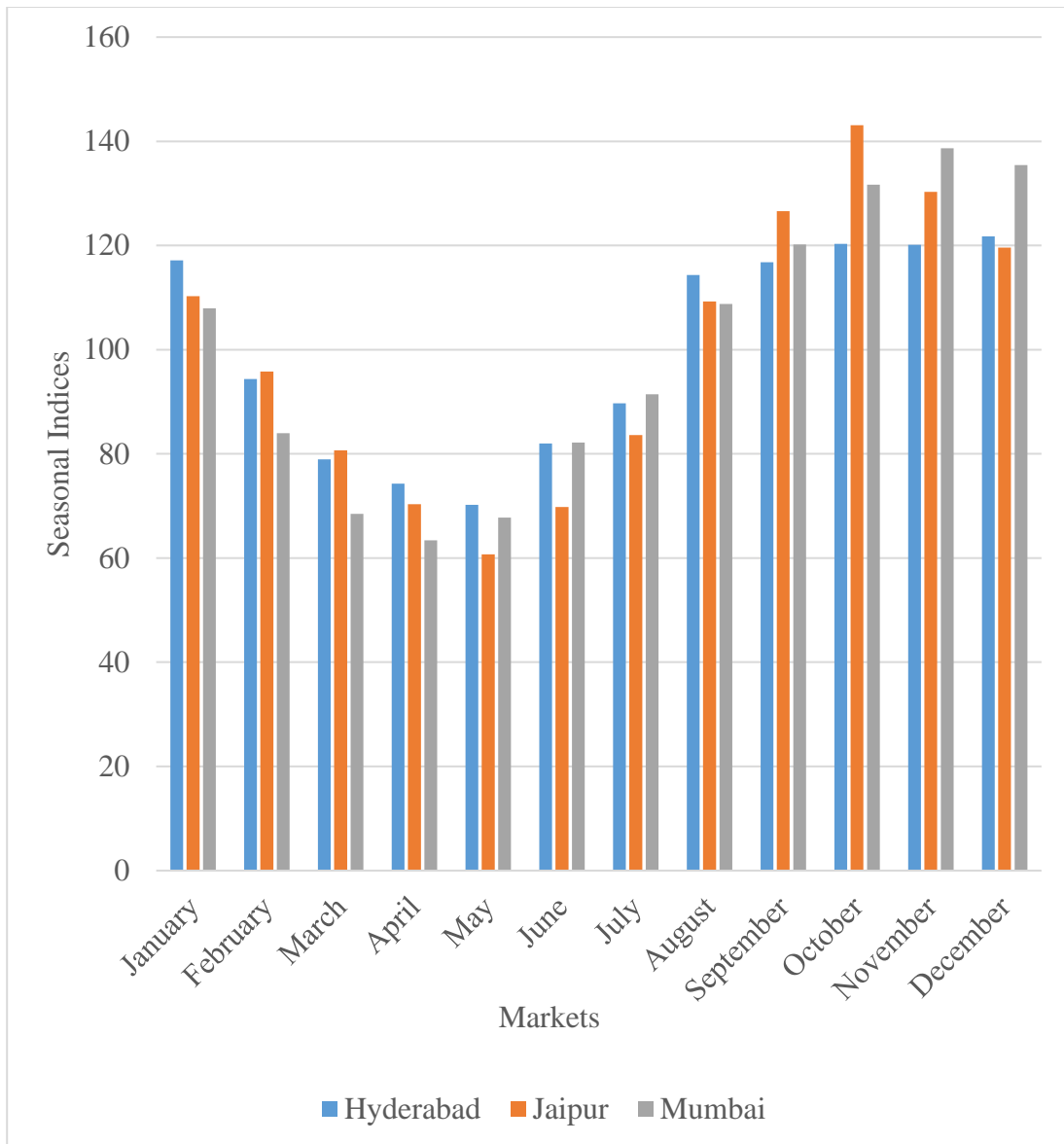


Fig. 4.4 Average seasonal variation in wholesale prices of onion in Hyderabad, Jaipur and Mumbai markets (2001 to 2020).

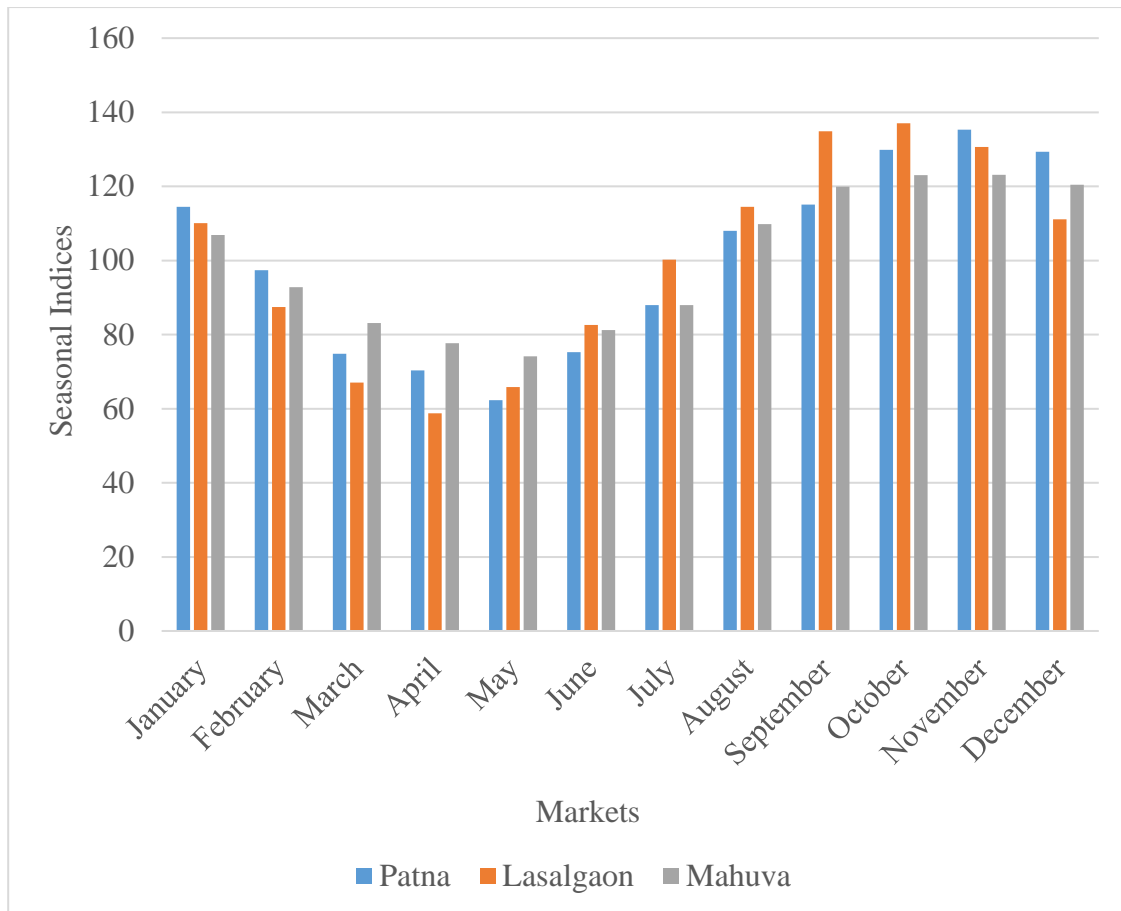


Fig. 4.5 Average seasonal variation in wholesale prices of onion in Patna, Lasalgaon and Mahuva markets (2001 to 2020).

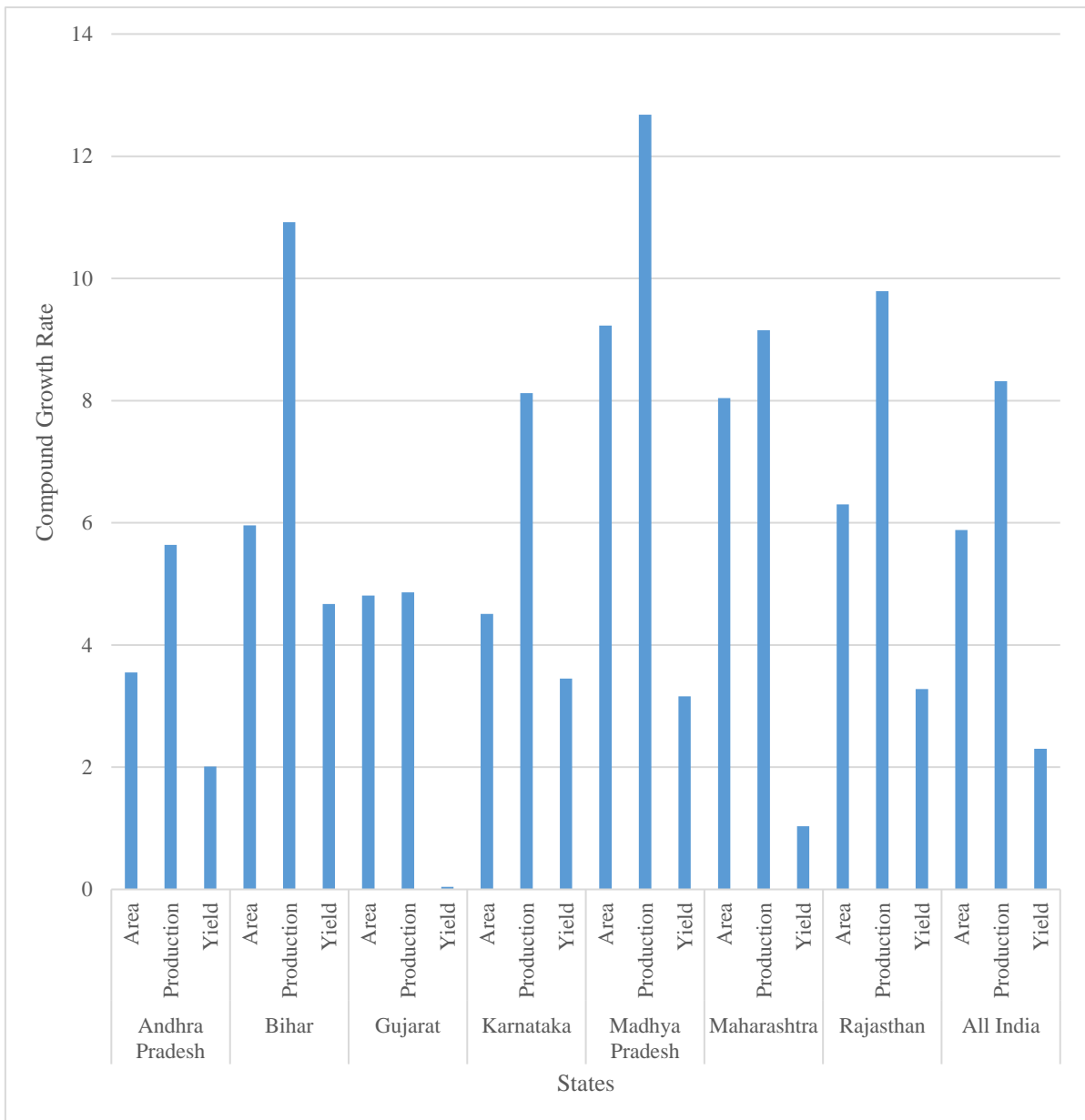


Fig 4.1: Period-wise growth rate of onion production in major states of India during 1990-91 to 2019-20.

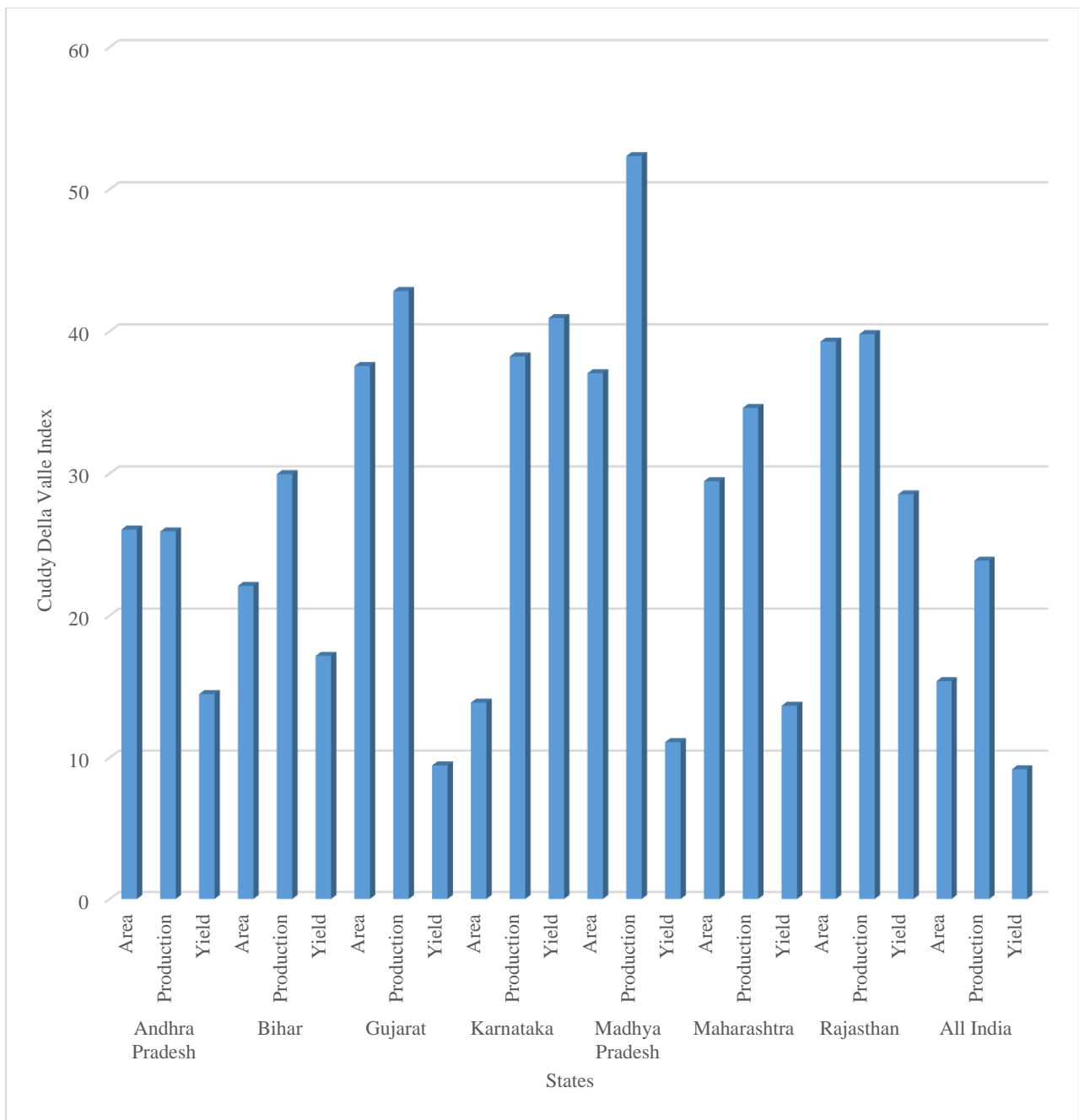


Fig 4.2: Instability of onion area, production and yield in major states of India during 1990-91 to 2019-20.