Chapter-I

CROP DESCRIPTION

1.1 Origin of rice

1.1.1 *Oryza Sativa*, it is believed, is associated with wet, humid climate, though it is not a tropical plant. It is probably a descendent of wild grass that was most likely cultivated in the foothills of the far Eastern Himalayas. Another school of thought believes that the rice plant may have originated in southern India, then spread to the north of the country and then onwards to China. It then arrived in Korea, the Philippines (about 2000 B. C.) and then Japan and Indonesia (about 1000 B. C.). When Alexander the Great invaded India in 327 B. C., it is believed that he took rice back to Greece. Arab travelers took it to Egypt, Morocco and Spain and that is how it travelled all across Europe. Portugal and Netherlands took rice to their colonies in West Africa and then it travelled to America through the 'Columbian Exchange' of natural resources. But as is traditionally known, rice is a slow starter and this is also true to the fact that it took close to two centuries after the voyages of Columbus for rice to take root in the Americas. Thereafter the journey of rice continues with the Moors taking it to Spain in 700 A. D. and then the Spanish brought rice to South America at the beginning of 17th century.

1.1.2 The journey of rice around the world has been slow, but once it took root it stayed and became a major agriculture and economic product for the people. In the Indian subcontinent more than a quarter of the cultivated land is given to rice (20011-12). It is a very essential part of the daily meal in the southern and eastern parts of India. In the northern and central parts of the subcontinent, where wheat is frequently eaten, rice holds its own and is cooked daily as well as on festivals and special occasions.

1.2 History of Rice in India:

1.2.1 India is an important centre of rice cultivation. The rice is cultivated on the largest areas in India. Historians believe that while the *indica* variety of rice was first domesticated in the area covering the foothills of the Eastern Himalayas (i.e. north-eastern India), stretching through Burma, Thailand, Laos, Vietnam and Southern China, the *japonica* variety was domesticated from wild rice in southern China which was introduced to India. Perennial wild rice still grow in Assam and Nepal. It seems to have appeared around 1400 BC in southern India after its domestication in the northern plains. It then spread to all the fertiled alluvial plains watered by rivers. Some says that the word rice is derived from the Tamil word *arisi*.

1.2.2 Rice is first mentioned in the Yajur Veda (c. 1500-800 BC) and then is frequently referred to in Sanskrit texts. In India there is a saying that grains of rice should be like two brothers, close but not stuck together. Rice is often directly associated with prosperity and fertility; hence there is the custom of throwing rice at newlyweds. In India, rice is always the first food offered to the babies when they start eating solids or to husband by his new bride, to ensure they will have children.

1.2.3 Key points

- Paddy grains found during excavation at Hastinapur (India) around 1000-750 B.C. considered as an oldest sample in the world.
- Southwest Himalayas has various types and varieties and indicated probable centre of origin.
- **De Condolle (1886) and Watt (1862)** mentioned **south India** is the centre of rice origin.
- **Vavillov** suggested **that India and Myanmar** should be regarded as the centre of origin of cultivated rice.
- According to **D. Chatterjee (1948),** there are altogether **24 species of genus** *Oryza* of which 21 are wild and two viz., *Oryza sativa* and *Oryza glaberrima* are cultivated. *Oryza sativa* is grown in all rice growing areas, but *Oryza glaberrima* is confined to the **West Africa** only. Thus it indicates that there might have been **two centres of origin** of our cultivated rice; South-eastern Asia (India, Myanmar and Thailand) and West Africa.

1.2 Importance of Rice:

1.2.1 Rice has shaped the culture, diets and economic of thousand of millions of peoples. For more than half of the humanity " rice is life". Considering its importance position, the United Nation designated year 2004 as the "International Year of rice. Importance of rice are as follows:

a. Rice is an important staple food crop for more than 60 per cent of the world people. In 2008, more than 430 million metric tons of rice were consumed worldwide, according to the USDA.
b. Ready to eat products eg. popped and puffed rice, instant or rice flakes, canned rice and fermented products are produced
c. Rice straw is used as cattle feed, used for thatching roof and in cottage industry for preparation of hats, mats, ropes, sound absorbing , straw board and used as litter material.
d. Rice husk is used as animal feed, for paper making and as fuel source.

e. Rice bran is used in cattle and poultry feed, defatted bran, which is rich in protein, can be used in the preparation of biscuits and as cattle feed.

f. Rice bran oil is used in soap industry. Refined oil can be used as a cooling medium like cotton seed oil / corn oil. Rice bran wax, a byproduct of rice bran oil is used in industries.

1.3 Scientific Name:

1.3.1 The two major rice varieties grown world wide today are *Oryza sativa indica* and *Oryza sativa japonica*. The two cultivated rice species, *Oryza sativa* L. and *O. glaberrima* Steud., belong to a species group called *Oryza sativa* complex together with the five wild taxa, *O. rufipogon* (sensu lato), *O. longistaminata* Chev. et Roehr., *O. barthii* A. Chev., *O. glumaepatula* Steud., and *O. meridionalis* Ng. Among these taxa, only *O. rufipogon* produces fertile F_1 hybrids with *O. sativa* and therefore these two species are considered to belong to a single biological species. Together with all circumstantial evidence, this suggests that *O. rufipogon* is the ancestor of *O. sativa*. Similarly, it leaves no doubt that *O. barthii* is the ancestor of African rice *O. glaberrima*.

1.3.2 Habit and distribution of different species of rice :

Species	**Habit**	**Distribution**
Oryza sativa	Annual, cultivated	South and South-east Asia
O. nivara	Annual, wild	South and South-east Asia
O. rufipogon	Perennial, wild	Tropical Asia, Australia
O. glaberrima	Annual, cultivated	Trpical west Africa
O. barthii	Annual, wild	Sub-Saharan Africa
O. longistaminata	Perennial, wild	Tropical west Africa
O. glumaepatula	Parennial, wild	Tropical west Africa
O. meridionalis	Wild	Tropical Australia
O. officinalis	Perinnial, wild	South and South-east Asia
O. minuta	Perennial , wild	The Philippines
O. rhizomatis	Wild	Sri Lanka
O. eichingeri	Wild	Sri Lanka, Tropical Africa
O. punctata	Wild	Tropical Africa
O.latifolia	Wild	Central and South America
O. alta	Wild	Central and South America
O. grandiglumis	Wild	South America
O. australiensis	Wild	Tropical Australia
O. granulata	Wild	Tropical Asia

O. meyeriana	Wild	South-east Asia
O. longiglumis	Wild	Indonesia, Papua New Guinea
O. ridleyi	Wild	South-east Asia, Papua New Guinea
O. schlechteri	Wild	Papua New Guinea
O. brachyantha	Wild	Tropical Africa
P. coarctata	Perennial, wild	South Asia

1.4 Botanical Description:

The rice plant is a member of Poaceae (old Gramineae) family. The common cultivated rice plant is an annual which usually grows to a height of a half meter or two meters but there are certain varieties that grow much taller (6-9 metres). Some deep water rice varieties grow with the gradual rise of the flood water level. Rice plant can be divided into main two parts namely root system and shoot system:

1.4.1 Root system:

When a rice grain germinates in a well drained, upland soil the sheath (coleorhizae) emerges. If it germinates in submerged low lands, coleoptile emerges ahead of the coleorhizae. The primary, embryonic roots (radicle) comes out through the coleorhiza shortly after it appears. This is followed by two or more secondary roots, all of which develop lateral roots. The embryonic roots later die and are replaced by secondary adventitious roots produced from the underground nodes of the culm.

1.4.2. Shoot System:

Collectively applies to all plant part visible above the ground level. It is mainly composed of culms, leaves and inflorescence (panicle).

i. **Culm**: The culm or stem is made up of a series of nodes and internodes. The rice culms are usually hollows except at the nodes. Each node bears a leaf and a bud. Under favorable conditions buds near ground level grow into tillers. The primary tillers give rise to secondary tillers which give rise to tertiary tillers.

ii. **Leaves:** The leaves of rice are sessile in nature. They are borne at an angle, on the culm in two ranks along the stem, one at each node. The leaf blade is attached to the node by the leaf sheath. The rice leaf is similar to that of wheat, but is usually distinguished from it by the length of the ligule. In the rice, ligule is very prominent, usually more than one centimeter. The leaf number is more on a primary tiller than on the secondry and tertiary tillers.

iii. **Panicle:** The rice inflorescence known as panicle is a group of spikelets borne on the uppermost node of the culm. The primary panicle branch is divided into secondary and sometimes tertiary branches. These bear the spikelet.

iv. **Spikelet:** The individual spikelet consists of two outer glumes. All the parts found above the outer glumes are collectively called floret. It consists of a hard covering the two sections of which are known as lemma and palea (the glumes) and the complete flower is between them. The lemma and palea together are known as the “hull”. The rice flower contains six functioning stamens (male organ) and a pistil (female organ). At the base of the flower are two transparent structures known as ‘lodicules’. Rice is a self pollinated crop. When rice flower becomes ready to bloom, the lodicules become turgid and push the lemma and palea apart, thus allowing the stamens to emerge outside the open floret. Rupturing of the anthers then leads to the shedding of pollen grains. After the pollen grains are shed on stigma the lemma and palea close.

1.4.3 Grain (Caryopsis): Rice grain develops after pollination and fertilization are completed. The grain is tightly enclosed by the lemma and palea. The dehulled rice grain is known as brown rice as brownish pericarp covers it. The pericarp is the outermost layer which envelopes the caryopsis and is removed when rice is milled and polished. The embryo lies at the ventral side of the spikelet next to the lemma. Adjacent to the embryo is a dot like structure the hilum. The embryo contains the plumule and radicle. The plumule is enclosed by a sheath known as coleoptile and the radicle by the coleorhizae.

1.5 Nutritional value of Rice:

1.5.1 Rice is a nutritional staple food which provides instant energy as its most important component is carbohydrate (starch). On the other hand, rice is poor in nitrogenous substances with average composition of these substances being only 8per cent and fat content or lipids only negligible, i.e., 1per cent and due to this reason it is considered as a complete food for eating. Rice flour is rich in starch and is used for making various food materials. It is also used in some instances by brewers to make alcoholic malt. Likewise, rice straw mixed with other materials is used to produce porcelain, glass and pottery. Rice is also used in manufacturing of paper pulp and livestock bedding.

1.5.2 The variability of composition and characteristics of rice is really broad and depends on variety and environmental conditions under which the crop is grown. In husked rice, protein content ranges in between 7per cent to 12per cent. The use of nitrogen fertilizers increases the percentage content of some amino acids.

1.5.3 The comparative nutritional value of cereals in the table 1 showed difference in nutritional content of rice bran and raw rice. The brown rice is rich in some vitamins, especially B1 or thiamine (0.34 mg), B2 or riboflavin (0.05 mg), niacin or nicotinic acid (4.7 mg). In contrast, the white rice is poor in vitamins (0.09 mg of vitamin B1, vitamin B2 0.03 mg and 1.4 mg of niacin) and minerals as they are found mostly in the outer layers of the grain, which are removed by polishing process, or "bleaching" whereas parboiled rice is rich in these vitamins as a result of their particular process.

Table 1: Nutritional value of cereals per 100 grams

Cereals	Protein (gm)	Fat (gm)	CHO (gm)	Minerals (gm)	Calcium (mg)	Fiber (gm)	Energy (K cal)
Wheat whole	11.8	1.6	71.2	1.5	41	1.2	346
Wheat flour	12.1	1.7	69.4	2.7	48	1.9	341
Rice bran	13.5	16.2	48.4	6.6	67	4.3	393
Rice (raw)	6.8	0.5	78.2	0.6	10	0.2	345
Rice (par boiled)	8.5	0.6	77.4	0.9	10	0.2	349
Maida	11	0.9	73.9	0.6	23	0.3	348
Bajra	11.6	5.0	67.5	2.3	42	1.2	361
Jowar	10.4	1.9	72.6	1.6	25	1.6	349
Ragi	7.3	1.3	72.0	2.7	344	2.6	328

1.5.4 Cooking procedures can reduce the richness of vitamins and minerals in rice, and in fact, cooking is usually done with water which is then neglected and much of these nutrients dissolve in water and get wasted. Rice is strongly recommended in preparing specific diets against stomach and intestinal disease processes as well as feeding the infants and old people due to its good digestible character.

1.6 Medicinal Value:

1.6.1 The immense diversity of rice germplasm is a rich source for many rice based products and is also used for treating many health related maladies such as indigestion, diabetes, arthritis, paralysis, epilepsy and give strength to pregnant and lactating mothers. Ancient Ayurvedic literature testify the medicinal and curative properties of different types of rice grown in India. Medicinal rice varieties like Kanthi Banko (Chhattisgarh), Meher, Saraiphul & Danwar (Orissa), Atikaya & Kari Bhatta (Karnataka), are very common in India. Few varieties cultivated in restricted pockets of Kerala for their medical properties e.g. Chennellu, Kunjinellu, Erumakkari & Karuthachembavu etc.

1.7 Rice Growing Region in India:

1.7.1 Rice is grown under so diverse soil and climatic conditions that it is said that there is hardly any type of soil in which it cannot be grown including alkaline and acidic soils. Rice crop has also got wide physical adaptability. Therefore, it is grown from below sea-level (Kuttanad area of Kerala) upto an elevation of 2000 metres in Jammu & Kashmir, hills of Uttaranchal, Himachal Pradesh and North-Eastern Hills (NEH) areas. The rice growing areas in the country can be broadly grouped into five regions as discussed below :

i. **North-Eastern Region:**This region comprises of Assam and North eastern states. In Assam rice is grown in the basin of Brahmnaputra river. This region receives very heavy rainfall and rice is grown under rain fed condition.

ii. **Eastern Region** This region comprises of Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Orissa, Eastern Uttar Pradesh and West Bengal. In this region rice is grown in the basins of Ganga and Mahanadi rivers and has the highest intensity of rice cultivation in the country. This region receives heavy rainfall and rice is grown mainly under rain fed conditions.

iii. **Northern Region:** This region comprises of Haryana, Punjab, Western Uttar Pradesh, Uttrakhand, Himachal Pradesh and Jammu & Kashmir. The region experiences low winter temperature and single crop of rice from May-July to September-December is grown.

iv. **Western Region:** This region comprises of Gujarat, Maharashtra and Rajasthan. Rice is largely grown under rain fed condition during June-August to October - December.

v. **Southern Region:** This region comprises of Andhra Pradesh, Karnataka, Kerala and Tamil Nadu. Rice is mainly grown in deltaic tracts of Godavari, Krishna and Cauvery rivers and the non-deltaic rain fed area of Tamil Nadu and Andhra Pradesh. Rice is grown under irrigated condition in deltaic tracts.

Chapter -2

Comparative Analysis:

2.1. Rice is one of the most important food crop of India. Major share of rice is cultivated during Kharif season. A small share of rice is grown in rabi /summer season with assured irrigation. Indian rice production largely depends on monsoon rains and only 59 per cent rice area has assured irrigation. The area during 1st plan was 30.68 m ha and it hah reached to 43.64 million hectare during 11th plan which is nearly 42.2 per cent of 1st plan . The rice production has registered a appreciable increase from 25.03 m tonnes during 1st plan to 97.05 tonnes during 11th plan, which is nearly 4 times over the 1st plan. The yield was 816 kg/ha during 1st plan and increased to 2224 kg/ha during 11th plan. Rice production shows a steady upward trend during 2005-06 to 2008-09. Production declined during 2009-10 due to severe drought, but it reached to 95.98 m tonnes in 2010-11 and further the highest record of 105.31 million tonnes in 2011-12.

2.2 Sate wise Area, Production and Yield of Rice during 2007-08 to 2011-12

A - Area in lakh hectares,
P - Production in lakh tonnes,
Y - Yield in kg/ha.

Sl No	STATES		2007-08	2008-09	2009-10	2010-11	2011-12
1	Andhra Pradesh	A	39.84	43.87	34.41	47.51	40.96
		P	133.24	142.41	105.38	144.18	128.95
		Y	3344	3246	3062	3035	3146
2	Assam	A	23.24	24.842	24.958	25.704	25.37
		P	33.19	40.085	43.358	47.366	45.163
		Y	1428	1614	1737	1843	1780
3	Bihar	A	35.726	34.96	32.137	28.325	33.24
		P	44.181	55.903	35.993	31.02	71.626
		Y	1237	1599	1120	1095	2155

Sl No	STATES		2007-08	2008-09	2009-10	2010-11	2011-12
4	Chhattisgarh	A	37.524	37.34	36.707	37.025	37.738
		P	54.266	43.918	41.104	61.59	60.284
		Y	1446	1176	1120	1663	1597
5	Gujarat	A	7.59	7.47	6.79	8.08	8.36
		P	14.74	13.03	12.92	14.966	17.9
		Y	1942	1744	1903	1852	2141
6	Haryana	A	10.75	12.10	12.05	12.45	12.35
		P	36.13	32.98	36.25	34.72	37.59
		Y	3361	2726	3008	2789	3044
7	Jammu & Kashmir	A	2.632	2.576	2.599	2.613	2.626
		P	5.613	5.631	4.974	5.077	5.447
		Y	2133	2186	1914	1943	2074
8	Jharkhand	A	16.537	16.836	9.95	7.203	14.69
		P	33.364	34.202	15.384	11.1	31.306
		Y	2018	2031	1546	1541	2131
9	Karnataka	A	14.16	15.14	14.87	15.4	14.16
		P	37.17	38.02	36.91	41.88	39.55
		Y	2625	2511	2482	2719	2793

Sl No	STATES		2007-08	2008-09	2009-10	2010-11	2011-12
10	Kerala	A	2.288	2.343	2.34	2.132	2.082
		P	5.285	5.903	5.983	5.228	5.69
		Y	2310	2519	2557	2452	2733
11	Madhya Pradesh	A	15.589	16.823	14.457	16.029	16.62
		P	14.619	15.597	12.606	17.721	22.273
		Y	938	927	872	1106	1340
12	Maharastra	A	15.74	15.22	14.70	15.18	15.41
		P	29.96	22.84	21.83	26.96	28.41
		Y	1903	1501	1485	1776	1841
13	Odisha	A	44.518	44.547	43.651	42.257	440.045
		P	75.407	68.127	69.175	68.277	58.07
		Y	1694	1529	1585	1616	1450
14	Punjab	A	26.10	27.35	28.02	28.31	28.18
		P	104.89	110.00	112.36	108.37	105.42
		Y	4019	4022	4010	3828	3741
15	Rajasthan	A	1.278	1.334	1.507	1.311	1.343
		P	2.596	2.411	2.283	2.655	2.534
		Y	2031	1807	1515	2025	1887

Sl No	STATES		2007-08	2008-09	2009-10	2010-11	2011-12
16	Tamil Nadu	A	17.892	19.318	18.455	19.057	19.038
		P	50.402	51.827	56.652	57.924	74.587
		Y	2817	2683	3070	3040	3918
17	Uttar Pradesh	A	57.09	60.34	51.867	56.57	59.47
		P	117.80	130.97	108.071	119.92	140.22
		Y	2063	2171	2084	2120	2358
18	Uttrakhand	A	2.89	2.96	2.94	2.90	2.8
		P	5.93	5.82	6.08	5.504	5.94
			2052	1966	2068	1901	2121
19	West Bengal	A	57.197	59.357	56.301	49.442	54.337
		P	147.195	150.372	143.407	130.459	146.058
		Y	2573	2533	2547	2639	2688
20	Others	A	10.56	10.65	10.48	11.13	11.132
		P	20.95	21.78	20.21	24.88	24.908
	All India	**A**	**439.144**	**455.374**	**419.185**	**428.625**	**440.068**
		P	**966.929**	**991.824**	**890.931**	**959.797**	**1053.122**
		Y	**2202**	**2178**	**2125**	**2239**	**2393**

2.3 Country wise Area, Production and Yield of Total Rice during 2005 to 2009

A - Area in lakh hectares,
P - Production in lakh tonnes,
Y - Yield in kg/ha.

Sl No	Country		2005	2006	2007	2008	2009
1	India	A	430.00	437.00	437.7	440.0	418.50
		P	1290.0	1365.10	1445.7	1482.6	1337
		Y	3000	3124	3303	3370	3195
2	China	A	293	293.8	291.791	294.93	298.82
		P	1842.5	1840.7	1873.97	1933.54	1966.81
		Y	6289	6265	6422	6556	6582
3	Bangladesh	A	110	112	107.32	117.41	113.54
		P	400.54	437.29	430.57	469.05	477.24
		Y	3641	3904	4012	3995	4203
4	Indonisa	A	118.01	114	121.476	123.09	128.84
		P	539.84	544	571.57	602.51	643.99
		Y	4575	4772	4705	4895	4998
5	Thialand	A	102	100.73	106.689	102.48	109.63
		P	270	292.69	320.99	304.67	314.62
		Y	2647	2906	3009	2973	2870
6	Vietnam	A	73.4	73.24	72.01	74.14	74.4
		P	363.41	358.27	358.68	387.25	388.95
		Y	4951	4892	4981	5223	5228

Sl No	Country		2005	2006	2007	2008	2009
7	Myanmar	A	60	72	82.0	82.00	80
		P	220	252	326.1	305.00	326.82
		Y	3667	3500	3977	3720	4085
8	Philippines	A	41.15	41.6	42.729	44.6	45.32
		P	148	153.27	162.4	168.16	162.664
		Y	3597	3684	3801	3770	3589
9	Pakistan	A	25	25.72	25.15	29.63	28.83
		P	73.51	81.37	83.03	104.28	103.245
		Y	2940	3164	3301	3519	3581
10	Japan	A	16.8	16.88	16.73	17.00	16.24
		P	109.89	106.95	108.93	110.29	105.925
		Y	6541	6336	6511	6488	6522
11	Brazil	A	39.36	29.75	28.909	28.62	28.72
		P	131.41	115.05	110.61	121.00	126.518
		Y	3339	3867	3826	4228	4405
12	Egypt	A	6.5	6.13	6.684	7.45	7.5
		P	62	65	68.77	72.53	75.0
		Y	9538	10604	10289	9736	10000

Sl No	Country		2005	2006	2007	2008	2009
13	U.S.A	A	13.53	11.42	11.121	12.04	12.5575
		P	100.12	87.87	89.99	92.4	99.722
		Y	7400	7694	8092	7674	7941
14	Russian Fed.	A	1.25	1.56	1.57	1.6	1.775
		P	4.9	6.86	7.09	7.38	9.13
		Y	3920	4397	4516	4613	5144
15	Others	A	205.12	207.41	206.239	214.56	218.33
		P	90.39	639.64	637.51	689.47	714.774
	Total	**A**	**1535.12**	**1543.24**	**1558.12**	**1589.55**	**1583.00**
		P	**5646.55**	**6346.06**	**6595.910**	**6850.13**	**6852.41**
		Y	**3678**	**4112**	**4233**	**4309**	**4329**

Source : Agricultural Statistics at a glance,2012

Chapter 4

CLIMATIC REQUIREMENT:

4.1In India rice is grown under widely varying conditions of altitude and climate. Rice cultivation in India extends from 8 to35ºN latitude and from sea level to as high as 3000 meters. Rice crop needs a hot and humid climate. It is best suited to regions which have high humidity, prolonged sunshine and an assured supply of water. The average temperature required throughout the life period of the crop ranges from 21 to 37º C. Maximum temp which the crop can tolerate 40^0C to 42 ^{0}C.

4.2 Temperature at different stage:

Minimum temperature for sprouting is10^0C at the time of tillering, the crop requires a high temperature than for growth. Minimum temperature for flowering range from 22-23^0C.Temperature requirement for blooming is in the range of 26.5to 29.5º C. Minimum temperature for grain formation from 20-21^0C at the time of ripening the temperature should be between 20-25ºC. Photo periodically, rice is a short- day plant. However, there are varieties which are non-sensitive to photoperiodic condition.

4.3 Potential Impacts of Temperature on Rice Production:

Temperature greatly influences not only the growth duration, but also the growth pattern and the rice crops. The temperature sum, range, distribution pattern, and diurnal changes, or a combination of these may be highly correlated with grain yields. Rice plant has nine growth stages with its three distinct growth phases and every stage has an optimum temperature range for its proper development. Duration of the critical temperature, have a great impact on physiological status of the plant. Extreme temperature, whether low or high, cause injury to the rice plant. High temperatures are a constraint to rice production and cause a significant yield reduction. When temperatures exceed the optimal for biological process, crops often respond negatively with a steep decline in net growth and yield. Critical temperature for the development of rice plant at different growth stages is given in table 4.a

Table 4.a : Critical temperature for the development of rice plant at different growth stages

Growth stages	Critical temperature (^{0}C)		
	Low	High	Optimum
Germination	16-19	45	18-40
Seedling emergence	12	35	25-30
Rooting	16	35	25-28
Leaf elongation	7-12	45	31
Tillering	9-16	33	25-31
Initiation of panicle primordial	15	---	---
Panicle differentiation	15-20	30	---
Anthesis	22	35-36	30-33
Ripening	12-18	.>30	19-20

4.4 Impact of temperature on rice production:

With the likely growth of world's population towards 10 billion by 2050, the demand for rice will grow faster than for other crops. There are already many challenges to achieving higher productivity of rice. In the future, the new challenges will include climate change and its consequences. The expected climate change includes the rise in the global average surface air temperature. At the end of the 21st century, the increases in surface air temperature will probably be around 1.4-5.8 °C, relative to the temperatures of 1980-1999, and with an increase in variability around this mean. Most of the rice is currently cultivated in regions where temperatures are above the optimal for growth (28/22 °C). Any further increase in mean temperature or episodes of high temperatures during sensitive stages may reduce rice yields drastically. In tropical environments, high temperature is already one of the major environmental stresses limiting rice productivity, with relatively higher temperatures causing reductions in grain weight and quality. Developing high temperature stress tolerant rice cultivars has become a proposed alternative, but requires a thorough understanding of genetics, biochemical, and physiological processes for identifying and selecting traits, and enhancing tolerance mechanisms in rice cultivars. The effects of high temperature stress on the continuous of soil-rice plant-atmosphere for different ecologies (with or without submerged conditions) also need detailed investigations. Most agronomic interventions for the management of high temperature stress aim at early sowing of rice cultivars or selection of early maturing cultivars to avoid high temperatures during grain filling. But these measures may not be adequate as high temperature stress events are becoming more frequent and severe in the future climate. There are considerable risks for rice production, stemming from high temperature stress but benefits from the mitigation or adaptation options through progress in rice research may sustain the production systems of rice in the future warmer world.

4.5 **Important growing ecology of rice:**

Rice farming is practiced in several agro ecological zones in India. No other country in the world has such diversity in rice ecosystems than India. Because cultivation is so widespread, development of four distinct types of ecosystems has occurred in India, such as:

- Irrigated Rice Eco System Rainfed
- Upland Rice Eco System
- Rainfed Lowland Rice Eco System
- Flood Prone Rice Eco System

Irrigated Rice Eco System: Irrigated ecosystems are the primary type found in East Asia. Irrigated ecosystems provide 75per cent of global rice production. In India, the total area under irrigated rice is about 22.00 million hectares, which accounts about 49.5per cent of the total area under rice crop in the country. Rice is grown under irrigated conditions in the states of Punjab, Haryana, Uttar Pradesh, Jammu & Kashmir, Andhra Pradesh, Tamil Nadu, Sikkim, Karnataka, Himachal Pradesh and Gujarat.Irrigated rice is grown in bunded (embanked), paddy fields.

Rainfed Upland Rice Eco System: Upland zones are found in Asia, Africa, and Latin America. In India, the total area under upland rain fed rice in the country is about 6.00 million hectares, which accounts13.5per cent of the total area under rice crop in the country. Upland rice areas lies in eastern zone comprising of Assam, Bihar, Eastern M.P., Orissa, Eastern U.P., West Bengal and North-Eastern Hill region. Upland rice fields are generally dry, unbunded, and directly seeded. Land utilized in upland rice production can be low lying, drought-prone, rolling, or steep sloping.

Rainfed Lowland Rice Eco System: Rainfed low-land rice is grown in such areas as East India, Bangladesh, Indonesia, Philippines, and Thailand, and is 25per cent of total rice area used worldwide. In India, low land rice area is about 14.4 million hectares, which accounts 32.4 per cent of the total area under rice crop in the country. Production is variable because of the lack of technology used in rice production. Rainfed lowland farmers are typically challenged by poor soil quality, drought/flood conditions, and erratic yields

Flood Prone Rice Eco System: Flood-prone ecosystems are prevalent in South and Southeast Asia, and are characterized by periods of extreme flooding and drought. Yields are low and variable. Flooding occurs during the wet season from June to November, and rice varieties are chosen for their level of tolerance to submersion**.**

Chapter 5

Basmati and its export

Basmati Rice means the rice varieties possessing aroma and gives pleasant flavour after cooking. In India Basmati rice is characterized by extra long, superfine slender grains having a length to breadth ratio of more than 3.5, sweet taste, soft texture, delicate curvature and an extra elongation with least breadth-wise swelling on cooking. The Basmati rice is also stated to be the Pearl of Rice. These superfine best quality of Basmati rice are most preferred specially for Biryani and Pulao preparation on special occasion and also meant for high premium value in the national and international market.

5.3 Grain characteristic of Basmati and non basmati Rice

Sl No.	Characteristics	Basmati (in-mm)	Basmati (Paraboiled)	Non Basmati (Parmal -PR-106)
1	Average Length of uncooked rice	7.3	7.5	7.0
2	Average breadth of uncooked rice	1.9	1.9	2.1
3	Average L/B ratio of uncooked rice	3.8	3.9	3.3
4	Average length of cooked rice	8.9	8.9	5.6
5	Average breadth of cooked rice	2.2	2.2	3.1

5.4 General Characteristics and Specifications of Rice

Type of Rice	Grade	Purity Level	Grain	Broken	Moisture	Foreign Matter	Red Streak & Wary Grains
Basmati	*Superior*	*90%*	*7mm*	*less than*	*14%*	*Nil*	*less than 1%*
	& above	*(Avg.)*		*1%*			
	A	*85%*	*6-7mm*	*less than 1%*	*14%*	*Nil*	*less than 1%*
	B	*75%*	*5-7mm*	*less than 1%*	*14%*	*Nil*	*less than 1%*
Non Basmati	*Terricot*	*100%*			*14%*	*Nil*	*less than 1%*
	PR 106	*100%*			*14%*	*Nil*	*less than 1%*
	IR8	*100%*			*14%*	*Nil*	less than 1%

5.5 **Traditional Area**

Basmati rice is mostly grown in the traditional areas of north and north western part of Indian sub-continent for many centuries. The super-fine best quality of Basmati rice is produced on either side of Indus valley in India. Its different varieties are mostly cultivated in the districts of Karnal, Panipat, Kurukshetra, Kaithal, Amritsar, Fatehgarh, Gurudaspur, Hoshiarpur, Jalandhar, Patiala, Ropar and Sangrur in Punjab; Kangra, Solan, Una, Mandi and Sirmour in Himachal Pradesh; Bundi in Rajasthan and in several districts of Uttar Pradesh. Some important districts of Uttar Pradesh are Saharanpur, Muzaffar Nagar, Piliphit, Bareily, Bijnour, Moradabad, Jyotibaphule Nagar, Rampur, Raibareily, Sitapur and Udham Singh Nagar; Haridwar and Dehradoon in Uttaranchal. Also, Basmati rice is grown to limited extent in Jammu and Kashmir.

5.6 .Varieties:

The important varieties of Basmati rice as notified under the seeds Act, 1966 are Basmati 386 , Basmati 217 , Ranbir Basmati , Karnal Local/ Taraori Basmati, Basmati 370, Type-3 (Dehradooni Basmati), Pusa Basmati-1, Pusa Basmati 1121, Punjab Basmati-1, Haryana Basmati- 1, Ranbir Basmati (IET-11348),Kasturi and Mahi Sugandha.

5.7. Export of rice:

5.7.1 Basmati Rice India is exporting Basmati Rice to various countries in the world. A total quantity of 7.087 lakh tones of basmati rice was exported to different countries from India during 2002-03. However, the export increased to 31.781 lakh tonnes during 2011-12, registering an increase 348 per cent during the last 10 years . The export increased during 2010-11 to 2011-12 and a total quantity from 23.706 to 31.781 lakh tones. The basmati rice registering a increase of 34 per cent over the export. The export of basmati rice from 2004-05 to 2007-08 was almost static with slight increase or decrease over the years.

The export earnings from basmati rice decreased during 2006-07 over previous year. Thus, export earnings decreased by 8.22 per cent during 2006-07 as compared to 2005-06. During 2002-03 export earning from the export of basmati rice was Rs. 2054.47 crores, which increased significantly to Rs.15449.60 crores during 2011-12, registering an increase of 650.54 per cent over 2002-03.

5.7.2 Non-Basmati Rice: India is also exporting substantial quantity of non-basmati rice to various countries in the world. However, the export of non-basmati rice has been fluctuating year to year due to Govt. policy. The export of non-basmati rice from India during 2002-03 was 42.59 lakh tonnes, the export rose to 52.86 lakh tones during 2007-08 and it came down to 1.006 lakh tones during 2010-11 in the last nine years. The increase in export of non basmati rice during 2011-12 was 39.977 lakh tones. The export declined from 2002-03 to 2011-12 and decrease was 6.14%.

During 2002-03, export earning from the export of non-basmati rice was Rs. 3772.77 crores and it increased to Rs.7410.03 crores during 2007-08 registering the increase of 96.40% over the year 2002-03. The export earning during 2009-10 & 2010-11 were Rs. 365.3 crores & Rs. 231.29 crores respectively. The earning of non-basmati rice was the lowest during the year 2010-11 in last nine years. During 2011-12, export earning of non-basmati rice was Rs. 8659.126 crores the registering the increase the earning of 129.52% over the year 2002-03.

India has exported total Rice (Basmati and Non-Basmati rice) to various countries in the world. A total quantity of rice 71.759 lakh tones was exported to different countries from India and export earning from the export of total rice (Basmati and Non-Basmati) was Rs.24108.72 crores during 2011-12.

Thailand was the world's leading exporter of basmati and non-basmati rices for decades. However, due to farmers support price policy locally called pledging price, Thai importers have fallen during 2012. It is estimated that Thailand due to this change in policy has lost 50% of its customers During 2012, it is estimated that India exported 10 million tones of rice both basmati and non-basmati rice which is the largest in the world Vietnam 7.2 million tones and Thailand 6.5 million tones.

2.5 Export of Basmati and Non Basmati Rice during 1991-92 to2010-11

Quantity in thousand tonnes
Value Rs in core

Year	Basmati		Non Basmati		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1991-92	266.53	499.18	411.94	256.41	678.47	755.59
1992-93	324.79	800.64	255.62	174.96	580.41	975.60
1993.94	527.23	1061.26	565.19	225.46	1092.42	1286.72
1994-95	442.13	865.32	448.5	340.47	890.63	1205.79
1995-96	373.31	850.67	5040.7	3717.41	5414.01	4568.08
1996-97	523.16	1247.64	1989.04	1924.72	2512.20	3172.36
1997-98	593.32	1685.62	1795.74	1985.38	2389.06	3671.00
1998-99	597.79	1876.91	4365.89	4403.85	4963.68	6280.76
1999-2000	638.38	1780.34	1257.79	1345.58	1896.17	3125.92
2000-01	849.02	2154.94	682.27	777.26	1531.29	2932.20
2001-02	667.07	1842.77	1541.49	1331.37	2208.56	3174.14
2002-03	708.79	2058.47	4259.08	3772.77	4967.87	5831.24
2003-04	771.49	1993.05	2640.57	2174.94	3412.06	4167.99
2004-05	1163.00	2823.9	3615.1	3945.02	4778.10	6768.92
2005-06	1166.57	3043.1	2921.6	3178.17	4088.17	6221.27
2006-07	1045.73	2792.81	3702.22	4243.1	4747.95	7035.91
2007-08	1183.36	4344.58	5286.08	7410.03	6469.44	11754.61
2008-09	1556.41	9477.03	931.89	1687.37	2488.3	11164.40
2009-10	2016.87	10889.46	139.54	365.3	2156.41	11254.76
2010-11 (P)	2186.45	10581.51	96.08	220.25	2282.53	10801.76
Source : Agricultural Statistics at a glance P= Provisional						

CHAPTER- 6

Genetic Potential

6.1 Biotechnology plays an important role in the field of agriculture. Biotechnology in modern parlance especially with regard to plants and crops means under standing genetic nuances at the DNA level which is a kind of genetic engineering. Crops are bred by pollination, cross pollination and molecular techniques. Molecular techniques genetically modify the crops. Rice is the first food crop which has genome sequence readily available, and so from a biotech point of view it is possible to identify the genes in rice that are responsible for productivity, environmental adaptation and resistance to stress.

In the 1980s, tissue culture techniques were adopted for producing better rice varieties. Then Agro bacterium tumefactions was used to implant foreign DNA in rice plants, which helped not only in improving the genetic make-up of different varieties of rice, but also helped to study the molecular biology of rice.

6.2. There are several ways to alter presently existing rice varieties. Now, marker-assisted methods can be used to select the wanted genes within a species or in transgenic alien genes can be used to get particular traits. Before molecular markers came on the scene, the evaluation of genetic factors associated with dominant traits was done using biometrical methods. The advantage with rice is that, since rice whole genome sequence is readily available it can be used to identify genes that are responsible for significant phenotypic variation.

6.3- Super rice Scientists at the International Rice Research Institute in the Philippines have developed" Super Rice" a high-yielding rice of the future which increases harvests by 25 percent. It is far less bushy as each plant consists of only 10 stems or so in comparison with 20 to 25 of the traditional rice plant. Besides that, a single super rice plant can produce 2,500 grains of rice compared to 1,500 grains from conventional plant.

6.4 Herbicide Tolerance Rice

Repeated use of herbicides in rice fields often leads to the growth of herbicide resistant weeds. There are hundreds of these weeds and especially Oryza rufipogon and Echinochloa crus-galli cause the maximum problems. This means that, the rice farmer has to alternatively use several herbicides or mixtures of different herbicides and there was no guarantee that these herbicides would be harmful to the rice plant as well.

As herbicide tolerance was often due to a single gene, the idea has been to create rice plants with the mammalian P450 enzyme that could detoxify several of these herbicides and make these rice plants tolerant to herbicides. Now, a transgenic rice plant with human gene CYP2B6 not only give good yields but also shows high herbicide tolerance capacity. They could detoxify several herbicides such as thiocarbamates, oxyacetamides and 2, 6-dinitroanilines. To the farmer this is extremely beneficial in terms of labor costs saved.

6.4 Insecticides resistance rice variety:

Insects are another cause of worry in rice fields. Bt proteins have been successful against some insect varieties but significantly have failed against building resistance to larvae of Scirpophaga incertulans that very much affects Asian rice fields. To solve this problem of S. incertulans the introduction Bt genes into rice is reckoned as a possibility so that they can produce toxins that combat the insects. Like all proteins, Bt toxins are coded for by genes (stretches of DNA found in the cells) and only a single gene encodes each Bt toxin. Other pests that need to be countered are yellow stem border caterpillar, and Chilo suppressalis (found in temperate areas). So bio-technology helps in avoiding the use of insecticides that harm both the environment and the farmer.

6.5 Nutrition value

Using genetic engineering techniques rice can produce beta-carotene (pro-Vitamin A) in the seed endosperm tissue as for example in Golden Rice (has a gene that produces vitamin A). Although the precise amount of beta-carotene that Golden Rice variety can produce is not clear, the fact remains that it could still be beneficial to millions of people with Vitamin-A deficiency that could possibly lead to blindness. Similarly research is underway to fortify rice with iron using molecular assisted breeding techniques as it could help reduce anemia in women. These efforts are particularly important, as rice being a staple food is the best mechanism to deliver nutrients to the needy, but nevertheless should not be seen as a substitute to an otherwise balanced diet. Rice milk, rice flour and rice grain cereals, are specially benefited with the emphasis on nutritional fortification of rice.

6.6 Genetically Modified Rice

In the long run, biotechnology aims to increase the productivity of rice farming through introduction of transgenic traits and help the developing world prepare adequately for food security. In this regard agronomists use the genetic make up of rice to plan its future evolutionary course. Although advances in plant genetic engineering may offer even better opportunities for the rice plant, the pace of development of new technologies in rice farming will depend on how the new traits in the rice will be commercially beneficial to the farming community.

Natural rice also known as Oryza sativa when introduced with foreign gene is known as genetically modified rice. It's the transgenic variety of rice better in many ways as compared to the natural rice. Different varieties of GM rice have been produced. Rice is the staple food of Asia which includes countries like Bangladesh i.e. the largest producer of rice; half of the world's population feeds on rice. Genes are inserted in edible parts of rice to produce beta-carotene which further produces pro-vitamin A. The advancement in the field of biotechnology another variety of transgenic rice was produced known as golden rice 2, having 23 times more beta-carotene than the original golden rice. It was a breakthrough in the field of biotechnology.

6.7.Uses

GM rice has more yields as compared to the wild rice, scientists compared the per hectare productivity of both crops and found GM crop to be 15 times more productive than the wild rice. They will solve the problem of food shortage throughout the world.

They yield high levels of vitamin A also known as retinol, eradicating the deficiency of vitamin A from the world, retinol keeps the moisture level of body in balance, monitors the light adjustability of eyes, neutralizes the free radicals in the body by acting as an antioxidant. Beta carotene a precursor of retinol is found to useful in treat of CAD (coronary artery disease). Beta carotene is produced by this crop which is converted in to retinol in digestive system of animals. Deficiency of vitamin A in human beings can lead to blindness; most vulnerable to these syndromes are children and pregnant women.

6.8 Hazards

As they are new and have not undergone many tests, so the harmful side effects they can have on human health are not known . They can cause many types of allergies in humans leaving them sick. Scientists are confused about the amount of vitamin A available to the people after proper cooking of this golden rice. People will stop consuming wild rice once this golden rice is made public so we'll lose the natural rice. They are low in nutritional value as compared to the wild rice except the beta-carotene because they are modified to produce higher beta carotene.

Chapter 7

Crop Production Practices :

7.1 In India Rice is mainly grown in two types of soils i.e., (i) uplands and (ii) low lands. The method of cultivation of rice in a particular region depends largely on factors such as situation of land, type of soils, irrigation facilities, availability of labourers intensity and distribution of rainfalls. The crop of rice is grown with the following methods :-

(i) Dry or Semi-dry upland cultivation

(a) Broadcasting the seed

(b) Sowing the seed behind the plough or drilling.

(ii) Wet or lowland cultivation

(a) Transplanting in puddled fields.

(b) Broadcasting sprouted seeds in puddled fields.

7.2 Selection of Seeds

The use of quality seeds in cultivation of rice is an important factor to get better crop yield. Therefore, proper care has to be taken in selecting seeds of the best quality. Much of the success in raising the healthy seedlings depends on the quality of seed. Seeds intended for sowing should satisfy the following requirements :-

a. The seed should belong to the proper variety, which is proposed to be grown.
b. The seed should be clean and free from obvious mixtures of other seeds.
c. The seed should be mature, well developed and plump in size.
d. The seed should be free from obvious signs of age or bad storage
e. The seed should have a high germinating capacity.

Before sowing the seed should be treated with fungicides which protects the seed against soil-born fungi and also give a boost to the seedlings.

7.3 Methods of Nursery Raising

There are three major methods of raising nursery - viz.

i. The dry nursery where the dry seed is sown in dry soil. This method is practiced in areas where water is not sufficient to grow seedlings in wet nursery

ii. Wet nursery where sprouted seed is sown on the moist puddled soil. Wet nurseries are preferred under irrigated condition

iii. And the "dapog" method. This method of raising nursery has been introduced in India from Philippines.

"Dapog" method is commonly prevalent in Philippines. The essential feature of this method is to have a very thick stand of the nursery seedlings without any contact with the soil. Generally, seedlings become ready for transplanting in 12 to 14 days.

7.4 Seed Rate

The seed rate naturally influences the growth of the seedlings. Thin sowing gives strong and tillered seedlings, whereas thick sowing provides thin and tall seedlings without tillers. Thin sowing in nurseries is always better and it will produce strong and sturdy seedlings, which can withstand adverse climatic conditions better and produce better yields. Therefore, 40 to 60 grams of seed per square metre should be sown in the nursery beds. About 500 square metre area of nursery is sufficient to transplant one hectare area. In case of late sowing of nursery, the nursery area should be increased to 750-1000 square metre.

7.5 Transplanting

Before transplanting, field should be puddled properly with bullock or tractor drawn puddlers. Puddling is a very important operation in transplanted rice. Puddling helps to kill the weeds and buries them in puddled soils. It also suppresses the germination of weeds in subsequent growing period of crop. Puddling keeps the soil surface in a more even condition, besides creating beneficial physical, biological and chemical conditions for rice plant growth.

Transplanting should be done with proper age of seedlings. In case of short duration varieties, the seedlings should be uprooted from the nursery beds for transplanting , when it is three to four weeks old. In case of medium and long duration varieties, four to five weeks old seedlings should be transplanted. Always healthy seedlings should be used for transplanting at the four to five leaf stage or when they are about 15-20 cms. high. As far as possible, delayed transplanting should be avoided because it leads to poor tillerings, early flowering of the main tillers and resulting in reduction in yield. In alkaline soils aged seedlings of 45 days old should be transplanted because old seedlings establish better than young seedlings of 25 days age or so.

7.6 Spacing

Under good management and adequate nitrogen levels, the optimum spacing for varieties like IR-8 should be around 20x10 cms both for kharif and rabi crops. With excellent cultural practices, the spacing may be slightly wider, say 20x15 cms but under sub-normal conditions, the spacing should be slightly narrower, say 15x10 cms.

7.7 Number of Seedlings per Hill

Transplanting two to three seedlings per hill under normal conditions is enough. The use of more seedlings per hill, besides not being any additional advantage, involves an extra expense on seedlings. In case of transplanting with old seedlings, the number of seedlings per hill can be increased.

7.6 Depth of Planting and Directions of Rows

Depth of planting has assumed considerable importance after the introduction of high yielding varieties. The high yielding varieties are characterized with high tillering capacity. The high tillering potential of these varieties is, however, best expressed with shallow planting. The tiller buds formed at the basal node are not suppressed in case of shallow plantings . Therefore, the seedlings should be transplanted at 2 to 3 cm depth. Shallow planting gives better yields. The deeper planting results in an increased height of the plants besides delays and inhibits tillering.

The crop planted with rows running in the north-south direction generally gives better yield particularly in rabi season. The adoption of this practice is worthwhile, since it does not involve any extra expenditure.

7.9 Practices in the Direct-Seeded Crops

The success of the direct seeded rice depends entirely on the monsoon rains, besides proper stand of crop. If sowing is done in a properly prepared land, proper stand of crop can be achieved. A field with fine tilth facilitates the seed to come in contact with the soil moisture after drilling and enables the seed to germinate quickly and uniformly. Thus, an ideal preparation of the land will help to achieve a uniform stand, facilitate weeding and fertilizer practices. Therefore, with number of ploughings of the field and timely sowing, the direct seeded crop generally gives better yield.

7.10 Different Methods of Seeding

Seeding is done in three different ways - viz. (i) drilling i.e. sowing in the furrow behind a plough, (ii) dibbling and (iii) broadcasting. The light soils which generally come into conditions quickly, any method can be adopted. Seeding with drilling method has got a greater advantage over other methods, because of the uniformity of the stand and the control of the population of the plants per unit area. Heavy soils which do not come in conditions quickly, other methods except broadcasting are not feasible. It has been found that drilling or dibbling always gives considerably better yields than broadcasting system.

7.11 Broadcasting Sprouted Seeds in Puddled Land

This method is adopted in an area where agricultural labourers are not easily available for transplanting or some time labourers are very expensive. In this method field is prepared and puddled just like in the case of transplanting. About 100 kg seed is required for one hectare area. In the puddled field sprouted seeds with radical length of one to two millimeter are uniformly broadcast by hand.

7.12 Manure and Fertilizer Application

7.12.1 Organic manures are as much as important for rice cultivation as inorganic fertilizers. In case of upland rice cultivation, the use of bulky organic manure is very much desirable in order to maintain the physical condition of the soil and also to increase the water holding capacity of the soil for maximum utilization of rain water. In upland fields 10-15 tonnes of well rotted Farm Yard Manure or compost should be applied in one hectare area preferably 4 to 6 weeks before sowing. Organic manures should be spread evenly on the upper surface of the soil and ploughed in to get it well mixed in the soil.

7.12.2 Application of chemical fertilizers depends basically upon (i) fertility states of the field and (ii) previous crop grown and amount of organic manure applied. Before deciding the fertilizer dose, soil is required to be got tested to know the status of the nitrogen, phosphorus and potassium in the soil. After testing the soil, fertilizer dose should be calculated accordingly.

Soil fertility status varies in different agroclimatic zones to a considerable extent. Therefore, common fertilizer dose can not be recommended for all regions. The Department of Agriculture of various states and State Agriculture University have formulated fertilizer recommendations for rice crop in their states keeping in view the variability in soil fertility and local conditions. The fertilizer dose recommendation by the Agriculture Department in different states are given in Table

7.12.3 Application of fertilizer in transplanted rice field is quite different from upland rice. A series of reactions-physical, chemical and biological take place in transplanted rice fields due to presence of excess water in the field. In the root zone anaerobic environment is formed from aerobic condition due to depletion of oxygen in the soil profile, which is responsible for gaseous loss of nitrogen fertilizer due to de-nitrification process. This anaerobic environment also affects the behavior of phosphorus and micro-nutrients specially iron and manganese.

7.12.4 The soil in the transplanted rice fields after puddling develops two zones in water logged conditions. The upper layer of soils (1 to 10 milli metre thick) generally receives Oxygen periodically from fresh supplies of irrigation water and turns in to brown colour called "Oxidised zone" and reacts like an unflooded upland soil. The remaining lower portion of puddled soil without oxygen is called "reduced zone". When ammonical nitrogen fertilizer is applied in such soils, it gets oxidised to nitrate (NO3) form in the oxidised zone (upper surface layer of the soil). Afterwards nitrate nitrogen is leached down to the reduced zone and further gets denitrified to gaseous nitrogen. This gaseous nitrogen is lost. If ammonical nitrogen is incorporated in to the reduced zone of the soil, where it is held, the loss can be prevented. Fertilizers containing nitrogen in the nitrate form are more susceptible to loss of nitrogen through leaching and de-nitrification process. Therefore, ammonical form of nitrogen is found more beneficial for rice crop.

7.12.5 Due to variation in soil fertility, rainfall and climatic condition, a common dose of fertilizer can not be recommended for all regions. However, in general a level of 30 to 40 kg of nitrogen per hectare in kharif and 60 to 80 kg of nitrogen per hectare in rabi appears to be the optimum dose for the tall indicas and double that level for the high yielding varieties on soils of average fertility in the southern and eastern regions. In the northern region, where sunshine is available for longer hours, higher dose of nitrogen is beneficial in the kharif season.

7.12.6 The maximum efficiency can be obtained in the direct seeded upland rice by applying 50 per cent nitrogen dose, three weeks after seeding, 30 per cent at 45 days age and the rest at the boot-leaf stage.

In order to obtain better results, full dose of phosphorus, potash and half dose of nitrogen should be applied before last puddling. Remaining half dose of nitrogen should be applied in two equal doses, first at tillering stage and second dose at panicle initiation stage.

7.13 Water Management

The water requirement of rice crop is comparatively higher than any other crop of the similar duration. Assured and timely supply of irrigation water has a considerable influence on the yield of the crop. During the crop growth period, the water requirement is generally high at the initial seedling establishment stage. After the transplanting , water should be allowed to stand in the field at a depth of two to five centimeters till the seedlings are well established. The second, the most important critical stage is tillering to flowering and in this period the crop should not be subjected to soil moisture stress. The water supply should be ensured in required amount during panicle initiation to flowering stage. About five centimeters depth of water should be maintained in the field up to the dough stage of the crop. Before harvesting, water should be drained out from the field to allow quick and uniform maturity of grain.

7.14 Harvesting and Threshing

The maximum quantity and better quality paddy and rice depend on the harvesting of the crop at the correct maturity stage. Therefore, it is of the paramount importance to harvest the crop at suitable time. Harvesting of the crop when it is not fully matured might result in loss of yield with poor quality grains. If harvesting is delayed, grain may be lost due to damage by rats, birds, insects, shattering and lodging. Thus, timely harvesting ensures better yield, good quality of grains, consumer acceptance and less breakage when milled. The right stage for harvesting as commonly understood by laymen is when panicles turn into golden yellow and the grains contain about 20 percent moisture. When the moisture in the paddy grains reaches 16-17 percent in the standing crop in the fields, the crop sustains a heavy loss owing to shattering and damage by birds and rodents.

Extensive studies have been carried out on specifying the optimum time of harvesting. Based on the results of the various studies, in general, three criteria are taken into consideration to specify the right time of harvesting viz. (i) the moisture content of the grains, (ii) the number of days after planting or flowering and (iii) the dry matter of the plant or seed.

The most common and old methods of threshing of paddy is trampling by bullocks or lifting the bundles and striking them on the raised wooden platform. Now pedal threshers are being used. Power driven stationary threshers are also used for quick threshing.

7.15 Rice Growing Season in India:

7.15.1 In India rice is grown under widely varying conditions of altitude and climate . Therefore, the rice growing seasons vary in different parts of the country, depending upon temperature, rainfall, soil types, water availability and other climatic conditions. In eastern and southern regions of the country, the mean temperature is found favourable for rice cultivation through out the year. Hence, two or three crops of rice are grown in a year in eastern and southern states. In northern and western parts of the country, where rainfall is high and winter temperature is fairly low, only one crop of rice is grown during the month from May to November. There are three seasons for growing rice in India viz.- autumn, winter and summer.

These three seasons are named according to the season of harvest of the crop. Autumn rice is known as pre-kharif rice. The sowing of pre-kharif rice is taken up during May to August. However, the time of sowing slightly differs from state to state according to weather condition and rainfall pattern. It is harvested in September-October. Autumn rice crop is know as 'Aus' in West Bengal, 'Ahu' in Assam, 'Beali' in Orissa, 'Bhadai' in Bihar, 'Virippu' in Kerala and 'Kuruvai/kar/ Sornavari' in Tamil Nadu. About 7 per cent crop is grown in this season. The varieties grown during this season are mostly varieties of short duration ranging from 90 to 110 days.

7.15.2 The main rice growing season in the country is the 'Kharif'. It is known as winter rice as per the harvesting time. The sowing time of winter (kharif) rice is June-July and it is harvested in November-December. Winter rice is know as 'Aman' in West Bengal, 'Sali' in Assam, 'Sarrad' in Orissa, 'Agahani' in Bihar and Uttar Pradesh, 'Sarava' in Andhra Pradesh, 'Mundakan' in Kerala and 'Samba/Thaladi' in Tamil Nadu. About 84 percent of the country's rice crop is grown in this season and generally, medium to long duration varieties are grown in this season.

7.15.3 Summer rice is called as Rabi rice. It is known as 'Boro' in Assam and West Bengal, 'Dalua'in Orissa, 'Dalwa' in Andhra Pradesh, 'Punja' in Kerala and 'Navarai' in Tamil Nadu and 'Garma' in Bihar. The sowing time of summer rice is November to February and harvesting time is March to June. The area under summer rice is only 9 per cent and early maturing varieties are mostly grown in this season.

7.15.4 The sowing/harvesting period of autumn, winter and summer rice, region/state-wise are shown below –

Region/state	**Autumn**		**Winter**		**Summer**	
	Sowing	**Harvesting**	**Sowing**	**Harvesting**	**Sowing**	**Harvesting**
A. Northern Region						
a. Haryana	May-Aug	Sep- Nov				
b. Punjab	May-Aug	Sep- Nov				
c. West U.P	June-July	Sep-Nov				
d. H.P	June-July	Sep-Nov				
e. J& K			Apr-July	Sep-Dec		
B. Western Region						
a. Gujrat			Jun-Aug	Oct-Dec		
b. Maharashtra			Jun-Aug	Oct-Dec		
c. Rajashthan			July-Aug	Oct-Dec		

C. North Eastern Region						
a. Assam	Mid Feb-Apr	June July	June-Aug	Nov-Dec	Dec-Feb	May-June
b. East M.P	June-Aug	Mid Sep-Mid Dec				
c. Orissa	May -June	Sep-Oct	June-Aug	Dec-Jan	Sec-Jan	May-june
d. East U.P	May-July	Sep-Nov	July-Aug	Nov-Dec	Jan-Feb	Apr-June
e. West Bengal	Mar-June (Broadcasting) May-June (Transplanting)	July-Nov	Mar-June (Broadcasting) May-June (Transplanting)	Nov-Dec	Oct-Feb	April- May
D. Southern Region						
a. A. P.	Mar –apr	July-Aug	May-June	Nov-Decd-	Dec-Jan	Apr-May
b. Karnataka	May-Aug	Sep-Dec	June-Oct	Nov-Mar	Dec-Feb	Apr-July
c. Kerala	April-June	Aug-Oct	Sep-Oct	Jan-Feb	Dec-Jan	Mar-Apr
E. Tamil Nadu			Early Samba		Late Samba	
Sonavari	April-may	July-Aug	June-July	Nov-Dec	Oct–Nov	Mar-Apr
Kar	May-June	Aug-Sep	July-Aug	Dec-Jan	Dec-Jan	Apr-May
			THALADI/Pishanam			
Kuruvai	June-July	Sep-Oct	Sep-Oct	Dec-Jan		

Chapter 8

CROPPING PATTERNS

8.1 India has a wide range of soil and climatic conditions and cropping pattern vary widely from region to region and to a lesser extent from one year to another year. In fact for deviding cropping patterns, it is necessary to divide the country into homogeneous regions based on physical, climatological or agronomic. While making division, the climatic index and the soil group may be taken into consideration. The soil and the climate are the important factors for adoption of cropping patterns, hence they constitute a better criterion for crop-zoning.

8.2 During the first decade of planning i.e., from 1950-51 to 1960-61, there was not much change in the cropping patterns in spite of significant increase of about 22 million ha. in cropped area. The proportion of area under rice and wheat together remained around 30 per cent (2010-10) of the total cropped area in the country during 1950-51 to 1960-61. Adoption of high yielding varieties on a large scale, increased use of fertilizers, plant protection chemicals and expansion in irrigated areas led to shifting in areas towards crops in which the impact of improved production technology on yield was apparent. Area under rice as proportion of total cropped area is about 26 per cent (2011-12).

8.3 The cropping pattern in different Agro-climatic zones has been adopted by the farmers after long experience based on suitability of soil, profitability, availability of market and industrial infrastructure and quantum of water available. Techniques such as relay cropping, inter cropping, mixed cropping, minimum tillage, weed control and use of fertilizers and pesticides have helped not only in reducing the cost of cultivation but also in sustaining high level of production over a period of time. Scientific cropping patterns can actually result in increased soil productivity by improving the physical, chemical and micro-biological properties of soils and increasing the fertility status.

Some of the rice based cropping patterns being followed in the country are discussed below :-

8.3.1 Rice-Rice-Rice: This crop rotation is most suitable for areas having high rainfall and assured irrigation facilities in summer months, particularly, in soils which have high water holding capacity and low rate of infiltration. In some canal irrigated areas of Tamil Nadu, a cropping pattern of 300per cent intensity is followed. In such areas three crops of rice are grown in a year.

8.3.2 Rice-Rice-Cereals (other than rice): This cropping pattern is being followed in the areas where the water is not adequate for taking rice crop in summer. The alternate cereal crops to rice being grown are Ragi, Maize and Jowar.

8.3.3 Rice-Rice-Pulses: In the areas where, there is a water scarcity to take up cereal crops other than rice in summer, the short duration pulse crops are being raised.

8.3.4 Rice-Groundnut: This cropping pattern is being followed by the farmers of Andhra Pradesh, Tamil Nadu and Kerala. After harvesting of rice crop, groundnut is grown in summer.

8.3.5 Rice-Wheat: This crop rotation has become dominant cropping pattern in the Northern parts of the country.

8.3.6 Rice-Wheat-Pulses: In this sequence of cropping pattern, after harvesting of wheat, green gram and cowpea as fodder are grown in the alluvial soil belt of Northern states. Besides, cowpea is grown in red and yellow soils of Orissa and black gram is grown in the black soils.

8.3.7 Rice-Toria-Wheat: This crop sequence is commonly followed in Northern parts of the country. Among the above mentioned cropping patterns followed in the country, Rice-wheat cropping pattern is the largest one. The Rice-wheat cropping pattern is being practiced in the Indo-Gangetic plains of India since long time.

8.3.8 Rice-Fish farming system: The field with sufficient water retaining capacity for a long period and free from heavy flooding are suitable for rice-fish farming system. This system is being followed by the small and marginal poor farmers in rain fed lowland rice areas. These farmers are not able to invest much in agricultural development. They raise a modest crop of traditional low yielding rice varieties. In order to improve the economic condition of these farmers has been developed.

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Chapter 9

Rice Milling And It's Products

9.1 Rice Milling:

Paddy in its raw form cannot be consumed by human beings. It needs to be suitably processed for obtaining rice. Rice milling is the process which helps in removal of hulls and barns from paddy grains to produce polished rice. Rice forms the basic primary processed product obtained from paddy and this is further processed for obtaining various secondary and tertiary products. The basic rice milling processes consist of Pre Cleaning, De-stoning, Parboiling, Husking, Husk Aspiration (Separating the husk from brown rice/ unhusked paddy), Paddy Separation (Separating the unhusked paddy from brown rice), Whitening(Removing all or part of the bran layer and germ from brown rice), Polishing (Improving the appearance of milled rice by removing the remaining bran particles and by polishing the exterior of the milled kernel), Length Grading (Separating small and large brokens from head rice), Blending (Mixing head rice with predetermined amount of brokens, as required by the customer), Weighing and bagging (Preparing the milled rice for transport to the customer).

9.2 Types of Rice Mill

Many of the rice processing units in India are of the traditional huller type and are inefficient. Modern rice mills are having high capacity and are capital intensive, although efficient small modern rice mills have been developed. Most of the small size mills are huller mills. Other various types are Battery of Huller mills, Huller-cum-Sheller mills, Sheller mills and modern mills. The process for modernization of rice milling industry in the country was initiated in 1970 with a view to obtaining higher yields of rice and better quality of by-products such as bran and husk, suitable for edible oil/industrial oil extraction and as a source of fuel respectively.

9.3 Traditional Method: Before the advent of mechanical milling, hand-pounding traditional method of rice milling was in practice. In fact, hand-pounding rice has got more nutritive value as compared to machine milling rice. In hand-pounding, a variety of implements is used such as:

- □□Mortor and Pestle
- □□Dhenki
- □□Hand Stone (Chakki)

9.4 Mechanical Method : With the introduction of mechanized mills, hand-pounding method has steadily decreased because it could not compete with machine mills. The conventional mills in use can be categorized into three main types:

- □□Huller mills
- □□Sheller-Huller mills

- Sheller cum Cone Polisher mills.

9.6 Rice Products

Rice is the primary source of carbohydrates and protein besides, rice also contains small quantities of fat, ash, fibre and moisture. Vitamins and mineral are present largely in bran and germ. Its byproducts form important components of poultry and dairy feed. The byproducts which we get from paddy milling are rice bran and husk. The amount of rice bran is approximately five per cent of paddy processed. The rice bran is a pericarp or outer cuticle layer that remains beneath the hull. It gets removed during the milling process. About two decades back, rice bran was considered almost a waste and hence most of it was burnt. It is now viewed to have high nutritive value. Being rich in protein and natural BVitamin, rice bran is used as a cattle feed. The rice bran processing has now gained momentum, with increasing consumer demand for bran oil, extracted from bran.

9.7 Use of Rice and it's By products like rice husk, rice bran and paddy straw

Rice plants produces approximately50% rough rice and another 50% straw on weight basis. The rough rice, on milling, produces brown rice, milled rice, germ, bran, broken and husk. Each of these components has unique properties and can be used in anumber ofways. The utilization pattern of these components directly or as derivatives decides the extent of value addition in rice.

9.7.1 Utilization of Rice Straw:

- At farmers levels, rice straw is mainly used for thatching, as cattle feed and the woody portion as fuel. Some times a portion of the straw is ploughed back in to the soil to be reused as bio-fertilizer.
- In handi craft industry, rice straw is usedin making certain fancy products like bags, wall hanging etc.
- Rice straw along with others fibrous materials can be used to prepare pulp for making boards and papers.
- Rice straw is cut in to pieces and then used for making beds for growing mushroom.

9.7.2 Utilization of Paddy:

- Paddy is mainly used for consumption as whole milled rice either in raw or parboiled condition.
- Beaten rice is a value added products made from paddy and is popular in all parts of India. People of all age groups from all sections like it and thus it is a mass consuption item.
- Paddy when directly propped in hot sandproduces a white expanded productcalled khai. After removing the husk, it is consumed as a snack food.

9.7.3 Utilization of brown rice:

When the outer most layer of paddy (husk) is removed, the resultant product is the brown rice. It is rich in vitamin B_1, B_2, B_3, B_6 and Iron as compared to polished white rice. Brown rice can be stored well in hermetic storageor freezing condition.

9.7.4 Utilization of polished white rice:

Polished white rice is mainly consumed as a staple food after cooking. A few value added product like quick cooking rice and rice cake canbe produced from this white rice.

9.7.5 Utilization of parboiled rice:

Parboiled rice is also consumed as a staple food in many parts of India.value of this product mainly depends on its quality intermsof size (short & long),colour, texture, smelletc.The few value added products that can be made from parboiled rice are: quick cooking parboiled rice and puffed rice. Furthur value can be added to the puffed rice by making puffed rice balls with jaggery and other ingredients.

9.7.6 Utilization of rice broken:

- The broken rice which brings one third the value of whole rice grain in the market for direct consumption such as in the form of Idli/ Dosa or sold as poultry feed. This low valuematerial can be converted into several value added products like ricenoodels, vermicelli, rice alcohol, rice flour and rice ethanol.
- Rice flour is used in many foods including baby foods, chips and crackers. The unique properties of rice flour also make it a prime candidate for producing resistant starch, a food ingredient that acts like a fiber in the human body and thus provides thehealth benefits of fiber.
- Gluten free rice bread is a highly popular value-added product made from rice broken on old rice stocks in Japan.

9.7.7 Utilization of rice husk:

Potential availability of rice husk in the country as a by-product of milling industry is about 24 million tons annually. As a renewable resource, its proper utilization would add enough valueto the rice crop. The two major components like carbon & silica present in the rice husk make it possible to develop several value added products.

(a)Direct use of husk:

Use of husk for production of thermal energy using various types of furnaces is quite common these days.Some other uses of husk areas soil mulch, poultry litter, making particle board, insulation material, packing material etc.

(b)Products based on carbon compounds:

It is possible to convert the carbon compounds by a process similar to dry distillation of wood such as producer gas, furfural, activated charcoal, lignins, oxalic acid and bear like beverage.

© Products based on silica content:

- Silica is extracted from rice husk either in the formof sodium silicate or by burning the husk as fuel to produce ash, which mostly contains silica.
- Crude ash obtained from husk fired furnace is used as insulation covers for stell ingots, abrasives in metal cleaning, carrier for fungicides, insecticides and catalysts,floor sweeping aid,light weight refractory bricks, lime silica bricks and sodium silicate.
- High purity silica for production of sintered glassware can be obtained from husk ash by acid leaching.
- High purity silicon powder can be produced by reducing the high purity husk silica by metals like magnesium or calcium.

9.7.8 Utilization of rice bran:

- Rice bran is the most valuable by-product of rice milling industry. It contains 18-20% of fat, 14-15 % protein and to some extent of minirals and vitamins. Usually solvent extraction method is employed to extract oil from rice bran. Maximum cash benefit is therefore possible through judicious use of rice bran in a variety of ways.
- The crude rice bran oil can be used for manufacturing of soap,enamel paints, varnishes, detergent,metal soap and squalene (for skin disease) can be extracted from crude bran oil.
- The edible grade rice bran oil can be prepared by refining the crude oil in order to make the refining process economical, the oil may either be extracted or the bran should be stabilized immediately after its removal from brown rice. The free fatty acid of rice bran other wise increases very rapidly owing to the presence of lipase making the oil uneconomical for refining. Stabilization can be done either by acid treatment or dry/wet heat treatment.
- De-oiled bran is most commonly used as animal feed or as fertilizer.

Chapter 10

Pest, Diseases and Weeds of Rice

10.1 Pests and diseases of Rice

(a) Important Pest

Stage	Pests	Control measures
Nursery	Stem-borer, gall midge, thrips, root-knot nematode, root nematode and white tip nematode	• For insect-pests and nematodes, apply Phorate 10 G @ 12.5 kg/ha or Fipronil 0.3 G @ 33 kg/ha of nursery, 5 to 7 days before pulling the seedlings for transplanting or spray with Chlorpyriphos 20 EC @ 2,500 ml/ha or Quninalphos 25 EC @ 2,000 ml/ha. • In the stem-borer endemic areas, install pheromone traps with 5 mg lure @ 8 traps/ha for pest monitoring and 20 traps/ha for direct control through mass trapping • In gall midge/stem-borer-endemic areas apply phorate 10 G/ha 5 to 7 days before pulling the seedlings for transplanting.
Vegetative stage	Stem-borer	• Clipping of leaf tips of the seedlings at the time of transplanting will help in destruction of egg masses. • Removal of excess nursery and incorporation into soil. • Clean cultivation and destruction of stubbles. • Apply Cartap 4 G @ 25 kg/ha or Phorate 10 G @ 10 kg/ha or Fipronil 0.3 G @ 25 kg/ha or Chlorpyriphos 10 G @ 10 kg/ha. • Install pheromone traps with 5 mg lure @ 8 traps/ha for pest monitoring or 20 traps/ha for direct control through mass trapping. Replace lures at 25 to 30 days interval during the crop period. • Inundative release of egg parasitoid, *Trichogramma japonicum* 5 to 6 times @ 100,000 adults/ha starting from 15 days after transplanting.
	Gall midge	• Apply Fipronil 0.3 G @ 25 kg/ha or Phorate 10 G @ 10 kg/ha
	Green leafhopper	• Spray Carbaryl 50 WP @ 900 g ha or BPMC 50 EC @ 600 ml/ha or Acephate 50 WP @ 700 g/ha or Ethofenprox 10 Ec @ 500 ml/ha or Imidacloprid 200 SL @ 125 ml/ha or Thiamethoxam 25 WG @ 100 g/ha or Clothianidin 50 WDG 30 g/ha. Alternatively, apply Phorate 10 G @ 12.5 kg/h or Fipronil 0.3 G @ 25 kg/ha.
	Hispa	• Spray Triazophos 40 EC @ 400 ml/ha or Phosalone 35 EC @ 850 ml/ha or Chlorpyriphos 20 EC @ 1,500 ml/ha or

		Quinalphos 25 EC @ 1,200 ml/ha or Ethofenprox 10 EC @ 450 ml/ha or Fipronil 5 SC @ 600 ml/ha
	Leaf folder	• Spray Chlorpyriphos 20 EC @ 1,500 ml/ha or Cartap 50 WP @ 600 g/ha or Quinalphos 25 EC @ 1,200 ml/ha or Acephate 50 WP @ 700 g/ha or Fipronil 5 SC @ 600 ml/ha or Phosalone 35 EC @ 850 ml/ha or Carbaryl 50 WP @ 900 g/ha or Triazophos 40 EC @ 400 ml/ha or apply Cartap 4 g @ 25 kg/ha • Inundative release of egg parasitoid, Trichogramma chilonis 5 to 6 times @ 100,000 adults/ha starting from 15 days after transplanting
	Whorl maggot	• Apply Fipronil 0.3 G @ 25 kg/ha or Chlorpyriphos 20 EC @ 1,500 ml/Ha
	Case worm	• Drain water from the field and spray Carbaryl 50 WP @ 900 g/ha or apply Carbaryl dust @ 30 kg/ha
	Mealy bug	• Spot application of Phorate 10 G granules
Reproductive Stage	Stem-borer	• Spray Cartap 50 WP @ 800 g/ha or Chlorpyriphos 20 EC @ 2,000 ml/ha or Quinalphos 25 EC @ 1,600 ml/h
	Brown planthopper, White backed planthopper	• Spray Imidacloprid 200 SL @ 125 ml/ha or Thiamethoxam 25 WG @ 100 g/ha or Ethofenprox 10 EC @ 500 ml/ha or Acephate 50 WP @ 950 g/ha or BPMC 50 EC @ 600 ml/ha or Carbaryl 50 WP @ 900 g/ha
	Green leafhopper	• Spray Imidacloprid 200 SL @ 125 ml/ha or Thiamethoxam 25 WG @ 100 g/ha or Ethofenprox 10 EC @ 500 ml/ha or Acephate 50 WP @ 950 g/ha or BPMC 50 EC @ 600 ml/ha or Carbaryl 50 WP @ 900 g/ha
	Leaf folder	• Spray Cartap 50 WP @ 800 g/ha or Chlorpyriphos 20 EC @ 2,000 ml/ha or Phosalone 35 EC @ 1,100 ml/ha or Quinalphos 25 EC @ 1,600 ml/ha or Triazophos 40 EC @ 500 ml/ha or apply Cartap 4 G @ 25 kg/ha
	Ear-cutting caterpillar/ cut worm	• Spray Quinalphos 25 EC @ 1,600 ml/ha or Chlorpyriphos 20 EC @ 2,000 ml/ha or Carbaryl 50 WP @ 1,500 g/ha or Phosalone 35 EC @ 1,100 ml/ha
	Leaf/Panicle mite	• Spray Sulphur wettable powder @ 3 g/litre, Dicofol @ 5.0 /ml/litre or Profenophos 50 EC @ 2.0 ml/litre water.
	Gundhi bug	• Spray Carbaryl 50 WP @ 1,500 g/ha during afternoon hours. • Dust Malathion or Carbaryl @ 30 kg of the formulation/ha

(b) Important diseases :

Disease/Crop stage/season	States/Places endemic	Control measures
Leaf blast Nursery and vegetative Kharif and rabi	Leaf blast is favoured by the low night temperature (22-28 ^{o}C), high relative humidity (>95%), dew deposit, leaf wetness for more than 10 hours and high nitrogen. The disease is a serious problem in upland, irrigated and hilly ecosystems. In high rainfall zones (rainfall >_1,500 mm) of north and north-eastern India, the disease is prevalent during June-September. In Western and Central India (rainfall around 1,000 mm) the disease occurs during August-October. In Southern India blast mainly occurs in dry season during November-February. During kharif season, the disease is prevalent throughout the rice-growing areas in India especially in Himachal Pradesh, Uttarakhand, Jharkhand, Madhya Pradesh, Chhattisgarh, Asom, Tripura, West Bengal, Orissa, parts of Maharashtra, Andhra Pradesh, Kerala, Karnataka and Tamil Nadu. During rabi season, the disease is prevalent in Southern States like Andhra Pradesh, Tamil Nadu, Karnataka. The disease is also common on boro rice in the states of Asom, Tripura, Eastern Uttar Pradesh, Orissa and West Bengal.	• In endemic areas, adopt seed treatment with Tricyclazole 75 WP @ 2 g/kg or Carbendazim 50 WP @ 1 g/kg. • Spray Tricyclazole 75 @ 0.6 g/litre or Carpropamid 30 SC @ 1ml/litre. or Isoprothiolane 40 EC @ 1.5 ml/litre or Iprobenphos 48 EC @ 2ml/litre or Propiconazole 25 EC @ 1ml/litre or Kasugamycin-B 3 SL@2.5 ml/litre or Carbendazim 50 WP @ 1 g/litre. • Grow resistant/tolerant varieties like Rasi, IR 64, Prasanna, IR 36, Vikas, Tulasi, Sasyasree etc.
Neck blast Flowering and after kharif/rabi	The neck blast phase of the disease is prevalent in the states like Andhra Pradesh, Asom, Chhattisgarh, Himachal Pradesh, Karnataka, Orissa and Uttarakhand. The disease is of common occurrence in boro rice in the states of Asom and Tripura.	• Spray Tricyclazole 75 WP @ 0.6 g/litre or Carpropamid 30 SC @ 1 ml/litre or Isoprothiolane 40 EC @ 1.5 ml/litre or Iprobenphos 48 EC @ 2 ml/litre or Propiconazole 25 EC @ 1 ml/litre or Carbendazim 50 WP @ 1 g/litre.
Sheath blight Maximum tillering, panicle initiation to booting stage kharif/rabi.	Sheath blight is a serious problem in coastal and high rainfall areas. The disease is mostly prevalent in areas where the relative humidity is very high (above 95%), the temperature is moderate (28-32 ^{0}C) and N application is high. The disease is prevalent in moderate to severe form in states like Andhra Pradesh(coastal),	• Spray Validamycin 3 L @ 2.5 ml/litre or Thifluzamide 24 SC @ 0.75 g/litre or Hexaconazole 5 EC @ 2 ml/litre or Propiconazole 25 EC @ 1ml/litre or Carbendazim 50 WP @ 1g/litre • Reduce or delay the top-dressing

	Asom, Bihar, parts of Chhattisgarh, Orissa, eastern Uttar Pradesh, West Bengal, Kerala, Haryana and Punjab. In boro season the disease has been observed regularly in moderate form in the states of Asom, Bihar, eastern Uttar Pradesh.	or nitrogen fertilizer and apply in 2-3 splits
Brown spot Vegetative stage Kharif/rabi	Brown spot is problem mainly during kharif season especially in uplands and hill ecosystem. The disease also assumes a serious proportion in irrigated ecosystem especially in ill-managed plots. The disease is predominant in Jharkhand, eastern Uttar Pradesh, Bihar, Chhattisgarh, tarai region of West Bengal, Orissa, Asom, Tripura, Uttarakhand and Punjab. The boro rice the disease has been recorded in the states of Asom, Bihar and eastern Uttar Pradesh.	• In endemic area, adopt seed treatment with Carbendazim (12%) + Mancozeb (63%) combination 75 WP @ 2 g/kg or Carbendazim 50 WP @ 2 g/kg or Mancozeb (63%) 75 WP @ 2 g/litre or Mancozeb 75 WP @ 2.5 g/litre • Growing of resistant/tolerant varieties like Rasi, Jagnanath, IR 36 etc.
False smut Post-flowering stage Kharif	False smut of rice has emerged as a major disease in the recent years. The incidence of the disease is particularly more on hybrid varieties. The incidence of the disease is more in those years when spells of wet weather coincide with the heading stage. The disease is favoured by the prevalence of relatively low temperature and high humidity with moderate rainfall well distributed during the period of flowering. The incidence of the disease is more in states like Haryana, Punjab, Uttarakhand, Bihar, Chhattisgarh, Gujarat, Jharkhand, Orissa, Uttar Pradesh, Himachal Pradesh, Jammu and Kashmir, Maharashtra and Tamil Nadu.	• Spray Propiconazole 25 EC @ 1 ml/litre or Chlorothalonil 75 WP @ 2 ml/litre or Copper oxychloride at around flowering.
Sheath rot and grain discoloration Post-flowering stage Kharif	Sheath rot and grain discolouration are especially more in crops affected by stem-borer, rice tungro disease and various other biotic and abiotic stresses. In cytoplasmic male sterile lines (A lines) where the emergence of the panicles is poor, the incidence of sheath rot is very high. Grain discolouration of rice has become a serious problem in recent years especially when there is post-flowering rain. A variety of micro-organisms, viz. *Drechslera Oryzae, Sarocladium oryzae, Alternaria padwickii, Curvularia spp., Epicoccum sp., Fusarium moniliforme* etc. have been found associated with the grain discolouratrion. These problems have become	• In endemic area adopt seed treatment with Mancozeb 75 WP @ 2.5 g/kg or Captan 50 WP • Spray Mancozeb 75 WP @ 2.5 g/kg or Propiconazole 25 EC @ 1 ml/litre or Hexaconazole 5 EC @ 2 ml/litre or Thiophanate methyl 70 WP @ 1 g/litre.

	wide spread in states like Andhra Pradesh, Tamil Nadu, Kerala, Orissa, Jharkhand, Bihar, West Bengal, Asom, eastern Uttar Pradesh, Gujarat, Haryana, Punjab, Uttarakhand and Chhattisgarh.	
Stem rot Panicle initiation to booting Kharif	Stem rot of rice has become an important disease of rice causing substantial loss due to increased lodging. The disease is favoured by high N fertilizers, high relative humidity, high temperature and waterlogging conditions. The disease is more in early planted crop because of high temperature and relative humidity prevailing during the susceptible stage of the crop. The disease is prevalent in Haryana, Bihar, Uttarakhand and Andhra Pradesh.	• Burning the rice stubbles after harvest. • Draining out the field. • Addition of organic manure reduces the disease. • Spray Iprobenphos 48 EC @ 2 g/litre of Carbendazim 50 WP @ 1 g/litre or Thiophanate methyl 70 WP 1 g/litre or Isoprothiolane 40 EC @ 1.5 ml/litre. • Growing of resistant varieties like Jalmagna, Latisali, Pankaj, Rasi, etc.
Foot rot/ Bakanae Vegetative Stage Kharif	Though the disease is of limited occurrence, it has potentiality to be highly serious. The disease is prevalent in Haryana, Tamil Nadu and Andhra Pradesh.	• Seed dressing with Captafol 80% @ 4 g/kg or Mancozeb 75 WP @ 2.75 g/kg. • When observed in nursery, spray Carbendazim 50 WP @ 1 g/litre
Bacterial blight Pre-tillering to mid-tillering and panicle initiation to booting Kharif	Bacterial blight is essentially a monsoon season disease. The intensity of the disease is much influenced by rainfall, cloudy, drizzling and stormy weather and high nitrogen fertilizer. The disease is prevalent in moderate to severe form in almost all the rice-growing areas during the monsoon season. The disease is prevalent in coastal Andhra Pradesh, Tamil Nadu, Kerala, Punjab, Haryana, Uttarakhand, Uttar Pradesh, Gujarat, parts of Maharashtra, Chhattisgarh, Bihar, West Bengal, Orissa and Asom.	• Apply judicious level of fertilization (60-80 kg N/ha with required level of potassium) without sacrificing the yield. Apply N in 3-4 splits. • Avoid field to field irrigation. • Avoid insect damage to the crop. • Destroy infected stubbles and weeds. • Avoid shade in the field. • Grow resistant/tolerant varieties like Ajaya, IR 64, Radha, Pantdhan 6, Pantdhan 10.
Rice tungro disease Nursery, tillering Kharif	Rice tungro disease is the most important virus disease of rice. It has been reported from many rice-growing areas of India. The disease is prevalent in Tamil Nadu, West Bengal, parts of Andhra Pradesh and Orissa.	• Remove and destroy infected plants and apply additional nitrogen for early recovery. • Incorporate Phorate 10 G @ 12-15 kg/ha or Fipronil 0.4 G @ 25 kg/ha or nursery in top 2-5 cm layer of the soil before sowing of sprouted seeds. If such incorporation is not possible,

		broadcast the recommended insecticides 4-5 days after showing in a thin film of water and allow this water to seep completely. • In the main crop, spray Carbaryl 50 WP @ 0.65 litre/ha or Fipronil 5 EC @ 1 litre/ha. • Grow resistant/tolerant varieties like Nidhi, Vikramarya, Radha, Annapurna, Triveni etc.

10.2 Weeds of Rice

(i). Grasses, Sedges and broad leaves weeds in upland rice:

S.N	Botanical Name	Common Name	Family
Grasses			
1.	Echinochloa colonum Echinochloa crusgali	Bansawan	Gramineae
2.	Cynodon dactylon	Doob grass	Gramineae
3.	Eleusine indica	Bankodo	Gramineae
4.	Dactyloctenium aegyptium	Makra	Gramineae
5.	Setaria glauca	Bottle grass	Gramineae
Sedges			
6.	Cyperus rotundus	Motha	Cyperaceae
Broad leaves			
7.	Caesulia axillarics	Thukaha(Gurguja)	Compositeae
8.	Eclipta alba	Bhangaria	Compositeae
9.	Euphoribia herita	Bari dudhi	Enphorbiaceae
10.	Solanum nigrum	Ban makoy	Solanaceae
11.	Leucces aspera	Gumma	Labiatae
12.	Phyllanthus niruri	Hazardana	Euphorbiaceae
13.	Lippia nodiflora	Mokana	Verbenaceae

(ii). **Recommended dose and application time of Herbicides in Upland rice:**

S.N	Herbicides	Recommended dose (Kg a.i. ha^{-1})	Application time
1.	Butachlor	1.5	Pre-emergence
2.	Pretilachlor	1.0	Pre and early emergence
3.	Pyrazosulfuronethyl	40 g	Pre and early post emergence
4.	Oxyflurofen	1.5	Pre-emergence
5.	Anilofos	0.2-0.4	Pre-emergence

6.	Trifluralin	1.5	Pre-plant
7.	2,4-D	1.0-1.5	Post emergence
8.	Thiobencarb	1.0-1.5	Post emergence
9.	Propanil	2-3	Post emergence
10.	Bentazone	2.0	Post emergence
11.	Phenoxaprop-p-ethyle	100 g	Early post emergence

Chapter 11

STORAGE

11.1 Rice storage facilities take many forms depending on the quantity of grain to be stored, the purpose of storage, and the location of the store. In general, it is recommended that rice for food purposes be stored in paddy form rather than milled rice as the husk provides some protection against insects and helps prevent quality deterioration. However, when rice is stored as brown rice, 20% less storage capacity is needed

The requirements for a good storage system include:

- Prevention of moisture re-entering the grain after drying
- Protection from insects, rodents and birds
- Ease of loading and unloading.
- Efficient use of space
- Ease of maintenance and management.

11. 2 Safe Storage Conditions For Grain

Safe storage of rice for longer periods is possible if three conditions are met:

- Grain is maintained at moisture levels of 14% or less and seed is stored at 12% or less
- Grain is protected from insects, rodents and birds
- Grain is protected from re-wetting by rain or imbibing moisture from the surrounding air.

The longer the grain needs to be stored, the lower the required moisture content will need to be. Grain and seed stored at moisture contents above 14% may experience the growth of molds, rapid loss of viability and a reduction in eating quality. The following table shows the 'safe' moisture content required for different storage periods.

Storage period	Required moisture content for safe storage	Potential problems
2 to 3 weeks	14 – 18 %	Molds, discoloration, respiration loss
8 to 12 months	12- 13 %	Insect damage
More than 1 year	9 % or less	Loss of viability

A rule of thumb for seed is that the life of the seed will be halved for every 1% increase in moisture content or a 5^{o}C increase in storage temperature.

11.3 Grain Storage systems

Grain storage systems can be classified as:-.

(a) **Bag storage system.** In most parts of Asia grain is stored in 40-80kg bags made from either jute or woven plastic. Depending on the size of storage, these bags are normally formed into a stack. When using bag storage consideration needs to be given to the following:

- Jute bags should not be stacked higher than 4m and plastic bags 3m. Plastic bags are more slippery and the stacks will be less stable
- Bags should be stacked under cover e.g. under a roof, in a shed or granary or under water proof tarpaulins
- A one meter gap should be left between and around stacks and 1.5 meters clearance between the top of the stack and the roof
- Bags should be stacked on pallets or on an above ground structure to avoid the possibility of absorbing moisture from the floor.
- Bags should not be stacked on a bed of rice husks or bags filled with rice husks, as these are difficult to keep free from insect infestation.
- Bags should be stacked so that fumigation can be undertaken easily. The dimensions of the stacks should be set to facilitate sealing with a single fumigation sheet.
- The efficiency of bag storage can be improved if a plastic liner bag is used inside the existing storage bag especially for seed and milled rice

Some farmers use bag storage in outside granaries, which have been constructed from timber or mud/cement or large woven bamboo or palm leaves.

(b) **Bulk storage:** At farm level grain is often stored in bulk in small outside granaries or in woven baskets or containers made from wood, metal or concrete, which are located under or inside the house. These storages vary in capacity from 200-000kg. Losses from insects, rodents, birds and moisture uptake are usually high in traditional bulk storage systems.

(c) **Hermetic Sealed storage:** Sealed or hermetic storage systems are a very effective means of controlling grain moisture content and insect activity for grain stored in tropical regions. Sealed storage containers come in all shapes and sizes. They may range from a small plastic container, a sealed 200-liter drum to the more complex and costly sealed plastic commercial storage units. Recent technological advances in plastic manufacturing have led to the development of PVC liners that provide the required durability to climate, gas permeability and physical properties that enable airtight storage for extended periods of time.

For storage of small seed lots a variety of plastic bags or packages can be used. Different types of plastic have different resistance against transmission of water vapor. Glass jars, hard PVC or bags containing aluminum liners or a gas barrier will provide the best protection against moisture re-entry.

11.4 Major Storage Pests in Rice

Rice storage pests include insects, pathogens, rodents and birds. These pests cause losses through a combination of feeding, spoiling and contamination of both paddy and milled grain.

Many different species of insects are found in rice but only a few are major pests. Insects in stored rice can be classified as either primary or secondary insects. Primary Insects: These are insects whose larvae feed entirely within the kernels of the grain. These include the rice weevil, angoumois grain moth and lesser grain borer. Secondary Insects are insects that feed from the outside of the grain even though they may chew through the outer coat and devour the inside. Two of the more prevalent secondary insects are the Saw-toothed Grain Beetle and the Rust-red flour beetle

11.5 Management of storage insects

The management of stored grain pests should be done in a sequential and integrated manner. An effective pest control system involves

- Harvesting, drying and storage of clean dry grain
- Disinfecting the storage system and
- Controlling or preventing pest infestation during the storage period.

11.6 Harvesting, drying and storage

Grain must be dried to at least 14% moisture (wet basis) and seed grain should be dried to12% moisture before storage. Grain needs to be harvested and dried so that it will not cause cracking of the grain, as cracked grains are easier for insects to infest. This requires:

- Harvesting and threshing at the correct stage of maturity (20-25% moisture content)
- Drying the grain at a rate and temperature that will not damage the grain. The first stage of drying from 25% moisture to 18% can be done at high temperatures e.g. above 50-60^{o}C. After this the grain needs tempering or cooling for at least 4 hours. Drying from 18% to 14% moisture should be much slower and the temperature should not exceed 42^{o}C.

11.7 When sun drying, the grain should be spread in thin layers, 2-5cm, and turned every 1-2 hours. When sun-drying seed, the grain should be turned more often and not exposed to temperatures above 42^{o}C. If high temperatures occur the seed should be dried in the shade. New grain should not be stored near older grain unless all insects have been eliminated from the older grain. It is preferable to store grain as paddy or rough rice as this is less susceptible to insect attack than milled rice. Parboiled rice is also less susceptible to damage than raw rice.

11.8 Grain stores must have a damp proof floor and have waterproof walls and roof. It is preferable to be able to seal the storage so fumigation is possible should the need arise. Sealing the storage also helps exclude rodents and birds. Where grain is to be stored in bags, the bags should be stacked on pallets at least 50cm away from the walls. Hermetic storage systems have proved to be an effective means of storing grain.

11.9 Disinfesting the storage system

Disinfestations require a systematic and thorough cleaning of all sources of infestation before storage. Old grain residues in the storehouses, grain bins, harvesting and threshing equipment should be treated, removed or destroyed.

Storage containers, structures and equipment can be treated with:

- Malathion (50EC) at 5ml/20l of water @20ml/m^2
- Fenitrothion (50EC) at 5ml/l water @20ml/m^2
- Deltamethrin (2.5% WP) at 1.5g/l water @20ml/m^2

If thorough cleaning of containers is not possible, the containers may need to be sealed and fumigated with phosphine. All second hand bags should be examined and where necessary treated with either a fumigant, insecticide or dipped in boiling water. Solutions of Malathion (50EC) and Fenitrothion (50EC) at 5ml/20l of water and Deltamethrin (2.5% WP) at 1.5g/l water @20ml/m2 can be used for dipping the bags.

11.10 Controlling infestations within the grain

Consumers are increasingly demanding grain that is free from live insects and free from chemical residues caused by controlling pests. While many chemical sprays are registered for rice, some markets will not accept grain treated with these registered chemicals. Farmers should always check with buyers to ensure that the pest control methods intended for use will be acceptable.

The first step in controlling any infestation is to determine the level of infestation and then select an appropriate method for control. All storage should be checked, preferably every fortnight, and at least monthly. Random samples need to taken from all grain and tested for infestation. If there are more than 4 insects per kg some form of treatment is required. A simple rule of thumb for the number of bags to be sampled is to use the square root of the lot size. For example if there are 100 bags in the lot, samples should be taken from 10 bags.

11.11 Keeping Rodents Out

The requirements of preventive rodent control must be taken into account whenever new stores are being built. Particular attention should be paid to doors, ventilation openings, brickwork and the junctions between the roof and the walls. Repair any damage to the store immediately! This applies especially to the doors

Chapter 12

RICE DEVELOPMENT PROGRAMMES

A brief description of various Rice Development Schemes implemented in the past is given below:

12.1 Special Rice Production Programme (SRPP)

On the basis of experience gained and constraints identified in different blocks during the implementation of the Pilot Project in 1984-85, a full fledged Centrally Sponsored "Special Rice Production Programme-SRPP" was started from 1985-86.The objective of the scheme was to bring the substantial increase in the productivity of low productivity areas. For implementation of the scheme, 1/5th of the total number of blocks in the States of Assam, Bihar, Eastern Madhya Pradesh, Orissa, Eastern Uttar Pradesh and West Bengal were taken up. Before taking up the scheme, the block-wise plans were prepared and based on the needs of each block different programmes were taken up. As the constraints vary from block to block the programme of work across the block also vary. The programme was implemented in 420 selected blocks instead of 417 selected initially as the Govt. of West Bengal implemented the programme in 70 selected blocks. Under the scheme, programmes were taken up to improve the supply of inputs like quality seeds, fertilizers, pesticides, plant protection equipments, farm implements and technology, programme requiring short-term measures for taking up the other works for the improvement of the irrigation , drainage and development of infrastructure facilities were also included.

During 1986-87, the scheme was extended to 10 additional blocks of Assam State. State of Tripura was also included during 1988-89 and 9 blocks of the State were identified for the implementation of the scheme. In all, the SRPP was implemented in 439 blocks of the 7 Eastern States. The funding pattern under the scheme was 50:50 sharing basis between the Govt.of India and concerned State Government.

12.2 Special Foodgrains Production Programme (SFPP)-RICE

Consequent to the mid-term appraisal of the 7th Five Year Plan a Centrally Sponsored "Special Foodgrains Production Programme (SFPP)" was launched with a view to achieve the minimum food production of 166 million tonnes during 1988-89 and 175 million tonnes for the terminal year 1989-90 of the 7th Five Year Plan. For implementation of SFPP-Rice, 106 potential districts in 13 States i.e. 6 SRPP States – Assam(3),Bihar(13), Madhya Pradesh(11), Orissa(5), Uttar Pradesh(21), West Bengal(7) and other 7 States-Andhra Pradesh(8), Gujarat(4), Haryana(5), Karnataka(8), Maharashtra(7), Punjab(3) and Tamil Nadu(8) were identified. The implementation unit of the SFPP-Rice Programme was district and all the areas in the identified districts were covered for the implementation of the programme. SFPP was 100 percent funded by the Government of India.

12.3 **Integrated Programme For Rice Development (IPRD)**

SRPP and SFPP-Rice were merged on the recommendations of the Planning Commission and unified scheme "Integrated Programme for Rice Development(IPRD)" was implemented from 1990-91. 4 additional States namely Goa, Himachal Pradesh, Jammu & Kashmir and Kerala and 1 Union Territory of Pondicherry were covered under the Scheme. Whereas the SRPP was implemented in the identified blocks and SFPP-Rice in the identified districts, the IPRD was implemented in all the districts of the States covered under the programme. The funding pattern under the scheme was modified to 75:25 to be shared between the Govt.of India and the concerned State Government.

From the year 1991-92, the scheme was further extended to 5 more additional States namely Arunachal Pradesh, Manipur, Meghalaya, Mizoram and Nagaland. Thus, the scheme was implemented in 23 States namely Andhra Pradesh, Arunachal Pradesh,Assam, Bihar, Goa, Gujarat, Haryana, Himachal Pradesh, Jammu & Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Mizoram, Nagaland, Orissa, Punjab,Tamil Nadu,Tripura,Uttar Pradesh, West Bengal and Union Territory of Pondicherry.

The State Governments were provided the flexibility to choose the most suitable components out of the approved components under IPRD namely distribution of certified seeds, micro-nutrients(zinc sulphate), herbicides, pesticides, PP equipments, seed treating chemicals, farm implements, supply to power tiller to small and marginal farmers and allocate funds to each components keeping in view of the specific constraints to rice production in the State and overall limited to Rs.57.44 lakh per district. Besides, field demonstrations and training programmes for farmers and farm labourers were also included under the scheme for effective transfer of crop production technology.

12.4 Integrated Cereals Development Programme In Rice Based Cropping System Areas(ICDP-RICE)

The On-going Integrated Programme for Rice Development (IPRD),Special Foodgrains Production Programme-Wheat and Special Foodgrains Production Programme-Maize and Millets Schemes have been modified. Schemes are as Integrated Cereals Development Programme in Rice Based Cropping System Areas(ICDP-Rice),Integrated Cereals Development Programme in Coarse Cereals Based Cropping System Areas(ICDP-Coarse Cereals) and Integrated Cereals Development Programme in Wheat Based Cropping System Areas(ICDP-Wheat). In an area, only one scheme is being implemented and there is no overlapping in the implementation of the scheme of ICDP-Rice,ICDP-Coarse Cereals and ICDP-Wheat. The objective of the modified scheme is to increase the overall productivity of cereals under specific crop based systems as a whole as against the individual crop approach.

The ICDP-Rice was implemented in 1200 identified blocks of 16 States namely Andhra Pradesh (120), Arunachal Pradesh (20), Assam (75), Bihar (220), Goa (4), Kerala (55), Eastern Madhya Pradesh (90), Manipur (12), Meghalaya (12), Mizoram (8), Nagaland (12), Orissa (115), Tamil Nadu (140), Tripura (8), Eastern Uttar Pradesh (180), West Bengal (125) and one Union Territory of Pondicherry (4).

12.5High Yielding Varieties

The Central Sector Rice Seed Minikit Programme including propagation of improved production technology has played vital role in increasing area under high yielding varieties and also in demonstration of improved crop production technology to the farmers. This scheme has contributed in increasing rice production and productivity. The high yielding varieties Programme was initiated during 1966-67 and the Directorate of Rice Development, Govt. of India commenced monitoring the scheme of high yielding varieties in a systematic manner from 1970 onword. The total area under rice during 1969-70 was 37.68 million ha in which the area under high yielding varieties (H.Y.V.) was about 4.34 million ha Thus, the share of H.Y.V was 4.5 per cent of the total area under rice in the country during 1969-70. But due to the successful implementation of the scheme, the area under H.Y.V increased significantly from 4.34 million ha during 1969-70 to 33.10 million ha during 1999-2000. The increase in area under H.Y.V registered more than 8 folds during the past 30 years. During 1969-70 only 16 H.Y.V. were released / notified for cultivation and there after, due to the concerted efforts of research 639 varieties of rice have been released and notified so far. Those varieties have been popularised at the farmers field through rice minikit programme which was initiated during 1971-72 and continued up to 9th plan period. Thus, the percentage of area under high yielding varieties has been increased from 11.5 per cent in 1969-70 to 79 per cent during 1999-2000. The plan-wise area under H.Y.V of rice is given below:-

Plan			Area (in 000 ha.)
4th Plan	(1969-70 to 1973-74)		7098.2
5th Plan	(1974-75 to 1978-79)	1	3986.4
6th plan	(1980-81 to 1984-85)		20255.4
7th Plan	(1985-86 to 1989-90)		24263.7
8th Plan	(1992-93 to 1996-97)		30905.6
9th Plan	(1997-98 to 2001-2002)		33147.4

With a view to increase the rice production and productivity in the country, the Govt. of India have been implementing from time to time various rice development programmes in all rice growing States through the Directorate of Rice Development, Patna. The details of the schemes implemented up to 9th Five Year Plan are given below:-

12.6 Rice Seed Minikit Programme

Seed is the basic input for increasing production and productivity. Therefore, maintenance of genetic purity through seed replacement is essential for stabilising the yield levels. In addition to the supply of certified seeds of high yielding varieties of rice to the farmers , seed minikits of recently released location specific high yielding varieties were being distributed to the farmers at nominal cost under Central Sector Rice Seed Minikit Programme since 1972 for popularisation of varieties and seed multiplication at the farmer's field level. This programme has helped in spread of recently released varieties and in coverage under high yielding varieties.

A number of recently released location specific high yielding varieties of rice spread through Central Sector Rice Seed Minikit Demonstration Programme during the IX Five Year Plan are given in Table-9

During the 9th Five Year Plan more emphasis was given on popularisation of location specific high yielding varieties of rice released/notified during the last 3 years for the favourable rainfed and irrigated areas and 5 years for the problematic areas like rainfed upland & lowland, coastal saline, saline-alkaline lands, high altitude cold stress areas. A total number of 33 lakh seed minikits of 419 location specific high yielding varieties of rice were distributed in different rice growing States during the 9th Five Year Plan.

12. 7.State Level Training Programme On Rice Production Technology

With a view to disseminate the latest rice production technology to the Extension Officers of the State Governments, State Level Training Programme on Rice Production Technology was organised Continously since 1975-76. The training programmes was conducted at ICAR Research Centres and State Agriculture Universities for three days duration with 3o participants up to 9th Five Year Plan period. An assistance limited to Rs. 22,900/- was given to the organising centres for conducting training programes.

12.8 Special Orientation Training Programme On Rice Production Technology

In addition to the State Level Training Programme, a Special Orientation Training Programme on Rice Production Technology was also organised at the State Agricultural Universities and Indian Council of Agricultural Research(I.C.A.R.) Institutes. The duration of training programme was for 5 days with 20 participants . The financial assistance of Rs.35,000/- was given to the organizer for each training course. This training programme was initiated during the year 1997-98 with a view to disseminate the latest rice production technology. This

training programme was conducted at the following Centres / Universities for different type of rice:-

Sl. No. Name of the Centre/University	Type of rice
1.G.B.Pant University of Agri. & Technology,Pantnagar	Basmati Rice
2.Bidhan Chandra Krishi Vishwavidyalaya, Kalyani.	Boro Rice

3.Directorate of Rice Research,Hyderabad.	Hybrid Rice
4.Directorate of Rice Research, Hyderabad	Irrigated Rice
5.Central Rice Research Institute,Cuttack.	Rainfed Rice
6.I.C.A.R.Research Complex for NEH Region,Shillong.	Rice Production Technology

12.9 Macro Management Scheme Of Agriculture

The Govt. of India has initiated Macro Management Scheme of Agriculture.This is a Centrally Sponsored Scheme. The objective of this scheme is to aim at all round development in agriculture through Work Plans prepared by the respective State keeping in view the following aspects:-

(a) Reflection of local needs/crops/regions specific/priorities etc.
(b) Providing flexibility and autonomy to States.
(c) Optimum utilization of scarce financial resource.
(d) Maximization of returns and
(e) Removal of regional imbalances.

The Govt. of India has merged 27 Centrally Sponsored Schemes into Macro Management Mode. The previous pattern of Centrally Sponsored Schemes(C.S.S.) was lacking in various flexibility resulting in large amount of unutilized balances with the State Govts. The present Macro Management approach will provide more flexibility to State Govts. to develop and persue programmes on the basis of regional priorities. The outlay of the Work Plan would be shared by the Centre and the States in the ratio of 90:10. In the case of North-Eastern States, the entire expenditure will be borne by the Govt. of India. Macro Management Scheme will be implemented in all States and Union Territories. The following 27 C.S.S. have been integrated into Macro Management mode:-

1.Assistance to Weaker Section.
2.Assistance to women Co operatives.
3.Non- overdue Cover Scheme.
4.Agri. Cerdit Stabilisation Fund.
5.Special Scheme for SC/ST.
6.Integrated Cereal Development Programmes in Rice Based Cropping System Areas.
7.Integrated Cereal Development Programmes in wheat Based Cropping System Areas.
8.Integrated Cereal Development Programmes in Coarse Cereals Based Cropping System Areas.
9.Special Jute Development Programme.
10. Sustainable Development of Sugarcane Based Cropping System Areas.
11. Balanced and Integrated use of Fertilizer.
12. Promotion of Agricultural Mechanization among Small Farmers.
13. Integrated Development of Tropical ,Arid & Temperate Zone Fruits.
14. Production and Supply of Vegetable seeds.
15. Development of Commercial Floriculture.
16. Development of Medicinal and Aromatic Plants.
17. Development of Roots and Tuber Crops.
18. Development of Cocoa and Cashew.
19. Integrated Programme for Development of Spices.
20. Development of Mushroom.

21. Use of Plastics in Agriculture.
22. Bee keeping.
23. National watershed Development Project for Rainfed Areas.
24. Schemes for Foundation & Certified Seed Production of Vegetable Crops.
25. Soil Conservation in Catchments of River Valley Projects and Flood Prone Rivers.
26. Reclamation and Development of Alkali Soils.
27. State Land use Boards.

12.10 NATIONAL FOOD SECURITY MISSION'

The National Development Council (NDC) in its 53rd meeting held on 29th May, 2007 adopted a resolution to launch a Food Security Mission comprising rice, wheat and pulses to increase the production of rice by 10 million tons, wheat by 8 million tons and pulses by 2 million tons by the end of the Eleventh Plan (2011-12). Accordingly, a Centrally Sponsored Scheme, 'National Food Security Mission', has been launched from 2007-08 to operationalize the above mentioned resolution.

The National Food Security Mission will have three components (i) National Food Security Mission - Rice (NFSM-Rice); (ii) National Food Security Mission - Wheat (NFSM-Wheat); and National Food Security Mission - Pulses (NFSM-Pulses).

Mission Objectives

- Increasing production of rice, wheat and pulses through area expansion and productivity enhancement in a sustainable manner in the identified districts of the country;
- Restoring soil fertility and productivity at the individual farm level;
- Creation of employment opportunities; and
- Enhancing farm level economy (i.e. farm profits) to restore confidence amongst the farmers.

Strategy

To achieve the above objectives, the Mission would adopt following strategies:

i.Implementation in a mission mode through active engagement of all the stakeholders at various levels.
ii. Promotion and extension of improved technologies i.e., seed, Integrated Nutrient Management including micronutrients, soil amendments, IPM and resource conservation technologies along with capacity building of farmers.
iii.Flow of fund would be closely monitored to ensure that interventions reach the target beneficiaries on time.
iv. Various interventions proposed would be integrated with the district plan and targets for each identified district would be fixed.
v.Constant monitoring and concurrent evaluation for assessing the impact of the interventions for a result oriented approach by the implementing agencies.

NFSM-RICE DISTRICTS

State District	State District	State District
Andhra Pradesh 1 Adilabad 2 Guntur 3 Khammam 4 Krishna 5 Mahaboobnagar 6 Medak 7 Nalgonda 8 Nellore 9 Srikakulam 10 Visakhapatnam 11 Vizianagarm	Assam 1 Barpeta 2 Bongaigaon 3 Darrang 4 Dhemaji 5 Goalpara 6 Karbi-Anglong 7 Kokrajhar 8 Lakhimpur 9 Morigon 10 Nalbari 11 Sonitpur 12 Nagaon 13 Tinsukia	Bihar 1 Araria 2 Bhanka 3 Champaran (East) 4 Champaran (West) 5 Darbhanga 6 Gaya 7 Katihar 8 Kishanganj 9 Madhubani 10 Madhepura 11 Muzaffarpur 12 Nalanda 13 Saharsa 14 Samastipur 15 Sitamarhi 16 Siwan 17 Supaul 18 Zamui
Chhattisgarh 1 Dantewara 2 Janjgir-Champa 3 Jashpur 4 Kawardha 5 Korba 6 Koriya State District State District 7 Raigarh 8 Raipur 9 Raj Nandgaon 10 Sarguja	Jharkhand 1 Simdega 2 Singhbhum(W) 3 Ranchi 4 Gumla 5 Hazaribagh Gujarat Dohad Panchmahal	Karnataka 1 Belgaum 2 Shimoga 3 Uttarakannada 4 Dakshin Kannada 5 Udupi 6 Hassan 7. Raichur Kerala Palakad
Madhya Pradesh 1 Anuppur 2 Damoh 3 Dindori 4 Katni 5 Mandla 6 Panna 7 Rewa.. 8 Satna 9 Shahdol	Maharashtra 1 Bhandara 2 Chandrapur 3 Gadchiroli 4 Gondia 5 Nasik 6 Pune Orissa 1 Bolangir 2 Jajpur 3 Dhenkanal 4 Angul	Orissa 5 Kalahandi 6 Nawapara 7 Keonjhar 8 Malkangiri 9 Nawarangpur 10 Phulbani 11 Boudha 12 Nayagarh 13 Deoghar 14 Jharsuguda 15 Sundargarh

State District	State District	State District
Tamil Nadu 1 Nagapattinam 2 Pudukkottai 3 Ramanathapuram 4 Sivagangai 5 Thiruvarur	Uttar Pradesh 1 Azamgarh 2 Badaun 3 Bahraich 4 Ballia 5 Balrampur 6 Banda 7 Bareilly 8 Basti 9 Deoria 10 Fatehpur 11 Gonda 12 Gorakhpur 13 Ghazipur 14 Hardoi 15 Mainpuri 16 Mau 17 Mirzapur 18 Raebareli 19 Rampur 20 Saharanpur 21 Shivasti 22 Siddharthnagar 23 Sitapur 24 Sonbhadra 25 Sultanpur 26 Unnao	West Bengal 1 24 Parganas (South) 2 Cooch-Behar 3 Dinajur (North) 4 Howrah 5 Jalpaiguri 6 Midnapur (East) 7 Midnapur (West) 8 Purulia

COMPONENT-WISE PATTERN OF ASSISTANCE ON INPUTS UNDER NFSM-RICE (2007-08-2011-12)

S.l No	Components	Pattern of assistant
1	Demonstration of improved package of practices	Rs. 2,500 per demonstration of 0.4 ha
2	Demonstration on System of Rice Intensification	Rs. 3,000 per demonstration of 0.4 ha
3	Demonstration on hybrid rice technology	Rs. 3,000 per demonstration of 0.4 ha
4	Support for promotion of hybrid rice seed (a) Assistance for production of hybrid rice seed (b) Assistance for distribution of hybrid rice seed	Rs. 1,000 per qtl or 50% of the cost, whichever is less Rs. 2,000 per qtl or50% of the cost, whichever is less
5	Assistance for distribution of HYVs Seed	Assistance @ Rs. 5 per kg or 50% of the cost. whichever is less
6	Seed Mini kits of High yielding varieties	Full cost of the seed
7	Incentive for micro nutrients (in deficient soils)	Assistance @ Rs. 500 per ha or 50% of the

		cost, whichever is less
8	Incentive for liming in acid soils	Assistance @ Rs. 500. per ha or 50% of the cost, whichever is less
9	Incentive for cono weeder and other farm implements	Assistance @ Rs.3,000 per farmer or 50% of the cost, whichever is less
10	Assistance for plant protection chemicals and bio-pesticides	Assistance @ Rs. 500 per ha or 50% of the cost, whichever is less
11	Farmers' Training (a) Training of farmers at FSS pattern	Rs. 17,000 per training (Full cost)
12	Awards for best performing District	Rs. 5.0 lakh per year(Full cost)
13	International exposure for technical knowledge enrichment to technical staff of Central and State Governments	Rs. 1.0 crore per year for initial two years
14	Incentive for video conferencing, mass media campaign and publicity of the National Food Security Mission	Rs. 25 crore during first year and Rs. 50 crore/year in remaining period
15	Miscellaneous Expenditure (a) Project Management Team and other miscellaneous expenses at district level (b) Project Management Rs. 13.87 lakh per Team and other State per year miscellaneous expenses at State level (c) Miscellaneous expenses Rs. 84.56 lakh per at National level year	Full cost Rs. 6.36 lakh per district per year
16	Zero Seed Till Drill	Assistance @. 5 0 % of the cost limited to Rs 15,000/ per machine. whichever is less
17	Multi crop planters	Assistance @. 5 0 % of the cost limited to Rs 15,000/ per machine. whichever is less
18	Seed drills	Assistance @. 50 % of the cost limited to Rs 15,000/ per machine. whichever is less
19	Rotavators	Assistance @. 50 % of the cost limited to Rs 30,000/ per machine. whichever is less
20	Incentive for disel pump set	Assistance @. 50 % of the cost limited to Rs 10,000/ per machine. whichever is less
21	Distribution of power weeder	Assistance @. 5 0 % of the cost limited to Rs 15,000/ per machine. whichever is less
22	Knap sack sprayer	Assistance @. 5 0 % of the cost limited to Rs 3,000/ per machine. whichever is less

Modified Component-wise pattern of assistance under National Food Security Mission – (NFSM)-Rice (2012-13)

S.l No	Components	Pattern of assistant
1	Demonstration of improved package of practices	
	i. Cluster Demonstrations by the state in collaboration with ICAR/ SAUs/ IRRI on direct seed rice / line transplanting/ SRI (target 1.5 % of area of district)	Rs.7500/- per ha
	ii. Cluster Demonstrations on hybrid rice (one cluster of 100 ha. target 0.5 % of the district)	Rs.7500/- per ha
	iii. Cluster demonstration on Swarna Sub-I/ Sahbhagi dhan of 100 ha each	Rs.7500/- per ha
	iv. Frontline Demonstration by ICAR/ SAUs on hybrid/varities (cluster of minimum 10 ha each)	Rs.7500/- per ha.
2	Support for promotion of hybrid rice seed (a) Assistance for distribution of hybrid rice seed	Rs. 1,000 per qtl or 50% of the cost, whichever is less Rs. 2,000 per qtl or50% of the cost, whichever is less
3	Assistance for distribution of HYVs Seed	Assistance @ Rs. 5 per kg or 50% of the cost. whichever is less
4	Incentive for micro nutrients (in deficient soils)	Assistance @ Rs. 500 per ha or 50% of the cost, whichever is less
5	Incentive for liming in acid soils	Assistance @ Rs. 500. per ha or 50% of the cost, whichever is less
6	Assistance for plant protection chemicals and bio-pesticides	Assistance @ Rs. 500 per ha or 50% of the cost, whichever is less
7	Incentive for cono weeder and other farm implements	Assistance @ Rs.3,000 per farmer or 50% of the cost, whichever is less
8	Zero Seed Till Drill/Multi-crop Planter Seed Drill	Assistance @. 5 0 % of the cost limited to Rs 15,000/ per machine. whichever is less
9	Rotavator	Assistance @. 50 % of the cost limited to Rs 30,000/ per machine. whichever is less
10	Distribution of power weeder	Assistance @. 5 0 % of the cost limited to Rs 15
11	Incentives on zero till Multi-crop planter	Assistance @. 5 0 % of the cost limited to Rs 15
12	Incentives for Laser Land Levelers	Assistance @. 5 0 % of the cost limited to Rs 15
13	Incentive for Ridge Farrow Planter	Assistance @. 5 0 % of the cost limited to Rs 15
14	Knap sack sprayer (Manual and power operated)	Assistance @. 5 0 % of the cost limited to Rs 3,000/ per machine. whichever is less
15	Incentive for pump set	Assistance @. 50 % of the cost limited to Rs 10,000/ per machine. whichever is less
16	Farmers' Training Cropping system based training (Four session of group of 30 farmers one before Kharif, one each during Kharif and rabi crops and one after rabi harvest)	Rs 3500/-per session Rs. 17,000 per training

12.11 Bringing Green Revolution in Eastern India:

An Inter ministerial task force was constituted in December 2009 under the chairmanship of Secretary (Agriculture) to make short-term and medium-term recommendations on efficient management of water, power and other inputs to maximize agricultural production on a sustainable basis including that of the Eastern India. The major recommendation of task force was for promoting efficiency in water management and encouraging innovative precision farming practices in consultation with the state Governments. It made specific recommendations for improving the rice productivity in the Eastern States through development of appropriate infrastructure with a view to stabilize rice based cropping system in the Eastern states.

Block demonstration of rice.The objective of the demonstration is to improve seed replacement rate, promote line sowing/ planting coupled with promotion of plant nutrient and plant protection technologies. Quality seed recommended for the area would be promoted to cover entire area of the unit. Package of practices proposed for scientific crop management under the demonstrations for different ecologies of rice along with physical and financial targets to the states are given respectively. It is proposed to promote hybrid rice technologies in 40 units of 1000 hectares each. Every farmer in these units would be encouraged to take up at least 0.40 hectares under hybrid rice. In case of rice, identified progressive farmers for a set of 100 hectares each, will be provided two drum seeders free of cost which will be used for facilitating the sowing of rice lines by all the farmers included in the unit. It is expected that concept of custom hiring in the area would be popularized while at the same time it would give additional incentive to the identified progressive farmers for coordinating various implementation activities

ANNEXTURE-

Cost per hectare (Rs.)

Sl. No	Activity	Rainfed Upland Rice	Rainfed Lowland rice			Irrigated Rice		Remark
			Shallow lowland (0-15cm)	Medium deep water(25-50cm)	Deep Water (50-100 cm)	Traditional	Hybrid Rice	
1.	Deep Ploughing and Land preparation	1500	1500	1500	1500	1500	1500	Extra cost if any will be met by the farmer
2.	Seed*	2000	2000	2000	2000	1000	2000	• Seed costRs 25/Kg • 80 Kg/ha for rainfed upland rice and shallow low land rice-direct seeding • 100 Kg/ha for direct seeding and 40Kg/ha for transplanted rice under medium deep water and deep water rice(Average is 70Kg/ha); • 40Kg/ha forirrigated rice and • 15Kg/ha for Hybrid rice and cost of hybrid rice is Rs.150/Kg
	Direct seeding (Line sowing by drum	1500	1500	1500	1500	1500	1500	• Only labour cost • Direct line sowing in rainfed upland & shallow low land • **50% areais direct seeding

	seeder)/transplanting							&50%transplanted-medium deep & deep water rice • 100% transplanting for irrigated rice
3.	Seed treatment	120	120	105	105	60	25	• Bavistin @ 2.5g/Kgseed; Rate of Bavistin Rs.600/Kg
4.	**Micro Nutrient**							
	Zink	875	875	875	875	875	875	• 25Kg/ha;Cost of Rs.35/Kg
	Boron	275	275	275	275	275	275	• 5Kg/ha;Cost of Rs. 55/Kg
5.	Weed Management	640	640	640	0	640	640	• Pretlachlor 1.6 lt/ha;cost Rs. 400/lt. • For SRI-Conoweeder, manual
6.	Plant protection	700	700	700	700	700	700	
7.	**Staff cost/Hand holding**							One staff for 1000 ha and he will be paid Rs.1000 as honorariumand Rs.1000/month for mobilityfor a period of six month. It comes out to be Rs. 123/ha for one staff forone paddy season.
	Honorarium	6	6	6	6	6	6	
	Mobility	6	6	6	6	6	6	
8.	**Progressive farmers**							**Progressive Farmer Cost:** One progressive farmer for ebvery 100 hectare will be paid Rs.1000 as honorariumand Rs.1000/Month for mobility for a period of six month. It comesout to beRs.120/Ha for one farmer for one paddy season.

	Honorarium	60	60	60	60	60	60	
	Mobility	60	60	60	60	60	60	
9.	Provision of Drum seeder	70	70	70	70	70	70	Each progressive farmer will be provided two drumseeder whosecost is Rs.3500 for one.
10.	Travel cost for KVK	100	100	100	100	100	100	For meeting the POL/TA/DA of KVK Scientists.

ANNEXTURE-3

State		**Demonstration**		**Asset Building (Water Structure)**								
	Rice area (Lakh ha.)	Total Financial Requirement	Nos. of demonstration	Shallow Tubewell (Nos.)	Financial requirement (Unit cost Rs.12000)	Pump set (Nos.)	Financial requirement (Unit cost Rs.10000)	Dugwells /Borewell (Nos.)	Financial requirement (Rs. 30,000)	Total	Site specific needs (Fin.)	Total fund requirements
Assam	23.59	1973	26	5000	600	5000	50		0	650	709	3332
Bihar	33.6	2809	37	6000	720	6000	60		0	780	1010	4599
Chhattisgarh	37.41	3127	41	0	0	7000	70	4000	1200	1270	1124	5522
Jharkhand	15.2	1271	17	4000	480	6000	60	3000	900	1440	457	3168
Odisha	44.62	3731	49	4500	540	5000	50	2000	600	1190	1341	6262
Eastern U.P	32	2675	35	6000	720	9000	90		0	810	962	4447
West Bengal	57.82	4834	64	4000	480	4000	40		0	520	1738	7092
GOI							0				0	400
Total	**244.24**	**20420**	**269**	**29500**	**3540**	**42000**	**420**	**9000**	**2700**	**6660**	**7340**	**34820**

Chapter 13

Important website

S.No.	Institute	Address
1.	Philippine Rice Research Institute Pan-Philippine Highway, Science City of Muñoz, Philippines Phone:+63 44 456 0285	*www.phil**rice**.gov.ph*
2.	International Rice Research Institute Pili Dr, College, Los Baños 4031, Philippines Phone:+63 2 580 5600	www.irri.org
3.	**Directorate of *Rice Research* (DRR)** Rajendra Nagar Andhra Pradesh Project Director pdrice@drricar.org **Fax No:** +91-40-24591217 040 2459 1217.	*www.drricar.org*
4.	Rice Research Institute, Kala Shah Kaku (Rrik) Gujarawala **Telephone** 042 7980368, 042 290368 **Fax** 042-290361	director_rriksk@yahoo.com http://http://www.tcdc.gov.pk/rice_ri_lhr/index.htm
5.	Tamil Nadu Rice Research Institute Thanjavur District Tamil Nadu, India Telephone: 0435-2472098 (Off.) 2472108 (Director-Per) 2472298 (Yard) Fax: 0435-2472881	E-Mail: dirtrri @tnau.ac.in *www.tnau.ac.in*
6.	Central Rice Research Institute Director Central Rice Research Institute Cuttack (Orissa) 753 006, India Phone: +91-671-2367757; PABX: +91-671-2367768-783 Fax: +91-671-2367663	*www.crri.nic.in* Email: directorcrri@sify.com | crrictc@nic.in
7.	Central Rainfed Upland Rice Research Station (CRURRS) Sub-Station Officer-In-Charge Central Rainfed Upland Rice Research Station	Email: crurrs.hzb@crri.in , | crurrs.hzb@gmail.com

	(CRURRS) Hazaribagh (Jhanrkhand) Phone: +91-6546-222263, Fax: +91-6546-223697	
8.	Regional Rainfed Lowland Rice Research Station (RRLRRS)	Officer-In-Charge Regional Rainfed Lowland Rice Research Station (RRLRRS) Gerua, Dist. Kamrup (Assam) Phone: +91-361-2820370, Fax: +91-361-2820370
9.	*Bangladesh Rice Research Institute* Director General *Bangladesh Rice Research Institute* Gazipur 1701, *Bangladesh* Phone: (880-2) 9252736; 9257401-05. Fax: (880-2) 9261110	**http://www.brri.gov.bd**
10.	*Rice Research Station* **Address:** 1373 Caffey Road, Rayne, LA-70578 **Contact Info:** Phone: (337) 788-7531, Fax: (337) 788-7553	
11.	Rice Experiment Station P.O. Box 306 , Biggs, CA 95917 *Shipping Address:* Rice Experiment Station 955 Butte City Highway (Hwy 162) Biggs, California 95917 *Tel. No.:* (530) 868-5481, *Fax No.:* (530) 868-1730	*Email Address:* ricestation@crrf.org http://www.plantsciences.ucdavis.edu
12.	China National Rice Research Institute (CNRRI)	http://english.caas.net.cn
13.	China National Rice Research Institute	http://www.cnrri.org
14.	Hybrid Rice Research Network India Directorate of Rice Research Rajendranagar, Hyderabad - 500 030 Fax # 040-4015308 (EPABX Ph # - 4015036-39, 4013109, 4013111-12);	http://www.hybridriceindia.org
15.	West Africa Rice Development Association	www.warda.org
16.	Food and Agriculture Organization of the United Nations	(www.fao.org
17.	Africa Rice Research Institute/ Centre	http://www.africarice.org/
18.	All-Russian Rice Research Institute ARRRI, p/o Belozernoe, Krasnodar, Russia, 350921 Telephone: +7 (861) 2-294-149; Fax: 2-294-149.	E-mail: arrri_kub@mail.ru http://eng.whoiswho.su/Krasnodar/?RiceResearch Institute
19.	rice research institute japan	*www.**rice**.or.jp*
	Australian Centre for International Agricultural Research (ACIAR) 38 Thynne Street, Fern Hill Park BRUCE ACT Phone: 61 2 6217 0500 | Fax: 61 2 6217 0501	http://aciar.gov.au

	ABN 34 864 955427	
20.	**Bayer CropScience** Bayer Crop Science Limited , **Bayer House, Central Avenue,, Hiranandani Gardens, Powai,.Mumbai - 400076.** **Tel.: 022-2571 1234, Fax: 022-25705940**	http://www.bayergroupindia.com
21.	**PHI Seeds Private Limited** Babukhan Millenium Centre III Floor, 6-3-1099/1100 Rajbhavan Road Somajiguda Ph : 91 - 40 - 30434400 Hyderabad - 500 082 Andhra Pradesh	http://www.pioneer.com/india

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