Status Paper on Rice in Himachal Pradesh

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I. NAME OF THE STATE: HIMACHAL PRADESH

II. INTRODUCTION

Himachal Pradesh, which forms a part of the North-Western Himalayas, has a geographical area of 55,673 sq. km., which is 1.69 per cent of the country's area and 10.54 per cent of the Himalayas /Himalayan Landmass. It lies between 30^0 22′ 40″ N to 33^0 12′ 40″ N latitude and 75^0 47′ 55″ E to 79^0 04′ 20″E longitude. The State is bordered by Jammu and Kashmir in the north, Punjab and Haryana in the south-west and part of Uttaranchal in the south-east. In the north-east the state forms international boundary with Tibet.

According to land use statistics, the state of Himachal Pradesh has an area of 3.396 m ha of which only 0.558 m ha (16.4%) is the net area sown. Hardly 18 per cent of the total cultivated area is irrigated. The area sown more than once is 0.414 m ha and the cropping intensity is thus 174 per cent. Forests occupy an area of 1.056 m ha, which is 31.1 per cent of the total area. The area under pastures and other grazing lands is 1.024 m ha (Anonymous, 2001).

During 2007-2008, rice was cultivated on an area of 78.6 thousand hectares with a production of 121.4 thousand tonnes and productivity of 1546 kg/ha. Rice is cultivated in ten of the twelve districts of the State except Kinnaur and Lahaul & Spiti with Kangra and Mandi districts alone accounting for 71.2% of area and 69.7% of production. There is a great diversity of

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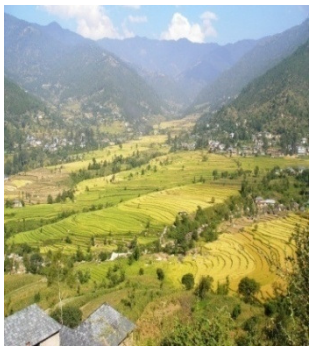
agro-climatic conditions under which rice is cultivated and its cultivation extends from foot-hills (350m) to high hills (upto 2300m).

Bahl Valley (Mandi)

700m



Karsog Valley (Mandi)

1500m

Ransar Valley (Rohru)

2200m

II1 ZONAL INFORMATION

a. Climate:

There are three well defined seasons- Summer, Monsoon and Winter. Spring acts as a transition period between winter and summer, with autumn as an intermediary between the monsoon and winter. Temperature decreases from west to east. The average temperature varies from 25^{0}C to less than 15^{0}C. The Shiwalik and lesser Himalayas record temperature upto 15^{0}C but central or middle Himalayan and greater Himalayan regions witness temperatures below 15^{0}C. The highest temperature is recorded in the month of June. The relative humidity is usually high in the months of July, August, and September and it varies between 76 and 95 per cent.

b. Soil type and nutrient management:

The rice soils correspond to alluvial loam soil group from sandy clay loam to heavy textured clay loam. The soil reaction ranges from neutral to strongly acidic. They are usually deficient to low in available nitrogen, low to medium in respect of available phosphorus. The available potassium status is rated as medium to high.

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c. Rainfall and its distribution:

Himachal Pradesh experiences considerable variation in the distribution of rainfall and temperature due to varying aspects and altitudes. Precipitation declines from west to east and south to north. While the average annual rainfall of Himachal Pradesh is 1111 mm, it varies from less than 500 mm in Lahaul & Spiti to about 3400 mm in Dharamshala, the district headquarter of Kangra which is the second wettest place in India after Mausimram in Meghalaya. Lahaul Spiti records an average annual rainfall of only 434 mm as a result of the rain shadow effect. Spiti is the driest as it is enclosed by high mountains. Although the State as a whole receives plenty of rainfall, most of it is experienced during the months of July to September (70%). Very little snowfall is experienced during winter below 1500 m but at an elevation of 3000 m the average snowfall is about 3 m, which lasts for four months from December to March. Above 4500 m there is almost perpetual snow. The amounts of rainfall and snowfall vary with the altitude. The months of December and January record minimum rain. In the dry temperate zone maximum snowfall is received from January to March.

Irrigation:

Main source of irrigation is through "*Kuhls*". These are small water channels constructed along the mountain-side loading water from the streams, springs or *NALLAHS (rivulets)* to the terraced fields. Tanks account for only 0.3%, canals 1.2% and wells and tube-wells about 4.0 % and remaining source of irrigation are "*Kuhls*". The irrigated rice area has fluctuated between 54 to 58% over the years (Anonymous 2001). This fluctuation of irrigated area depends upon the precipitation of snow in the mountain ranges and hill-tops during the preceding winter and the onset and distribution of monsoon rains which is the main source of irrigation through "*Kuhls*" in Himachal Pradesh.

d. Agro-climatic zones:

Based on altitude, rainfall, temperature, humidity and topography, four different homogenous agro-climatic zones may be identified as follows:

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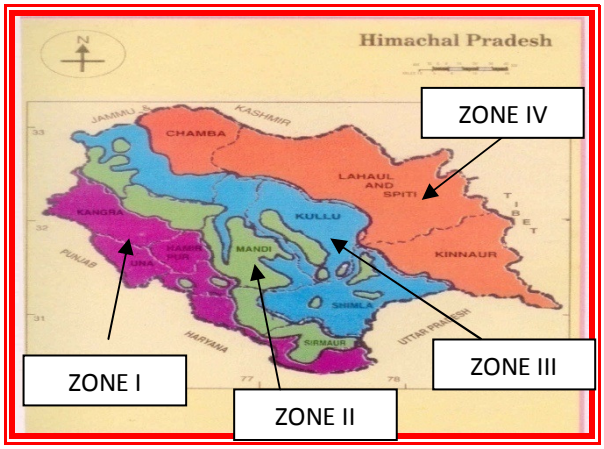
I) Sub-mountain Low Hills and Sub-Tropical – upto 650m amsl

II) Sub-humid Mid Hills – 650 to 1800m amsl

- Lower altitudinal range 650 to 1500m amsl
- Higher altitudinal range 1500 to 1800 m amsl

III) High Hills Wet Temperate – 1800 to 2200m amsl

IV) High Hills Dry Temperate Dry – above 2200m amsl



e. Rice and cultural heritage in the state:

Rice has an important place in the daily diet of the hill people. It is also an important part of all religious ceremonies**.** Chhohartu, a farmers' red rice variety, grown in Chhohara Valley, Rohru (Distt. Shimla) is a part of cultural heritage of the area. Since times immemorial the paddy of this variety is gifted under different names on various occasions such as *Poli* when gifted on occasions of happiness like marriages/religious ceremonies/child birth etc., as *Path* when gifted to a sick person, and as *Sattu* on occasions of sorrow such as death of a person. The rice of this variety is served during community lunches and *yajnas*. The *Pichh* (excess water of thick consistency decanted after cooking of rice) of this red rice is considered very useful for pregnant ladies and children.

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Chhohartu-the red rice from Chhohara Valley Distt Shimla)

Traditional rice varieties:

The area under traditional rice varieties at present is very less. However, some traditional varieties are still grown in some isolated pockets because of their wide adaptability to stress situations like drought, quick germination, quality preference, early maturity and cold tolerance etc. These are found in mid & high hills. In the mid hills traditional varieties like Kalizhini, Madhu Malti, Mushkan, Achhoo, Chetru Basmati, Seond Basmati and Ramjawain, are grown for their local preference for quality (Katoch, *et al*. 1987; 2003). These varieties have medium bold, long bold /long slender grains and intermediate amylose content, most of them have mild to strong aroma, remain moist after cooking but lack basmati like elongation after cooking. In the high hills, traditional varieties viz., Jattoo, Matali, Lal Dhan, Debal, Zeera, Sukara Dhan *etc*. have short bold grains, low amylose content, cook sticky and are tolerant to low temperature. Local people in the high hills prefer rices, which cooks sticky. In Kullu Valley, high hills of Shimla & Sirmaur districts, Chamba, and parts of Kangra red rices (red pericarp) are grown because of local preferences. Some of these red rices include Chhohartu from Rohru (Shimla distt.), Sukara, Tiyun (Chamba), Lal Zhini, Red Ramjawain from Kangra distt, and Jattoo & Matali from Kullu district. Annual weedy rice, locally known as "*Reesa*" is a problem in rice fields in mid hills and to eradicate this farmers use traditional purple foliage rice varieties like Tapta and Purple China. Rana *et al*., (2000) conducted survey of paddy land races in Himachal Pradesh and reported that about 100 landraces were being grown in the State in late seventies (1977-78) and over a period of 20 years 50-55% have gone out of cultivation.

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All these traditional varieties are tall, do not respond to high nitrogen and lodge under high fertility conditions. These varieties are susceptible to blast, a serious problem of hill rice.

IV RICE PRODUCTION SCENARIO:

a. Growth trends of area, production and productivity of rice:

The area under rice in the state has decreased from ninety eight thousand hectares in 1971 to around eighty thousand hectares in 2007, but the productivity has increased from 1056 kg to 1546 kg per hectare during this period. This decrease in area is partly due to submergence of paddy lands under dam reservoirs and partly due to diversification of irrigated area to vegetables. Growth trends of area, production and productivity of rice during the last thirty seven years in the state is given in Table 1.

b. Ecosystem-wise productivity:

On the basis of prevailing ambient and irrigation water temperature at various growth stages of the crop into different altitudinal ranges and the varietal adaptability response, rice cultivation in the State is grouped in to three zones. There is considerable variation in the ecosystem as well as zone-wise productivity. Zone-wise altitudinal range, per cent area under rice and rainfall pattern are given below:

Particulars	Zones		
	I	II	III
Altitude (m)	Upto 650	650 to 1500	> 1500
Area (%)	26 to 28	60 to 62	12 to 13
Rainfall (mm)	About 1000	1200-3400	About 1000

In rainfed upland ecosystem where crop is entirely dependent on rainfall, the productivity is low and often less than one ton of rice/ha. In irrigated ecosystem in mid hills the productivity is

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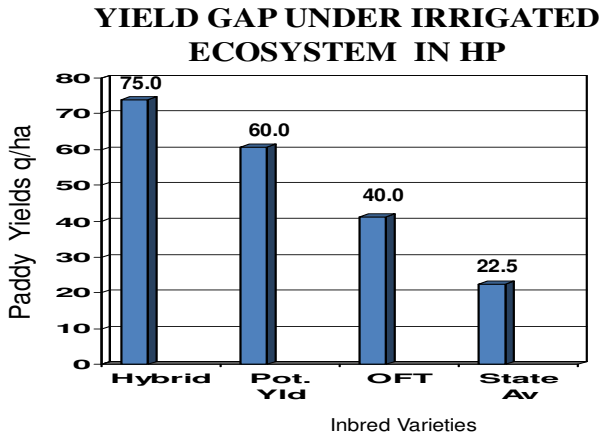
about 1.5 tonnes/ha, and in plains & foothills, the productivity is high and touches 2-2.5 tonnes/ha.

c Yield gap and reasons:

The great diversity of agro-climatic conditions under which rice is cultivated in the State ranging from foot-hills to high–hills, from very high rainfall to low rainfall areas, under transplanted and wet sown to direct seeded rainfed conditions and from warm sub-tropical to temperate areas create many constraints to rice production in the State (Katoch *et al*., 1989). The average yield of the state in terms of paddy is 22.5 q/ha, whereas the yields in On Farm Trials are around 40 q/ha and hybrids have shown yield potential of about 75 q/ha in mid hills below 1000m under good management. In general, the yields in mid and high hills are low, which can be attributed to following factors:



- **Small and fragmented holdings**, poor economic condition of the farmer, absentee landlords and poor management along with non availability of timely inputs.
- **Low nutrient use efficiency**: In addition to imbalanced fertilizer use, high nutrient losses occur due to run off on account of terraced rice fields on the hill slopes, undulating topography and difficult water management.

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- **Cloudy weather and short growing season**: Average sun shine per day from July to September is limited to 4 hours only. The crop duration is restricted (seed to seed 125-130 days) due to closed growing season because of early onset of winters.

d. **Contribution to GDP**: Rice is an important cereal crop of the State next only to maize during wet season. Rice accounts for 10.8 % of area and 10.2 % of production on total food grain basis and 22.2% of area and 18.8% of production on wet season crops basis in the State.

V. REGION-WISE/DISTRICT-WISE RICE ECOSYSTEMS:

There are two main ecosystems under which rice is cultivated in different districts in the state.

In **Irrigated ecosystem,** where 58 per cent of the rice area lies in the state, following traditional cultural practices are used for raising rice crop:

- Broadcast of sprouted seeds in puddled fields followed by "*HALOD*" or "*HODD"*, a practice of ponding water in the fields after about three weeks, ploughing with bullock driven plough, removal of weeds, proper spacing of seedlings and gap filling. The practice is followed in 10-12 per cent of the areas where timely and assured irrigation is available.
- Broadcast of seed under optimum soil moisture (*VATTAR*) condition followed by "*HALOD*". The practice is followed in 18-20 per cent of the area.
- Transplanting of 25-30 days old seedlings in puddle fields as per standard method. This practice is followed in about 30 per cent of the area.

In **Rain-fed upland ecosystem**: About 42% of rice is grown under rain-fed upland situations. Area under this ecosystem fluctuates depending upon onset of monsoon rains. Following cultural practices are generally used under this ecosystem:

- Broadcast or line sowing of seed behind the bullock drawn plough with the pre-monsoon showers in the mid and high hills. About 8-10 per cent area is covered under this practice.
- Broadcast of seed with the pre monsoon showers followed by "*Halod*". The practice is followed in about 32-35 per cent of the area.

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VI. RICE PRODUCTION AND ECONOMIC ANALYSIS: Though, the rice farmers, in the state are themselves the consumers of their produce, with the introduction of high yielding varieties and hybrids, the farmers have now started selling their surplus produce in the local markets and markets in the adjoining states.

VII. RICE AND RICE BASED CROPPING SYSTEMS: As mentioned elsewhere, rice is grown under two main ecosystems viz., rain-fed and irrigated. Major proportion of the rain-fed rice area goes to wheat/ wheat + mustard with some areas being put under, barley, lentil, etc. The irrigated rice area is put to a variety of crops during rabi season. Prominent among them are wheat, potato, linseed/flax, berseem, oats and vegetables.

VIII. RICE GROWING SEASONS IN THE STATE:

Only one crop of rice is grown in the state during wet season from May to October. The direct seeding and nursery sowings start by the end of May and continue upto about 15th of June. However, in Kullu Valley and other higher hills of Shimla, Mandi and Chamba districts of the State the nursery sowings start as early as mid-April. The transplanting starts around 20th of June depending on the onset of monsoons and availability of irrigation water in the area and continue upto first fortnight of July.

IX. RECOMMENDED PACKAGE OF PRACTICES:

a) Varieties/hybrids

In the early period pure line selections were made from the local group of varieties grown by the farmers to meet the quality preferences, higher yield and suitability for different cultural conditions followed for rice cultivation in the State. As a result of this 9 varieties (Ramjawain 100, Phul Pattas 72, Lal Nakanda 41, Dhunder 43, R 575, China 988, Norin 18, Norin 8, T 23) were released upto 1971 in the State. Except R 575, a purple foliage variety, which is the out come from the cross Ramjawain 100/CP-1 (pigmented), all others are either pure line selections or introductions. These varieties were generally tall, leafy with drooping leaves, and lodging susceptible and not responsive to fertilizer application.

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***Japonica* varieties:**

The yield potential of rice varieties developed through pure line selection and inter varietal hybridization in forties and fifties was very limited. However, during this period *japonica* varieties *viz.,* Norin 18, and Norin 8 were also introduced in the mid hills of Himachal Pradesh because of their cold tolerance and responsiveness to fertilizers and recommended for cultivation under irrigated conditions from 1000 to 1500m altitude in 1967 and 1968, respectively. Today these varieties are grown only in some isolated pockets. Out of five typical *japonica*s, imported from Japan in 1995 by DRR, Hyderabad two entries namely "Koshihikari"and "Hinohikari" were found to be most promising varieties for yield and quality parameters based on three years of testing in hills. Koshihikari has been found to be suitable for cultivation above 1500 m altitude, where as Hinohikari in the mid hills upto 1500 m altitude. In 2005 variety Bhrigu Dhan developed from a cross Chucheng/Deval ®//Matali at Research Sub Station, Katrain, H.P. was released by the State Variety Release Committee. This variety has red grains and yield potential of 6.5 to 7.0 t/ha with an average yield of 3.8 t/ha in high altitude locations above 1500 m.

High yielding varieties:

Although, advent of semi-dwarf varieties in late sixties led to the green revolution in the tropics, yet the spread of semi-dwarf varieties in higher altitudes in tropics was delayed because these varieties were late maturing and lacked cold tolerance. Systematic programme for germplasm improvement for developing cold and drought tolerant and blast resistant varieties for hills was started in 1970-71 at Palampur/Malan (Himachal Pradesh) with the intensification of research on rice under the **All India Coordinated Rice Improvement Project** (AICRIP). Under this scheme, a multi disciplinary approach is being followed for the development of cold tolerant cultures of rice with blast resistance. From 1975 onwards our crossing programme involved crosses among semi-dwarfs found suitable for higher altitudes and crosses of semi-dwarfs with local/improved tall traditional varieties. In 1986, Himalaya 741 a selection from early generation materials in the International Rice Cold Tolerance Nursery was released for general cultivation in

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the State. The variety was cold tolerant, had durable resistance to blast and was suitable for cultivation in both irrigated and rainfed upland ecosystems. It gave yields as high as 7t/ha on farmers field demonstrations and remained a very popular variety with the farmers for 6-7 years before it succumbed to blast in 1992 (Sharma *et al*., 1983).

Till date 20 rice varieties have been released for different ecosystems and altitudinal ranges in the mid and high hills of Himachal Pradesh. The detailed information of these varieties is given in the Table 2. Presently the notable varieties for irrigated conditions in high hills above 1500m altitude are Naggar Dhan, Bhrigu Dhan and Varun Dhan. In the mid hills (650 to 1500m) predominant varieties under irrigated conditions are HPR 2143, HPR 1068, RP 2421, Palam Dhan 957, Kasturi (upto 1000m) and Hassan Serai (1000 to 1300m), whereas under rainfed conditions, China 988, VL Dhan 221 and Sukara Dhan 1 are popular. RP 2421, a predominant variety for the last 15 years due to its early maturity and resistance to blast in mid hills, has now succumbed to blast during Kharif 2009 season. Palam Dhan 957, though now susceptible to blast is still liked by farmers due to its very high yield potential and good grain and cooking quality. These varieties occupy about 62-65 per cent of the rice area in themid hills. In low hills/plain areas (upto 650m) varieties from adjoining states (Punjab, Haryana & Western UP) are generally cultivated and among them IR 8, Jaya, HKR 126 and PR series among non-scented and Pusa Basmati 1, Traori Basmati and Basmati 370 among basmati are predominant. A number of breeding lines from the State have been found to be resistant donors for different diseases and insect pests (Table 4).

RP 2421 devastated by neck blasduring kharif 2009

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Hybrid rice: Scope and limitations in the State:

Except for some academic studies, which included identification of maintainers, restorers, heterotic combinations and assessment of out-crossing rates of different CMS lines under mid hill conditions, not much headway has been made under hybrid rice. However, for the irrigated ecosystem of low hills and valley areas upto 650 m altitude of the State, rice hybrids developed in the AICRIP programme and adjoining states have been directly introduced, evaluated and adopted by farmers for cultivation. In 2007, HRI 152 (ARIZE 6129) was recommended by the University for general cultivation in the state for irrigated areas below 1000m elevations. Over the years the hybrid showed high level of resistance to blast and fitted well in the rice-wheat rotation. It gave yields as high as 8.5 t/ha at RWRC, Malan. The hybrid is now fast spreading in the Bahl Valley of Mandi District and parts of Kangra district.

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b) Management inclusive of mechanization

Nutrient management:

Nutrient recommendations for rice vary with the kind of varieties being grown.

	Nutrients (kg/ha)			Fertilizers					
	N	P_2O_5	K_2O	kg/ha			kg/bigha (800m^2)		
				Urea	SSP	MOP	Urea	SSP	MOP
High yielding Vars:	90	40	40	195	250	65	16	20	5
Local varieties:	50	25	25	108	156	42	9	12	3

It is recommended to apply whole of phosphorus and potash and half nitrogen prior to last puddling operation and the remaining nitrogen in two splits- one 3 weeks after transplanting and the other 3-4 weeks later at panicle initiation stage. In case, FYM is added @ 5 t/ha on dry weight basis then only half the recommended dose of nutrients should be given. In acidic soils in high rainfall regions and submersed areas the application of P_2O_5 and K_2O may be avoided if these nutrients have been applied in recommended doses to the preceding rabi crop. In water logged soils where only paddy crop is taken, only nitrogen and phosphorus may be applied @ 60 kg and 40 kg/ha, respectively.

Zinc deficiency:

Zinc deficiency is wide spread and frequent where top soil has been removed or soils have high pH, high $CaCO_3$ and high organic matter content. The characteristic symptom of zinc deficiency in paddy is bloaching of the mid rib of leaves. Zinc deficiency can be corrected by application of zinc sulphate @ 25 kg/ha. In transplanted paddy, mild zinc deficiency can also be corrected by dipping seedlings for 30 minutes in 2% zinc oxide solution prior to transplanting. Zinc sulphate should be applied at least 2 days after the application of P

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fertilizer. If the deficiency symptoms appear on the leaves, 0.5% zinc sulphate solution (@750 L/ha) should be sprayed.

Effect of Zinc Application at ORS, Kangra duing Kharif 2008

8-8-08 28-8-08

Iron deficiency/ Iron toxicity:

Light textured soils with high pH are prone to iron deficiency prevalent in Una district. Rice seedlings raised on such soils exhibit yellowing of the newly emerged leaf. In the absence of corrective measures the whole seedling may become white and later die. Iron toxicity is commonly observed in flooded rice soils in Palam Valley of Kangra district.

Weed Management:

In Himachal Pradesh, rice is mainly raised/ established through three methods viz.,direct seeding (in unpuddled fields), direct seeding of sprouted seeds in puddled fields and transplanting. In broadcast sown sprouted or dry seeded rice, an interculture operation locally called as 'halod' which involves use of bullock driven desi plough in standing rice after impounding 8-10 cm water in the field about 25-30 days after sowing is quite common. This operation is carried out to check weed growth and fill the gaps.

To ensure effective weed control in direct sown rice, chemical method of weed control is very effective and economical. For the control of grassy weeds in direct seeding in unpuddled fields it is recommended to use Butachlor @ 1.5 kg or Pendimethalin 1.5 kg or Oxadiazon 0.75 kg in 750 L water per hectare 2 days after sowing.

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In sprouted rice culture, grassy weeds can be kept under check by the application of granular formulation of Butachlor @ 1.5 kg or liquid formulation of Butachlor @ 1.5 kg mixed well in 150 kg sand and broadcast in one hectare in 4-5 cm standing water 7 days after sowing. Butachlor (liquid formulation) mixed with safener can also be applied 3 days after sowing. Alternatively, the grassy weeds in this culture can also be controlled by Pyrazosulfuron-ethyl 0.025 kg per hectare 8-12 days after sowing or Cyhalofop-butyl 0.09 kg per hectare 15-20 days after sowing.

In transplanted rice culture, the puddling of field and proper water management destroys many weeds and saves the crop from the first flush of weeds for about two weeks after transplanting. The weeds appear thereafter and should be controlled. With popularization of SRI the use of cono-weeder is also becoming popular among the transplanted rice farmers. The common herbicides recommended for controlling grassy weeds in transplanted rice are Butachlor 1.5 kg (granular or liquid) or Pendimethalin 1.5 kg or Oxyfluorfen 0.15 kg using 750 L water per hectare 4-5 days after transplanting. Use of Pyrazosulfuron-ethyl 0.025 kg per hectare 8-12 days after sowing or Cyhalofop-butyl 0.09 kg per hectare 15-20 days after sowing also gives effective control of the grassy weeds.

The broad leaved weeds and sedges in all the above mentioned rice cultures can be effectively and conveniently controlled by 2-4 DEE @ 0.8 kg applied 20-25 days after transplanting or 30-35 days after direct seeding.

Precautions:

- Do not apply granular formulations of herbicides in direct seeded upland rice.
- Use hand gloves while applying machete or mixing with hand.
- Do not tank mix cyhalofop-butyl with 2,4-D
- To avoid the herbicide resistance problem, follow herbicide rotations

Note: In case of light textured soils, reduce the dose of herbicides by 25%.

Management of Insect-pests and diseases

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Leaf hopper: The nymphs and adults cause heavy damage during August-September.

- Spray carbaryl 50 WP @ 1500 g/ ha or monocroptophos 1500 ml /ha.
- Repeat application if hopper population persists beyond a week after application.

Caseworm: The pest is active during September and damage is done to both direct seeded and transplanted rice.

- Spray 1250 ml chlorpyriphos 20 EC (0.05%) in 500 litre water per hectare.

Chaffer bettles *(Popillia lucida*): The beetle is active during flowering stage of the crop. Peak activity is observed from the last week of August to second week of September.

- Spray Cypermethrin 10 EC @ 625 ml/ha or Chlorpyriphos 20 EC @ 1250ml/ha at panicle emergence stage of the crop for the control of

Management practices for rice hispa, leaf folder, stem borer and whorl maggot are mentioned under IPM

Blast: The disease damages the crop both at leaf and neck stages. The severity is some times so intense that it results in total loss of the crop.

- Treat the seed before sowing with Bavistin 50WP or Beam 75WP (2 kg/ha seed).
- Spray the crop with Blitox 50 (Copper oxychloride) once at nursery stage (12 g in 4 L water for 100 m^2) and again depending on the need at the time of tillering, panicle emergence and late booting stages with 2.250 kg Blitox 50 WP or 750 g Bavistin 50 WP or 750 ml Hinosan in 750 L water/ha or 300g Beam 75WPin 500 L water/ha.
- Do not apply excessive doses of nitrogenous fertilizer
- Plant resistant varieties HPR 2143, HPR 1068, Sukara Dhan 1, VL Dhan 22 and Kasturi.

False smut: High relative humidity, rainy and cloudy days during the flowering period increase incidence of the disease**.** Disease incidence is high on hybrids.

- Collect the diseased panicles and burn them.

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- Avoid excessive doses of nitrogen fertilizers.
- Give two sprays of copper oxychloride 50WP (0.3%) at heading and 10 days after this.

Bacterial blight: Known to be a disease of tropics, it has made is appearance in the mid-hills over the last 10 years probably due to climate change.

- Before seeding dip the seed in 5% salt solution to remove light seeds.
- Plant resistant varieties like RP 2421, HPR 1068, Sukara Dhan 1 etc.
- Do not apply excessive dose of nitrogen.
- Do not pound water in the field.

X. INDIGENOUS TECHNICAL KNOWLEDGE (ITK) SPECIFIC TO STATE: At the time of planting, the traditional rice farmers put branches of *Vitex nigundo* (Banah) at the water inlet of rice fields anticipating control of leaf blast. Leaves of this plant are also scattered in the rice fields. Similarly, the leaves of *Ageratum* and *Lantana* are scattered in the field to control rice hispa. Leaves of Darek (*Melia azardirachta*) are used for safe storage of rice.

XI. BYE-PRODUCTS/EXTENDED USE OF RICE SPECIFIC TO THE STATE:

There is acute shortage of fodder for cattle in the hill state. As a result paddy straw is used as fodder for the cattle and for bedding purpose in house hold dairies. Local beverage called, "*Zhol*" is prepared from rice. In religious places puffed rice in the form of "*Khil*" and "M*urmure*" prepared from local rice varieties is sold for offering. "*Chirwa",* prepared from beaten rice is used as breakfast cereal. Few rice farmers and other people use stuffing of paddy straw for making "*Bandri*" a kind of mat used for bedding purposes. A mixture of hull and bran called *"Fuk"* is sold in the market as feed for horses and poultry.

XII. RICE AND COMMERCE (Exports and revenue generation):

In general in mid and high hills the land holdings are very small and rice yields are low, as a result the farmer is the consumer also. There is no regulated market for rice in the state. However, there is great demand for some speciality rices of the state like red rices and scented

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rices which get premium in the market. Chhohartu, a red rice variety, grown in an area of about 1000 ha in Chhohara Valley, Rohru (Distt Shimla) is in great demand because of its unique red pericarp colour. It is sold in the local market at a premium price of more than Rs 100 per kg.

XIV STATUS OF RECENT RICE PRODUCTION TECHNOLOGIES:

a. **SRI:** Based on experimentation at the Rice & Wheat Research Centre, Malan and at the main campus of the Himachal Pradesh Krishi Vishvavidyalaya, a package of practice for SRI in the state was given to the farmers in 2009. For the last three years the Peoples' Science Institute, Dehradun has been engaged in propagating SRI in the state with the help of different NGOs, the State department of Agriculture and the University scientists. Now based on encouraging results the state government is also giving push to this technology by providing weeders and markers on subsidized rates.

b. **Hybrid rice:** Spread of hybrid rice in the mid hills was delayed due to non availability of early maturing and blast resistant hybrids. It was only in 2006 that from the All India Coordinated Irrigated Hybrid Rice Trial –Early, two hybrids HRI 152 and R6329 were found to be early maturing and blast resistant at the Rice & Wheat Research Centre, Malan. Of these HRI 152 (ARIZE 6129) was finally recommended by the university for general cultivation in the state for irrigated areas below 1000m elevations. Over the years the hybrid showed high level of resistance to blast and fitted well in the rice-wheat rotation. It gave yields as high as 8.5 t/ha at RWRC, Malan. The hybrid is now fast spreading in the Bahl Valley of Mandi District and parts of Kangra district.

c. **Aerobic rice/conservation agriculture:** The work on aerobic rice and conservation agriculture in rice crop is still in infancy.

d. **Biotechnological interventions/golden rice:** Marker Assisted Selection for pyramiding blast resistant genes from Fukunishiki and Tetep and bacterial blight resistant genes from IR 24 pyramid lines is being done in collaboration with the Biotechnology Centre of the university. Blast resistant pyramid lines are in advanced stages of testing at the Centre and the material with xa5, xa13 and Xa21 bacterial blight resistant genes is in BC_2F_3 generation.

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e. **IPM/IDM:** The integrated pest & disease management strategies, being followed in collaboration with the Bio-control lab of the Department of Agriculture are given below:

Pest monitoring technique used	i) Rapid Roving survey ii) Field scouting iii) Agro ecosystem analysis iv) Pheromone/ light trap	Light trap monitoring
Economic threshold level	i) Leaf folder, *Cnaphalocrocis medinalis* ii) Rice hispa, *Dicladispa armigera* iii) Stem borer, *Scirpophaga innotata*	10 % damaged leaves or 3 freshly damaged leaves/ hill at post active tillering stage 10 % damaged leaves or 2-3 freshly damaged leaves/ hill 5 % dead hearts or 1 egg mass/ m^2 or 1 adult moth/ m^2

IPM strategies:

Crop stage/ month	Pest(s)	Management practices
Nursery	Stem borer	○ Apply chlorpyriphos 20 EC @ 1250 ml/ ha or Carbofuran @ 33 kg/ ha in nursery, 5-7 days before

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May-June	Whorl maggot Nematodes	pulling the seedlings for transplanting. ○ In stem borer endemic areas, install pheromone traps with 5 mg lure @ 8 traps/ ha for pest monitoring.
Planting to panicle initiation/ flowering stage **July-Sept**.	Stem borer	○ Clipping of leaf tips of the seedlings at the time of transplanting will help in destruction of egg masses of stem borer, whorl maggot and immature stages of hispa ○ Remove the left over nursery and incorporate into soil. ○ Install pheromone traps with 5 mg lure @ 8 traps/ ha for pest monitoring or 20 traps/ ha for direct mass trapping. ○ Inundative release of egg parasitoid, *Trichogramma japonicum* five to six times @ 50,000 adults/ ha starting from 15 DAT. ○ Apply carbofuran (Furadan 3 G) by broadcasting in 3-4 cm standing water @ 1 kg a.i./ha(33.3 kg of formulation), 10 DAT or 40 days old direct sown crop or by end of July /early August. If necessary the treatment can be repeated after 40 days. OR ○ Spray 1000 ml endosulfan 35 EC or 500ml methyl parathion (Metacid 50 EC) in 500 L of water at the appearance of the pest.
	Leaf folder	• Spray chlorpyriphos 20 EC @ 1250 ml/ha in 500 L of water or monocrotophos 36 EC@ 835 ml/ha at the appearance of the pest.

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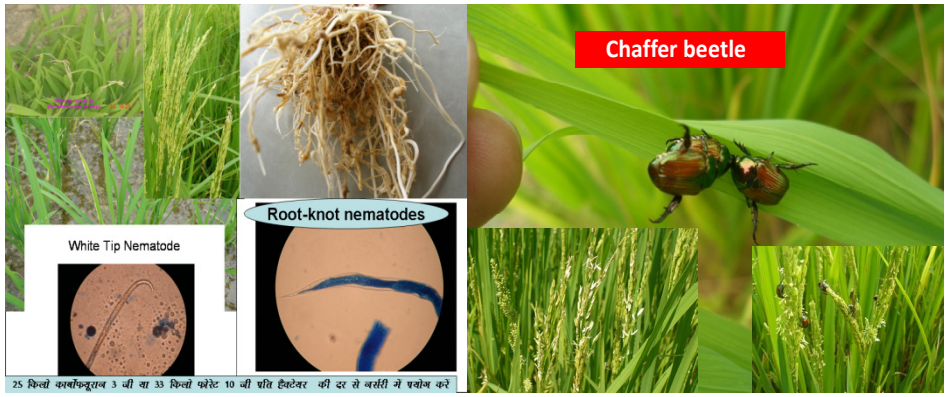
		• Inundative release of egg parasitoid, Trichogramma chilonis five to six times @ 50,000 adults/ ha starting from 15 DAT.
	Rice hispa	• Broadcast cartap (Padan 4 G) in 3-4 cm standing water @ 1 Kg a.i./ha(4 Kg of formulation), 10 DAT or 40 days old direct sown crop or by end of July /early August. If necessary repeat the treatment after 40 days. OR • Spray 600 ml methyl parathion (Metacid 50 EC) or1000 ml fenitrothion in 500 L of water at the appearance of the pest. OR • Spray chlorpyriphos 20 EC @ 1250 ml/ha in 500 L of water at 10 DAT fb another spray of chlorpyriphos or Neemazal @ 1500ml/ha after 40 days of first spray.
Flowering and after	Stem borer	Spray 1000 ml endosulfan 35 EC or 500ml methyl parathion (Metacid 50 EC) in 500 L of water, if pest population approaches ETL of 5% white ears.
	Leaf folder	Spray chlorpyriphos 20 EC @ 1250 ml/ha in 500 L of water or monocrotophos 36 EC@ 835 ml/ha, if pest population approaches ETL of 10% damaged leaves.



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XV. Organizations of Agricultural Research in the State:

Organizational set up for rice research:

The research work on rice was started in the hilly areas of erstwhile undivided Punjab during the year 1936 at Saloh near Bhattoo, district Kangra now in Himachal Pradesh. During 1970-71, ICAR sanctioned a main center of an All India Coordinated Rice Improvement Project for Himachal Pradesh having multidisciplinary approach with head quarter at Palampur. It was, subsequently inherited by H.P. Krishi Vishvavidyalaya, Palampur in 1978. In 1980 the university purchased additional land at Malan (Nagrota Bagwan) and the head quarter of Coordinated Rice Improvement Project was shifted to this location in 1985. This station is situated in the Kangra Valley on Pathankot-Mandi highway about 4 km from Nagrota Bagwan town at an elevation of 950m amsl at latitude $32^0$1' N and longitude 76^0 2' E.

Present set up

- Main Rice & Wheat Research Centre, Malan (Distt Kangra) HP.1936/1985: Headquarter of All India Coordinated Rice Improvement Project,.
- Department of Crop Improvement, Palampur, District Kangra (Mid hills)-1970: Testing and evaluation center for cold tolerant and short duration genotypes.
- Research Sub Station, Sundernagar, Distt. Mandi (Mid hills)-1962: Testing and evaluation center for rain-fed upland rice.
- Research Sub Station, Katrain, District Kullu (High hills)-1981-82: Research on cold tolerant and *japonica* rices.
- Regional Research and Extension Centre, Dhaulakuan, District Sirmaur (Low Hills & Valley areas): Testing and evaluation centre for long duration and basmati genotypes.
- Extension work in the state is carried out through a net work of Krishi Vigyan Kendras and the State Department of Agriculture extension set up at grass root level.

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XVI. CONSTRAINTS TO RICE PRODUCTION:

a. Biotic stress: Diseases, Insects, Nematodes and Weeds

Among diseases rice blast is the major constraint followed by glume discolouration and brown spot. Blast epidemics are of frequent occurrence in the hills and the life of an improved popular variety is hardly 4-5 years. This is because of the buildup of inoculum of the new virulent race affecting the variety. In low hills and valley areas bacterial blight (BLB), stem rot and sheath blight also cause considerable damage. Whereas, among insect pests rice hispa, leaf folder and stem borer are important. Brown plant hoppers and white backed plant hoppers are also problems in low hills.

Shift in the spectrum of diseases and insect pests: Diseases viz., false smut, sheath blight, bacterial blight and leaf spot, which were of minor nature earlier in hill rices are becoming important probably due to climate change. Bacterial blight has also started appearing in the mid hills. In 2007 hopper burn was observed for the first time in Kangra Valley in mid hills. Similarly insect pests viz., rice whorl maggot, case worm, brown plant hopper, white backed plant hopper, leafhoppers, Chaffer beetles and white grubs are now causing considerable damage to rice crop more frequently. In addition, white tip and root knot nematode problem has also increased particularly in the nursery beds and upland rice crop.

Weeds in different ecosystems:

The **upland rice environment** is favourable for the germination of a variety of weeds. These germinate almost simultaneously with the rice seeds. Prevalent weeds in this ecosystem are **Grasses**: *Echinochloa crusgalli, Echinochloa colonum,, Cynodon dactylon, Panicum dichotomiflorum*, *Ischaemum rugosum, Setaria* sps., *Paspalum* sps., **Sedges**: C*yperus rotundus,* C*yperus esculentus* and **Broadleaved:** *Ageratum conyzoides, Commelina benghalensis, Aeschynomene indica, Phyllanthus niruri, Euphorbia heterophylla* etc.

Prevalent weeds in puddle and flooded rice are: Grasses: *Echinochloa colonum, E. crusgalli, Paspallum sp*, *Cynodon dactylon*, **Sedges***: Cyperus iria, Cyperus difformis, Cyperus esculentus,*

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Eriocaulon sps, *Scirpus* sps. **Broad leaved:** *Monochoria vaginalis* , *Ammania pentandra* , *Ipomoea aquatic, Eclipta alba, Aeschynomene indica,* etc.

Generally weeds cause 25 to 40 per cent yield losses and is a major problem in direct seeded rain-fed rice, where the yield losses may go as high as 60 per cent.

b. Abiotic stresses: Cold irrigation and ambient temperatures during growing season and drought due to erratic monsoon are the major abiotic stresses**:**

Low temperature stress: About 60% of rice area of the state falling in mid and high hills is affected by cold stress due to cool irrigation water and/or low ambient temperature. Of this 12% area in high hills suffers cold stress at seedling as well as reproductive stages, whereas the remaining area in mid hills experience cold stress at reproductive stages only. The mean maximum/minimum temperature during different stages of crop growth at four representative centers in the low (Dhaulakuan), mid hills (Malan & Palampur) and high hills (Katrain) of the State are given in Table 3. The mean maximum/minimum temperatures during reproductive phase are in the range of 31-26/21-16 ^{0}C at Dhaulakuan and 22-18/13-8 ^{0}C at Katrain.

Low temperatures due to snowfall in higher hills in September induces sterility

Low temperature induced sterility at Karsog during Kh 2009 due to late planting

Drought stress: In addition to 42% rain-fed area, even the irrigated area suffers from inadequate and irregular irrigation water availability depending mainly on snow fall in the high hills during the preceding winter and delayed onset and early withdrawal of monsoon rains.

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c. **Institutional constraints:** Lack of State Seed Corporation and non availability of timely inputs like seed and fertilizer are major institutional constraints.

d. **Socio**-economic constraints: Small land holdings, absentee land lords, terraced sloppy fields, difficult water management, poor economic condition of farmer are major socio-economic factors.

XVII. STATUS OF SEED PRODUCTION OF MAJOR VARIETIES/AGENCIES INVOLVED/ DEMAND AND SUPPLY

The state of Himachal Pradesh does not have a State Seed Corporation to regulate seed production in the state. Rice & Wheat Research Centre, Malan is the only source of basic seed i.e. nucleus & breeder seed and produces about 30-40 quintal breeder seed every year. This seed is then given to the State Deptt. of Agriculture for further multiplication on Govt. Seed Multiplication Farms. However, for the last few years the Govt. Seed Multiplication Farms are almost defunct. Now the Krishi Vigyan Kengras of the University are producing seed through the Seed Village setup. The Deptt. of Agriculture is also following this seed village chain for seed multiplication now. The seed replacement is about 15% per annum.

Breeder/Foundation Seed Produced at RWRC, Malan

Varieties	2004	2005	2006	2007	2008
RP 2421	5.4	4.3	5.2	2.1	2.2
HPR 2143	0.6	4.3	6.3	8.7	12.0
HPR 1068	1.0	3.2	7.4	8.0	15.4
Kasturi	1.5	1.5	2.3	7.3	3.0
Hassan serai	0.2	0.5	0.5	0.8	0.1
Sukara Dhan 1	1.0	2.5	2.2	7.2	7.0
VL 221	1.3	1.3	2.2	4.2	0.7
Bhrigu Dhan	0.7	0.2	0.6	0.2	0.2
Varun Dhan	-	-	0.3	0.3	0.2
Total	**12.3**	**18.0**	**24.8**	**38.8**	**40.8**

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XVIII. Future strategies:

Because of undulating topography, highly diverse agro-ecology of hills and about 45 per cent area under rainfed rice coupled with low temperature stress at different stages of crop growth in mid and high hills and serious problem of blast disease, more precise location specific research need to be conducted for different altitudinal ranges in the hills. The priority areas of research for improvement of hill rice in the State are:

- Enhancement hill rice genetic resources through collection and conservation. Molecular characterization of elite germplasm (improved & traditional) and identification of nutritionally superior, blast resistant and cold tolerant genotypes and utilization in breeding programmes.
- Development of rice varieties with higher yield potential, durable resistance to pests particularly blast and superior grain quality through recombinant breeding for rainfed upland and irrigated ecosystems.
- DNA marker technology for gene characterization, marker assisted selection and gene pyramiding using biotechnological tools to incorporate durable resistance to blast. Assessment of genetic diversity in the host, pest and pathogen of rice.

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Table 1: Growth trends of rice production and productivity in Himachal Pradesh (1971-2007)

Year	Areas ('000ha)	Production ('000t)	Productivity (kg/ha)	Irrigated Area (%)
1971	97.7	103.2	1056	54.4
1972	**95.0**	**88.0**	**910**	-
1973	97.0	118.0	1214	-
1974	92.0	97.0	1051	-
1975	94.4	124.1	1300	53.8
1976	87.9	98.2	1117	-
1977	88.3	114.1	1292	-
1978	98.5	122.8	1247	-
1979	**97.6**	**87.5**	**897**	-
1980	**109.4**	**96.9**	**886**	-
1981	91.3	95.6	1040	55.6
1982	**88.2**	**73.0**	**828**	-
1983	92.8	111.5	1202	-
1984	94.8	117.2	1236	-
1985	90.8	125.4	1382	56.1
1986	95.9	105.6	1101	-

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1987	**90.2**	**76.1**	**844**	-
1988	86.6	89.8	1037	-
1989	88.7	94.5	1065	-
1990	84.9	106.5	1254	-
1991	83.3	103.0	1237	60.0
1992	81.9	110.3	1347	61.4
1993	823	101.9	1238	57.0
1994	82.6	112.2	1358	61.4
1995	82.5	111.2	1348	61.4
1996	81.7	108.6	1329	58.6
1997	86.2	120.4	1397	58.1
1998	82.8	117.8	1423	-
1999	80.2	120.4	1501	-
2000	81.5	124.9	1532	
2001	80.6	137.4	1705	
2003	81.3	120.6	1463	
2004	77.0	120.0	1558	
2007	78.4	121.4	1536	

Source: Fertilizer statistics/ Statistical Outline of Himachal Pradesh

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Table 2: Salient features of Rice Varieties Released in Himachal Pradesh during 1970-2007

Variety	Year	Adaptability	Maturity (Days)	Av.Yield (t/ha)
T 23*	1971	Irrigated(< 1000m)	140-145	2.5-3.0
IR 579	1975	Irrigated(< 1000m)	140-145	4.0-4.5
Himdhan	1978	Irrigated(mid-hills)	130-135	3.5-4.0
Himalaya 1*	1982	Irrigated(mid-hill)	115-120	4.0-4.5
Himalaya 2*	1982	Irrigated(mid-hills)	120-125	3.5-4.0
Himalaya 741*	1986	Irrigated & rainfed (mid-hills)	115-125	3.8-4.2
Himalaya 799*	1992	Irrigated (mid-hills)	120-125	3.7-4.0
Naggar Dhan	1992	Irrigated (>1400m)	135-140	3.5-4.0
RP 732	1992	Irrigated (Low hills)	130-135	5.0-5.5
Himalaya 2216*	1994	Irrigated (mid-hills)	125-130	3.8-4.2
RP 2421*	1994	Irrigated (mid-hills)	120-125	3.7-4.0
Kasturi	1994	Irrigated (<1000m)	135-140	3.0-3.5
VLDhan 221	1994	Rainfed upland	100-105	2.5-3.0
Palam Dhan 957*	2000	Irrigated (mid-hills)	125-130	4.0-4.2
Hassan Serai*	2000	Irrigated (1000-1300m)	120-125	2.8-3.2

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Sukara Dhan 1	2004	Rainfed (mid-hills)	115-120	2.8-3.2
HPR 2143	2005	Irrigated (mid-hills)	125-130	3.5-4.0
HPR 1068	2005	Irrigated (mid-hills)	120-125	3.8-4.5
Bhrigu Dhan	2005	Irrigated (>1200m)	150-155	3.3-4-4
Varun Dhan	2007	Irrigated (>1200 m)	140-145	2.5-3.6

* Varieties which are now susceptible to blast

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Table 3: Ambient temperatures during various growth stages of rice crop at representative locations in Himachal Pradesh

Centres	Altitude (m)	Prevailing temperatures ^{o}C (Max. /Min.)			
		Seedling	Tillering	Flowering	Maturity
Dhaulakuan (low hills)	467	39-33/25-21 H	35-36/25-22 H	32-28/23-17 H to M	31-26/21-16 H to M
Malan (mid hills)	950	36-31/23-18 H to M	33-27/24-19 H to M	29-24/20-15 M	28-23/18-13 M to L
Palampur (mid hills)	1290	32-27/21-16 H to M	29-25/21-27 M	26-22/17-13 M to L	25-21/16-11 M to L
Katrain (high hills)	1525	29-24/18-12 M	28-22/18-14 M	25-20/15-11 M to L	22-18/13-8 L to VL

H = High, L = Low, M = Moderate, VL = Very Low

Table 4. HP breeding lines identified as resistant donors to different diseases and insect pests at national level

	Donor varieties
Insect pests	
Stem Borer	HPU 824, HPU 838, HPU 862, Himalaya 2216, RP 2421
Rice Hispa	HPR-1198, HPR 2025, HPR 2031, HPR 2033, HPR 932
Leaf Folder	HPR-2031, HPR 2032, HPR 2033 , HPR 2001, HPR 2002, HPR 2086

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Gundhi Bug	HPR 2054
Diseases	
Leaf Blast	HPR 2001, HPR 2083, , HPR 2315, HPR 2352, HPR 2501, HPR 2593,
Neck Blast	HPR 2143,, HPR 2302, HPR 2339, HPR 2363, HPR-2373, HPR 2512
Leaf & Neck Blast	HPR 2072, HPR 2167, HPR 2309, HPR 2322, HPR 2329, HPR 2504
Sheath Blight	HPR 2163
Sheath Rot	HPR 1179, HPR 2362
Bacterial Leaf Blight	HPR 2001, HPR 2129, HPR 2315, HPR 2413, HPR 2505, HPR 2530
Rice Tungro Virus	HPR 2001, HPR 2083, HPR 2310, HPR 2373

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