

GRAIN CROPS

RICE

Rice is one of the major food crops of Himachal Pradesh cultivated on 86,200 hectares during 1997-98 with a production of 1,20,680 tonnes and an average yield of 1400 kg per hectare. Kangra and Mandi districts which have more than 65% rice area in the State, have great potential for improving their yields and increasing rice production in the State.

The main reasons for low yields of rice in H.P. are low plant population, less use of fertilizer and inadequate weed control. Besides, low temperature due to cold irrigation water and low ambient temperature at flowering stage, coupled with high incidence of blast disease add more to the dimensions.

Varieties

Palam Dhan-957 : It is a semi-dwarf timely maturity and high yielding variety recommended for irrigated condition under mid hills of H.P. It is blast resistant. Average yield is 40 q/ha.

Himalaya - 2216 : It is medium duration high yielding variety with intermediate plant height and recommended for transplanted/irrigated conditions. It matures in 125-130 days and has long slender translucent grains. Its average yield is 40 q/ha. It possesses field resistance to major rice diseases.

RP-2421 : It is an early maturing high yielding variety with intermediate plant height and recommended for transplanted/irrigated conditions. It matures in 120-125 days and has medium bold grains. Its average yield is 38 q/ha. It possesses field resistance to major rice diseases.

VL Dhan-221 : It is a semi-dwarf early maturing high yielding drought tolerant variety suitable for rainfed upland conditions of H.P. It matures in 105-110 days and has medium bold grains. Its average yield is 28 q/ha and possesses resistance to major rice diseases.

Hasan Sarai : It is semi-dwarf variety suitable for irrigated condition from 1000-1300 m altitude. Its grains are long, scented and bright. It matures within 125-135 days. It is diseases resistant. Its average yield is 26 q/ha.

Kasturi : It is a semi-dwarf high yielding basmati variety meant for areas upto 1000 m altitude and matures in 135-145 days in the mid hills and has long, slender, scented grains with awns. Its average yield is 30 q/ha and has moderate field resistance to blast.

Himalaya-741 : It is early maturing, semi-dwarf and high yielding variety suitable for cultivation in mid and low hills of Himachal Pradesh both under transplanted and direct sown conditions. It is cold resistant widely adaptable, comparatively resistant to blast, glume blotch and brown spot diseases. It has long slender grains with good cooking quality, having 6% protein and 17 per cent amylose contents. On an average, its yields 39 q/ha should be discouraged in areas where blast severity is high.

China-988 : It is a medium coarse tall variety for irrigated as well as rainfed areas all over Himachal Pradesh because of its early maturity. It has a very good germination capacity and can withstand drought spells. It is suitable for direct sown conditions, both on dry and puddled soils, as also for transplanted conditions. It matures in 115-125 days and yields, on an average, 25 q/ha. China-988 has a wide adaptability. It is susceptible to lodging, shattering and blast.

IR-579: It is a dwarf, high yielding-cum-high quality variety suitable for cultivation in low hills and valley areas (below 750 m asl). It has long slender grains with very good cooking quality. It matures in 130-140 days. It has the yield potential of more than 60 q/ha with an average yield of 40 q/ha. It possesses field resistance to major diseases and insect-pests.

R-575 : It is a tall and purple foliage variety suitable for growing under all conditions upto an elevation of 1,000 m to fight the menace of wild rice i.e. rissa. It is susceptible to lodging under moderate fertilizer application. It is also

susceptible to blast disease and prone to the attack of stem borer. It has long bold grains having more than 10% protein. It matures in 130-135 days. Its average yield is 25 q/ha.

Himalaya-799(HPU-799): It is a semi-dwarf, early maturing, cold tolerant variety recommended for cultivation from 650-1500 m asl. It mature in 120-125 days, has long bold grains with small awns and field resistance to major diseases and insect-pests of mid-hills. Its average yield is 30 q/ha and ha an yield potential of 62 q/ha. It has good cooking quality with intermediate amylose content and gelatinization temperature having 8.12% protein. This variety has different source of resistance to blast than that of Himalaya-741 and thus will provide varietal diversification in mid hill zone.

Naggar Dhan (Ching Shi-15): It is semi-dwarf, cold tolerant "Japonica" variety recommended for high altitude areas above 1400 m asl in Kully valley and similar other parts of the State. It matures in 140-145 days in high hills and has short bold grains. Its average yield is 35 q/ha with an yield potential of 65 q/ha. It out-yields the local popular variety - Jatoo & Matali by more than 70% and Norin-18 by 20%. It has low amylose, cooks sticky and liked by people of high altitude areas. This variety has field resistance to blast, glume discoloration and brown spot.

Bhrigu dhan (HPR-179) :It is a new variety recommended for high altitude areas above 1400 m asl in Katarai of Kullu valley and Naggar areas and similar other parts of the State. It is grown in both irrigated and rainfed areas. It is early maturing and tolerant to cold. It has short and bold grains. It has resistance to blast, brown spot, glume diseases and stem and leaf folder /roller.

PR-108, PR-109 & Jaya : PR varieties are recommended in areas of Nalagarh and Una district but not in Dhaulakuan and Nurpur areas where brown spot disease is a problem, whereas Jaya is recommended for Dhaulakuan and Nurpur areas.

HKR-126 : It is recommended for low hills. It has resistance to lodging and diseases. It has long grains and matures within 137 days. Average yield is 39 q/ha.

Soil

Paddy is adaptable to all kind of soils varying in texture from sandy loam to clayey, with soil reactions ranging from acidic to alkaline, provided sufficient water is available either through assured rainfall or irrigation. The semi-aquatic nature of the crop, however, necessitates of heavy soil through which rain or irrigation water does not percolate easily.

Manuring:

	Nutrients (kg/ha)			Fertilizers					
	N	P ₂ O ₅	K ₂ O	Urea	Kg/ha SSP	MOP	Kg/bigha		
							Urea	SSP	MOP
High Yielding Varieties	90	40	40	195	250	65	16	20	5
Local Varieties	50	25	25	108	156	42	9	12	3

Apply whole of phosphorus and potash and half nitrogen prior to last puddling operation but not more than 1-3 days before transplanting. Incorporate the fertilizers well in the top 10 cm of puddled soil. Apply the remaining nitrogen in two splits - one 3 weeks after transplanting and the other 4-5 weeks later at panicle initiation stage. About 5-10 tonnes of well rotten FYM or compost per hectare should be incorporated before puddling. In case of

sub-optimal dose of N, a single top dressing at the time of active tillering or panicle initiation would be more beneficial as compared to applying it at transplanting or in multiple splits.

When the soil are continuously submerged for whole of the year and only paddy crop is taken, nitrogen and phosphorus may be applied at the rate of 60 kg and 40 kg/ha respectively.

Application of P_2O_5 and K_2O may be avoided if these nutrient were applied to preceeding rabu crops. It the whole quantity of nitrogen is not available as urea or ammonium sulphate, CAN may be used for the split application. But there may be considerable loss of nitrogen when applied through CAN.

Zinc deficiency

Generally, zinc deficiency is not wide spread micro-nutrient disorder in paddy crop. The incidence of this deficiency is frequent where top soil has been removed or soils have high pH, high $CaCO_3$ content and high organic matter content. The characteristic symptoms of zinc deficiency in paddy is bleaching of the mid rib of leaves. The symptoms are most marked on the 3rd or 4th basal leaf after 3-4 weeks of transplanting. While the mid ribs becomes yellowish particularly at the base of the leaf, the leaf tip remains normal green.

Besides this, light yellowish spots appear on the leaves, which later enlarge and coalesce and turn deep brown. The entire leaves becomes brown in colour and dries out with the advancement in age. Infact, irrespective of the age of the plant, if the mid rib is lighter colour than lamina, zinc deficiency is suspected. Zinc deficiency can be corrected by application of zinc sulphate @ 25 kg/ha. Soil and plant analysis need to be done for the confirmation of its deficiency and deciding its dose. In transplanted paddy, mid zinc deficiency has also been corrected by dipping seedlings in 1-4% zinc oxide solution prior to transplanting. Zinc sulphate should be applied atleast 2 days after the application of P fertilizer. If the deficiency symptoms appear in the leaves, 0.5 per cent zinc sulphate solution (5 kg zinc sulphate mixed with 2.5 kg calcium hydroxide per ha) could be sprayed.

Agronomic Practices

There are two main methods of rice cultivation -

(A) Transplanting method:

The transplanting method is feasible in those areas where sufficient assured water exists. In this method, first the nursery is raised and then seedlings are transplanted in puddled fields when they are 15-20 cm tall and have developed 4-5 leaves.

Selection of Seed : Properly filled seeds should be selected for sowing. For selecting such seeds, dissolve 2.5 kg common salt in 25 L water and dip 3.7 kg seed at the time in this solution and discard the seeds floating on the surface. Wash and dry the healthy seeds well. 25-35 kg seed is sufficient for transplanting one hectare area.

Seed Treatment : Treat the dry seeds with Bavistin (1:400) against seed borne diseases. 2.5g of chemical is required for 1 kg seeds. The treatment can be given in a rotating drum or putting the seed in a container and shaking it well after adding chemical.

Nursery Raising

Success in getting high yields of rice lies in raising healthy sturdy and uniform seedlings. The nursery can be grown by dry of wet methods as described below :

(i) **Dry method** : Prepare fine raised seed-bed 10 cm high of 8x1.25 m dimension. Apply 65 g urea and 150 g superphosphate per bed and mix it thoroughly in the upper 5 cm layer of the bed. Sow 400 g good quality treated seeds on each bed, preferably in rows 10 cm apart. Cover the seed with a fine layer of soil. 20-30 kg well rotten FYM should be properly mixed in soil per bed before the incorporation of urea and superphosphate.

Another dose of 45 g urea per bed may be applied a fortnight after sowing so as to get the seedlings ready for transplanting in about 25-30 days. 4 such seed beds will be required for transplanting on bigha.

Keeping the nursery free of weeds, irrigate it regularly. If the seedlings in the nursery show yellowing of leaves, spray it with 0.5% ferrous sulphate solution after adding unsalted lime equal to half the weight of ferrous sulphate.

For weed control in rice nursery, spray Oxadiazon (Ronstar) @ 4 L/ha after 14 days of sowing. This herbicide results in temporary phytotoxic effect on the rice seedlings but the plants recover afterwards. Spray of Thiobencarb (Saturn) or Butachlor (Machete) @ 2 L/ha 7 days after sowing also controls the weeds effectively.

(ii) **Wet method** : After incorporating farm yard manure in soil at the rate of 20-30 kg per bed of 8x1.25 m size, flood the field and puddle it well. Leave the puddle for 2 to 3 days as such. Prepare raised seed-beds 20 cm high of 8x1.25 m size with 1/3 m water channel in between the two rows of beds. All the practices after this are the same as for dry method except that instead of dry seed, the pre-germinated seeds is used in this nursery raising method. To obtain the pre-germinated seed, soak seed for 24 hours in water and keep it in dark room for 36 to 48 hours.

Time of Nursery Sowing : The nursery should be sown 4 weeks before the time of transplanting. The schedule for nursery raising is given below :-

Tall and dwarf varieties	:	20 May to 7 June
Basmati varieties	:	15 May to 30 May

Field preparation

- (a) Repair all bunds.
- (b) Incorporate all the organic matter about two weeks ahead of transplanting by ploughing the field to enable decomposition. Begin puddling about 2-3 days before transplanting.
- (c) Work the field into a soft puddle. This will help minimise losses due to percolation of water.
- (d) Uniformly level the fields before application of fertilizers.
- (e) Apply all phosphorus, potassium and 1/2 nitrogen prior to the last puddling operation not more than 1-3 days before transplanting.

Uprooting of seedlings

The seed-bed should be irrigated a day before uprooting of the seedlings. The seedlings should be pulled gently so that the roots are not injured.

Method of transplanting

- (i) Transplant the seedlings in rows, not more than 3 cm deep.
- (ii) Transplant 2-3 seedlings per hill.
- (iii) Space seedlings 15 cm x 20 cm for normal planting and 15 cm x 15 cm for late planting in case of tall varieties. Transplant at 15 cm x 15 cm for both normal and late plantings in case of dwarf varieties.
- (iv) Fill the gaps twice, 5 and 10 days after transplanting.
- (v) Keep the water standing in the field to cover about two third length of the transplanted seedlings for 5 days after transplanting. This help in proper establishment of the seedlings.

Avoid

- (i) Transplanting over-age seedlings
- (ii) Deep transplanting and wide spacing as these affect the yield adversely.
- (iii) On uneven field.

Time of transplanting

Tall and dwarf varieties 15 June to 7 July
Basmati varieties 20 June to 1 July

Interculture and weed control

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. Use of paddy weeder or hand weeding can help in controlling weeds but the effective, easy and better method is through chemical control.

1. Machete 5% granules @ 30 kg/ha in 4-5 cm standing water or Machete 50 EC @ 3 L in 150 kg sand and broadcast in one hectare after 3-4 days of sowing in standing water.
2. Stomp 5% granules @ 30 kg/ha or Stomp 30 EC @ 4 L/ha after 4-5 days of transplanting also effectively controls weeds.
3. Broadcast application of Saturn 10% granules @ 20 kg/ha or Saturn 50 EC @ L/ha after 4-5 days of transplanting gives excellent weed control.
4. Goal sprayed @ 600 ml/ha after 4-5 days of transplanting or 1% granules @ 15 kg/ha also effectively controls the weeds.
5. If majority of the weeds comprises of nut sedge (*Cyperus* spp.) and broad leaved weeds, apply 2,4-DEE 4% granules @ 20 kg/ha after 4-5 days of transplanting.
6. Butachlor should be applied within 48 hr of sowing of rice as pre-emergence under proper moisture conditions.

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

Precaution : Use hand gloves while applying machete or mixing with sand.

(A) (B) Direct sowing method :

In this method, the seeds of paddy are sown directly in the fields and nursery is not raised. This method is also of two types :

- (a) Direct sowing of pre-sprouted seeds in puddled field
- (b) Direct sowing of unsprouted seed in unpuddled soil

The first method is locally called as Machch method and practised in those areas where water is available for puddling. Transplanting, however, gives significantly higher yields than this method. The farmers are, therefore, advised to adopt transplanting method where water is available.

In the second method of direct sowing, the dry seeds of paddy are sown directly in the field either after onset of monsoon or even before that in dry soils. This is adopted in those fields which are unpuddled and assured supply of water is not available. Due to lack of proper water management, the yield of such rice is very low. As a preference, such lands should be put under maize for better return. However, if rice is to be grown on such lands, the following guidelines should be followed to increase the yield.

Land preparation: Prepare the land thoroughly by first ploughing with furrow turning plough and desi plough afterwards. The soil should be friable and sufficient moisture should be ensured at the time of sowing.

Sowing time : The sowing time of direct seeded rice is the same when nursery for transplanted rice is grown. Late sowing results into lesser yields. Generally, sowing should be done with the first rain.

Method of sowing : In this method, 100-125 kg seed per hectare is required. The seed should be sown in rows at 20 cm spacing behind the plough at a depth of 3-4 cm for better plant population and quick emergence. Broadcast method is not recommended as it gives very poor yield.

Weed control : In direct seeded rice, weed control is very important and only timely control can result in better production. The first weeding at 2-3 leaf stage is more critical and must be done. Thereafter, weeding should be done as and when required.

To ensure effective weed control in direct sown rice, chemical method of weed control is very effective and economical. Application of Oxadiazon (Ronstar) @ 3 L/ha or Butachlor 50 EC (Machete) @ 3 L/ha should be done by mixing with 800 L/ha water before the emergence of crop and weeds (pre-emergence). The above mentioned doses are on the basis of commercial product.

Precaution: Do not apply granular formulations of herbicides in direct seeded upland rice.

Water management

Paddy crop is strongly influenced by water supply. Water should be kept standing in the field throughout the growth period. In water scarcity areas, saturated soil in a chemical reduced stage is desirable. The characteristics of flooded soil which are conducive to high yields are (i) greater availability of nutrients such as phosphorus, iron and manganese, (ii) suppression of weed competition, (iii) elimination of moisture stress as a limiting factor, (iv) micro-climate favourable to crop production. In order to achieve the above mentioned objectives, the following practices should be adopted.

1. Raise paddy nursery at a place where assured irrigation is available.
2. Level the fields uniformly
3. Where irrigation facilities are not available, store all the rain water in paddy fields by making 25 to 30 cm raised bunds.
4. Maintain about 8-10 cm of water level in the fields at puddling time and subsequently depth of ponded water may be maintained throughout the growing period.
5. It is desirable to control the water in the individual fields.
6. Withhold water for few days till the seedlings have established.
7. In areas of low temperature of irrigation water, the practices of continuous running water from field to field should be stopped and water should be kept ponded in the fields at 4-5 cm level.
8. Drain-off water for about 2 days prior to the application of fertilizers.
9. Drain-off water completely for 5 to 7 days following tillering and flowering stages. This helps to remove the toxic substances like sulphides and regulates oxygen supply to roots.

Harvesting

The water should be drained out from the field 7 to 10 days before harvesting. To avoid the shattering losses, the crop should not be allowed to over-mature and remain in the field after maturity. The brownish colour and dried leaves of plants indicate maturity.

Crop rotation

Profitable rice based crop rotations of Zone I comprising of Una, Bilaspur, Hamirpur districts and parts of Sirmour, Kangra, Solan and Chamba districts adjoining the Punjab and Haryana State are -

Rice - Linseed - Maize Fodder,
Rice - Linseed - Potato/wheat

Control of wild rice

- (i) **Method of cultivation** : In the water and maach rice cultures, wild rice can be weeded out by hand picking after the crop has been fairly established. Transplanting method reduces the chances of wild rice and should be practised wherever feasible.
- (ii) **Varietal difference** : Varieties with purple foliage colour like R-575 should be grown to weed out wild rice at an early stage.
- (iii) **Rotation of crop** : Rice should follow wheat or linseed crop in winter.
- (iv) **Seed selection** : For the areas infested with wild rice, the seed for the next crop should be procured from such areas where there is no wild rice problem.
- (v) **Eradication of wild rice from cultivated areas** : Wild rice growing in marshy and swampy places in the neighbourhood of cultivated fields should be destroyed before earing.

Plant Protection

Sign of attack/symptom	Control
Insect-pests	
Grasshopper: Both nymphs and adults feed on leaves in nursery and in the fields. The adults are often serious and attack the periphery of the panicles.	1. Spray 1250 ml Chloropyriphos 20 EC (0.05%) per 500 L water/ha on appearance of pest. 2. Remove weeds and grasses on bunds.
Paddy black beetle: Beetles appear soon after transplanting and attack the under-ground portion of the system. The infested plants then wither and die.	Apply 2 L Chloropyriphos 20 EC mixed with 25 kg sand per ha at sowing time.
Rice bug: Usually appears with early rains. Both nymphs and adults suck juice from the young succulent leaves, shoots and milky grains. The panicles of such plants are chaffy. A brown/black spot appears around the feeding hole on the grain.	1. Remove weeds and other alternate hosts. 2. Collect eggs, nymphs and adults and destroy them. 3. Before flowering, spray 1250 g cabraryl (Sevin 50 WP) or 1250 ml fenitrothion (Folithion/ Sumithion/ Accothion 50 EC) in 1250 L water/ha. Caution : Dust or spray only when there are 10 bugs/100 heads or rice.
Rice hispa: Both larvae and adults attack the rice plant. The larvae mine into the leaf between the epidermal membranes producing longitudinal white streaks. Affected leaves wither and die.	1. Remove grasses from the bunds. 2. Spray 600 ml methyl parathion (Metacid 50 EC) or 1000 ml fenitrothion (Folithion/ Sumition/ Accothion 50 EC) in 500 L water/ha. 3. Apply Cartap 4 (Padan) @ 1 kg ai/ha (25 kg/ha) 10 days after transplanting or 40 days old crop in 3-4 cm standing water. The water be

	<p>kept standing for 2-3 days.</p> <p>Note : Spray only when infestation is more than 10 per cent.</p>
<p>Stem borer: Damage is caused by feeding of the larvae within the stem. The damaged plants result in 'dead heart' and 'white head' formation. The damage is noticeable from July to October.</p>	<ol style="list-style-type: none"> 1. Apply carbofuran (Furadan 3 G) by broadcasting in 3-4 cm deep standing water @ 1 kg/ha (a.i.) 10 days after transplanting, if necessary. 2. Spray 1000 ml endosulfan (Thiodan 35 EC) or 500 ml methyl parathion (Metacid 50 EC) in 500 L water/ha. Repeat after 45 days. <p>Caution : Apply insecticides only if 5 per cent or more plants are infested.</p>
<p>Leaf folder or leaf roller: Caterpillars infest leaves of young plants fastening the edges of the leaf together and live inside rolled leaf.</p>	<ol style="list-style-type: none"> 1. Clip-off the affected leaves. 2. Remove weeds especially graminaceous ones 3. Spray 1250 ml chloropyriphos 20 EC (0.05%) or 835 ml monocrotophos 36 EC (0.06%) per 500 L water/ha on pest appearance.
<p>Leaf hopper: The nymphs and adults of hoppers cause heavy damage to this crop by sucking the sap from various parts of the plant during August-September.</p>	<ol style="list-style-type: none"> 1. Spray 1250 ml Chloropyriphos 20 EC (0.05%) per 500 L water/ha on appearance of pest.
<p>Diseases</p> <p>Blast : Brown to reddish brown, spindle shaped lesions with grey or whitish centre are produced on leaves in nursery and at tillering stages. Lesions are also produced on nodes, parts of panicles and grains. Leaf blast stunts the plants, reduces the number of panicles and grain weight. Plants infested early in the season are often completely killed.</p>	<ol style="list-style-type: none"> 1. Treat the seed before sowing with Bavistin 50 WP or Beam 75 WP @ 2 g/kg seed. 2. Spray the crop with Blitox 50 (Copper oxychloride) once at nursery stage (12 in 4 L water for 100 m²) and again depending on need at the time of tillering, late booting and panicle emergence stages with 2.250 kg Blitox 50 or 750 g Bavistin 50 WP or 750 ml Hinosan in 750 L water/ha or spray the crop at late booting and panicle emergence stages with Beam 75 WP (300 g in 500 L water/ha). In high rainfall areas, sticker Stickwel @ 0.2 g/L water should be added. 3. Do not apply excessive dose of nitrogenous fertilizers. 4. Plant resistant varieties. Himalaya - 741 should not be cultivated in blast prone areas.
<p>Bacterial blight : The disease manifests particularly during the flowering stage of the crop. Lesions usually start as streaks along the margins of upper part of leaf blade. The lesions may cover the entire leaf blade turning it whitish grey.</p>	<ol style="list-style-type: none"> 1. Use heavy seed for nursery sowing. Dip the seed in 5% salt solution to remove light seed. 2. Plant moderately resistant variety like IR-579.

<p>Stem rot : The disease starts with a small, blackish irregular lesion on the outer leaf sheath near the water line when the plants are 2-3 months old. Infested culms soften, rot and collapse causing plants to lodge. In case of severe infection, plants die. Affected plants which survive remain sterile or produce shrivelled grains. The presence of small black bodies called sclerotia which can be seen by splitting open the diseased culm are the diagnostic symptoms.</p>	<ol style="list-style-type: none"> 1. Do not allow water to stagnate in field. 2. Stubbles should be collected and burnt after the harvest of crop. 3. Plant resistant varieties like Basmati group.
<p>Brown spot :Seedlings are affected before and after emergence showing typical spots on leaves which are oval, brown grey or whitish centre when fully developed. Heavy infection may cause withering of leaves. On glumes, black or dark brown spots, sometimes covering the entire glume may appear and result in blighted kernel. mut : The symptoms are observed at the time of tasselling and are formed.</p>	<ol style="list-style-type: none"> 1. Treat seed with Thirm @ 3 g/kg seed 2. Spray the crop in the nursery with Indofil M-45 or Indofil Z-78 @ 0.25% (5 g in 2 L water of 10 m² nursery bed). 3. In disease prone areas, cultivate Himalaya-741 which is moderately resistant.
<p>Glume blotch : The disease appears when the panicle is still enclosed in the boot leaf. Brownish black spots which individually are roundish, appear on the glumes. Heavy and early infection results in blackening and blighting of the entire grain. Moderately severe infection reduces grain weight but light infections do not affect,</p>	<ol style="list-style-type: none"> 1. Spray Bavistin (0.1%) at 50% panicle emergence stage and repeat twice at 10 days interval. 2. Plant resistant varieties in disease prone areas. 3. Do not apply higher dose of nitrogen fertilizer.
<p>False smut : The individual grains are transformed into large greenish Velvety spore balls, which become visible as the panicles start to mature. The spore mass looks green on the outside and yellow to orange inside. High relative humidity, rain and cloudy days during the flowering period increase the incidence of the disease.</p>	<ol style="list-style-type: none"> 1. Collect the diseased panicles and burn them. 2. Avoid excessive doses of nitrogen fertilizers
<p>Sheath rot: The disease induces rot on the upper most leaf sheaths where oblong to irregular grey brown lesions develop. Later, the lesions coalesce and cover the entire sheath. In severe cases, young panicles either do not emerge or emerge partially and often remain sterile.</p>	<ol style="list-style-type: none"> 1. Use disease-free seed. 2. Burn the stubbles after harvesting the infested crop.

MAIZE

Maize is one of the most important *Kharif* crop in Himachal Pradesh. The total area under maize in the State during 1997-98 was 3,12,000 hectares with production of 6,20,700 thousand tonnes which is next only to area under wheat. The average yield per hectare was 19.9 quintals. Although the average yield of maize in Himachal Pradesh is much higher yet there is a considerable scope to improve the yield by sowing good quality seeds of the recommended varieties, application of recommended fertilizer doses and keeping the weeds under control.

Varieties

Girija (L-118) : It is suitable for high rainfall area of low and mid hills where water drainage is not proper. It matures timely (110 days). It gives an average yield of 40 q/ha. The plants are medium tall with thick stem and erect dark green leaves. The plants generally bear two cobs.

Sartaj Hybrid : It has medium tall plants with semi-erect, green to dark green leaves. The stem is thick with medium cob placement, medium branched compact tassel and compact husk cover. It is tolerant to *Erwinia* stalk rot under field conditions but susceptible under artificial inoculation. It is moderately resistant to *H. turcicum*; *H. maydis* leaf blights. It is resistant to lodging and give best response on per hectare basis at 80 N + 40 Kg P₂O₅ + 20 kg K₂O + FYM under rainfed conditions. It is tolerant to moisture stress and is suitable for low rainfall areas of the state and is suitable for cultivation upto 1200 m, asl in the districts of Sirmour, Una, Bilaspur, Hamirpur and in lower mid hills of Kullu, Mandi, Solan, Shimla and Chamba. It has good chapati making qualities because of orange yellow flint grains and is also suitable for dairy cattle because the stems are green at harvest time. Its average yield on the basis of on-farm trails conducted in the state is 46 q/ha. However, being hybrid variety, its seed is to be purchased fresh every year.

Early Composite : It is a composite variety. It is suitable for cultivation in areas lying between 750 to 1,450m above mean sea level. The plants are medium tall with thick stem. The cobs are mediumly placed which make them less prone to lodging and easy to harvest. The average yield of this variety is 33 q per hectare and matures in 105-110 days. It gives good performance even under low-fertility and unirrigated conditions. Under complete drought conditions, the variety when sown in last week of May gives outstanding performance and has been found to be particularly suitable for Kullu, Bilaspur, higher Chamba, drier areas of Kangra and Solan districts. Because of its early maturity, more residual moisture is left in the soil for proper germination of the following crop. The grains are light orange, flint to semi-flint having good chapati making quality. It is more resistant to *Helminthosporium turcicum* than the local. It requires well drained fields for best results. It should not be planted in the fields where water stands due to excessive rain.

Parvati : This composite is suitable for cultivation in low and mid hill areas of the State, particularly in areas where stalk rot is prevalent. The plants are medium tall with medium to slightly higher cob placement. The plants generally bear two cobs. The average yield is 35 q/ha and it matures in 110-115 days. The grains are orange to yellow and flint to semi-flint. The flour of this variety has very good chapati making qualities.

Navin Composite : It is an early maturing, medium tall and lodging resistant composite having yellow, bold, flint to semi-flint grains. It is recommended for low hills (Zone I) and because of its short duration it fits well in maize-wheat rotation. It is highly resistant to brown stripe, downy mildew and other foliar diseases. Its average yield is 35 q/ha.

Him-123 : This is a hybrid variety of maize and as such, the farmers should get fresh seed for sowing every year. The average yield of this variety is recommended for lower areas of Himachal Pradesh and is particularly suited to irrigated and high fertility conditions.

Pop Corn : This a special type of maize and good for popping only. The variety U.P.A.U. pop corn is recommended. The average yield is 20 q/ha and matures in 100-105 days. The variety is fairly resistant to leaf blight. It sells at a premium in the market.

Seed Production

The seed of hybrid variety like Him-123 and Sartaj is to be purchased a fresh every year, although the seed of composite varieties like Early Composite, Parvati and Navin composite can be kept for atleast 3-4 years, provided the following precautions are observed by farmers.

1. Avoid mechanical mixture with other varieties
2. An area of one acre or more should be planted with the composite variety. The cobs from the central portion of the field leaving 9 to 10 m all around should be harvested and bulked. Then the best cobs should be selected from the harvested pile and used as seed for the next year. It is necessary to select large number of cobs (3,000 to 5,000) from the harvested pile so as to form a representative sample. The seed from the finally selected cobs should be bulked and kept as seed for next year as per requirement.

Soil

Maize crop grows satisfactory on well drained loam and silt loam soils characterised by adequate organic matter and plant nutrients.

Manuring

		<u>Nutrients (kg/ha)</u>			<u>Fertilizers</u>					
		N	P ₂ O ₅	K ₂ O	Kg/ha			Kg/bigha		
					Urea/CAN	SSP	MOP	Urea/CAN	SSP	MOP
Hybrid & Composite										
i)	High rainfall	120	60	40	260/480	375	65	21/38	30	5
ii)	Low rainfall	90	45	30	195/360	280	50	15/29	22	4
Local										
i)	High rainfall	80	40	30	175/320	250	50	14/25	20	4
ii)	Low rainfall	60	30	20	130/240	185	33	10/19	15	3

The fertilizer schedule of the maize crop involves incorporation of adequate quantities of organic matter into the soil (FYM 10-15 tonnes/ha). This is important particularly for light textured and heavy soils for maintaining good soil structure and enhancing water-holding capacity. The newly reclaimed soils require relatively higher qualities of organic matter (30-40 tonnes/ha).

In acidic soils (pH<6) application of a mixture of rock phosphate and superphosphate in the ratio of 50:50 proves equally beneficial as compared to application of superphosphate only to provide P₂O₅ to the crop. Lime application in acidic soils should be done on soil test basis.

Apply one-third of N and whole of P and K at the sowing time. The basal dose of N, P and K should be applied bands 5 cm to the side and 5 cm deeper to the seed. The remaining 2/3 of N should be applied in two equal splits, one at knee-high stage of the crop (40-45 days after sowing) and another at pre-tasselling stage. In

low hill sub-montane areas, apply 1/8 N at the time of sowing, 3/4 N at knee-high stage and 1/8 N at tasselling stage. The second and third dose of N should be applied 10-15 cm to the side of the rows and raked properly. Under rainfed conditions, in case nitrogenous fertilizers are not available at sowing time, 1/3 N CAN be applied 2-4 weeks after sowing with first hand weeding and remaining 2/3 N CAN be applied at knee-high and pre-tasselling stages. Earthing up of soil may also be followed for better incorporation of fertilizer in the soil. In areas where lodging of the crop due to wind is a common feature, the late application of N may counteract adverse conditions by slowing down the growth. Application of zinc sulphate @ 25 kg/ha has been found beneficial in coarse textured soils of Una and Indora area.

In maize-wheat rotation, the application of FYM to maize only and that of phosphatic fertilizer to wheat only may be more beneficial in high rainfall areas. The continuous application of P fertilizer without FYM to maize may accentuate zinc deficiency.

If zinc deficiency symptoms have been observed in the previous crop or soil test data indicating low available Zinc, 25 kg zinc sulphate/ ha may be added before sowing of the crop. But it should not be mixed with any fertilizer at the time of application. In case, the zinc deficiency is noted in the standing crop, foliar application of zinc sulphate @ 0.5 per cent (5 kg zinc sulphate and 2.5 kg calcium hydroxide/hectare) should be done. In order to facilitate the farmers and extension workers in recognising zinc deficiency, symptoms observed on leaves are given below:

Two to three week old plants develop broad bands of white or light yellow colour stripes between mid rib and edges though the leaf tip still remains normal green. In extreme deficiency cases, young leaves unfolding in the bud appear white and light yellow and hence called white bud disease of maize. At the age of 25-35 days, 4th, 5th and 6th basal leaves also develop white patches on both sides. A distinctive feature of zinc deficiency in maize is that even in worst affected leaves, the margin and upper third portion of the leaf is greener than rest of the leaf lamina.

Preparation of land

First ploughing should be done with soil turning plough so that existing weeds and crop residues are buried deep in soil, 3-4 more ploughings or harrowing make the field ready. Planking should be done after each ploughing to break the clods and make the soil friable.

Time of sowing

For good harvest, sowing should be done at right time. The optimum times for maize sowing in the State on the basis of agro-climatic zones are given below :

High hills	May 15 to first week of June (April 15 to first week of May where monoculture of maize is a practice)
Mid hills	May 20 to June 15
Low hills	June 15 to June 30

Since maize cultivation in the State depends on monsoon rains, it is not possible to give a rigid schedule of sowing time. The time can be changed to some extent depending on the onset of monsoon rains. In mid-hill sub-humid zone, if major crop of maize could not be sown due to delayed onset of monsoon or fails due to adverse climatic conditions, the sowing of mash/kulthi should be done upto first week of August. In case the sowing is delayed, inter-cropping of legumes has proved more beneficial.

Method of sowing

The general practices of farmers in the State is to sow maize by broadcast method which is undesirable because of improper distribution of growth factors like space, light, CO₂, nutrient and water among plants, apart from the damage of seed which remain on surface or buried deep in soil and creates difficulty in intercultivation in standing crop. Therefore, for better yields, maize must be sown in lines behind the plough at the spacing of 60 cm

between rows and 20 cm between seeds leading to a maximum population of 75000 plants per hectare. Since maize is a non-tillering crop, maintenance of adequate number of plants per unit area is a must and plant population below 50,000 plants/ha at the time of harvest may not result in a better harvest.

Maize seed should be sown at a depth of 3-5 cm for quick emergence. On slopy lands, where soil erosion is problem, the rows of maize should be kept across the slope and approximately on contours.

Seed rate

The rate of maize is 20 kg/ha which is sufficient to meet the desired plant population.

Moisture conservation and drainage

Mulching with pine needles or any other locally available waste material @ 10 tonnes/ha is very useful in enhancing crop yields under rainfed conditions as it avoids moisture stress during prolonged dry spells.

Application of mulch of Lantana, Eupatorium, Sal leaves, Basuti or any other locally available waste material @ 10 tonnes/ha in standing maize by August helps in conservation and carry over of moisture for sowing of rainfed wheat.

The critical stages of irrigation in maize are tasselling and silking. If rains fail at these stages and facility for irrigation is available, the crop should be irrigated. In maize standing water is not desirable. Therefore, proper arrangement for its drainage should be made. The work becomes much easy when crop is sown in lines. Water at any stage should not be allowed to stand for a couple of hours.

Intercropping in maize

In Himachal Pradesh, it is very common to sow some leguminous crop in maize with a view to get an additional crop from the same land. The practice, no doubt is good, but the techniques followed by farmers is not correct hence the profitability is low. Crops like soybean under all conditions and mash where rains are comparatively low can successfully be grown in between two rows of maize. When maize is sown at 60 to 75 cm row spacing, one row of soybean or mash can easily be accommodated in between two rows of maize. This results in better utilization of space and other growth factors including nutrients and water. Apart from these advantages, this practices serves as a security measure against natural calamities and attack of insect-pests and diseases. The legumes, thus, grown also help in supressing the weeds and checking the soil erosion on slopy lands. The care should be taken to apply full dose of fertilizers for maize along with additional 20-25 kg P₂O₅ and 15-20 kg nitrogen per hectare as an allowance to soybean being intercropped. However, when blackgram (mash/urd) is intercropped with maize, no additional fertilizer dose is required to be added. But in horsegram when intercropped with maize, 50 per cent of the recommended fertilizer (7.5 kg N & 22.5 kg P₂O₅ per hectare) should be applied to the legume crop. In zone I, intercropping of one row of seasamum in between two rows of maize sown at 60 cm row to row spacing is recommended.

The seed rate of the inter-crop should be reduced to half of its recommendation for the pure crop.

Weed control

Proper weed management in maize is essential particularly at early stages of growth (20-30 days after sowing), for efficient use of other inputs and increasing yield. Hand weeding being labour intensive is costly and sometimes becomes impractiable due to continuous rains during kharif season. Therefore, chemical weed control is cheaper and effective method of check weed competition from the beginning.

To control both grassy and broad leaved weeds, apply Tafazine or Atrataf in 750-800 L water with high volume sprayer within 48 hours of sowing. The doses for different types of soils are as follows ::

Light soils	1.25-1.75 kg/ha
Medium soils	1.75-2.25 kg/ha
Heavy soils	2.25-2.75 kg/ha

In case of mixed cropping in maize with legumes, apply Saturn or Lasso @ 3 L/ha or Stomp @ 4.5 L/ha or Thiobencarb or Alachlor 1.5 L/ha within 48 hours of sowing or Basalin (Fluchloralin 45 EC) @ 2.25 L/ha as pre-plant incorporation in 750-800 L water with high volume spray pump. The integrated weed control approach, i.e. intercropping of soybean with maize (1:1), 75,000 maize plants per hectare with 25 per cent high fertility than recommended followed by one weeding within first 30 days of sowing gives control of weeds.

In maize and blackgram/horsegram intercropping system, hand weeding and hoeing should be done within 5 weeks of sowing.

***Ageratum conyzoides* (Neela fulnu) :**

Weed appears at tasselling/ silking stage of the crop. Though it does not harm the maize crop but hinders land preparation for the following *rabi* crops. It can be controlled by spraying 1.25-2.75 kg/ha, depending upon the soil type, Atrazine as pre-emergence and another post-emergence spray of the same herbicide @ 0.75 kg/ha in 700-800 L water at the tasselling stage. Pre-emergence. It can also be controlled by a direct spray of 0.5 L/ha of Glyphosate or Gramazone in 750-800 L water before the weeds flower. *Ageratum houstonianum* is another obnoxious weed found in waste lands which could be controlled by spraying 10% sodium chloride solution or 0.5 L/ha of Glyphosate.

If *Cyperus rotundus* (Motha):

is serious weed in maize fields apply Glyphosate @ 0.75 L/ha + 0.5% ammonium sulphate fertilizer in 750 L water on actively growing motha as foliar spray after the harvest of wheat or about 7 days before sowing of maize. Directed spray of Glyphosate @ 0.75 L/ha on motha at 35-40 days after sowing of pure maize also gives effective control of this weed.

Harvesting

The maize grains of high yielding varieties mature even when the plants are green. The cob sheath dries and becomes brownish. Grains having moisture content below 30% can be harvested and should not be allowed to stand in the field any more to avoid the damage by birds or animals. The cobs after separation from plants should be dried, shelled and the dried seed, upto the moisture content of 15% can be marketed. The green or semi-dried plants of maize can be fed to cattle as fodder. Practically, there is no harm if plants are harvested with cobs, dried, stored in small bundles and threshed afterwards due to lack of time any other reason.

Crop rotation

The profitable maize based crop rotations for zone are :

(a) Irrigated areas :

Maize - Toria - Maize - Fodder

(b) Rainfed areas :

Maize + Til - Wheat + Gram

Plant Protection

Sign of attack/symptom	Control
Insect-pests	
<p>Maize borer : Caterpillars initially feed on young leaves in the whorl which show shot hole symptoms and borne into central shoots and stem. They feed on the tissues of the stem and cause dead hearts. Attacked plants gradually dry and wither. The damage is more serious on young plants. In older plants, larvae sometimes bore into cobs and eat the ripening grains.</p>	<ol style="list-style-type: none"> 1. Adopt clean cultivation by removing weeds, ploughing and removing alternate hosts. 2. Use high seed rate to compensate for early attack. Uproot and destroy those plants showing shot holes or borer injury. 3. Apply in soil 2 g phorate (Thimet 10 G)/M row before sowing sprinkle the granules over the central whorl especially of those plants showing shot holes. 4. At harvest, cut the plants as near the ground as possible. Collect the stubbles and burn them. <p>Caution : Do not use insecticides on maize fodder.</p>
<p>Hairy caterpillars and grasshoppers : Both insects feed on foliage and soft stems of young maize plants. Hairy caterpillars initially feed gregariously and are noticeable.</p>	<ol style="list-style-type: none"> 1. Collect and destroy the congregating caterpillars. 2. Dust Folidol 2% @ 20-25 kg/ha
<p>Cutworms, black beetles and white grubs : These insects remain hidden in soil and cause heavy damage to seedlings immediately after germination mixed with 25 kg sand per ha at sowing time.</p>	<ol style="list-style-type: none"> 1. Use of well decomposed FYM 2. Use high seed rate 3. Apply 2 L Chloropyriphos 20 EC
<p>Blister beetle : Adults feed voraciously at the tasselling stage.</p>	<p>Spray 1250 ml endosulfan (Thiodan/ Endocel 35 EC) or 625 ml methyl parathion (Metacid 50 EC) in 625 L water/ha at the tasselling stage.</p>
Diseases	
<p>Bacterial stalk rot : The disease generally appears at the time of flowering. One or a few basal internodes above the soil line become tan to dark brown, water soaked and soft. The stems easily break at the point of attack. Alcoholic smell in the affected plant is a diagnostic feature of the disease.</p>	<ol style="list-style-type: none"> 1. Apply judicious doses of nitrogen and potassic fertilizers. Avoid heavy nitrogen fertilization. 2. Field should be properly drained off excess water. 3. Drench maize field with bleaching powder (3%) @ 16.5 kg/ha or Klorocin granules @ 15 kg/ha (one application only) a week before tasselling or initial appearance of disease. Give two more drenches at weekly intervals in case of bleaching powder application. 4. Grow resistant variety in low and mid hills.
<p>Leaf blight : Blight generally appears when the crop is about 30-40 days old, appearing first on flower leaves and progressing upwards. Lesions due to turcicum leaf blight are long, elliptical, greyish green or tan reaching upto 15 cm length whereas those of maydis leaf blight are tan coloured with parallel sides ranging from 1-2 cm in length. The disease affect leaf sheaths, earhusks, shanks, ears and cobs also. In severe cases, drying up of leaves and premature death of the plants also occurs.</p>	<ol style="list-style-type: none"> 1. Early sowing preferably before 10th June results in less disease. 2. Apply recommended dose of nitrogenous fertilizers. 3. Spray the crop with Indofil Z-78 or Indofil M-45 (1.5 kg in 750 L water/ha) when disease is first observed. Repeat at 10-day interval in case of seed crop, sweet corn or pop corn.

<p>Brown stripe :Lesions develop on leaves as narrow, chlorotic or yellowish stripes, 3-7 mm wide with well defined by the veins. Strips later become reddish to purple in colour. Whitish downy growth on the early morning is diagnostic feature of disease.</p>	<p>Spray the crop with Indofil M-45 (1.5 kg in 750 L water/ha) at bi-weekly interval starting as soon as the disease is noticed.</p>
<p>Head smut : The symptoms are observed at the time of tasselling and ear formation which are completely or partially transformed into black powdery mass.</p>	<ol style="list-style-type: none"> 1. Treat seed with vitavax/Bavistin @ 2.5 g/kg before sowing. 2. Rogue out the infected plants 3. Follow a rotation of 4-5 years in infested fields.
<p>Seed rot and seedling blight : Infected seeds when sown especially in cold wet soil may result in killing of embryos before germination or in the killing of the seedlings before or after emergence. Seedling blight may occur due to soft rot of the stem tissue and water soaking near the ground level.</p>	<ol style="list-style-type: none"> 1. Sow healthy seed of recommended varieties by eliminating seed lots showing streaking or pericarp injury. 2. Treat seed with Thiram @ 2.5 g/kg seed. 3. Avoid sowing in cold wet soil
<p>Leaf and sheath banded blight : This disease appears at pre-tasselling stage on 40-50 days old plants in the form of 1-2 cm straw coloured bands. From distance, symptoms look like as cast-off snake skin. On the stalk, disease starts from soil level and the lesions develop on leaf sheath upto 4-5 internodes.Later on, dark brown coloured sclerotia of the fungus develop on these lesions. Silk fibers darken at the end and caked up and turned into hardened structure. Sometimes grains fails to develop. Crown portion of the grain becomes lusterless. Kernels turn light in weight and chaffy. All plant parts except root and tassels are infected.</p>	<ol style="list-style-type: none"> 1. Infected plants should be uprooted and burnt. While uprooting plants, care should be taken that the sclerotia of the fungus do not fall in the field. 2. Grow moderately resistant varieties like Early Composite and Parvati. 3. The recommended row to row and plant to plant distance should be strictly followed in order to avoid contact of diseased leaves with healthy leaves. 4. When the crop is 40-45 days old the disease sheaths and leaves should be removed from infected plants and burnt. 5. Spray Indofil M-45 (0.2%) as soon as the disease appears. Repeat the spray after 10 days depending upon the stage of crop and disease severity.
<p>Late wilt : Sudden wilting of leaves at tasselling with the leaves turning dull green. Lower stalk portions become dry, shrunken and hollow. The stalk when split shows discoloration of the split tissue. The disease is severe in sandy or clay soil.</p>	<ol style="list-style-type: none"> 1. Apply recommended dose of potassic fertilizer at sowing at sowing time in drought prone areas. 2. Irrigate the crop at flowering stage
<p>Brown spot : Symptoms appear on leaf blades, leaf sheaths and stalks; lesions concentrated towards the leaf base small, yellowish which later turn brown. Stalk also get infected at the nodes beneath the sheaths. Severe infection leads to stalk breakage.</p>	<p>Practice crop rotation and sanitation.</p>