Rice (Oryza Sativa) Cultivation in Temperate Areas of India

Original Research Article

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ORIGIN OF RICE:

Rice botanically called as *Oryza Sativa*, 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 BC, and then Japan and Indonesia 1000 BC(Anonymous, 2012).Further, genetic evidence has shown that rice originates from a single domestication 8,200–13,500 years ago (Molina *et al.,* 2011) in the Pearl River valley region of China(Huang*et al*., 2012).

India is also believed to be the origin of the rice (Pallavi 2011).In 327 B. C., it is believed thatfrom Greece, the Arab travelers took rice to Egypt, Morocco and Spain and that is how it travelled all across Europe.

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 (20011-14). 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 position and is cooked daily as well as on festivals and special occasions.

History of Rice in India: India is an important Center 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 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. Among the states of the India, rice is the most important staple crop of the Kashmir region. Over a period of time, a number of high yielding varieties suitable for the high as well as the low altitude situation have been developed (SKUAST-K, 2011).It is the agricultural commodity with the third-highest worldwide production, after sugarcane and maize, according to data of FAOSTAT 2012 (FAOSTAT, 2014).

According to the Department of National Economics and Statistics (2015) during 2012-13 and 2013-14, the world production of rice has increased by 1% (from 472 Million Tonnes to 476 Million Tonnes), trade by 8% (from 38 million MT to 41 million MT) and consumption by 3% (from 469 million MT to 481 million MT).

India's rice production has increased at the rate of 3.32 percent during 2002-03 to 2013-14. Area under rice cultivation has not increased substantially during 2002-03 and 2013-14. India was the largest exporter of Rice in 2013-14 followed by Thailand, Vietnam and USA. Iran is the leading importing country for Basmati rice from India followed by Saudi Arab and Iraq. Unit cost of basmati rice has increased for all countries in 2013-14 over the previous year. Highest increase in unit price recorded for Saudi Arab and Jordan. According to USDA (2015) during 2014 the China is the top producers of the rice followed by India.

Vision 2030: Indian rice production has nearly trebled between 1960 and 2010, with a compounded growth rate of 2.53% (CRRI, 2011). The Green Revolution has helped the country to regional food surpluses with Punjab leading the country in rice production and productivity. Looking to the future, Indian rice production will come under pressure from intense competition for land and water, a more difficult growing environment because of climate change, higher price for energy and fertilizers and greater demand for reduced environmental footprint. However, there is still scope for improving rice production in this handicapped ecology through proper scientific intervention and policy decisions. The government of India has set a target of expanding the cultivation of hybrid rice to 25 % of the area occupied by the crop by 2015 (Spielman *et al*., 2013). Higher yields increase on-farm incomes and ensure supplies of rice that reduce or stabilize prices for both urban and rural food-insecure households(Lin and Pingali, 1994).

II. RICE AND CULTURAL HERITAGE IN THE JAMMU AND KASHMIR

State is rich in riceculture from the ancient times and a number of landraces and traditional rice varieties grown earlier have been phased out by the cultivation of high yielding varieties (HYV). However some of the farmers are continuing to grow those traditional varieties to get the yields even in odd years. Some areas in the state, people are growing the traditional rices like, Kumad, Begum, Musk-ki-Budji, Qadir Baig, Tilla Zag, Mughal, Gull Zag etc. as a their traditional heritage. Today, most of the landraces and traditional rice are being grown and maintained by these people.

Rice crop plays a significant role in livelihood of people of Jammu and Kashmir State. Although area under rice is very small of about 0.27 m ha, it plays an important role in the state economy. Rice productivity in the state is high (2.2 t/ha) compared to the national average productivity of about 1.9 t/ha. The total annual rice production in the state is about more than 0.59 MT. The state of Jammu and Kashmir is mainly comprises of three geographical regions, namely Jammu region, Kashmir region and Ladakh region lying north of the Indian Union comprise the extreme western part of the Himalayas (32.440N and 74.540E). In Jammu region, the cultivation of rice extends from Jammu plains with an elevation of 200 m to the mid and high hills extending upto 2300 m altitude. In Kashmir valley the cultivation of rice extends from the area having altitude 1600m above the mean sea level to high hills 2300 m above MSL. In Ladakh there is no cultivation of rice. Rice is grown only once in a year because of extreme climatic conditions. Further, the diversity in agro-climate, coupled with farmers' preferences, give rise to wide range of grain preference from bold, coarse grains in temperate region to fine, aromatic and basmati in sub-tropical areas. Jammu region represents almost all the zones ranging from sub-tropical one to mid hills extending to high hills (high altitudes) thus constituting temperate zone. Basmati rices in sub-tropical zone of Jammu region are grown on more than 32,000 hectares of area. Basmati of Jammu region, particularly of R. S. Pura belt is world famous for its high aroma. The business from basmati rice annually fetches more than 45 crores of rupees. Thus, the cultivation of rice in this region offers a great potential for its improvement.

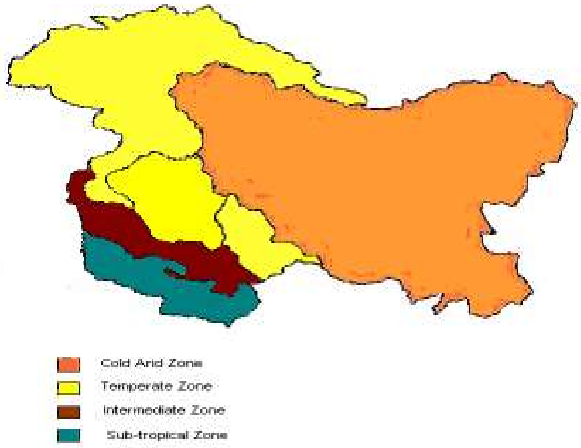

Fig1: Agro-climatic Zones of Jammu & Kashmir

Nutritional value of Rice

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. 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. The comparative nutritional value of cereals in the table 1 showed difference in nutritional content of rice bran and raw rice. Brown rice is better for you than white (Kennedy, 2015). As the brown rice is rich in some vitamins, especially B_1 or thiamine (0.34 mg), B_2 or riboflavin (0.05 mg), niacin or nicotinic acid (4.7 mg) (Kennedy, 2015). 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.

A detailed analysis of nutrient content of rice suggests that the nutrition value of rice varies based on strain of rice that is between white, brown, black, red and purple varieties of rice. It also depends on nutrient quality of the soil rice is grown in, whether and how the rice is polished or processed, the manner it is enriched, and how it is prepared before consumption (Bienvenido, 1993).

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)
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

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.

Medicinal Value:

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.

III. RICE GROWING REGION IN INDIA:

Rice is grown under so diverse soil and climatic conditions that it is said that there is hardlyany 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 meters 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:

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.

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.

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.

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

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 deltaictracts.

Agro-climatic zones in Jammu and Kashmir: On agro-climatic conditions, the state has been divided into ninezones. These are (i) Eastern Ladakh cold arid with cool summer, (ii) Western Ladakh cold type arid with warmer summers, (iii) North-West Kashmir cool dry and and semi-arid, (iv) High mountainous Central Kashmir with temperate dry sub-humid conditions, (v) Kashmir valley with temperate moist sub-humid conditions, (vi) Western Jammu with warm moist sub-humid conditions, (vii) Eastern Jammu with warm moist sub-humid conditions, (viii) Jammu Shivaliks with hot sub-humid

IV. CLIMATIC REQUIREMENT FOR RICE CULTIVATION WITH RESPECT TO JAMMU AND KASHMIR:

Temperature at different stage:

Minimum temperature for sprouting is10ºC at the time of tillering, the crop requires a high temperature than for growth. Minimum temperature for flowering range from 22-23ºC.Temperature requirements for blooming is in the range of 26.5to 29.5ºC. Minimum temperature for grain formation from 20-21ºC 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.

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 2 below:

Table 2: Critical temperature for the development of rice plant at different growth stages.

S. No	Growth stages	Critical temperature (0C)		
		Low	High	Optimum
1	Germination	16-19	45	18-40
2	Seedling emergence	12	35	25-30
3	Rooting	16	35	25-28
4	Leaf elongation	8-12	35	25-30
5	Tillering	9-16	33	25-31
6	Initiation of panicle primordial	15	-	-
7	Panicle differentiation	15-20	30	-
8	Anthesis	22	35-36	30-33
9	Ripening	12-18	.>30	19-20

V. JAMMU AND KASHMIR

Factors essential for rice cultivation

Climate requirement: The altitude ranges from 200 to more than 7000 m above mean sea level (MSL). In Kashmir region, the temperature remains generally low, varying from -100C during winter to 300C during summer, with a yearly average of 130C. In Jammu region, the temperature varies from 60C during winter to 450C during summer. The temperate zone in the state stretches from whole Kashmir valley and Ladakh region to upper reaches of Doda, Udhampur, Reasi, Kishtwar, Ramban, Rajouri, Poonch and Kathua districts of Jammu region. The climate of Jammu region ranges from subtropics to mid hills and to high hills.

Soil type: The soils of Jammu and Kashmir State show large variation. In general, theyare skeltonized to deep alluvial, mountain meadows, podzolic and brown soils. In plains and valleys, there are vast deposits of gravel, coarse sand, alluvial soil and at some places red loams. The soil is sandy loam and clay loam with a neutral pH is also present in sub-tropical zone of the state.

Rainfall and distribution: Annual precipitation varies from 700 to 1,500 mm. Therainfall is less than 100 mm in Ladakh region. The state has an extremely rugged topography and in general, a very high altitude. Much of the northern part of state is covered with snow and rocks and is uninhabited and uncultivated. In Jammu hills and valleys, where irrigation is not available, rice cultivation is solely dependent on monsoon. In these areas, rice crop gets exposed to moisture stress periodically due to gaps in monsoon or erratic distribution of rainfall.

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.

VI. MAJOR CONTRIBUTING FACTORS IN DIFFERENT ECOLOGIES OF KASHMIR

Potential yield of varieties varies with the ecology as well as the agro-climatic region.Precise knowledge on zone and ecosystem specific potential is a pre-requisite for meaningfully determining the still untapped yield of the currently popular high yielding varieties.

Irrigated ecology: Faulty irrigation/brackish water/high water table is causing salinity/alkalinity and low organic matter content with varied macro and micro nutrient deficiencies (N, P, S, Fe, Mn, Zn).

Rainfed ecology: Moisture stress is rainfed ecosystem of the region is associated withlow organic matter content in soils, low N and P and widespread Zn, Boron deficiency.

Hill ecology: Moisture stress at more than one growth stage, blast and brown spot diseases, and lack of exposure to productive technology package of practices.

Region-wise rice eco-systems in state J&K.
Jammu region
i. Irrigated rice eco-system
ii. Rainfed rice eco-system
iii. Cold/hill rice eco-system
Kashmir region
i) Irrigated rice eco-system
ii) Cold/hill rice eco-system

VII. GENETIC POTENTIAL

Biotechnology plays an important role in the field of agriculture. Biotechnology in modern parlance especially with regard to plants and crops means understanding 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. 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.

Super rice : 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.

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, transgenic rice plants 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.

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.

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.

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 makeup 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.

In state **J&K** now work has been started to transfer bacterial blight resistance (BLB) genes insusceptible basmati and non-basmati rice varieties through molecular-assisted backcross breeding (MABB) programme. Work on anther culture of basmati as well as non-basmati has also been started to develop stable homozygous rice lines.

VIII. INTERCROPPING SYSTEMS OF RICE IN JAMMU AND KASHMIR

Rice and rice based cropping system

Jammu region

Rice - Wheat

Rice-Toria-Wheat

Rice-Berseem

Rice-Mustard

Kashmir region

Rice-Toria

Rice growing seasons of different regions of J &K

Jammu region

Kharif season (Sowing in May-June and harvesting in Oct.-Nov.)

Kashmir region

Kharif season (Sowing in May-June and harvesting in Oct.-Nov.)

Crop Production Practices : 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, and availability of labourers' intensity and distribution of rainfalls. The crop of rice is grown with the following methods.

Dry or Semi-dry upland cultivation

- ✓ Broadcasting the seed
- ✓ Sowing the seed behind the plough or drilling

Wet or lowland cultivation

- ✓ Transplanting in puddled fields.
- ✓ Broadcasting sprouted seeds in puddled fields

Methods of cultivation of rice in Jammu and Kashmir

- ✓ Broadcasting the seed
- ✓ Sowing the seed behind the plough or drilling

Wet or lowland cultivation

- ✓ Transplanting in puddled fields.
- ✓ Broadcasting sprouted seeds in puddled fields

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. 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.

Preparation of the nursery

In Kashmir area for an area of one hectare (20 kanals) land a nursery of one kanal is sufficient to provide healthy seedlings, prepare well puddled (2-3 times) weed free nursery seed bed. The water level of 2-3cm is maintained in the bed.

Types of NurseryRaising

Protected: Nursery is sown in strips of an area 1m covered with polythene sheets.

Modified protected: In this method a mixture in the ratios of 2:2:1:1 of soil, sand, organic matter and ash are made and laid on the polythene sheet making a layer of 20-30 cm thick, as medium (SKUAST-K, 2011).

There are three other methods of raising nursery-*viz*

i) The dry nursery where the dry seed is sown in dry soil. This method is practiced in areas wherewater is not sufficient to grow seedlings in wet nursery, particularly in state of J&K.

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

iii) And the "dapog" method. This method of raising nursery has been introduced in India fromPhilippines but no success of it has been achieved in J&K.

Nutrient management

Apply 275 g urea, 450g DAP and 200g MOP per Marlas ($25m^2$). Fertilizer is applied in the nursery bed during the soil preparation.

Seed Rate

According to the package of practices recommended by the SKUAST-K, Srinagar. For direct seeding about 80kg/ha is needed for the varieties planted in lower belts. Whileas, 100kg/ha of seed rate is recommended for the varieties grown in higher belts.in case of the transplanted crop about 50-60kg/ha is recommended for the lower belts. Whileas, 80kg/ha is sown for the uplands.

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.In J&K generally, 40 to 60 grams of seed per square metre is sown in the nursery beds.

Soil preparation: The aim of good tillage is to ensure suitable puddling of the soil, which restrict the loss of the water due to the percolation and consequent loss of the fertilizers. Under the double cropping area, plough the land immediately after the harvest of the rabicrop. Plough in all the stubble and weeds so that they are covered by the soil and get decomposed completely. Plough the land 2-3 times followed by the clod breaking and organic manure applications then pouddling.to ensure the good puddling, irrigate the field when soil is dry. After the proper puddling then add the fertilizers as per the recommended package of practices. In case the arte damage has been observed during the previous crop, the bund should be dug up in the beginning of the spring season. Bunds should be prepared afresh.

Transplanting : Transplanting should be done with proper age of seedlings. Commonly recommended age of the transplanted seedling should be 30-35 days, with spacing from plant to plant about 15 x 15cm. spacing. 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 cm 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.In J&K before transplanting, fields are puddled properly with bullocks or tractor drawn puddlers. Healthy and 25 day old are used for transplanting at the four to five leaf stages.

Care during the transplanting

- Avoid aged (>35days) seedling.
- Avoid deep transplanting and wider spacing as in both cases yield reduction is possible.
- Avoid root damage to seedlings during uprooting
- After uprooting keep seedlings in water till they will be transplanted

Early transplanted (1st week of May) is recommended for the lower belts of Kashmir; while as, in higher belts up to 2nd week of the June will not affect yield. Modified protected nursery should be raised as it is recommended over the traditional methods as for as the yield is concerned.

Spacing : Under good management and adequate nitrogen levels, the optimum spacing for varieties like IR-8 should be around 20x10 cms. 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.Spacing, plant to plant and row to row of 10x20 cm is commonly followed in the state.

Number of Seedlings per Hill : Transplanting two to three seedlings per hill under normal conditions is enough in state. 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.

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.

Practices in the Direct-Seeded Crops : The direct seeded method is the oldest practice of rice growing in Kashmir, and the success of it 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. It needs more labors for intercultural operations so becomes less economic.

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.

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.

Manure and Fertilizer Application: 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 .

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 cannot be recommended for all regions. The State Agriculture University has formulated fertilizer recommendations for rice crop keeping in view the variability in soil fertility and local conditions.

Preferably the fertilizer application is advocated on soil test basis. However, in absence of the soil test, following fertilizer schedule is recommended by SKUAST-K, Srinagar.

FYM@ 10t/ha should be incorporated in the soil at the final preparation of the land.
For the varieties grown in lower belts fertilizer schedule is as:
120kg N, 60kg P_2O_5, 30kg K_2O and 10-15kg Zn SO_4 /ha.
For varieties planted in under waterlogged areas
90kg N, 60kg P_2O_5, 30kgK_2O and 10-15 kg $ZnSO_4$/ha.
In case of higher belts.
80kg N, 60kg P_2O_5, 30kgK_2O and 10-15 kg $ZnSO_4$/ha
Half dose of the nitrogen along with the full dose of P_2O_5, K_2O and $ZnSO_4$ should be applied as basal dose before the transplanting. Remaining dose should be applied in the two equal splits, one at the early tillering stage (15-18 DAT) and other at the panicle stage (38-45DAT).

If incase the, $ZnSO_4$ is not given and deficiency appears later, then foliar applicationof zinc phosphates@ 11-12kg in 600litrs of water is applied.

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.

Water Management : In state 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 increasing the tillering and thereby on yield of the crop. During the crop growth period, the water requirement is generally high at the initial seedling 30 establishment stage. After the transplanting, water should be allowed to stand in the field at a depth of 2-3 cms 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.

Weed management : As per recommended package of practices for rice cultivation in Kashmir region, weeds can be reduced by proper puddling and proper water level maintenance in the field. Either mechanical control methods or the chemical application is used and recommended for the weed control.butachlor@1.5kg a.i/ha is recommended. After herbicide applications maintain 2-3 cm level of the water in the field for 4-5 days. It should be followed by manual weeding at 15-20 days after application of the weedicide. If incidence of the weeds likes*Potamogeton distinctus* and *Marsillia quadrifolia* is observed alternate wetting and drying should be carried out to check the weeds. In Kashmir paddy wheeler is also used to check weeds.In case of the direct sowing apply butachlor@1.5kg a.i/ha 4-6 days after sowing of the sprouted seed followed by manual weeding at 12-15 days after application of the butachlor.

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.

Rice Growing Season : 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 favorable for rice cultivation throughout 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. In J& K paddy is sown in Apr-July and harvested in Sep-Dec.

Harvesting and Threshing: The right stage for harvesting is when panicles turn into golden yellow and the grains contain about 20 per cent moisture. In general, three criteria are taken into consideration to specify the right time of harvesting viz. (a) the moisture content of the grains, (b) the number of days after planting or flowering and (c) the dry matter of the.

Indigenous technical knowledge (ITKs) specific to state J&K.

- ✓ In Kashmir during weeding, farmers paint their legs and arms with resin of pine to avoid the injury due to potashic & phosphatic fertilizers.
- ✓ For sprouting of seeds during low temperature conditions earthen pots or gunny bags.

filled with soaked seeds are kept in cowsheds or covered with green brassica plants.

Byproducts/extended use of rice specific to the state J&K.

1. **Usage and consumption:** Rice is mainly used as staple food in Jammu as well asKashmir region. Begham dhan a traditional rice variety, rich in iron content, is generally fed to pregnant women.

2. **Market value:** We export the best quality of basmati rice that is known for the aroma.

3. **Milling products:** Rice flour can be used for making chapatti which is staple food in some pockets of hilly areas of the state. Waxy rice mostly grown in hill areas are good for chapatti making.

4. **Rice based food products:** Mainly rice is being used for making noodles, baked crackers and puffed rice. Rice water is prescribed by the Pharmacopoeia of India as an ointment to counteract inflamed surface.

Table 2: Successful Varieties of rice released by SKUAST-K, Shalimar, Srinagar (SKUAST-K, 2009)

Variety	Year of Release	Chief characteristics
Ranbir Basmati	1996	Suited to non-basmati growing areas, yield potential 20-30 q/ha; altitudinal tolerance upto 1000 m.
Jehlum	1996	Disease tolerant; average yield 60-65 q ha^{-1}; altitudinal tolerance upto 1700 m.
Chenab	1996	Better phenotypic acceptability; average yield 60-65 q ha-1; altitudinal tolerance upto 1500 m.
Kohsar	2001	Yield potential 40-45 q ha-1; revealing a distinct superiority of cold tolerant, early maturing, moderately resistant to blast, and easy threshability; altitudinal tolerance of 1700-2100 m
Shalimar Rice-1	2005	Suitable for lower belts of the valley upto an altitude of 1650m. The grain is short, slender with non-glutinous endosperm and non-aromatic features. The variety exhibits resistance to blast under field conditions. Early maturing, 60-70 q ha^{-1}.

IX. CONSTRAINTS IN RICE PRODUCTION IN JAMMU AND KASHMIR.

Insect pest stress: Paddy grass hopper (*Oxya nitidula* or *Hieroglyphus banian*) both the nymphs and adult. The damage to the rice by this pest is more serious in the higher belts of the Kashmir with the sandy loam soil. Major rice insect pests include: the brown plant hopper (BPH),(Preap *et al*., 2006).Several spp. of stem borers- including those in the genera *Scirpophaga* and *Chilo*,(IRRI, 2014) the rice gall midge(Benett*et al*.,2004) several spp. of rice bugs(Jahn *et al*, 2004a)notably in the genus *Leptocorisa*,(Jahn *et al*, 2004b) the rice leafroller and rice weevils.

Table 4: Common Pestsof riceand their management

Stage	Pests	Control measures
Nursery	Stem-borer Thrips Gall midge	• 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. Inundative release of egg parasitoid, *Trichogrammajaponicum*
	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 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 or Acephate 50 WP @ 700 g/ha or Fipronil 5 SC @ 600 ml/ha or Phosalone 35 EC; 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/litr water.
	Gundhi bug	Spray Carbaryl 50 WP @ 1,500 g/ha during afternoon hours. Dust Malathion or Carbaryl @ 30 kg of the formulation/ha

Other important pests of rice in Kashmir Paddy snails (*Lymnae stragnalis* and *Triops canceriformis*)
It is an important Mollusca pest in the nursery or at the time of transplanting of the rice in Kashmir. The pest dislodges the seeds and destroys the emerging radical, plumes, lacerate the tender leaves and nibble the seedlings. Sometimes the damage is so severe that whole of the seedlings are damaged and patches appear in the plot. The peak period of appearance remains from April to June.
Management:

- To reduce their population, ducks may be released in the nursery beds before the sowing of the seeds
- To prevent the entry of the snails in the field or nursery beds, a sieve may be provided at the point of the entry of then water into the field
- During the sunny days water should be removed for 4-5 hours. Before the seed sowing apply the mixture of the CuSO4 and Lime in the ratio of 2:5@10kg/ha or chloropyriphos granules at 10G @ 20kg/ha, or carbofuran granules 3G@32.5kg/ha.

Cray fish (*Eocyzicus orientalis*)
This pest belongs to the crustacea and is the fresh water arthropod the Cray fish damage the paddy at the nursery stages and at the transplanting stage. It feed on the roots by pulverizing the soil and dislodges the young seedlings. Removing the water for 4-5 hours during the sunny days is necessary for their control.

X. COMMON DISEASES OF THE RICE IN KASHMIR

a) Seed rot and pre-emergence damping off:
It is caused by fungi such as *Rhizoctonia solani*, *Fusarium* spp. and *Cochliobolus miyabeans*.

Symptoms: The failure of the seedlings to emerge from the soil is the most obvious symptom. The close examination of the seedlings may reveal a white cottony mycelial growth in and around the seed coat and emerging seedlings especially on the surface and collar of the plumule and thereby indicating the attack by water molds. The effected seedlings will become chlorotic and turn pale yellow and appear stunted and thinner then healthy ones.

b) **Blast**: Rice blast caused by *Magnaporthe grisea* is a serious problem in the state. Both leaf blast as well as neck blast is prevalent in the state. Due to prevailing atmospheric low temperature at specific growth stages is conducive for blast build-up and subsequently widely occurring blast epidemics in rice in the state.

Symptoms: Depending upon the site of the attack and symptoms it is referred as leaf blast, collar blast, node blast and neck blast. Symptoms include the lesions appeared on the leaves as minute bluish flecks and later assume elliptical shape with more or less pointed ends. The spots increase in size and become spindle shaped and lesions seldom appear on the leaf sheath. The central portion of the lesion become water soaked, pale or greyish green or straw colored and often with dark brown margins.

c) **Seedling blight**: it is caused by *Rhizoctonia solani*, *Fusarium* spp. And *Sclerotium rolfsii.*

Symptoms: The disease symptoms include dark colored rot on the base of the plant and white moldy growth on the lower plant part. Small round and tan to brown sclerotia less than 2mm in diameter may be seen attached to the roots and lower leaves near the soil surface.

d) **Brown spot** or **Helminthosporiose leaf spot**:

Symptoms: The disease appears on the leaves, glumes, coleoptiles, and leaf sheath and panicle branches. On the leaves and sheath the disease appears as typical oval or circular spots. The spots are evenly scattered all over the leaf surface. The spots when fully developed are dark brown to purplish in color with grayish white center. On the susceptible cultivars, the spots are larger and attain the length of 1cm or more. On the glumes, black or dark brown oval spots develop which generally cover the entire surface. Coleoptile may become infected from diseased seeds. The spots on the coleoptile are small, brown and circular to oval which rarely become long streaks. The disease causes the discoloration of the grains so reduce the seed and grain quality as well as affects the yield.

a) Brown spot disease caused by *Cochliobolus miyabeanus* is one of the serious diseases, particularly in Jammu region. This disease reduces the market value of basmati rice when brown spots appear on glumes.
b) **Bacterial blight**: Bacterial leaf blight caused by *Xanthomonas campestris* pv. *Oryzae* mostly appears in lower belt of Jammu region, particularly basmati rice cultivated areas. This disease also causes significant crop loss in the state.
c) **Sheath rot**: Sheath rot caused by *Sarocladium oryzae* was considered only a minor disease till a few years ago, has now attained the status of a major disease in the state.

Abiotic stress Low temperature: In Jammu and Kashmir, rice is grown an elevation of uptomore than 2300 m AMSL though a major portion of it is grown at an elevation of1200 m. The entire area is irrigated, the source of irrigation being melting snow inthe higher peak ranges. The temperature of irrigation water is around 10^0C to15^0C. The atmospheric temperature during rice growing period ranges from 130Cto 360C. The low temperature stress is, therefore, caused both by the ice-coldirrigation water as well as by low atmospheric temperature. This will result inspikelet sterility in rice crop.

Drought in hills: As mentioned earlier, rice cultivation in hills is solely dependent on monsoon. In these areas, rice crop gets exposed to moisture stress periodically due to gaps in monsoon or erratic distribution of rainfall. The moisture stress during vegetative and flowering stages causes substantial yield loss.Drought represents a significant environmental stress for rice production, with 19–23 million hectares of rainfed rice production in South and South East Asia often at risk(IRRI, 2013a, b). Under drought conditions, without sufficient water to afford them the ability to obtain the required levels of nutrients from the soil, conventional commercial rice varieties can be severely impacted – for example yield losses as high as 40% have affected some parts of India, with resulting losses of around US$800 million annually (Palmer, 2013)

The International Rice Research Institute (IRRI) conducts research into developing drought tolerant rice varieties, including the varieties 5411 and Sookha dhan, currently being employed by farmers in the Philippines and Nepal respectively (IRRI, 2013). In addition, in 2013 the Japanese National Institute for Agrobiological Sciences led a team which successfully inserted the DEEPER ROOTING 1 (DRO1), from the Philippine upland rice variety Kinandang Patong, into the popular commercial rice variety IR64, giving rise to a far deeper root system in the resulting plants. This facilitates an improved ability for the rice plant to derive its required nutrients in times of drought via accessing deeper layers of soil, a feature demonstrated by trials which saw the IR64 + DRO1 rice yields drop by 10% under moderate drought conditions, compared to 60% for the unmodified IR64 variety (Annonymous, 2013).

Salinity: Rice cultivation in Ravi-Tawi canal area is mostly affected by salinity results in significant yield loss in this high potential area.Soil salinity poses a major threat to rice crop productivity, particularly along low-lying coastal areas during the dry season (IRRI, 2013) for example, roughly 1 million hectares of the coastal areas of Bangladesh are affected by saline soils (Fredenburg, 2013). These high concentrations of salt can severely impact upon rice plants' normal physiology, especially during early stages of growth, and as such farmers are often forced to abandon these otherwise potentially usable areas (Ferrer, 2013)

Progress has been made, however, in developing rice varieties capable of tolerating such conditions; the hybrid created from the cross between the commercial rice variety IR56 and the wild rice species *Oryza coarctata* is one example.(IBP, 2013)*O. coarctata* is capable of successful growth in soils with double the limit of salinity of normal varieties, but lacks the ability to produce edible rice. Developed by the International Rice Research Institute, the hybrid variety can utilise specialised leaf glands that allow for the removal of salt into the atmosphere. It was initially produced from one successful embryo out of 34,000 crosses between the two species; this was then backcrossed to IR56 with the aim of preserving the genes responsible for salt tolerance that were inherited from *O. coarctata*. Furthermore, extensive trials are planned prior to the new variety being available to farmers by approximately 2017–18.

Water-logging: In the Kashmir valley and in some parts of Jammu region, waterlogging or improper water drainage exerts negative influence on rice crop productivity potential. The lowland water-logging conditions leads to premature lodging of crop, low tillering, poor response to fertilizer application and sprouting of matured seeds of the lodged crop.

Mineral stress: In water-logged soil situations, soil minerals such as Al, Mn, Zn, Fe, etc. are increased and caused toxic effects on the crop. This results in poorcrop growth and ultimately poor crop yield.

Flood tolerant rice: Flooding is an issue that many rice growers face, especially in South and South East Asia where flooding annually affects 20 million hectares. Standard rice varieties cannot withstand stagnant flooding of more than about a week, mainly as it disallows the plant access to necessary requirements such as sunlight and essential gas exchanges, inevitably leading to plants being unable to recover. In the past, this has led to massive losses in yields, such as in the Philippines, where in 2006; rice crops worth $65 million were lost to flooding.

Institutional constraints

i) Shortage of manpower

ii) Lack of rice molecular and quality laboratories

Socio-economic constraints

Traditional rice varieties are being cultivated by the farmers mainly for their consumption purposes only, moreover these varieties are very poor yielder and susceptible to lodging.

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