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A STUDY OF RICE IN THE MAJOR GROWING COUNTRIES OF THE WORLD
THEIR GROWTH INSTABILITY AND WORLD SHARE

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Abstract. Fifty percent of the human population on earth, especially of the East use rice as the basic diet and as such vast cultivation of rice is common throughout the world. On the whole, rice is by far the greatest price getting food crop. Agricultural growth with stability has been a matter of concern in the strategy of agricultural development in the world, especially in developing countries. This paper analyzes 22 years (1974-75 to 1995-96) of rice production in the world in terms of its growth and instability in area, production and productivity. The period has been divided into two sub-periods, *viz.* period I (1974-75 to 1984-85) and Period II (1985-86 to 1995-96) to clearly bring out the trends in more recent period. The study reveals that during period I the growth in production was mainly due to the growth in productivity while in period II area and productivity both contributed to production. In period I the developing countries show a low degree of instability in area, production and productivity as compared to USA. In period II the instability in area, production and productivity are more or less the same between USA and developing countries. The new farm technology has added to instability in production in most countries while it shows a decline in some countries in both the periods.

I. INTRODUCTION

Fifty percent of the human population on earth, especially of the East use rice as the basic diet and as such vast cultivations of rice are common throughout the world. The world produced 586787 thousand tons of rice in 1999-2000. On the whole, rice is by far the greatest price getting food crop. Of all staple diets, rice is easiest to digest. Children, aged people, the sick and the weak may not digest wheat, barley, corn or other staple diets. Rice is

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the best food for them. Rice seeds have elements of protein, starch, oil, salt and fibre in them which are all the needs of human body. Moreover, rice also contains enough of vitamins B, E and G. Vitamins are vital elements of foods. Unfortunately most of these vitamins are lost with the husk, the fibrous cover of the rice seed. Indigenously husked rice retains some of these vitamins. However, polish removes all the vitamins from rice. Outside the Far East rice is the predominant food in only a few countries, but it is increasingly popular in many parts of Africa, Latin America and the Near East. In total, over 586787 thousand tons of milled rice are eaten annually, contributing half or more of the available calorie supplies in rice-eating countries as well as a major part of the protein.

Many, though not all, of the major rice-eating countries are characterized by population pressure on the land, which is further aggravated by the rapid expansion of the population, low productivity of agriculture, and inadequate industrial development. Institutional barriers, faulty marketing system and many other general impediments to the economic growth of developing countries are, in fact, typical problems facing the world rice economy. Nevertheless, the rice economy is undergoing a constant process of evolution and change. Nine tenths of the world's rice production remains concentrated in the Far East. In several developed countries, too, and particularly in parts of southern Europe and of the United States, rice is important both in agriculture and in industry. Today, therefore, rice is cultivated under a wider variety of conditions and by more varied methods than any other major crop.

According to 1996 FAO Food Balance Sheet, rice provides more than 60% of the national calories intake in Myanmar, Bangladesh, Indonesia and Vietnam, between 50% to 60% in Thailand, Philippines, China and Korea, and from 40% to 50% in India and Japan. In Pakistan and USA, it provides 20% to 30% national calories intake.

Rice consumption per head is also rising in many countries of the Near East, West Africa and Latin America. Table 1 shows the annual per capita consumption of rice in kilograms for some developing countries. As far as consumer preferences of rice in different countries are concerned, parboiled rice is preferred only in parts of India, Sri Lanka, Mauritius, Bangladesh, Guyana, Madagascar and Sierra Leone. The former French African people prefer the yellowish colour of parboiled rice, while the peasants of Madagascar, Northern Guyana and the marshlands of southern Iraq favour red varieties. In the Philippines, India, Thailand and Guyana, there is some preference for translucent rice. In Japan, Indonesia and Thailand freshly

milled rice is preferred, while in India and Pakistan, rice which has been at least 6 months in storage, sells at a higher price. There is a liking for scented rice in Vietnam, French speaking Africa and parts of Indian consumers enjoy the odour associated with parboiled rice. The annual per capita consumption or per capita daily availability of rice is highest in Vietnam, followed by Bangladesh, Indonesia, Myanmar, Thailand, China, India and Philippines. Pakistan ranks last.

TABLE 1

Annual Per Capita Consumption of Rice in Pakistan and Some Developing Countries

Countries	Kg per Year
Bangladesh	152
Myanmar	140
Brazil	39
China	92
India	91
Guyana	82
Indonesia	146
Iraq	24
Japan	62
Malaysia	87
Philippines	91
Pakistan	16
Sri Lanka	89
Sierra Leone	90
Thailand	114
Vietnam	162

Source: *Food Balance Sheet*, 1994-1996 Averages. FAO, Food and Agriculture Organization, United Nations.

It would now be of interest if we compare the area, production and yield per acre of rice in selected countries. In Table 2 and Figure 1 through onward the position of major growing countries has been shown for the last 5 years (from 1995-96 to 1999-2000). As far as the area of the crop is concerned India has the first position and Korea (12^{th}) has last position (1999-2000). China has first and Korea has last (12^{th}) position in rice production. Pakistan

ranks 11th in rice production. As far as the yield of the crop is concerned USA ranks first and Thailand ranks last. The yield per acre of rice in India, Bangladesh, Myanmar, Philippines and Pakistan is also below world standard.

TABLE 2

Comparison of Area, Production and Yield per Hectare of Rice in the Major Growing Countries of the World

Year	India			China		
	Area (000 hectares)	Production (000 tons)	Yield (per hectare in kg)	Area (000 hectares)	Production (000 tons)	Yield (per hectare in kg)
1995-96	42500	122372	2879	31109	187192	6017
1996-97	43283	122000	2819	31754	197074	6206
1997-98	43086	125200	2906	32113	202701	6312
1998-99	42300	122244	2890	31848	192971	6059
1999-2000	43000	127600	2967	31684	200719	6335

Year	Bangladesh			Thailand		
	Area (000 hectares)	Production (000 tons)	Yield (per hectare in kg)	Area (000 hectares)	Production (000 tons)	Yield (per hectare in kg)
1995-96	9950	24659	2478	9020	21130	2343
1996-97	10020	28184	2813	9267	22332	2410
1997-98	10177	28183	2769	9932	23339	2350
1998-99	10263	28293	2757	10000	23240	2324
1999-2000	10470	29857	2852	10300	23000	2233

Year	Myanmar			Philippines		
	Area (000 hectares)	Production (000 tons)	Yield (per hectare in kg)	Area (000 hectares)	Production (000 tons)	Yield (per hectare in kg)
1995-96	6475	20109	3106	4145	11002	2654
1996-97	5545	17835	3216	3840	11365	2960
1997-98	5768	17673	3064	3842	11269	2933
1998-99	5408	16651	3079	3170	8555	2699
1999-2000	5600	17848	3187	3900	11200	2872

Year	Japan			Pakistan		
	Area (000 hectares)	Production (000 tons)	Yield (per hectare in kg)	Area (000 hectares)	Production (000 tons)	Yield (per hectare in kg)
1995-96	2100	12625	6012	2162	2950	2753
1996-97	1977	12930	6540	2251	6457	2868
1997-98	1953	12531	6416	2317	6500	2805
1998-99	1801	11200	6219	2424	7011	2892
1999-2000	1800	11300	6278	2515	7733	3070

Year	USA			Indonesia		
	Area (000 hectares)	Production (000 tons)	Yield (per hectare in kg)	Area (000 hectares)	Production (000 tons)	Yield (per hectare in kg)
1995-96	1257	7888	6274	11439	49744	4349
1996-97	1133	7771	6860	11570	51102	4417
1997-98	1228	8115	6609	11141	49377	4432
1998-99	1342	8530	6354	11730	49237	4197
1999-2000	1439	9622	6688	11624	50866	4376

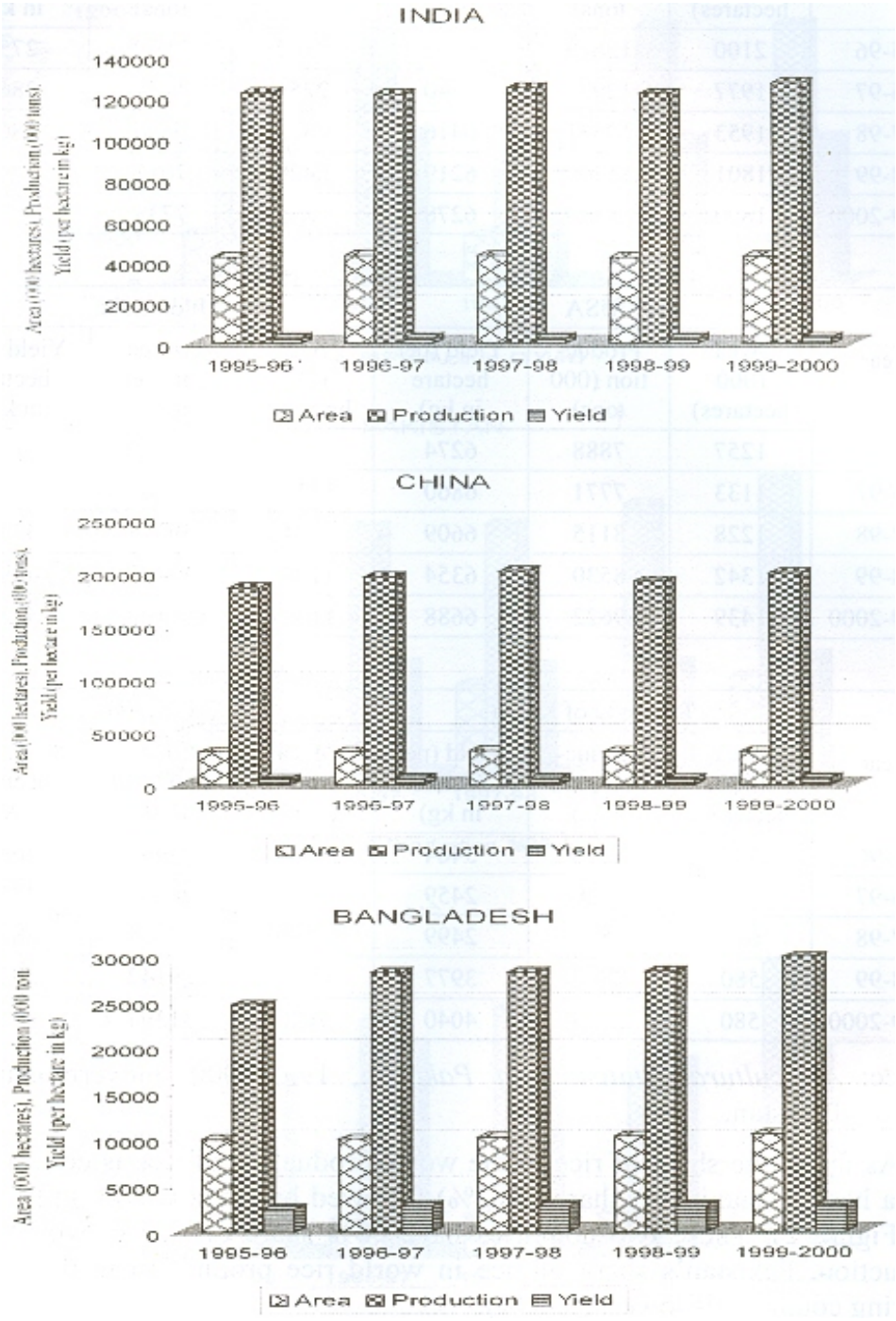
Year	Republic of Korea			Vietnam		
	Area (000 hectares)	Production (000 tons)	Yield (per hectare in kg)	Area (000 hectares)	Production (000 tons)	Yield (per hectare in kg)
1995-96	582	2016	3464	6766	24964	3690
1996-97	580	1426	2459	7004	26397	3769
1997-98	611	1527	2499	7100	27524	3877
1998-99	580	2307	3977	7362	29142	3958
1999-2000	580	2343	4040	7648	31394	4105

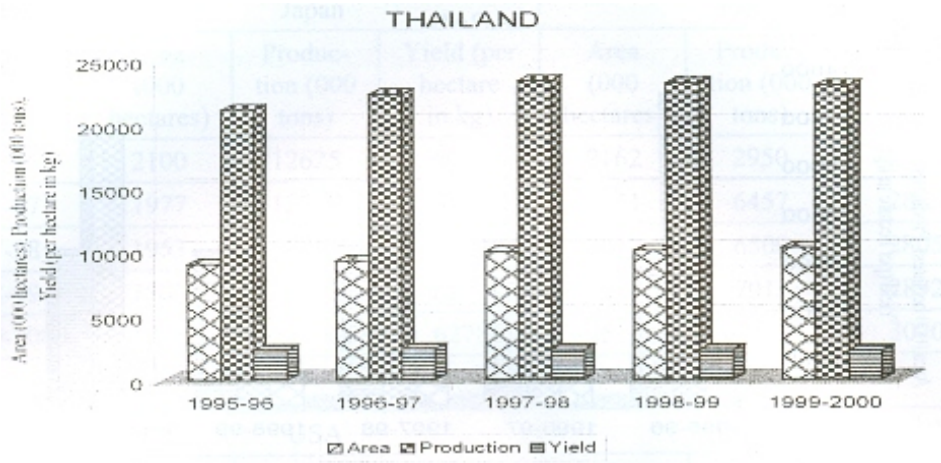
Source: *Agricultural Statistics of Pakistan*, 1999-2000. Government of Pakistan.

As far as the share of rice in the world production of rice is concerned, China has the maximum share (34.2%) followed by India (21.7%) (Table 3 and Figure 2). These two countries have 50% share of rice in world rice production. Pakistan's share of rice in world rice production in the major growing countries is lowest (0.40%).

FIGURE 1

Area, Production and Yield of Rice in Major Growing Countries

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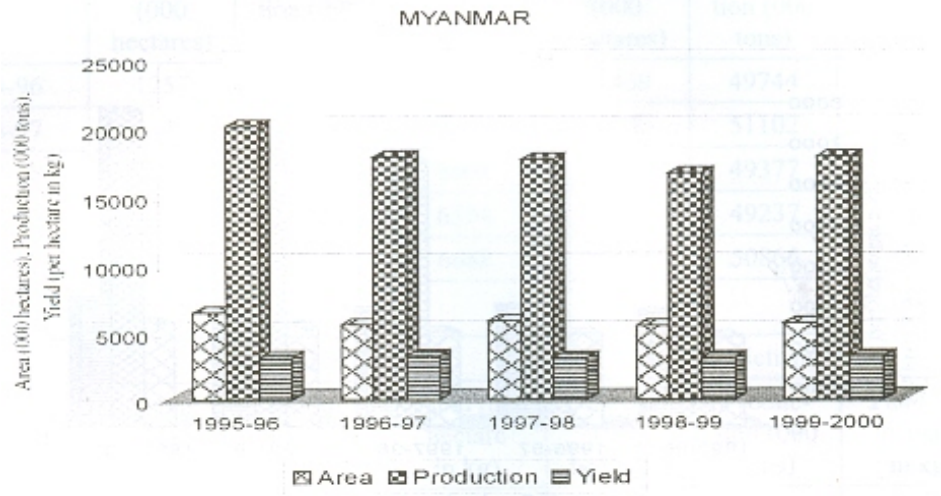
1995-96
1996-97
1997-98
1998-99
1999-2000
Area
Production
Yield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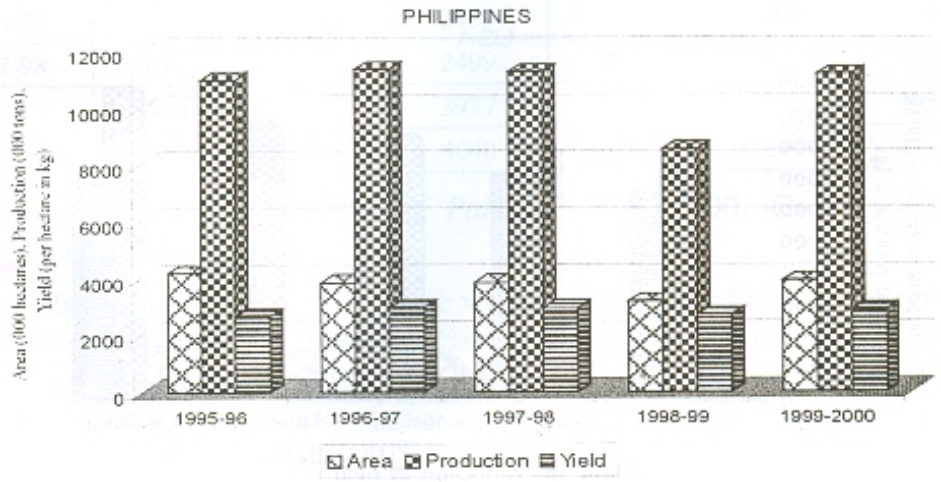
15000
10000
5000
0
1995-96
1996-97
1997-98
1998-99
1999-2000
Area
Production
Yield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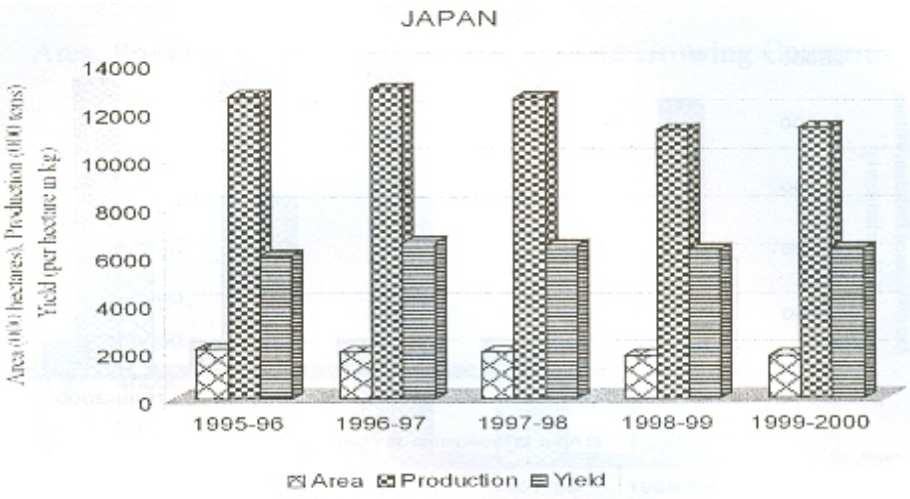
6000
4000
2000
0
1995-96
1996-97
1997-98
1998-99
1999-2000
Area
Production
Yield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Yield (per hectare in kg)
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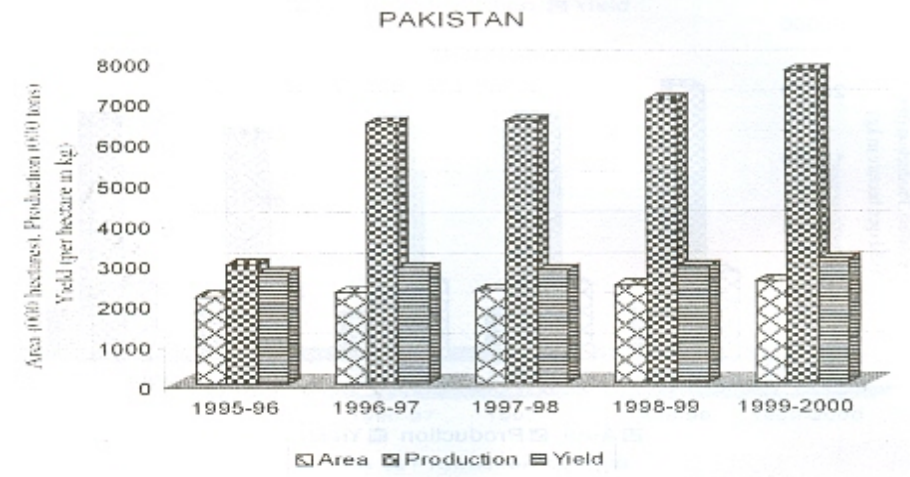
10000
8000
6000
4000
2000
0
1995-96
1996-97
1997-98
1998-99
1999-2000
Area
Production
Yield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Yield (per hectare in kg)
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6000
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4000
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2000
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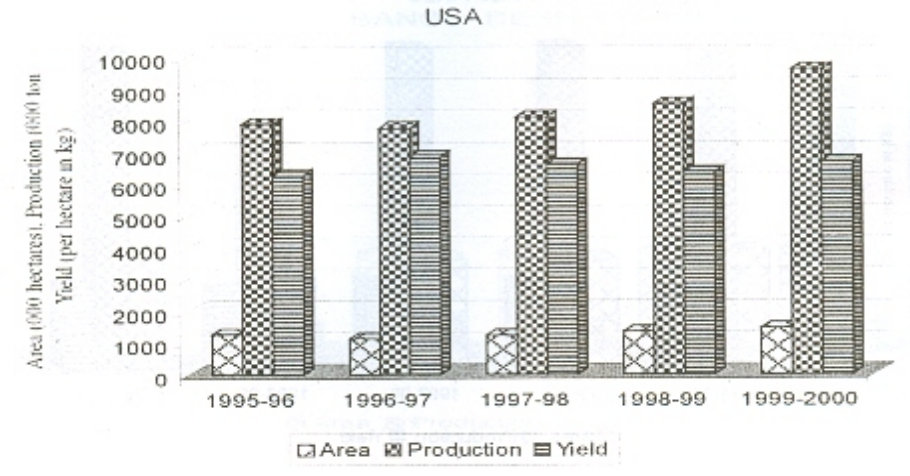
1996-97
1997-98
1998-99
1999-2000
Area
Production
Yield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Area (000 hectares), Production (000 ton
Yield (per hectare in kg)
10000
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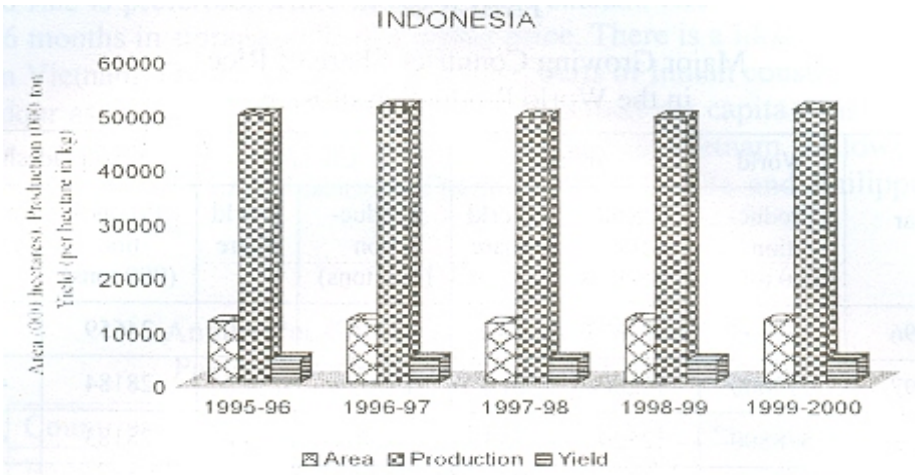
8000
7000
6000
5000
4000
3000
2000
1000
0
1995-96
1996-97
1997-98
1998-99
1999-2000
Area
Production
Yield


INDONESIA
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50000
40000
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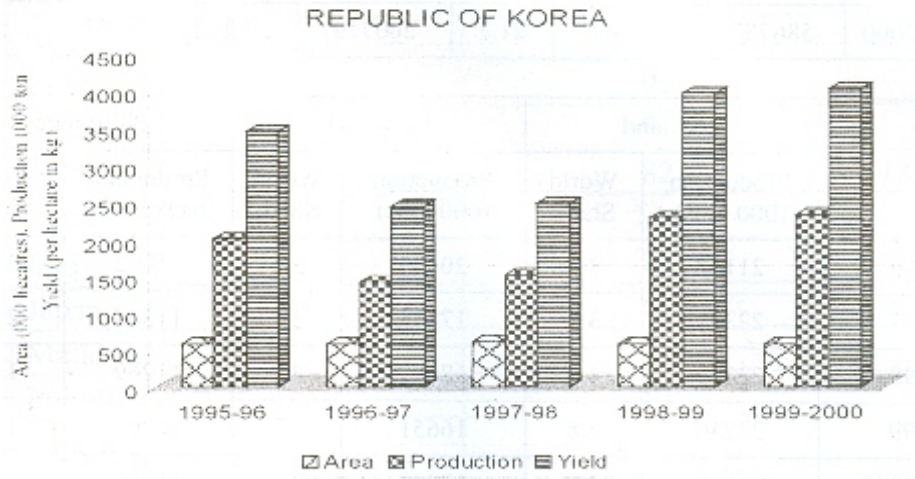
1995-96
1996-97
1997-98
1998-99
1999-2000
Area
Production
Yield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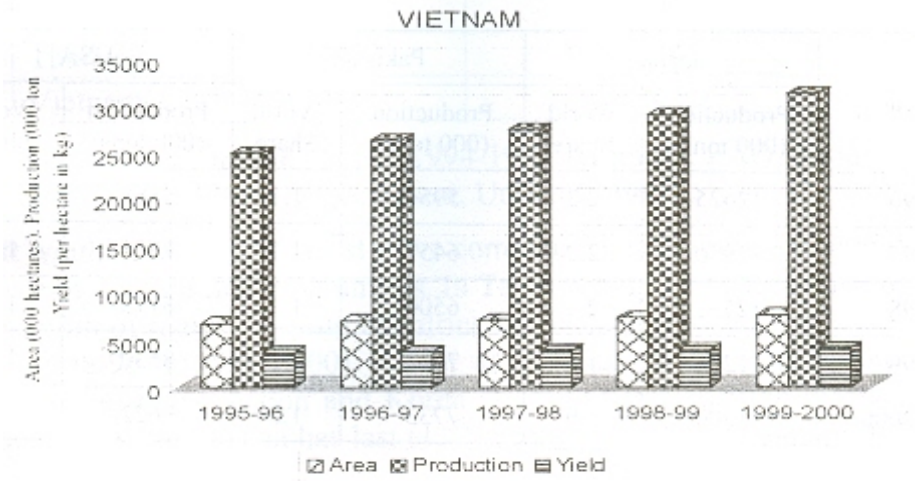
4000
3500
3000
2500
2000
1500
1000
500
0
1995-96
1996-97
1997-98
1998-99
1999-2000
Area
Production
Yield


VIETNAM
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30000
25000
20000
15000
10000
5000
0
1995-96
1996-97
1997-98
1998-99
1999-2000
Area
Production
Yield

TABLE 3

Major Growing Countries Share of Rice
in the World Production of Rice

Year	World	India		China		Bangladesh	
	Production (000 tons)	Production (000 tons)	World Share	Production (000 tons)	World Share	Production (000 tons)	World Share
1995-96	550193	122372	22.2	187192	34.0	24659	4.5
1996-97	579000	122000	21.1	197074	34.0	28184	4.9
1997-98	578800	125200	21.6	202701	35.0	28183	4.9
1998-99	606700	122244	20.1	192971	31.8	28293	4.7
1999-2000	586787	127600	21.7	200719	34.2	29857	5.1

Year	Thailand		Myanmar		Philippines	
	Production (000 tons)	World Share	Production (000 tons)	World Share	Production (000 tons)	World Share
1995-96	21130	3.8	20109	3.6	11002	2.0
1996-97	22332	3.8	17835	3.1	11365	2.0
1997-98	23339	4.0	17673	3.0	11269	1.9
1998-99	23240	3.8	16651	2.7	8555	1.4
1999-2000	23000	3.9	17848	3.0	11200	1.9

Year	Japan		Pakistan		USA	
	Production (000 tons)	World Share	Production (000 tons)	World Share	Production (000 tons)	World Share
1995-96	12625	2.3	5950	1.1	7888	1.4
1996-97	12930	2.2	6457	1.1	7771	1.3
1997-98	12531	2.2	6500	1.1	8115	1.4
1998-99	11200	1.8	7011	1.2	8530	1.4
1999-2000	11300	1.9	7733	1.3	9622	1.6

Year	Indonesia		Republic of Korea		Vietnam	
	Production (000 tons)	World Share	Production (000 tons)	World Share	Production (000 tons)	World Share
1995-96	49744	9.0	2016	0.37	24964	4.5
1996-97	51102	8.8	1426	0.25	26397	4.5
1997-98	49377	8.5	1527	0.26	27524	4.7
1998-99	49237	8.1	2307	0.36	29142	4.8
1999-2000	50866	8.7	2343	0.40	31394	5.3

Source: *Agricultural Statistics of Pakistan*, 1999-2000. Government of Pakistan.
Statistical Yearbook for Asia and the Pacific, 2000. Bangkok, Thailand, United Nations.

FIGURE 2

World Share Production of Rice in the Major Growing Countries in 1999-2000

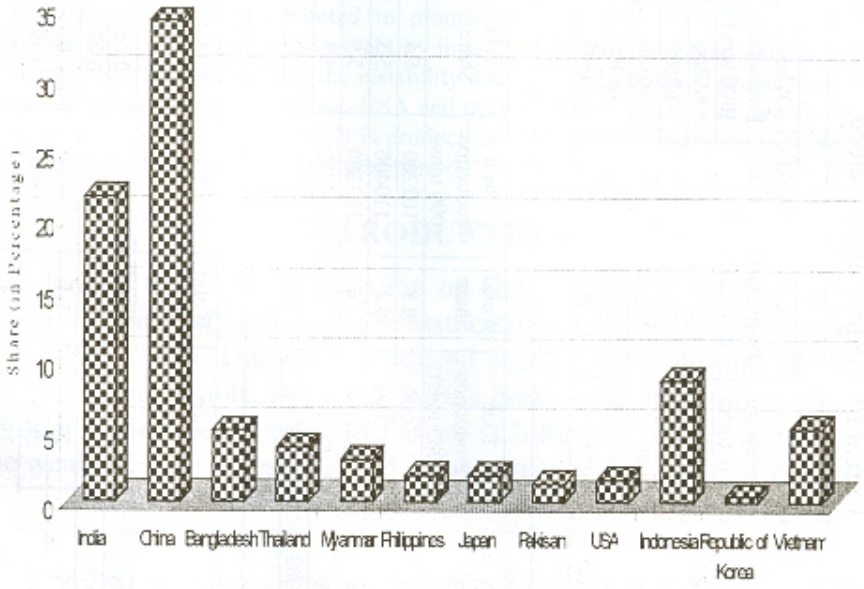

TABLE 4

Cereal Production in the Selected Countries and its Share in Total World's Cereals Production

Year	World Cereals Production (000 tons)	INDIA									
		Rice Production (000 tons)	World Share	Wheat Production (000 tons)	World Share	Barley Production (000 tons)	World Share	Maize Production (000 tons)	World Share	Millet Production (000 tons)	World Share
1995-96	1896300	122300	6.4	65800	3.5	1300	0.07	8900	0.47	8600	0.45
1996-97	2069500	122200	5.9	62600	3.0	1700	0.08	9400	0.45	11100	0.54
1997-98	2098000	125200	6.0	69300	3.3	1400	0.07	9600	0.46	10500	0.50
1998-99	2081500	122200	6.3	66300	3.2	1700	0.08	10700	0.51	10500	0.50
1999-2000	2074500	127600	6.1	70800	3.4	1500	0.07	10700	0.51	8100	0.39

Year	CHINA									
	Rice Production (000 tons)	World Share	Wheat Production (000 tons)	World Share	Barley Production (000 tons)	World Share	Maize Production (000 tons)	World Share	Millet Production (000 tons)	World Share
1995-96	185200	9.8	102200	5.4	4420	0.23	111986	5.9	3019	0.16
1996-97	195100	9.4	110400	5.3	4280	0.21	127471	6.1	3572	0.17
1997-98	200700	9.6	123300	5.9	4310	0.20	104309	5.0	2312	0.11
1998-99	198700	9.5	109700	5.3	3800	0.18	132954	6.4	2554	0.12
1999-2000	198400	9.6	113800	5.5	3850	0.18	128086	6.2	2800	0.13

Year	BANGLADESH									
	Rice Production (000 tons)	World Share	Wheat Production (000 tons)	World Share	Barley Production (000 tons)	World Share	Maize Production (000 tons)	World Share	Millet Production (000 tons)	World Share
1995-96	26398	1.4	1245	0.06	NIL	NIL	NIL	NIL	NG	NG
1996-97	28184	1.4	1369	0.07	NIL	NIL	NIL	NIL	NG	NG
1997-98	28152	1.3	1454	0.07	NIL	NIL	NIL	NIL	NG	NG
1998-99	28293	1.3	1803	0.09	NIL	NIL	NIL	NIL	NG	NG
1999-2000	29858	1.4	1988	0.09	NIL	NIL	NIL	NIL	NG	NG

Year	THAILAND									
	Rice Production (000 tons)	World Share	Wheat Production (000 tons)	World Share	Barley Production (000 tons)	World Share	Maize Production (000 tons)	World Share	Millet Production (000 tons)	World Share
1995-96	22016	1.2	NIL	NIL	NIL	NIL	4155	0.22	NIL	NIL
1996-97	22332	1.1	NIL	NIL	NIL	NIL	4533	0.22	NIL	NIL
1997-98	23580	1.1	NIL	NIL	NIL	NIL	3832	0.18	NIL	NIL
1998-99	23240	1.1	NIL	NIL	NIL	NIL	4986	0.24	NIL	NIL
1999-2000	23271	1.1	NIL	NIL	NIL	NIL	4630	0.22	NIL	NIL

Year	MYANMAR									
	Rice Production (000 tons)	World Share	Wheat Production (000 tons)	World Share	Barley Production (000 tons)	World Share	Maize Production (000 tons)	World Share	Millet Production (000 tons)	World Share
1995-96	18199	0.96	NG	NG	NG	NG	284	0.01	123	0.006
1996-97	17957	0.87	NG	NG	NG	NG	275	0.01	150	0.007
1997-98	17835	0.85	NG	NG	NG	NG	318	0.01	149	0.007
1998-99	17673	0.85	NG	NG	NG	NG	286	0.01	150	0.007
1999-2000	16651	0.80	NG	NG	NG	NG	308	0.01	167	0.008

Year	PHILIPPINES									
	Rice Production (000 tons)	World Share	Wheat Production (000 tons)	World Share	Barley Production (000 tons)	World Share	Maize Production (000 tons)	World Share	Millet Production (000 tons)	World Share
1995-96	11284	0.59	NIL	NIL	NIL	NIL	4161	0.22	NIL	NIL
1996-97	11365	0.55	NIL	NIL	NIL	NIL	4345	0.21	NIL	NIL
1997-98	11269	0.54	NIL	NIL	NIL	NIL	4332	0.21	NIL	NIL
1998-99	10236	0.49	NIL	NIL	NIL	NIL	3823	0.18	NIL	NIL
1999-2000	11388	0.55	NIL	NIL	NIL	NIL	4643	0.22	NIL	NIL

Year	JAPAN									
	Rice Production (000 tons)	World Share	Wheat Production (000 tons)	World Share	Barley Production (000 tons)	World Share	Maize Production (000 tons)	World Share	Millet Production (000 tons)	World Share
1995-96	10748	0.57	444	0.02	204	0.01	NIL	NIL	NIL	NIL
1996-97	10344	0.50	478	0.02	216	0.01	NIL	NIL	NIL	NIL
1997-98	10025	0.48	573	0.03	179	0.01	NIL	NIL	NIL	NIL
1998-99	8960	0.43	570	0.03	131	0.006	NIL	NIL	NIL	NIL
1999-2000	9175	0.44	583	0.03	186	0.009	NIL	NIL	NIL	NIL

Year	PAKISTAN									
	Rice Production (000 tons)	World Share	Wheat Production (000 tons)	World Share	Barley Production (000 tons)	World Share	Maize Production (000 tons)	World Share	Millet Production (000 tons)	World Share
1995-96	5950	0.31	17002	0.90	164	0.008	1259	0.07	228	0.01
1996-97	6457	0.31	16907	0.82	174	0.008	1251	0.06	162	0.007
1997-98	6500	0.31	16651	0.79	150	0.007	1302	0.06	146	0.007
1998-99	7011	0.34	18694	0.90	174	0.008	1401	0.07	211	0.01
1999-2000	7733	0.37	17858	0.86	137	0.007	1450	0.07	213	0.01

Year	USA									
	Rice Production (000 tons)	World Share	Wheat Production (000 tons)	World Share	Barley Production (000 tons)	World Share	Maize Production (000 tons)	World Share	Millet Production (000 tons)	World Share
1995-96	7888	0.41	62099	3.3	7606	0.40	187300	9.9	NIL	NIL
1996-97	7771	0.37	62000	3.0	7809	0.38	234527	11.3	NIL	NIL
1997-98	8115	0.39	67523	3.2	8132	0.39	233867	11.1	NIL	NIL
1998-99	8530	0.41	69410	3.3	7614	0.36	247943	11.9	NIL	NIL
1999-2000	9622	0.46	62777	3.0	8163	0.39	238287	11.5	NIL	NIL

Year	INDONESIA									
	Rice Production (000 tons)	World Share	Wheat Production (000 tons)	World Share	Barley Production (000 tons)	World Share	Maize Production (000 tons)	World Share	Millet Production (000 tons)	World Share
1995-96	49744	2.6	NIL	NIL	NIL	NIL	8246	0.43	NIL	NIL
1996-97	51102	2.5	NIL	NIL	NIL	NIL	9307	0.45	NIL	NIL
1997-98	49377	2.3	NIL	NIL	NIL	NIL	8771	0.42	NIL	NIL
1998-99	49237	2.4	NIL	NIL	NIL	NIL	10169	0.49	NIL	NIL
1999-2000	50866	2.4	NIL	NIL	NIL	NIL	9134	0.44	NIL	NIL

Year	REPUBLIC OF KOREA									
	Rice Production (000 tons)	World Share	Wheat Production (000 tons)	World Share	Barley Production (000 tons)	World Share	Maize Production (000 tons)	World Share	Millet Production (000 tons)	World Share
1995-96	2016	0.11	125	0.006	180	0.009	1366	0.07	NG	NG
1996-97	1426	0.07	100	0.005	160	0.008	825	0.04	NG	NG
1997-98	1527	0.07	100	0.005	140	0.006	1014	0.05	NG	NG
1998-99	2307	0.11	165	0.008	90	0.004	1765	0.08	NG	NG
1999-2000	2343	0.11	169	0.008	106	0.005	1235	0.08	NG	NG

Year	VIETNAM									
	Rice Production (000 tons)	World Share	Wheat Production (000 tons)	World Share	Barley Production (000 tons)	World Share	Maize Production (000 tons)	World Share	Millet Production (000 tons)	World Share
1995-96	24964	1.3	NIL	NIL	NIL	NIL	1177	0.06	NIL	NIL
1996-97	26397	1.3	NIL	NIL	NIL	NIL	1537	0.07	NIL	NIL
1997-98	27524	1.3	NIL	NIL	NIL	NIL	1641	0.08	NIL	NIL
1998-99	29142	1.4	NIL	NIL	NIL	NIL	1612	0.08	NIL	NIL
1999-2000	31394	1.5	NIL	NIL	NIL	NIL	1752	0.08	NIL	NIL

Source: *Statistical Yearbook for Asia and the Pacific*, 2000. Bangkok, Thailand, United Nations.
Agricultural Statistics of Pakistan, 1999-2000, Government of Pakistan.

The share of cereals production in total world's serials production[1] of the selected countries are presented in Table 4. In all the selected countries (except USA and Pakistan) the share of rice production is highest among the world's cereals production. In Pakistan rice has the 2nd highest share in production after wheat while in USA rice has 3rd highest production share after maize and wheat.

Agricultural growth with stability has been a matter of concern in the strategy of agricultural development in the world, especially in developing countries. Growth and instability of yields and production of crops have been discussed in the literature both from theoretical and empirical perspectives. While some studies in India and Pakistan (Mehra, 1981; Hazell, 1982; Ray, 1983; Parthasarathy, 1984; Mitra, 1990 and Wasim, 1999) indicate that the new farm technology has added to instability in production.[2]

Rice thrives best between latitude 45° North and 40° South of the equator. Optimum areas for getting higher yields are tropical and sub-tropical. The factor which cheeks the paddy cultivation is water. Paddy crop thrives well in high temperatures and abundant sunshine with temperatures between 68° to 100°F throughout its growth period. Total degrees of temperature required during this period ranges between 3,000° to 4,000°F. The lowest limits for successful paddy growing are 5,500 ft. and 1200 hours of sunshine.

It is amazing to note that although rice is a main agricultural crop of tropical and subtropical areas, yet national average of temperate countries higher than those of the tropical and subtropical, *e.g.* national average for Japan, USA and Australia and other temperate zones ranges between 4 to 6 metric tons per hectare, and that of India, Bangladesh, Thailand, Myanmar, Philippines, Pakistan, Indonesia, Republic of Korea and Vietnam have about 1 to 4 tons per hectare. China has about 3 to 6 tons per hectare. In case of paddy cultivation the suitability of oil is not so significant but the conditions under which plants are grown are more important.

Examination of the issues stated above is expected to throw light on the nature of variability in rice production and, following from this on how far

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[1]We have taken the major cereals crops. These are rice, wheat, barley, maize and millet.

[2]There is no specific crop-wise study on production instability. For example, studies done by Parthasarathy, Hazell and Mehra are of foodgrains, while the studies done by Ray, Deshpande, Wasim and Mitra include food and cash crops.

the current technology involving use of HYV seeds, fertilizer and different sources of irrigation could be said to be instrumental in bringing about increase in yield. An analysis of fluctuations in rice output, apart from its growth rates is of importance for understanding the nature of food security and income stability. Thus, the present study has, therefore, been undertaken to examine the production behaviour of rice in the major growing countries of the world. The specific objectives of the study are:

1. To estimate the compound growth rates and instability of area, production and productivity of rice, for each major growing country of the world.
2. To make a comparison of growth rates in area, production and productivity of rice within the major growing countries of the world.
3. To make a comparison of instability in area, production and productivity of rice within the major growing countries of the world.
4. To make a comparison between growth and instability of area, production and productivity of rice in the world countries.

II. BRIEF HISTORY ABOUT RICE

Rice is number one food crop of the world. It is called ice/paddy in English, Irz in Arabic, Biranj in Persian and Chawal in Urdu language. Its generic botanical name is *Oryza sativa*. Rice cultivation started before the dawn of civilization and from the evidence it seems that rice was first cultivated as a staple food crop of Asia. From the earliest records of the writings of Chinese, some 5000 years ago, it has been found out that the privilege of sowing, rice was limited to the emperors only. The country from which the rice plant had its origin cannot be ascertained but from the evidence available it is clear that it has got its origin from South East Asia from where it spread towards North Asia (Sauer, 1952; Grist, 1955). In South Asia it was known in ancient times. Old scriptures of the Hindu religion and its use in religious offerings bear testimony to its antiquity in South Asia. According to Chatterji (1951), rice is mentioned in Arthra Veda, about 1000 BC. Wheeler (1959) has reported the discovery of charred grains of rice from Hastinapur in Ganga-Jumna doab (800 BC) and from Narda Toli in Central India. This is the farthest west and the oldest date where rice has been established by archaeology. It is not known if rice was also grown in Sindh and Punjab during Narda Toli times, but Majumdar (1938) claims that rice was exported from the ports of the Indus before the Aryan Sanskrit dialect was known. Grist (1955) has also suggested the diffusion of rice before the Aryans. If pre-Aryan diffusion of rice is accepted, the presence of rice in the early Indus valley civilization is

likely. Childe (1952) and Pusalker (1951) also believe that rice may have been cultivated during the Indus valley civilization time. From the main land of its origin it spread to south and east, with the flow of human culture. It was introduced in Indonesia in 1500 BC by Deutero-Malays at the time of his migration. In Ceylon (Sri Lanka), rice or paddy had been cultivated even before 543 BC and probably grown as dry land crop. In Japan, this crop was introduced around 100 BC from China. Muslims took this plant to most of Africa and Europe in their early valorous days. In America rice cultivation was introduced in the year 1694, when a ship from Madagascar brought rice seeds there. The Portuguese were responsible for introducing rice to Brazil, Central and South America. In Hawaii, rice was introduced in 1853. The French introduced it to Newcastle delta, and the Germans to New Guinea. The cultivation of paddy on commercial scale in Australia was started in 924 AD. It did not take long for paddy crop to become an important food crop in USA.

III. DATA AND METHODOLOGY

The data relating to area and production of rice are compiled from various published sources, mainly from statistical yearbook for Asia and the pacific, United Nations, Statistical Yearbook, United Nations and International Historical Statistics, The Americans and Australasia, MacMillan Reference Books. Country-wise time series data for 22 years, 1974-75 to 1995-96, pertaining to area, production and productivity of rice were collected. The period 1974-75 to 1995-96 has been divided into two sub-periods, *viz.* period I (1974-75 to 1984-85) and period II (1985-86 to 1995-96) to clearly bring out the trends in more recent period.

The compound growth rates for each period are estimated by using loglinear functions on the time series data on area, production and productivity. The equation fitted to analyze the trend growth rate is semilog exponential form.

$$\text{Log } Y_t = a + bt$$

Where,

Y = area/production/productivity of rice

a = constant

b = expresses the rate of change and when multiplied by 100 gives the percentage growth rate

t = time variable in year (1, 2, …. 22)

Instability is one of the important decision parameters in development dynamics and more so in the context of agricultural production. An analysis of fluctuations in crop output, apart from growth, is of importance for understanding the nature of food security and income stability. Wide fluctuations in crop output not only affect prices and bring about sharp fluctuation in them but also result in wide variations in disposable income of the farmers. The magnitude of fluctuations depends on the nature of crop production technology, its sensitivity to weather, economic environment, availability of material inputs and many other factors.

The measurement of instability in time series data requires an explicit assumption of what constitutes the acceptable and unacceptable components. A systematic component which can be predicted does not constitute instability and, hence, it should be eliminated from the data. The remaining unpredictable component represents the instability. There are a number of techniques available to measure the index of instability. Such techniques are found in Coppock (1962), MacBean (1966) and Massel (1970). In this study, the instability index (I) is measured by a method suggested by Parthasarathy (1984), which was based on residuals:

$$I = \sqrt{\frac{\sum_{i=1}^{n} e_i^2}{n-k}}$$

Where,

e_i = value of residual of ith observation

n = number of observations

k = number of variables

IV. GROWTH RATES IN AREA, PRODUCTION AND PRODUCTIVITY AND ITS COMPARISON WITHIN THE MAJOR GROWING COUNTRIES

The growth rates in area, production and productivity are presented in Table 5.

India

During period I, rice witnessed a growth rate of 0.29% in productivity, which was due to increase in area and production both but production contributed more than area. Between period I and II, the growth of production and productivity accelerated from 0.25% and 0.29% to 4.03% and 3.70%

respectively. The acceleration in production came mainly through the improvement in productivity. The improvement in period II may be due to improvement in technology.

TABLE 5

Period-wise Compound Growth Rates of Area, Production and Productivity of Rice in the Major Growing Countries of the World

(percent per annum)

Countries/ World	Period I (1974-75 to 1984-85)			Period II (1985-86 to 1995-96)		
	Area	Production	Productivity	Area	Production	Productivity
India	0.05 (3.57)*	0.25 (2.60)**	0.29 (2.28)**	0.33 (1.28)	4.03 (4.75)*	3.70 (4.97)*
China	–0.07 (2.81)**	0.30 (10.59)*	0.51 (9.11)*	–0.66 (2.77)**	0.62 (1.85)***	1.28 (6.83)*
Bangladesh	0.48 (2.26)**	2.31 (7.19)*	1.83 (6.33)*	–0.31 (1.06)	1.90 (2.33)**	2.21 (3.53)*
Thailand	2.35 (6.97)*	3.58 (6.32)*	1.23 (2.46)**	–0.59 (1.14)	0.99 (1.73)	1.58 (3.54)*
Myanmar	–0.75 (2.07)***	6.02 (10.88)*	6.77 (13.62)*	2.82 (4.65)*	2.76 (2.49)**	–0.06 (2.95)**
Philippines	–0.92 (2.88)**	3.71 (7.86)*	4.64 (15.90)*	1.16 (1.93)***	2.14 (5.05)*	0.98 (2.95)**
Japan	–2.43 (7.51)*	–2.52 (2.81)**	–0.09 (0.13)	–0.58 (1.73)	–1.13 (1.07)	–0.55 (0.55)
Pakistan	1.93 (4.02)*	3.45 (5.26)*	1.52 (4.91)*	1.01 (2.94)**	1.88 (2.55)**	0.87 (1.49)
USA	1.27 (0.77)	3.04 (2.07)***	1.77 (4.03)*	2.98 (4.91)	3.40 (4.80)*	0.42** (1.87)*
Indonesia	1.55 (6.87)*	5.49 (11.28)*	3.94 (8.66)*	1.37 (6.22)*	2.47 (8.99)*	1.10 (6.95)*
Republic of Korea	0.01 (0.07)	–0.26 (0.18)	–0.27 (0.19)	–1.61 (5.28)*	–0.53 (0.47)	1.08 (1.14)
Vietnam	0.79 (9.67)*	2.88 (2.93)**	2.10 (2.11)***	1.86 (9.63)*	4.74 (10.52)*	2.89 (8.06)*
World	0.74 (5.91)*	3.06 (13.31)*	1.89 (6.27)*	0.25 (1.57)	1.94 (6.93)*	1.05 (5.40)*

Figures in parentheses are *t* values.

* Significant at 1% level.

** Significant at 5% level.

*** Significant at 10% level.

China

During period I, China recorded a growth rate of 0.51% in productivity, which was mainly due to increase in production because area recorded a negative growth of 0.07%. Between period I and II, while the growth of production and productivity accelerated from 0.30% and 0.51% to 0.62% and 1.28% respectively, that of area decelerated from –0.07% to –0.66%. The acceleration in productivity was mainly due to the acceleration in production. This improvement in productivity in period II was mainly due to the improvement in technology.

Bangladesh

During period I, the increase in production was due to the increase in both area and productivity, but productivity contributed more than area. Between period I and II, while the growth in productivity accelerated from 1.83% to 2.21%, that of area and production decelerated from 0.48% and 2.31% to –0.31% and 1.90% respectively. The growth in productivity was mainly due to the growth in production. The improvement in productivity was due to the improvement in technology. If potential growth rates in agriculture are to be met, progress is specially important in three areas: (*a*) improving water development and management, (*b*) promoting new initiatives in rain-fed crop development and (*c*) strengthening agricultural support institutions.

Thailand

During period I, area, production and productivity all show a positive growth. The growth in production was due to the growth in area and productivity, but area contributed more than productivity. This shows the less utilization of improved technology. Between period I and II, while the growth in productivity accelerated from 1.23% to 1.58%, the area and production decelerated from 2.35% and 3.58% to –0.59% and 0.99% respectively. The growth in productivity is mainly due to the growth in its production.

Myanmar

During period I, the increase in productivity was mainly due to increase in production rather than area. Between period I and II, while growth of area accelerated from –0.75% to 2.82%, the production and productivity decelerated from 6.02% and 6.77% to 2.76% and –0.06% respectively. The growth in production in period II was mainly due to the growth of its area.

Philippines

In period I, the growth in productivity was mainly due to the growth in production rather than area. Between period I and II, while the growth in area accelerated from –0.92% to 1.16%, production and productivity decelerated from 3.71% and 4.64% to 2.14% and 0.98% respectively. The growth in production in period II was mainly due to the growth in its area.

Japan

In period I, Japan recorded negative growth in area, production and productivity. In period II also the area, production and productivity remained negative.

Pakistan

During period I, production recorded a growth rate of 3.45% which was due to the growth in area and productivity. Between period I and II, the area, production and productivity decelerated from 1.93%, 3.45% and 1.52% to 1.01%, 1.88% and 0.87% respectively. The growth in production in period II was mainly due to the growth in area.

USA

During period I, production recorded a positive growth which was mainly due to the growth in its productivity. It means that the effect of new technology was prominent. Between period I and II, while the growth of area and production accelerated from 1.27% and 3.04% to 2.98% and 3.40% respectively, the productivity decelerated from 1.77% to 0.42%. It means that in period II area and productivity both contributed to production but area contributed more than productivity.

Indonesia

Area and productivity both contributed to production during period I. Productivity contributed more than area. Between period I and II, the growth in area, production and productivity decelerated from 1.55%, 5.49% and 3.94% to 1.37%, 2.47% and 1.10% respectively. The growth in production in period II was due to the growth in area and productivity both.

Korea

During period I, area, production and productivity were insignificant. Production and productivity are negative while the area is positive. Between period I and II, the area, production and productivity accelerated from 0.01%, –0.26% and –0.27% to –1.61%, –0.53% and 1.08% respectively.

Vietnam

During period I, the growth in production was due to the growth in area and productivity, but productivity contributed more than area. Between period I and II, the growth in area, production and productivity accelerated from 0.79%, 2.88% and 2.10% to 1.86%, 4.74% and 2.89% respectively. The growth in production in period II was due to the growth in area and productivity.

Comparison

During period I, the increase in production of world countries was 3.06% per annum (Table 5). This increase in production was due to increase in both area and productivity, but productivity contributed more than area. Within the world in period I, Myanmar recorded the highest rate of growth in production followed by Indonesia, Philippines, Thailand, Pakistan, USA, Vietnam, Bangladesh, China, India, Korea and Japan. As far as the area is concerned, Thailand recorded the highest growth followed by Pakistan, Indonesia, USA, Vietnam, Bangladesh, India, Korea, China, Myanmar, Philippines and Japan. In productivity, Myanmar recorded the highest growth followed by Philippines, Indonesia, Vietnam, Bangladesh, USA, Pakistan, Thailand, China, India, Japan and Korea. Within world countries in period II, Vietnam recorded the highest growth in production followed by India, USA, Myanmar, Indonesia, Philippines, Bangladesh, Pakistan, Thailand, China, Korea and Japan. USA recorded the highest growth, whereas Korea recorded the lowest negative growth in area. In productivity, India recorded the highest growth, whereas Japan recorded the highest negative growth.

V. INSTABILITY IN AREA, PRODUCTION AND PRODUCTIVITY AND ITS COMPARISON WITHIN THE GROWING COUNTRIES

Instability index in rice output of the major world countries are presented in Table 6.

India

It may be observed that in period I, the area, production and productivity recorded the low degree of instability. The magnitude of instability increased in period II relative to period I and the fluctuations in area or productivity turned out to be the dominant factor behind this instability. The instability in productivity was lower than instability in production in period II. It indicated the importance of area instability.

TABLE 6

Period-wise Instability Index in Rice Output of the Major World Countries

Countries/ World	Period I (1974-75 to 1984-85)			Period II (1985-8 to 1995-96)		
	Area	Production	Productivity	Area	Production	Productivity
India	0.001	0.01	0.01	0.03	0.09	0.08
China	0.003	0.002	0.01	0.02	0.03	0.02
Bangladesh	0.02	0.03	0.03	0.03	0.08	0.06
Thailand	0.04	0.06	0.05	0.05	0.06	0.05
Myanmar	0.04	0.04	0.05	0.06	0.12	0.06
Philippines	0.03	0.05	0.03	0.06	0.04	0.03
Japan	0.03	0.09	0.07	0.03	0.11	0.10
Pakistan	0.002	0.07	0.03	0.03	0.08	0.06
USA	0.17	0.15	0.05	0.06	0.07	0.02
Indonesia	0.02	0.05	0.05	0.02	0.03	0.02
Republic of Korea	0.01	0.15	0.15	0.03	0.12	0.10
Vietnam	0.01	0.10	0.10	0.02	0.05	0.04
World	0.01	0.02	0.03	0.02	0.03	0.02

China

It recorded low degree of instability in area, production and productivity in both the periods.

Bangladesh

In period I, area, production and productivity recorded the low degree of instability. The magnitude of instability in production and productivity increased in period II relative to period I and the fluctuation in productivity turned out to be the dominant factor behind this instability. The instability in productivity was lower than instability in production in period II. It indicated the importance of area instability.

Thailand

The instability in area, production and productivity was low and almost the same in both the periods.

Myanmar

In period I, the area, production and productivity recorded a low degree of instability. The magnitude of instability in production increased more in period II relative to period I and the fluctuation in area and productivity turned out to be the dominant factor behind this instability. The instability in productivity was lower than instability in production in period I. It indicated the importance of area instability.

Philippines

The instability in area, production and productivity was low and almost the same in both the periods.

Japan

It may be observed that in period I the production registered a high degree of instability. As the fluctuations in production are the compound result of fluctuations in crop acreage and crop productivity, area and productivity both contributed towards fluctuation. The magnitude of instability in production increased during period II relative to period I and the fluctuation in productivity turned out to be the dominant factor behind this instability. The instability in productivity in both the periods were lower than instability in production. It indicated the importance of area instability.

Pakistan

In period I, area, production and productivity registered low degree of instability. The magnitude of instability in production increased more in period II relative to period I and the fluctuation in both area and productivity turned out to be the dominant factor behind this instability. The instability in productivity in both the periods were lower than instability in production. It indicated the importance of area instability.

USA

It may be observed that in period I, the production registered the highest degree of instability. As the fluctuations in production are the compound result of fluctuations in crop acreage and crop productivity, area and productivity both contributed towards fluctuation but area contributed more than productivity. The magnitude of instability in production decreased during period II relative to period I and the fluctuation in both area and productivity turned out to be behind this instability. The instability in productivity in both the periods were lower than instability in production. It indicated the importance of area in instability.

Indonesia

It recorded a low degree of instability in area, production and productivity in both the periods.

Korea

It may be observed that in period I, the production registered the highest degree of instability. As the fluctuation in production is the compound result of fluctuations in crop acreage and crop productivity, productivity turned out to be the dominant factor behind this instability. The magnitude of instability in production decreased during period II relative to period I and the fluctuation in both area and productivity turned out to be behind this instability. The instability in productivity in period II was lower than instability in production. It indicated the importance of area instability. The instability in productivity and production in period I were equal.

Vietnam

In period I, production registered the highest degree of instability. Productivity turned out to be the dominant factor behind this instability. The magnitude of instability in production decreased during period II relative to period I and the fluctuation in productivity turned out to be behind this instability. The instability in productivity in period II was lower than instability in production. It indicated the importance of area instability. The instability in production and productivity were equal in period I.

Comparison

During period I and II, the world countries recorded a low degree of instability in area, production and productivity. The instability in productivity in period II was lower than instability in production. It indicated the importance of area instability. Within the world in period I, USA recorded the highest degree of instability in production followed by Korea, Vietnam, Japan, Pakistan, Thailand, Philippines, Indonesia, Myanmar, Bangladesh, China and India. As far as the area is concerned, USA recorded the highest degree of instability in area followed by Thailand, Myanmar, China, Philippines, Japan, Bangladesh, Pakistan, Indonesia, India, Korea and Vietnam. In productivity Korea recorded the highest degree of instability followed by Vietnam, Japan, Thailand, Myanmar, USA, Indonesia, Bangladesh, Philippines, Pakistan, India and China. Within the world countries in period II Myanmar recorded the highest degree of instability in production followed by Korea, Japan, India, Bangladesh, Pakistan, USA, Thailand, Vietnam, Philippines, China and Korea. In area Myanmar recorded

the highest instability followed by Philippines, USA, Thailand, India, Bangladesh, Japan, Pakistan, Korea, China, Indonesia and Vietnam. Myanmar, Philippines and USA recorded the highest instability in area followed by Thailand, India, Bangladesh, Japan, Pakistan, Korea, China, Indonesia and Vietnam. In productivity Japan recorded the highest instability followed by Korea, India, Bangladesh, Myanmar, Pakistan, Thailand, Vietnam, Philippines, China, USA and Indonesia.

In period I, the developing countries show a low degree of instability in area, production and productivity as compared to developed countries. In period II, the instability in area, production and productivity were more or less the same between USA and developing countries.

VI. COMPARISON BETWEEN GROWTH AND INSTABILITY OF AREA, PRODUCTION AND PRODUCTIVITY OF RICE IN THE WORLD COUNTRIES

Agricultural growth with stability has been a matter of concern in the strategy of agricultural development in the world, especially in developing countries. The new farm technology has added to instability in production in developed countries (Japan and USA) while it shows a decline in developing countries in both the periods. Myanmar recorded the highest growth in production and productivity with low instability in period I. In period II, Vietnam recorded the highest growth in production with low instability. In productivity India recorded the highest growth with high instability.

VII. CONCLUSION AND POLICY IMPLICATIONS

The study reveals that during period I the growth in production was mainly due to the growth in productivity while in period II area and productivity both contributed to production but productivity contributed more as compared to area. In both the periods, the growth in production were possible due to favourable weather conditions, favourable prices and. the market intervention schemes. Within the world in period I, Myanmar recorded the highest growth rate in production followed by Indonesia, Philippines, Thailand, Pakistan, USA, Vietnam, Bangladesh, China, India, Korea and Japan. In period I, in China, Myanmar and Philippines, the increase in productivity was possible only through increase in production because the area had negative growth. In period II, in China, Bangladesh and Thailand, the growth in productivity was only possible through increase in production only not area. In period I, the developing countries show a low degree of instability in area, production and productivity as compared to

USA. In period II the instability in area, production and productivity are more or less the same between USA and developing countries. The instability in productivity in period II was lower than instability in production. It indicated the importance of area instability. In period I, USA recorded the highest degree of instability in area and production. In period II, Myanmar recorded the highest degree of instability in area and production. The new farm technology has added to instability in production in most countries while it shows a decline in some countries in both the periods.

From the above conclusion the important steps to improve growth with stability in production are:

(*a*) The yield per acre of rice in most of the growing countries are very low. So there is a need to increase the yield of the crop through HYV seeds, better fertilizer application, new farm technology, pest control, better time of nursery sowing, better soil condition, better lad preparation, uprooting and transplanting nursery, better irrigation, better zinc deficiency, better weed control and better method of rice harvesting.

(*b*) The result of the study indicates that in China, Myanmar, Philippines, Bangladesh and Thailand, the area of the crop has to be increased. This can be done by decreasing the area of marginal crops. By doing this these countries can increase their export of rice and can earn more foreign exchange.

(*c*) The share of rice to total world production of rice in most of the growing countries is very low. So in order to increase its share, these countries have to increase its production by increasing the per acre yield of the crop through HYV seeds, better and timely application of fertilizer, new farm technology and pest control.

(*d*) In order to reduce instability in production there is a need to develop less risky technologies. Policies to stabilize the supplies of fertilizers and electric power for irrigation pumps might be more effective.

(*e*) There is an urgent need to evolve disease resistant varieties tolerant to stress caused by droughts, frost and pest to bring about more stability in productivity.

(*f*) More concerted efforts are needed on the part of the agricultural universities/institutions for solving/relaxing the area-specific productivity constraints by bridging the research and extension gaps pertaining to rice.

The exact policy that can effectively reduce the instability in rice production remain elusive. There is still a need for further research directed at providing a better understanding of the sources of the increased yield. Such research might delineate more precisely how policies to stabilize fertilizer and electricity supplies could reduce production instability, as well as possibly revealing other causal factors that can be controlled through policy interventions. But a large part of the increase in production instability probably has to be accepted as a necessary consequence of successful agricultural growth.

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