1. INTRODUCTION

Rice is the second most important crop which brings economic prosperity of the growers as well as earns billions of rupees through its export for country. Pakistani fine rice commonly known as Basmati is world famous and enjoys monopoly in the international market, due to its quality characteristics, strong aroma, slender and long kernel, gelatinization, temperature and high degree of grain elongation on cooking. However, the grain yield of basmati rice varieties is very low. In order to remain in the International market, we have to further improve the quality as well as yield of basmati varieties. Rice plays a pivotal role in the agro-based and occupies a prominent position in agricultural economy of Pakistan. It is planted on an area of over 2.57 million ha (10% of the total cropped area) and accounts for 17% of the total cereals produced annually.

In Pakistan, rice is mainly grown in the Sindh and Punjab. The Sindh is specialized in producing long grain white rice IRRI-6 and IRRI-9, while Punjab is producing world class Basmati rice among IRRI-9 and other varieties. In Swat (Zone I) at high altitude mountain valleys, cold tolerant rice varieties are grown. In the south of KPK, Sindh and Baluchistan (Zone III and IV), IRRI type medium long grain heat tolerant tropical rice varieties are grown. Punjab is the biggest producer of rice in the country and contributes 58 per cent to national production while the provinces of Sindh, Baluchistan and KPK to 29, 3 and 10 per cent, respectively.
2. NUTRITIOUS VALUE OF RICE
Rice is a good source of proteins, phosphorus and iron. Rice is rich in carbohydrates; it acts as fuel for the body and aids in normal functioning of the brain. Rice is an excellent source of vitamins and minerals like niacin, vitamin D, calcium, fiber, iron, thiamine and riboflavin. It also contains some amounts of calcium and small quantities of vitamin B. As rice is low in sodium, it is considered best food for those suffering from high blood pressure and hypertension. Most of the nutrients and minerals in rice are concentrated in the outer brown layers known as husk and germs. Hence brown rice, which is rice from which only husk has been removed, is the most nutritious type of rice. Unfortunately, many consumers prefer pseudo cosmetic preferences and demand white rice or polished rice, in which the germ and bran has been removed.

3. GROWTH STAGES
i. Seed Germination

Seed germination occurs when the seed coat has imbibed adequate water becoming soft and elastic. The coleorhiza elongates slightly, emerging through the seed coat and radicle breaks through the coleorhiza and becomes anchored in the soil. The coleoptile or primary leaf elongates, thus under dry-seeded or aerobic conditions the radicle emerges before the coleoptile. Under water-seeded (anaerobic) conditions, coleoptile may emerge before the root. This occurs within two days when temperatures are between 70\degree to 97\degree F. Below or above this temperature, germination requires more time.

ii. Seedling Emergence

Seedling emergence occurs when the first internode called mesocotyl has elongated and pushed the tip of rice coleoptile through the soil surface. The length of the mesocotyl varies with cultivars. Some semi-dwarf varieties may have a very short mesocotyl and generally will not emerge if covered by more than 1/2 to 3/4 inch of soil. The mesocotyl only develops in the dark and doesn’t show up in water-seeded rice.
iii. **Pre-Tillering**

Pre-Tillering is a period from the development of first to fourth leaf stage requires 15 to 25 days. During this time, seminal roots further develop, the secondary or lateral roots develop and the first four leaves appear.

iv. **Tillering**

Tillering usually begins at the fifth leaf stage when first tiller is visible and emerges from axillary bud of second leaf on culm. Tillering continues when the sixth leaf emerges, second tiller comes from axillary bud of the third leaf.

After maximum tillering has occurred, no more effective tillers are produced. A portion of late tillers will generally die due to competition effects. In direct-seeded rice fields with a normal plant population (10 to 20 plants per square foot), rice plants generally produce 2 to 5 panicle bearing tillers per plant compared to 10 to 30 tillers per plant in transplanted rice where more space is available between plants.

v. **Stem Elongation**

This is period from end of active tillering to the beginning of reproductive stage. Tiller number decreases; height and stem diameter continue to increase but at a slower rate. The length of this period is a function of maturation period of cultivar. For very-short season cultivars with 110-day maturity, this period may not be evident. In this situation, maximum tillering stage and the beginning of reproductive growth may overlap. In a 150-day rice cultivar, stem elongation period may last more than two weeks.
vi. **Panicle Initiation to Booting**

- This stage is begins with the initiation of panicle primordium at the tip of growing shoot and end when young panicle is about to emerge.
- The panicle becomes visible to the neked eye about 7-10 days after initiation as a white feathery cone.
- Initially it occurs first in the main culm and follows in other tillers in an uneven pattern.
- As the panicle develops, the spikelets become distinguishable and panicle extends upward inside the flag leaf sheath.
- Booting is a final part of panicle development stage. About 16 days after visual panicle initiation, the sheath of flag leaf swells. This swelling is called booting.

vii. **Heading – Ear Head Emergence**

- Heading stage is defined as the time when 50% of panicles have exerted.
- Heading starts when panicle emerges from flag leaf sheath and ends when it completely protrudes from sheath.
- The topmost internode elongates rapidly and pushes up panicle.
- It usually takes 10 – 14 days for all plants in the field to complete heading.

viii. **Flowering Stage**

- Anthesis follows after heading and refers to the series of events between opening and closing of the spikelets.
- At the time of anthesis, panicle erect and following events takes place, the florets are open mostly at morning time, the stamen elongate, anthers move out of flowering glumes as pollen is shed, pollen grains fall out of stigma and then floret closes.
- Flowering occurs about 25 days after visual panicle initiation regardless of variety.
ix. Milk Stage

- The grain starts to fill with a white milky liquid that can be squeezed out.
- The top of panicle bends gently in an arc.
- The panicle and 3 uppermost leaves are green.

x. Dough Stage

- The milky portion of the grain turns into a soft then a hard dough.
- The panicle arches about 80 degrees at the tip and 90 degrees at middle. The grain turns yellow and whole field looks yellowish.
- The last two remaining leaves of each tiller begin to dry from tips.

xi. Ripening

- The grains are fully developed, mature, hard and yellow.
- A greater portion of upper leaves are dry and panicles bend down.

4. CLIMATE

Optimum areas for getting higher yields are tropical and subtropical. The climatic factors that influence rice production are temperature, day-length and humidity. Paddy crop thrives well in high temperatures and abundant sunshine with temperatures between 20 °C to 38 °C throughout its growth period.

5. SOIL

Rice is grown in almost all types of soils in Pakistan. The soils most suited for the cultivation of rice are clay, loam and dry soils. Such soils are capable of holding water for long period. The loss of water by seepage is less through such soils, which is the main reason for selecting heavy soils for rice culture.
In the arid and semiarid regions, rice is frequently grown on alkaline soils with a high pH. Rice is fairly resistant to salinity and it can be grown for reclamation.

6. VARIETIES
There is no specific rice variety for the aerobic rice planting. The rice varieties being used by the farmers can also be used in dry rice planting. Aerobic or dry rice culture is a new method in which rice is planted as direct seeding like wheat or maize crop; any other approved rice variety can be used for this system.

At present, hybrid rice is cultivated on an area of approximately 500,000 acres in Pakistan. Total 3,000 to 4,000 metric tons of hybrid rice seeds are imported every year, while sowing rate is 7 to 8 kilograms per acre. In Sindh, hybrid rice is cultivated on vast tracts in Larkana, Jacobabad, Kandhkot, Shikarpur, Thul, Kashmore, Badin, Tando Mohammad Khan, Golarchi, Sujawal, Thatta etc. In Baluchistan, it is cultivated in Jafferabad, Nasirabad and Usta Muhammad etc. Multan, Sadiqabad, Rahim Yar Khan, Dera Ghazi Khan, Bhawalpur etc. are places in Punjab where hybrid seeds are widely used.


Approved Hybrid Varieties
GNY-50, GNY-53, Guard-402, Guard-403, Dagha-I, Arize-403, Emkay-H401

7. SEED AND ITS QUALITIES
Seed should be high yielding variety, pure, sound, high germination capacity, vigour, uniform in size, free from weed seeds and diseases.

8. TIME OF SOWING
The best planting time of aerobic rice is 15 to 20 days earlier than the traditional transplanting period. So, for basmati rice varieties 10 – 30 June is optimum time while for non-basmati rice varieties, 15 May – 10 June is the appropriate time

9. LAND PREPARATION
The preparation of land varies from place to place, depending upon method of sowing, soil characteristics and supply of water and climatic conditions. Mostly field is disked and harrowed in dry condition to obtain fine seed bed. On flooding
leveling is must to get uniform water level. Before land preparation pre irrigation is necessary to germinate weed seeds. Cultivator or tine harrow is once necessary to collect the roots and bulbs of weeds.

10. SOWING METHOD
a. Aerobic Rice Cultivation (Direct dry seeding)
   - First of all, prepare the land in dry to fine seedbed with disking & harrowing and then irrigate it. At optimum moisture condition, again prepare the seedbed to fine with 2-3 ploughings and planking. The seed may be soaked for 15 hours and dry it for few hours in the shade to decrease its moisture content which facilitates its free flow during seed drilling. Then use Rabi Drill/Zero-Till Drill in well-leveled field at optimum moisture level for seed sowing at a distance of 6-9”. In case, the drill is not available, seed (soaked for 30-35 hours) may be broadcast in open tilled field and then planked.
   - The land is leveled, ploughed and clod crushed till desired seed bed is obtained. Seeds are then drilled at proper space between rows at the seed rate of 30-38 kg per acre. Care should be taken so that seed should be drilled not beyond the depth of 1.5 – 2 cm. (i) when drilling is complete then field should be shallow irrigated with flood irrigation water. (ii) After drilling field is slightly irrigated with sprinkler irrigation system on continuous basis till crop maturity.

b. An-Aerobic Rice Cultivation (Direct and indirect wet seeding)
i. Broadcasting in Water
   After land has been thoroughly prepared in dry condition, the fields are flooded at depth of 5-10 centimeters for 2-3 days. The seeds are then broadcast in standing water at the rate of 30-40 kg per acre. It will be desirable if the seeds are soaked for 10-12 hours before sowing. For healthy establishment of young seedlings excess water from the field may be drained leaving thin layer of one inch water for 10 days.

ii. Nursery Raising
   - The selected area should be near water source so that water application will be easy when it required.
   - The selected area should be well ploughed, harrowed, leveled and tilthy.
Area is divided in beds with desired dimensions that may be narrow and long, in square shape or in rectangular.

For hard soil the beds are filled with trash or straw or farm yard manure and that spread evenly on plot to make 2 inches layer.

Burn the spreaded material to make ash and provide soft layer for root development.

Two beds of 23' x 23' are enough for one acre nursery.

20 – 25 kg seed is enough for IRRI varieties in Sindh and 8 – 10Kg for Punjab.

For basmati rice varieties, seed should be 12-14 kg per acre.

Don't broadcast seed on hot ash but wait for next day or till the smoke and fire ends.

Seed should be uniformly broadcasted and mixed with ash.

After seed broadcasting immediately plots are irrigated with water.

Be careful, seed do not gather at one end with water flow.

2-3 days are critical for water application and seed germination.

Apply light irrigation for few days.

Urea is applied in 2 – 3 splits with the rate of 1-2 Kg per plot.

The seedlings are ready in 21 days in case of short duration and 30-35 days in the case of long duration varieties.

The pulling should be done after watering the nursery beds.

After pulling the seedlings are bound in convenient size bundles.

Care should be taken when pulling of seedling to avoid injuries in stem and roots.

**Transplanting Methods**

a. **Random transplanting**

- In random planting, rice seedlings are transplanted at random in the field.

- Distance of planting is not uniform and no definite pattern is followed.

- It is mostly done manually.

b. **Straight Row Planting**

- The seedlings are transplanted in straight rows.

- Optimum plant spacing is possible.

- Set planting guides in the field before transplanting.

- In this method, make sure the roots and base of seedlings are inserted into the soil right under the loop or mark on the planting wire.
• After planting one row of seedlings, move the guides to the next row and then continue planting. Move backward for each subsequent row.
• Mark the rows with a wooden marker of 6 x 6” width and Length.
• Plant the seedlings where lines intersect.
• Another method of transplanting in straight rows can be done with mechanical or machine transplanter.

11. FERTILIZER APPLICATION IN AEROBIC RICE

Full dose of P and K (1-1.5 bags DAP and 1 bag SOP per acre) may be applied at sowing. While 80 percent recommended dose of Nitrogen (2.0-2.5 bags Urea for Basmati and 2.5-3.0 bags for non-basmati) should be applied in different splits with fertigation system between 30-70 days after sowing of rice. The remaining 20 % nitrogen may be applied before flowering. The deficiency of zinc appears in all rice varieties. Therefore, it is imperative to apply zinc (35%) @ 8 kg per acre after two weeks of rice transplanting) to get good yield.

<table>
<thead>
<tr>
<th>Rice Varieties</th>
<th>Fertilizer dose (Kg/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basmati type</td>
<td>55 – 30 – 25 N-P-K</td>
</tr>
<tr>
<td>IRRI Type</td>
<td>70 – 40 – 25 N-P-K</td>
</tr>
<tr>
<td>All Types</td>
<td>8 – Zn Sulphate</td>
</tr>
</tbody>
</table>

12. IRRIGATION APPLICATION

• The new cropping system allows farmers to grow rice with less water and labor.
• Aerobic rice crop does not require continuous flooding and can be safely irrigated.
• Rice is a very shallow-rooted crop, so heavy irrigation applications are generally not appropriate.
• In the early season, light, frequent applications are recommended.
• First irrigation may be given when germination completes and plants require irrigation water.
• A typical irrigation amount is ½-inch or 12.5 mm of water every other day.
• Moisture must be maintained from the surface down to approximately 8-10 inches (20-25 cm) when the root system is fully developed.
• Then, the interval between irrigations may be increased to keep field at optimum moisture level. However water stress be avoided at tilling, panicle initiation, and grain filling stages which are very crucial for obtaining higher yields.
• As the crop develops, the application depth is increased and the frequency of application is decreased. This will improve irrigation efficiency and allow wheel tracks to dry. However, the application depth must be matched with ability of soil to accept water.
Typical Rice Irrigation Scheduling For Hyderabad Region

<table>
<thead>
<tr>
<th></th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETo mm</td>
<td>8.6</td>
<td>7.9</td>
<td>6.2</td>
<td>5.6</td>
<td>6.1</td>
<td>4.9</td>
<td></td>
</tr>
<tr>
<td>Kc</td>
<td>1.05</td>
<td>1.20</td>
<td>1.20</td>
<td>1.20</td>
<td>0.90</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>ET mm</td>
<td>9.03</td>
<td>9.48</td>
<td>7.44</td>
<td>6.72</td>
<td>5.49</td>
<td>2.94</td>
<td></td>
</tr>
<tr>
<td>Days</td>
<td>15</td>
<td>30</td>
<td>31</td>
<td>31</td>
<td>30</td>
<td>13</td>
<td>150</td>
</tr>
<tr>
<td>ET mm for the Period</td>
<td>135</td>
<td>284</td>
<td>231</td>
<td>208</td>
<td>165</td>
<td>38</td>
<td>1061</td>
</tr>
<tr>
<td>Preci: mm for Period</td>
<td>15.0</td>
<td>15.0</td>
<td>61.0</td>
<td>44.0</td>
<td>16.0</td>
<td>3.0</td>
<td>154</td>
</tr>
<tr>
<td>Net CWR in mm</td>
<td>120</td>
<td>269</td>
<td>170</td>
<td>164</td>
<td>149</td>
<td>35</td>
<td>907</td>
</tr>
</tbody>
</table>

13. WEED MANAGEMENT IN AEROBIC RICE CULTURE
Weeds are a major concern for high productivity in aerobic rice crop. The pre planting herbicides like Roundup, Pendimethalin, and Stamp should be applied immediate after seeding. Then, at 30-35 days after sowing, when maximum weeds appear, post-emergence herbicides like, Clover (Nominee; marketed by Four-Brother Ltd) can be used for effective control of grass weeds. For the control of rice weeds following herbicides can be used.

RICE WEEDS CONTROL

<table>
<thead>
<tr>
<th>WEEDS</th>
<th>RECOMMENDED HERBICIDE</th>
<th>DOSE/ACRE</th>
<th>TIME OF APPLICATION</th>
<th>COMPANY/ DISTRIBUTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broad leaf, grasses and sedges</td>
<td>Sunstar 15WG</td>
<td>80 gm</td>
<td>3-10 days after transplanting and 15-20 days after broad-casting.</td>
<td>Bayer Crop Science</td>
</tr>
<tr>
<td>Aikar, Gider Gah, Mirch Booti, Mono Chowpatti, Phulri, Kutta Kani, Burlish Kal/Kabah, Cheeho &amp; Dhatoro Gah.</td>
<td>Machati 60EC</td>
<td>800 ml</td>
<td>3-5 days after transplanting.</td>
<td>Monsanto</td>
</tr>
<tr>
<td>Grasses &amp; broad leaf</td>
<td>RilofH 500EC</td>
<td>800 ml</td>
<td>3-5 days after transplanting.</td>
<td>Syngenta</td>
</tr>
<tr>
<td>Sawri, Gandhir, Snwoon &amp; Danahi</td>
<td>Rifit 500EC</td>
<td>500 ml</td>
<td>3-5 days after transplanting.</td>
<td>Syngenta</td>
</tr>
<tr>
<td></td>
<td>Machati 60EC</td>
<td>800 ml</td>
<td>3-5 days after transplanting.</td>
<td>Monsanto</td>
</tr>
</tbody>
</table>
14. INSECT PEST OF RICE

In Pakistan, major insect pests are stem borers, leaffolder and white backed plant hopper, which cause 15-20% on recurrent basis. The rice stem borers are one of the most destructive pests of rice in Pakistan. The mealy bugs occur periodically in Sindh. The incidence of pests varies from one region to other: Leaffolder is predominant all over the rice growing areas, stem borers are predominant in Punjab and D. I. Khan areas, whitebacked plant hopper in Sindh and Baluchistan and grasshoppers in Swat areas.

i. Yellow Stem Borer – Scirpophaga incertula – Lepidoptera

Yellow stem borer could attack most of the growing stages of rice plant, beginning with seedling through tillering and up to ear head setting. Its caterpillars bore into the rice stem and hollow out the stem completely. The damage symptoms vary according to the stage of growth of the plant. During the very early stages of growth the larvae damage the growing point in the terminal shoot. This condition is known as ‘Dead heart’. The larvae also feed internally within the leaf sheath and damage the vascular tissue by feeding inside the stem. The damage to stem results in the entry holes around. If the borer attack occurs at the flowering stage the resulting panicles become white and empty, a condition known as the ‘white head’. Among the other symptoms of damage of this pest is the presence of egg clusters on the leaves, presence of adult moth either flying around or floating on water and the curling of the young leaves.

ii. White Stem Borer – Scirpophaga innotata – Lepidoptera

Rice stem borers are considered the most serious insect pest of rice in Asia. This pest uses its strong mandibles to penetrate and feed on its plant host. Newly
hatched larvae bore inside the young rice plant, travelling downward between leaf sheaths and causing death of young tip (dead hearts) in vegetative stage and empty panicles (white heads) in generative stage. First-instar larvae may use silken threads to move to other plants.

iii. Pink Stem Borere – Sesamia inferens – Lepidoptera

The adults of stem borer species are nocturnal, negatively phototropic and strong flies. Larva feed on green tissues of leaf sheath for 2-3 days and then bore into the stem at nodal position and feed on inner tissue of plant. Central leaf whorl does not unfold turns brown and dries off. Lower leaves remain green and this position is known as dead heart.

Larva bore at peduncle node and feed it from inner side in result white head appears. Maximum damage occurs at this stage and this position is known as white head.

a. IPM CONTROL

Farmers mainly use insecticide to control these pests. No single method can manage all the pests or even a single pest under all situations. Integrated pest management (IPM) offers promise to reduce dependence on pesticides. IPM is an intelligent selection and use of pest management tactics by taking into consideration appropriate economical, ecological and sociological factors. Pests can be managed by logical integration of various tactics like use of resistant varieties, modifications of pest environment (removal of alternate food sources, timely sowing, water management (AWD) and manipulation of biodiversity in agri-matrix), conservation and utilization of bio-control agents (parasitoids, predators etc), balanced use of fertilizers and when necessary, an appropriate and timely use of insecticides. It is therefore, imperative to adopt integrated approach for the management of these pests and achieve sustainable crop production and environmental protection.

AGRONOMY
b. CHEMICAL INSECT PEST CONTROL

<table>
<thead>
<tr>
<th>INSECT PESTS</th>
<th>RECOMMENDED INSECTICIDE</th>
<th>DOSE/ACRE</th>
<th>NAME OF THE COMPANY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice stem borer</td>
<td>Regent 50SC</td>
<td>480 ml</td>
<td>Bayer Crop Science</td>
</tr>
<tr>
<td></td>
<td>Padan 4G</td>
<td>10 kg</td>
<td>Arysta</td>
</tr>
<tr>
<td></td>
<td>Furadan 3G</td>
<td>12 kg</td>
<td>F.M.C.</td>
</tr>
<tr>
<td></td>
<td>Rotap 4G</td>
<td>910 kg</td>
<td>Syngenta</td>
</tr>
<tr>
<td></td>
<td>Hostathion 40EC</td>
<td>600 ml</td>
<td>Bayer Crop Science</td>
</tr>
<tr>
<td></td>
<td>Deltaphos 30EC</td>
<td>400 ml</td>
<td>Bayer Crop Science</td>
</tr>
<tr>
<td></td>
<td>Karate 2.5EC</td>
<td>200 ml</td>
<td>Syngenta</td>
</tr>
<tr>
<td></td>
<td>Razex 4G</td>
<td>9 kg</td>
<td>Pak Agro Chemicals</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White backed plant hopper &amp; brown hopper</td>
<td>Confidor 200SL</td>
<td>60 ml</td>
<td>Bayer Crop Science</td>
</tr>
<tr>
<td></td>
<td>Jozer 202SL</td>
<td>100 ml</td>
<td>Pak Agro Chemicals</td>
</tr>
<tr>
<td></td>
<td>Karate 2.5EC</td>
<td>200 ml</td>
<td>Syngenta</td>
</tr>
<tr>
<td></td>
<td>Actara 25WP</td>
<td>24 gm</td>
<td>Syngenta</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mealy bug</td>
<td>Kurifost 40EC</td>
<td>1000 ml</td>
<td>Pak Agro Chemicals</td>
</tr>
<tr>
<td></td>
<td>Asophage 75WP</td>
<td>750 gm</td>
<td>Welcon</td>
</tr>
<tr>
<td></td>
<td>Curacron 500EC</td>
<td>800 ml</td>
<td>Syngenta</td>
</tr>
<tr>
<td></td>
<td>Lorsban 40EC</td>
<td>1000 ml</td>
<td>Dow Agro Sciences</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rice leaf folder</td>
<td>Hostathion 40EC</td>
<td>400-500 ml</td>
<td>Bayer Crop Science</td>
</tr>
<tr>
<td></td>
<td>Deltaphos10+350EC</td>
<td>400 ml</td>
<td>Bayer Crop Science</td>
</tr>
<tr>
<td></td>
<td>Karate 2.5EC</td>
<td>200 ml</td>
<td>Syngenta</td>
</tr>
<tr>
<td></td>
<td>Decis Super 100EC</td>
<td>80 ml</td>
<td>Bayer Crop Science</td>
</tr>
</tbody>
</table>

15. DISEASES OF RICE

The rice crop is subjected to more than forty diseases, which are one of the factors for low yields of rice in the world (including Pakistan). The diseases may appear at any stage of growth and development of plant, attacking the seed sown, root system, foliage, stalk, leaf sheath, inflorescence and even the developing of grain. The fungi, bacteria, nematode and virus cause different infectious diseases. Non-infectious diseases may be caused because of low or high temperature, decrease or increase in different nutritional elements essential for the crop. These all diseases are injurious in some areas, in some years and on some plant parts. All parts of plant are subject to disease and one or more diseases can occur on virtually every plant and in every field.
A. BLIGHT OR BROWN SPOTS (Helminthosporium oryzae)
Symptoms: This disease has been recorded all over Pakistan. Initially small dots or circular eye shaped or oval spots appear light in color on leaves. These spots coalesce and result in linear spots brown in color. Later on withering and yellowing of leaves occur. Seed setting also affected and causes sterility, shriveling and show rotting and poor germination.
Perpetuation: Diseased seeds, plant debris and soils help the fungus to survive, while air and irrigation water help to the fungus for transmitting from diseased to healthy plants.
Control Measures
- Use of resistant varieties or disease free seed in healthy soils.
- Sanitation and crop rotation.
- Hot water seed treatment at 54 °C for 10 minutes or with seed dressing fungicides.
- Collection and destruction of stubble and spraying with copper fungicides at right time.
- Application of suitable foliar fungicides may help to minimize further dissemination of the disease.

B. BUNT OF RICE (Tilletia barclayana)
Symptoms: This disease also called black or kernel smut is generally distributed wherever rice is grown. Diseased grains are filled with black powder which can be detected by breaking them. Only a few grains may be affected wholly or partially in an ear. If not severely infected, seeds may germinate but seedlings are stunted.
Perpetuation: The disease causing organism is soil borne.
Control Measures
- Cultivation of resistant varieties.
- Use of healthy seed.
- Sowing early maturing varieties.
- Avoid high rates of nitrogen fertilizer.
- Avoid winnowing and threshing of diseased crop in field.
- Treat the seed with suitable chemicals easily available in the market.
- Collect and burn diseased ear heads.

C. Rice blast (Pyricularia oryzae)
Symptoms: Sometimes this disease refers as Pyricularia blight or rotten neck, generally distributed where ever rice is grown. Small spots appear on leaves, nodes, panicles and grains and sometimes on leaf sheaths. The spots begin as
small, water-soaked, whitish, greyish or bluish dots. These spots rapidly increase and become grey in center. Brown to black spots also develops on inflorescence and glumes. In later stages, diseased heads appear blasted and whitish in color. Grain development is affected and the panicles droop.

**Perpetuation:** The disease perpetuates through diseased plant debris lying in the field, seed and wild grasses.

**Control Measures**
- Burn and destroy diseased plant debris and stubble.
- Early planting
- Cultivation of resistant varieties.
- Use of healthy seed
- Dusting the seed with any one of the organic mercurial seed dressing fungicides
- Spray the crop with organo-mercurials
- Avoid excessive depth application of irrigation water
- Avoid excessive plant population.
- Control grasses and other weeds.

**D. Bacterial blight (Xanthomonas oryzae)**

**Symptoms:** Water soaked stripes appear along the margin of leaf blades, which later on enlarge and turn yellow. These lesions may cover the entire blade, may extend to the lower end of leaf sheath. Similar symptoms may occur on glumes of green grains.

**Perpetuation:** Survive in rhizosphere of weed hosts, infected straw and root stubble. Disseminate by wind and water.

**Control:** Cultivation of resistant varieties is alone easy and safe way to prevent the crop against diseases including this disease also.

**E. Stem Rot (sclerotium oryzae)**

**Symptoms:** Two to three months old plants begin to wither and ultimately dry up; the sheaths soon turn somewhat dark and start rotting. Black dots (fruiting bodies of sclerotia) occur at the base of dried leaves and leaf sheaths. Stem begins to rot and become soft, plant falls down.

**Perpetuation:** Infested soil helps the organism for its survival.

**Control Measures**
- Use of resistant varieties
- Burning of diseased rice stubble
- Crop rotation
- Antagonistic organisms.
16. HARVESTING AND THRESHING

Crop is ready for harvesting when grain moisture reaches approximately at 20 to 22%. The harvesting of early and medium rice varieties can be done 25 – 30 days after flowering. In the case of late maturing varieties harvesting can be done 35 – 40 days after flowering. The delay in harvesting beyond optimum dates increases shattering of grains and over drying results in poor milling recovery.

In Pakistan rice is mostly harvested manually with the help of sickle, reaper and in Punjab with combine harvesters. Harvested crop is left 2-3 days in field for drying. Best results can be obtained only if crop is harvested in the morning and threshed in the afternoon on the same day. Threshed paddy should be cleaned properly to fetch good market price.

17. YIELD

Rice yield depends upon the soil fertility, crop growth and varieties i.e. Local, Basmati, IRRI, hybrids and non-hybrids. All the non-hybrid varieties can produce up to 70 – 80 maunds per acre and hybrid varieties can produce upto 110 – 120 maunds per acre.

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