GUIDELINES FOR SEED PRODUCTION OF HYBRID RICE

DEPARTMENT OF AGRICULTURE & COOPERATION
MINISTRY OF AGRICULTURE
GOVERNMENT OF INDIA
Krishi Bhawan, New Delhi-110001

National Food Security Mission

Guidelines
for
Seed Production of Hybrid Rice

Government of India
Ministry of Agriculture
Department of Agriculture & Cooperation

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FOREWORD

Rice is the staple food of about 65% of Indian population. Our rice requirement by the year 2020 is estimated to be around 122 million tons as against the present production of about 100 million tons, thus leaving a gap of about 22 million tons.

In order to bridge the demand-supply gap, Government of India launched National Food Security Mission (NFSM) where rice is one of the three food crops (rice, wheat and pulses). Among various interventions under NFSM, there are clear indications that System of Rice Intensification (SRI) and hybrid rice are the drivers for accelerating the rice production rate to meet the growing consumption requirement of our ever increasing population. Whereas SRI is totally agronomic intervention, the yield gains of the order of 15-20 % from hybrids over the open pollinated varieties are due to genetic phenomenon (heterosis or hybrid vigour).

Ever since the inception of the Mission the target fixed for hybrid seed production could not be fulfilled. As a result, the envisaged area coverage under Hybrid Rice has not materialized so far. Production of hybrid rice seeds is considered a bit complicated and requires a good understanding of the underlying principles by the seed producing farmers for returning desired outcomes. Therefore, the **"Guidelines for seed production of hybrid rice"** in the form of a booklet prepared by Dr. Shanker Lal, National Consultant (Seeds) under NFSM was the long felt need of the program managers and the extension machinery.

These guidelines aim at to inform the readers about different hybrid rice varieties released in India, source of breeder seeds of these varieties, scope for promotion of hybrid rice, suitable areas for taking up seed production, recommended package of practices for production and quality assurance. I am glad to see that only the essential elements of different aspects of hybrid rice are presented in an easy to read format.

I am confident that the booklet will be of help as a reference and as an operational manual to the farmers, National and State Seed Corporations, private seed producing companies and State Agricultural Departments in their efforts to intensify the production of targeted quantities of hybrid rice for fulfilling the requirement of the farmers.

August, 2010

(P.K. Basu)

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PREFACE

Rice is an important food crop of India. Its production and productivity have increased substantially with the development of dwarf and input responsive varieties. Recently, there has been deceleration in production growth rate of this crop. Hybrid technology which has made wonders in rice production in China may give similar dividends in India in case the adequate quantity of quality seed of hybrid rice is made available at reasonable price to the farmers. This will be possible when ambitious programme on seed production is launched involving farmers and public and private sectors in a mission mode manner.

The technology of hybrid seed production in rice is quite different from that of maize, sorghum and pearl millet (*Bajara.*). Rice being self-pollinated, hence the cytoplasmic male sterility (CMS) is used in hybrid seed production. In order to make the farmers and seed producing organizations aware of hybrid rice seed production methodology an attempt has been made to write the **"Guidelines for seed production of hybrid rice"** in the form of a bulletin in seed producers' friendly language.

This bulletin is comprised of 15 chapters which include the definition of Hybrid, Chinese and Indian experience on this technology and procedure of development of hybrids. The list of 43 rice hybrids developed so far alongwith information like duration, year of release, grain quality, resistance to biotic stresses, tolerance to abiotic stresses and the organizations responsible for their development has been given. The statewise recommended hybrids have also been given which will facilitate the farmers in selecting the hybrids of their choice. The stepwise procedure on hybrid seed production right from nursery raising to harvesting has been outlined. Testing of genetic purity by modern method of genetic markers has also been outlined. The method of cultivation of hybrid rice and major challenges in their spread and possible solution have also been given.

The information contained in this bulletin will be of immense value to the farmers, seed producing and marketing agencies and ultimately will help in increasing rice production in the country through making available the quality seed of rice hybrids to the farmers.

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ABBREVIATIONS

1. AC: Amylose Content
2. ADB = Asian Development Bank
3. ASV : Alkali Spreading Value
4. AVT-I = Advanced Varietal Trial-I
5. AVT-II = Advanced Varietal-II
6. BL = Blast
7. BLB = Bacterial Leaf Blight
8. BPH = Brown Plant Hopper
9. BS = Brown Spot
10. BS = Breeder Seed
11. CMS = Cytoplasmic Male Sterility
12. CS = Certified Seed
13. CVRC = Central Varietal Release Committee
14. DNA = Deoxyribose Nucleic Acid
15. ER = Expansion Ratio
16. FAO = Food and Agriculture Organization
17. FS = Foundation Seed
18. GA = Geberrellic Acid
19. GC : Gel Consistency
20. GLH = Green Leaf Hopper
21. GM = Gall Midge
22. GOT = Grow Out Test
23. HRR = Head Rice Recovery
24. HYVs = High Yielding Varieties
25. ICAR = Indian Council of Agricultural Research
26. IHRT = Initial Hybrid Rice Trial
27. IRRI = International Rice Research Institute
28. KB = Kernel Breadth
29. KL = Kernel Length
30. KLAC = Kernel Length After Cooking
31. LF = Leaf Folder
32. MR = Moderately Resistant
33. NATP = National Agricultural Technology Project
34. R = Resistance
35. RTV = Rice Tungru Virus
36. SB = Stem Borer
37. ShBL = Sheath Blight
38. SVRC = State Varietal Release Committee
39. T = Tolerant
40. UNDP = United Nations Development Programme
41. VER = Volume Expansion Ratio
42. VIC = Varietal Identification Committee
43. WBPH = White Backed Plant Hopper
44. WP = Wettable Powder

Guidelines for Seed Production of Hybrid Rice

1. Introduction:

Rice is staple food of more than 60 % of Indian population. It accounts for about 43 % of total food grain production and 46 % of total cereal production in the country. In order to meet the domestic demand of the increasing population the present day production of 99 million tons (2008) of milled rice has to be increased to 125 million tons by the year 2030. Since the yield of high yielding varieties (HYVs) of rice is plateauing, it is rather difficult to achieve this target with the present day inbred varieties. Therefore, to sustain the self sufficiency in rice, additional production of 1.5 million tons is needed every year. Among the limited options, hybrid technology is the only proven technology currently available for stepping up rice production significantly. The rice hybrids, recently introduced in cultivation, on an average, give 10 to 15 q/ha additional yield over the conventional varieties (about 20 % increase). Therefore, the introduction of hybrids and popularization of their production technology are feasible and readily adoptable to achieve targeted production.

2. What is hybrid rice?

Like in other crops, the first generation progeny (F_1) obtained by crossing two genetically different varieties (parents) of rice is called 'Hybrid'. Since rice is self-pollinated, cytoplasmic male sterile (CMS) parent is used as female parent, which is normally called 'A' line. The fertility restoring line which is called 'pollinator' to the female parent is known as male parent. It is generally referred to as 'R' line, and is used for hybrid seed production. The hybrid combines the desirable characters from CMS line and R line. They exhibit vigour for several quantitative characters including yield. They exhibit buffering capacity to counteract several biotic and abiotic factors that limit productivity. While developing/evaluating hybrids, the combinations of varieties that exhibit vigour or heterotic effect for yield are selected. The hybrid seed is purchased or procured afresh every year/ season for raising the commercial crop. The harvested grains from hybrid crop should not be used for planting the next crop.

3. Chinese experience of hybrid rice:

The Chinese scientists were the first in the world to develop commercial hybrids in rice and the first hybrid was released in 1976. Now, China covers 53% of

its rice area and about 58% of production under hybrid rice. So far on account of cultivation of hybrids, about 350 million tons of additional rice has been produced in China. Now China is developing 'Super Hybrid' rice targeting yield level of 15 t/ha. This kind of effort is needed in India where rice productivity is still below 3 t/ha.

4. Hybrid rice in India:

Taking cue from the success of hybrid rice technology in China, systematic research efforts on hybrid rice in India were initiated in 1989, when Indian Council of Agricultural Research (ICAR) launched a special goal oriented and time bound project on '**Promotion of Research and Development Efforts on Hybrids in Selected Crops'**. For rice, **National Network Project** involving 12 centres was initiated. The technical support was received from the International Rice Research Institute (IRRI), Philippines and Food and Agriculture Organization (FAO), Rome and financial support from United Nations Development Programme (UNDP), Mahyco Research Foundation, World Bank funded National Agricultural Technology Project (NATP) and IRRI/ADB projects on hybrid rice.

Generous support of policy makers, liberal funding from donors and creation of research infrastructure enabled India to become second country in the world after China to develop and commercialize hybrid rice. In India, in 2008, hybrid rice occupied 1.4 million hectares of area and contributed additional rice production of about 1.5 to 2.5 million tons. Besides China and India, the hybrid rice technology has also been adopted in other countries of the world **(Table 1).**

5. Development of rice hybrids:

Initially, the experimental hybrids are developed by the centres included in the **Hybrid Rice Research Network**. The hybrids developed by the network and some others developed by IRRI and private sector are categorized into three maturity groups i.e., early (<120 days), mid-early (121 to 130 days) and medium (131-140 days). The hybrids of these three maturity groups are then evaluated in **Initial Hybrid Rice Trial** (IHRT) at 25-30 locations across the country. Such hybrids which exhibit yield advantage of 15 % over the National check varieties are promoted to **Advanced Varietal Trial-I (**AVT- I) and evaluated at multi-locations. The promising hybrids are further evaluated in **Advanced Varietal Trial-II** for yield, quality, resistance to insect pests and diseases and response to agronomic practices. The hybrids found superior

to National check varieties are identified for release by the **Varietal Identification Committee (VIC)** convened by Deputy Director General (Crop Sciences), I.C.A.R during **All India Coordinated Rice Improvement Project workshops** every year. Finally, the hybrids are released by the **Central Sub-Committee on Crop Standards, Notification and Release of Varieties.**

So far (between1994 to 2009) 43 hybrids (**Table 2)** have officially been released for commercial cultivation in different parts of the country. Out of these, 28 hybrids have been developed by the public sector, while remaining are from private sector. Twenty three hybrids have been released by the State Variety Release Committee (SVRC) and remaining 20 by the Central Variety Release Committee (CVRC). Among the hybrids released by CVRC , KRH-2, PRH-10, DRRH-2, DRRH-3 and Sahyadri are from public sector. The rice hybrids released for various States in the country are listed in **Table 3.**

First Basmati Rice Hybrid Popular Basmati Rice Variety

Most popular public bred rice hybrid

Most popular private rice hybrid

5.1 Hybrids for different agro ecological conditions: Rice is cultivated under diversified ecological conditions in India. Rice hybrids suitable for different soil and temperature conditions are listed in **Table 4.**

5.2 Grain quality of hybrids: The rice grain quality is assessed in terms of milling, head rice recovery, size, appearance and cooking characteristics. In rice, the cooking quality preferences vary from region to region. The adoption of hybrids depends on the profitability which in turn depends on its yield advantage over the inbred (pure line) varieties and market price of the produce as determined by cooking quality and eating characteristics. Therefore, quality characteristics are of paramount importance in popularization of rice hybrids. The rice hybrids released are almost at par or better than the popular varieties like IR 64, Jaya and Annada in terms of quality. Some of the newly released hybrids have quality features identical even to BPT 5204. First hybrid (PRH-10) of Basmati quality has also been released in India. The grain quality characteristics of hybrids are given in **Table 5**.

5.3. Resistance of hybrids to biotic stresses: Apart from tolerance to abiotic stresses, resistance/tolerance to important insect pests and diseases is of utmost importance for yield stability of hybrids. The major pests of rice are stem borer, brown plant hopper, white backed plant hopper, leaf folder and gall midge. The major diseases are blast, bacterial leaf blight, brown spot, sheath blight and sheath rot. Hybrids are also screened against these pests and diseases in the 'National Screening Nursery'

in AICRIP Programme. Resistance/ tolerance reaction of the released hybrids is given in **Table 6**.

6. Hybrid Seed Production:

The success of hybrid rice technology primarily depends on genetic purity, timely availability and the affordability of hybrid seed costs to the farmers. The production of pure hybrid seed at affordable price in rice- a self-pollinated crop, is a highly skill oriented activity. A good hybrid may not reach a large number of farmers, unless it is feasible to commercially produce the seed on large scale economically.

Though there are two systems (2-line and 3- line) hybrid breeding and seed production, but at presently three line method, using cytoplasmic male sterility system, is in vogue. In this system, three lines (parents) are involved in hybrid seed production. These parents are:

a) **A line:** It is cytoplasmic male sterile line which is used as female parent in hybrid seed production. It is maintained by crossing with the B line (maintainer line). Both these lines are iso-genic having homozygous recessive nuclear genes conferring male sterility, differing only in cytoplasm which is sterile (S) in A line and fertile (N) in its maintainer, the B line.

b) **B line:** It is iso-genic to A line and is used as pollen parent to maintain male sterility in A line. This line is maintained by growing in isolation, atleast 5 m away from any rice variety.

c) **R line:** This is also called as fertility restorer or pollinator line. This is used in hybrid seed production by growing along-with A line in a standard row ratio. It is also maintained by growing in isolation, at least 5 m away from any rice variety.

Hybrid seed production technology is quite different from the technology for varietal seed production. Fresh hybrid seed is essentially purchased /procured by the farmers every year/season. The hybrid seed should have the purity of about 99 %. Strict isolation of seed production areas and thorough roguing of the ‘off type’ plants can help to achieve required seed purity of > 99.8 %. Therefore, utmost care has to be taken while producing the hybrid seed. The persons engaged in hybrid seed production should be well trained in various steps involved in hybrid seed production. Following are the requirements for hybrid seed production in rice.

6.1 Climatic and resource requirement: At present Karim Nagar, Warangal, Kurnool and Nandyal districts in Andhra Pradesh, Tumkur, Mandya and Mysore districts in Karnataka, Kohlapur district in Maharashtra and Erode and Bhawanisagar districts in Tamil Nadu are being used for seed production of hybrid rice. Public and private sectors both have strong seed production programme in these districts. However, the private sector has taken lead in hybrid rice seed production. In these districts, on an average, hybrid seed yield of 15 to 20 q/ha is obtained.

i) **Seeding time and season:** The transplanting of seedlings of parental lines should be planned in such a way that flowering doesn't coincide with rains which result in poor seed setting due to pollen wash. This is the reason that hybrid seed production is not so successful during *kharif* (rainy season) both in the North and the South, but *rabi* season is most suitable in the Central and the Southern India. Other potential states for hybrid seed production of rice in the country are Chhattisgarh and Orissa.

ii) **Temperature requirement**: The transplanting of seedlings of parental lines should be planned in such a way that flowering coincides with most favorable conditions such as daily mean temperature of 24-30^0 C, relative humidity of 72-80 %, difference in day and night temperature in the range of 8-10^0 C, bright sunshine, moderate wind velocity and no continuous rains, particularly at the time of flowering.

iii) **Soil conditions:** The field should be fertile with uniform topography, having good drainage and irrigation facilities and free from 'volunteer plants'. The uniform topography and homogeneity of the field in respect of fertility will ensure synchronous flowering and ultimately the highest yield of hybrid seed.

6.2 Nursery raising and seed rate: To ensure multi-tillered (4-5 tillers) seedlings and convenience in uprooting, sparse seeding in nursery is desirable. For this, 30 g seeds/m^2 would be required. Fifteen kg seed for A line and 5 kg seed for B or R line would be required for planting crop in one hectare of land. Since seed of parental lines is costly, fine preparation of nursery bed is essential for ensuring cent percent germination and normal healthy growth of the seedlings. Wet beds of one metre width and of convenient length with good drainage facility should be prepared. 250 kg FYM, 1 kg N and 1/2kg each of phosphorus and potash per 100m^2 should be applied. Parental line seeds should be soaked for 12-15 hours. Pre-soaked seeds should be

treated with carbendazim (50%WP) @ 4 g/kg of seeds. The seeds should be incubated in gunny bags for 1-2 days for better sprouting. The sprouted seeds should be sown sparsely and uniformly on well prepared seed beds. Total nursery area required for sowing 20 kg of seeds is 1000-1200 m^2.

A thin film of water should be maintained and the beds should not be allowed to get dry at any time. The nursery beds should be top dressed after 15 days of sowing with 600-800g of Nitrogen per 100 m^2. Appropriate plant protection measures should be taken during the period when the seedlings are in the nursery bed.

6.3 Isolation: For ensuring genetic purity of the parental and hybrid seeds, optimum isolation is required. The isolation of the hybrid seed production plot from other rice varieties can be provided by the following means:-

a) Barrier isolation: This can be achieved through physical barriers: (i) natural means like mountains, forests and rivers and (ii) growing taller crops like sorghum (*jowar*), maize, pearl millet (*bajra*), sugarcane, *Sesbania* (*daincha*), etc. These barrier crops are planted covering a distance of 30 m between hybrid seed producing plot/parental seed producing plot and other rice varieties.

Artificially created physical barrier for isolation

b) Time isolation: It can be provided by planting the parental lines of the hybrid in such a way that they come in full flowering stage 21 days either prior or after the rice varieties grown nearby start flowering.

c) Space isolation: For providing the space isolation, it is essential that no other rice variety should be grown in a distance of 100 m. For the seed production of A line, this distance should be still larger (500 m).

6.4 Row ratio and planting pattern: The row ratio may vary from region to region, depending upon the weather conditions, morphological features of parental lines and management of crop raising. Following features of rice plant have profound effect on row ratio.

a) Taller the pollinator, larger number of female rows it may cover or pollinate.

b) Vigorous pollinator may pollinate larger number of female rows.

c) Larger size of the inflorescence or panicle of the pollinator (R line), larger amount of pollen grains will be produced and pollinate larger number of rows of female (A) parent.

d) If the duration of opening of floret (flower) in A (female) line is longer, large number of female rows may be alternated with 2 rows of R line.

e) If the stigma of A line is fully exserted, the number of rows of this parent could be increased.

The row ratio of female (A line) and R (pollinator or male) parent is kept 10:2, whereas in seed production of A line, the row ratio of A and B line is usually kept 8:2. The higher out-crossing may be attained if the row direction is adjusted nearly perpendicular to the wind direction prevailing at the time of flowering.

6.5 Spacing and method of transplanting: The spacing between various parents should be as follows.

- Male : Male = 30 cm
- Male : Female = 20 cm
- Female : Female = 15 cm
- Plant : Plant =15 cm or 10 cm

At each hill, 2-3 seedlings should be transplanted at the age of 21-25 days. The transplanting of older seedlings delays flowering, whereas for younger seedlings flowering occurs in advance.

If the growth duration of the seed (female or A) parent and pollen parent (R) is the same, simultaneous transplanting i.e., 2 rows of R line followed by 10 rows of A line at the spacing of 30 cm in hybrid seed production and 8 rows of A line and 2 rows of B line for the maintenance of A line is recommended. If the female parent has characteristic of flowering later than the R parent, its 10 rows are first transplanted leaving the gap of 2 rows of R parent which should be transplanted after the time gap by which the female line is later than the male parent. Conversely, if the male parent has characteristic of flowering later than the female parent, the former should be transplanted first (2 rows), leaving the gap of 10 rows for female parent which should be transplanted after the time gap by which the two parents differ in growth duration.

6.6 Application of gibberellic acid (GA_3): It is an efficient and effective growth hormone, which stimulates the cell elongation and thus advances the panicle exsertion in female line. This hormone has the following favourable effects:-

a) Increases the duration of floret opening, thus ensures pollination.

b) Increases the stigma exsertion and its receptivity.

c) Promotes plant height.

d) Widens the flag leaf angle and thus facilitates easy entry of the pollen grains.

e) Influences flowering and thus transplanting in parental lines can be adjusted.

f) Promotes panicle exsertion and growth rate of secondary and tertiary tillers.

In hybrid seed production plots of rice, 5-10 % panicle emergence stage is most appropriate for first spraying (40%) and the remaining 60 % of GA_3 should be sprayed on the following day. The ideal time for spraying is from 8 A.M to 10 A.M and from 4 P.M to 6 P.M. The spraying should be avoided during cloudy weather and when the wind velocity is high. The dose of 45-60 g/ha GA_3 in 500 liters of water is optimum. This hormone does not dissolve in water and hence it should be first dissolved in 70 % alcohol (1 g of GA_3 in 25-40 CC of alcohol).

6.7 Synchronization: Synchronization of flowering of male and female parents ensures higher hybrid seed yield. However, normally in most of the hybrid combinations

the parental lines differ in flowering. Synchronization in flowering can be attained by the following measures.

a) **Seeding interval:** The parental lines differing in their growth duration can be sown on staggered dates in the nursery beds, so that they come to flowering at the same time in the main field where hybrid seed is to be produced. This is called 'staggered' or 'differential' sowing. In South Indian conditions, R line is sown in three splits i.e., 3, 5 and 7 days after sowing of A line. However, the nursery of both the parents is transplanted on the same date. The nursery of R line sown on two dates is transplanted in alternate hills in the same rows.

b) **Through fertilization:** Depending upon the environmental conditions, synchronization of two parents can be adjusted by foliar spray of nitrogenous/ phosphatic fertilizers. The spray of 2% urea to early parent delays flowering by 2-3 days and use of phosphatic fertilizer to late parent enhances flowering by 2-3 days. However, the dose of the fertilizers will depend upon the difference in growth duration and responsiveness of the parental lines.

6.8 Roguing: Roguing is a process of removal of unwanted rice plants from the seed production plots. To ensure high genetic and physical purity of hybrid seed, it is essential to follow roguing in the following stages:-

a) **At vegetative phase**: On the basis of morphological characters of leaf and the plant, leaf shape and pigmentation.

b) **At flowering:** Early and late types, absence/presence of awns, panicle exsertion, anther colour, panicle characteristics, etc.

c) **At maturity**: Per cent seed set on plants in the female parent, grain type, shape, etc.

6.9 Flag leaf clipping: Generally, the flag leaves are longer and erect compared to panicle and therefore, they pose hindrance for easy pollen grain dispersal and could influence the out crossing rate. Therefore, clipping of flag leaf helps in free movement and wide dispersal of pollen grains to give higher seed yield. The flag leaves should be clipped off when the main culms are in booting or pre-emergence of panicle stage. About half to two-third portion of flag leaf from the top should be removed. However, the cutting of flag leaf is not advisable in the plots infested with diseases as this operation may spread the disease further.

6.10 Supplementary pollination: Rice is self-pollinated crop and hence there is need for supplementary pollination for enhancing out-crossing. In this operation, the pollen parent plants are shaken which helps in shedding and dispersal of pollen grains over the A line. This can be done either by rope pulling or by shaking the pollen parent with the help of two bamboo sticks. The first supplementary pollination should be done at peak anthesis time when 30 to 40 % of the spikelets are open and anthers are fully exserted. This process is repeated three to four times during the day at an interval of 30 minutes. This process should be done for 7-10 days during flowering period.

Panicle with fully exserted anthers

Supplementary pollination in hybrid seed production plot

6.11 Weed management: 2.5-3.0 kg of Butachlor should be mixed in 50-70 kg of sand and apply in one ha area after 5-6 days of transplanting. Need based hand weeding is also recommended to ensure healthy crop.

6.12 Nutrient Management: 25% of the recommended dose of N in the form of urea should be applied at 30-35 days of planting and remaining 25% nitrogen and 25% of potash should be applied at 70-75 days after transplanting or at panicle initiation stage.

6.13 Water Management: A thin film of water should be maintained for initial 30 days. The water level is increased later on to 4-5 cm when the crop reaches maximum tillering stage.

6.14 Harvesting, threshing and processing: In order to have high seed purity utmost care should be taken while harvesting female (seed) and R line. First, the male parent (pollen parent or R line) should be harvested, followed by the female parent. Also, the threshing should be done separately, if possible on separate threshing floors. After drying, the seed should be bagged with labels both inside and outside the bags.

The seed yields used to be very low (3 to 5 q/ha), but with experience over the years, 15 to 25 q/ha average yields are being obtained now. The seed yields are higher in dry season as compared to wet season. Hence large scale seed production is generally taken in dry season only. Hybrid seed production in the country, starting from less than 2000 q in the year 1995 has crossed 3, 00,000 q from 20,000 ha **(Table 7).**

7. Economics of seed production of hybrid rice:

The production of hybrid rice seed is very lucrative proposition. By adopting the technology of hybrid rice seed production, an average seed yield in large scale seed production is 15 to 25 q/ha (average 20 q/ha). At the procurement price of Rs 70/kg, the gross returns are Rs 140000 /ha. The cost of seed production is around Rs.55000 /ha. Hence the gross return in hybrid seed production works out to be Rs 85000 /ha, whereas a farmer would get only Rs 10,000 to 12,000 /ha from a commercial rice crop of a variety. The benefits can further be increased if we are able to increase the hybrid seed production to 30 to 40 q/ha. In China, the hybrid seed yield as high as 70q/ha has been reported. Besides, the hybrid seed production has generated

additional employment of 60-80 man days/ha, particularly for rural women in the operations like flag leaf clipping, supplementary pollination, roguing, etc. **(Table 8)**.

8. Comparison of economics of seed production of hybrids and HYVs of rice:

In a recent study conducted by Directorate of Rice Research, Hyderabad in rice seed production areas of Karim Nagar and Warangal districts of Andhra Pradesh cost comparison of seed production of hybrids and HYVs (per ha) of rice was brought out. It revealed that the cost of hybrid rice seed production is Rs 33075 in comparison to Rs 25785 for HYVs. In addition, there are other costs on account of items like cost of GA_3 and human labour for GA_3 application, supplementary pollination, leaf clipping and roguing which amounts to Rs 8190. Thus the total cost for hybrid rice seed production becomes Rs 41265 as compared to Rs 25785 for HYVs.

As regards total returns, hybrid seed production gives Rs 76050 /ha, while for HYVs, it is only Rs 43425. It clearly indicates that hybrid rice seed production is 75 per cent more profitable than seed production of HYVs.

9. Cultivation of hybrid rice

Adoption of hybrid rice is growing at steady rate though at a slower pace due to many factors, particularly inconsistency in yield, grain quality and consequently, lower market price for the produce, thereby affecting overall profitability. The yield advantage of hybrids is only in the range of 15-20 % over the high yielding inbred varieties. However, adoption of hybrids has picked up during the last 4-5 years, because of significant yield gains in eastern Uttar Pradesh, Bihar, Jharkhand, Orissa, Assam and Chhattisgarh. The adoption of hybrid rice is also picking up in Western U.P., Haryana and Punjab due to development and release of PRH-10, an early, super fine and aromatic hybrid. Medium short duration hybrids are also becoming popular in areas following rice-wheat system, where timely sowing of wheat is ensured .Hybrid rice can also be sown directly in the wet seed bed through drum seeder. By this system seed rate of hybrid can also be reduced to 5-6 kg/ha besides giving better performance.

The package of cultivation practices for hybrid rice is almost identical to that for high yielding varieties, except nursery management and planting density. Since the cost of hybrid seed is high, there is need to economize on seed cost. Hence only

15-20 g seeds/m^2 is to be sown in nursery bed uniformly. Sparse sowing is very important as it helps to obtain healthy and vigorous seedlings with 3-4 tillers/seedling within 20-25 days of sowing. Another way to economize on seed rate is to plant only one or at the most two multi-tillered seedlings per hill, instead of 4-5 seedlings /hill in case of high yielding varieties. By doing so, 15 kg/ha seed is required. The cultivation of hybrid rice by SRI method requires only 5 kg seeds/ha.

10. Problems in hybrid seed production:

i) **Constraints of suitable area:** At present rice hybrid seed production is concentrated in Karim Nagar and Warangal districts of Andhra Pradesh. More than 90 % of hybrid rice seed is produced in this region. Therefore, there is an urgent need to identify new areas in other states for large scale hybrid seed production. However, the beginning has been made to produce hybrid seed in other States.

ii) **Poor performance of seed production of public bred rice hybrids:** Though a large number of good hybrids have been bred by public institutions, but their seed production has not been encouraging. The National Seeds Corporation, State Farms Corporation of India and State Seeds Corporations are to be encouraged and should be provided required facilities and infrastructure for hybrid seed production. The ICAR institutes and SAUs should also be motivated and provided the requisite funds to make availability of pure nucleus and breeder seed of parental lines for their foundation and certified seed production and certified seed production of hybrids.

iii) **High seed cost:** The cost of seed is prohibitive. The private seed companies are marketing seed @ Rs 150-200 /kg. The seed cost is to be reduced to affordable level and comparable with the cost of public bred hybrids (Rs 70 /kg).

iv) **Less time gap between harvest of seed and its use for sowing:** There is not adequate time between harvest of hybrid seed during *rabi* season in southern India and its use for *kharif* planting in northern India after processing. In order to increase the time gap the nursery for hybrid seed production should be raised earlier so that the production of hybrid seed could be

advanced. Also, molecular marker technique should be used for testing the genetic purity of the hybrid seed instead of going for GOT.

11. Testing genetic purity of rice hybrid seed through Grow out Test (GOT):

Genetic purity of hybrid seed is most crucial as one per cent impurity in the hybrid seed results in reduction in the yield of commercial hybrid crop upto 10 q/ha. Normally, the genetic purity is tested through **"Grow out test"** which takes one season, besides it has following disadvantages.

a) Requires space for growing the samples drawn.

b) It takes considerable time (one season after harvest) till flowering and maturity.

c) Requires labour for growing and testing the crop.

d) Seed stocks and the investment are locked up till the results from GOT are obtained.

12. Testing of genetic purity by molecular markers:

Molecular markers have been developed to hasten the testing process of hybrid seed lots. The DNA isolated from individual seedlings (100 plants) is analyzed with set of individual markers. The hybrid plant would exhibit two bands, one each representing parental A and R lines. If the two bands are missing in number (i.e., only one band appears) and even if the two bands do not conform to the parental bands of A and R lines in morphology, the sample under test should be considered not to be hybrid or of the claimed parentage. Therefore, if the private seed companies which do not follow certification process, the purity of the hybrid seed lots can be assessed through this method, provided the companies provide the genetic markers of two parents (A and R) or the samples of leaves or DNA of the two parents. This will also help checking the hybridity of non-notified hybrids being distributed by private seed companies

This method is easy and quick and costs only Rs.25-30 /- seedling, thus for a sample of 100 seedlings Rs. 2500 -3000 /- are required. For this purpose, investment in establishing laboratories in the SAUs for promoting hybrid technology in the country is required. Each laboratory will cost about Rs. 8-10 lakhs towards the cost of the

equipments and some amount of recurring contingency to meet the cost of markers, chemicals, etc.

13. Major challenges and road map for sustaining hybrid rice technology:

For adoption of hybrid technology to be truly a successful strategy, for meeting the national demand of food security, consolidation of and selective refinement over what has been achieved so far is an important step. This requires an integrated approach at following levels:

A. Research level:

i) Tailoring of medium/ medium late hybrids ideally suiting the large *kharif* irrigated area in the traditional southern and non- traditional north- western India.

ii) Development of hybrids which may meet region specific needs such as

a) Non–lodging habit for high fertility soils of Punjab, Haryana and Western Uttar Pradesh.

b) Non –sticky and non-aromatic quality hybrids as preferred in southern states.

c) Medium early maturing hybrids combining tolerance to low temperature during vegetative phase and high temperature during summer for *boro* season in eastern states (North–Eastern region, Eastern U.P., Bihar, West Bengal, Orissa and Jharkhand).

iii) About 5 m ha area with shallow low- land and coastal ecosystem is available in A.P., Tamil Nadu, Karnataka and Orissa for which hybrids of 140-150 days duration and tolerance to salinity are required.

iv) Lack of acceptability of hybrids in southern India due to region specific grain quality requirement. The hybrids having medium slender grains and cooking and eating qualities similar to that of BPT 5204 are required.

v) Development of short duration hybrids for rainfed uplands and for adoption in multiple cropping system.

vi) Maintenance research for continuously upgrading the hybrids, particularly

enhancing the present level of yield gains of 15-20% so that cultivation of hybrid rice could be lucrative.

vii) High cost of hybrid seed is a deterrent for large scale adoption and hence there is need to reduce the cost of seed production and/ or refine/improve the hybrid seed yield by developing proper agro-technology of seed production.

viii) Development of region specific production technology for cultivation of hybrids.

ix) Improving rice quality through bio-fortification similar to that of golden rice for vitamin A and brown rice with high iron, zinc and other micronutrients.

x) There is no rice hybrid for water submerged/ flood prone areas, particularly for eastern India.

xi) There is need for development of ' **Super Hybrids'** for raising yield level more than15 t/ha as is being done in China.

xii) Exploring possibility of hybrid seed production following two line or 1 line system of breeding.

xiii) In the process of development of hybrids emphasis needs to be given for consumer, miller and market requirement/ preference.

xiv) For stability purpose, continuous efforts are needed for resistance/tolerance against major diseases and insect- pests and tolerance against some abiotic stresses, particularly drought.

xv) There should be free exchange of germplasm with National Institutions, particularly from ICAR (NBPGR) and SAUs, besides IRRI.

xvi) To reduce the varietal release complexity as it takes 4-5 years for release. This period can be reduced by conducting evaluation and agronomic trials simultaneously.

xvii) ICAR/SAUs should identify more areas for seed production through conducting trials at their regional stations/ KVKs.

xviii) For developing suitable hybrids for each segment (grain quality, duration, etc.) attractive incentive for R&D should be provided.

B. Development level:

i) The spread of public bred rice hybrids is very poor and slow due to paucity of seed and hence the public sector should be motivated/ energized to take up large scale seed production programme.

ii) The seed production should be encouraged under public-private partnership as per guidelines already given by the Indian Council of Agricultural Research.

iii) The lack of awareness among farmers and seed producing organizations due to inadequate transfer of hybrid seed production technology measures. The training programme during crop season should be organized by the DAC through ICAR Institutes and SAUs.

iv) Development of technical human resource in the field of hybrid seed production.

v) Strengthening of technology transfer strategies like block demonstrations on cultivation of hybrid rice and seed production are truly needed.

vi) Intelligence for marketing should be developed.

vii) Development of infrastructure for testing of genetic purity of the seeds of hybrids and parental lines is very essential.

viii) Improved infrastructure for water/irrigation/electricity should be provided.

ix) Advocate extensive adoption by farmers by utilizing all platforms of media to popularize hybrid rice.

x) Promotion of mechanization to meet the labour shortage/ efficiency improvement.

xi) Uniform communication to all rice growing states for promoting hybrid rice adoption.

xii) Field education support to farmers to encourage and adopt hybrid rice.

xiii) Capacity building of extension personnel.

C. Policy level:

i) Identification of potential environments for hybrid seed production in the country should be earmarked administratively.

ii) Identification of reliable public and private organizations in the seed industry

and these industries should be supported exclusively for hybrid seed production.

iii) Molecular marker technique for testing genetic purity of the hybrid seed lots should be made mandatory and it should be included in the Seed Act.

iv) Establishment of 'National Hybrid Rice Research Center' for basic and strategic research.

v) Promotion of public-private partnership in research and development of hybrid rice.

vi) The National Seed Corporation and State Seed Corporations should have the mandate of foundation and certified seed production of rice hybrids.

vii) MoU between public sector developing the hybrids and private seed companies should be established for hybrid seed production as per guidelines of ICAR.

viii) Entering into bilateral agreement with China for sharing the material and knowledge on hybrid rice.

ix) Low interest credit to hybrid rice growers to meet seed and other input costs.

x) Procurement of hybrid paddy on attractive MSP.

xi) Distribution of hybrid rice via PDS.

xii) Support for processing plants for timely supply of processed and packed seeds after harvest in April/May to destinations across the country.

xiii) Support for warehouses and godowns with control temperature and humidity to companies with planned carryover of hybrid seeds.

xiv) To create transparent conflict resolution mechanism for claim settlement in seed producing areas.

xv) The contracts of seed production with farmers should have legal sanctity.

xvi) Funds for farmers' education to facilitate expansion of production areas in new geographies should be provided.

xvii) Provision for compensating the farmers on account of lower productivity in initial years.

xviii) Freedom to operate-no interference on seed pricing.

xix) The bonus on produce of hybrids over MSP should be announced.

xx) The major emphasis should be given to popularize rice hybrids in North, Central and Eastern states.

14. Impact of hybrid rice technology:

i) There is an yield advantage of hybrids to the extent of 10 to 20 q/ha over the varieties.

ii) Additional net profit by cultivation of rice hybrid over the check ranged from Rs. 2781 to 6291 /ha.

iii) The net profit by undertaking hybrid seed production is around Rs. 85000 / ha at seed yield level of 20 q/ha and seed price of Rs. 70 /kg.

iv) The farmers and extension workers are convinced now that hybrids yield are higher as compared to the inbred varieties.

v) There is some reluctance by the millers, particularly in the state of U.P. to offer similar price for hybrids as compared to the inbred varieties.

vi) Hybrid seed production generates additional employment of 65 person days /ha and most of these are women.

15. Future prospects of hybrid rice in India:

15.1 New opportunities

i) Higher market price of rice

ii) Expansion of *boro* rice area in the country due to shallow tubewell development

iii) Short duration of hybrids to capture upland rainfed areas

iv) Cultivation of hybrids under SRI and direct seeding through drum seeder in wet land or drill in dry land will reduce the seed rate, besides increases the yield.

v) Continued technological progress

vi) Expanded possibilities of public-private partnerships.

vii) Rising demand for rice from Africa

15.2 Prospects of promotion of hybrid rice in some major rice growing states

State	Rice area (m ha)
1. West Bengal	6.15
2. Uttar Pradesh	5.93
3. Madhya Pradesh/Chhattisgarh	5.35
4. Bihar/Jharkhand	5.30
5. Andhra Pradesh	4.13
6. Punjab/Haryana	2.60
7. Tamil Nadu	2.16
8. Karnataka	1.44
Total	33.06 m ha area of the 44 m ha in the country

15.3 Issues in seed production of public bred hybrids:

i) Synchronization problem in parents.

ii) Ideal locations/ seasons not identified

iii) Higher production input cost

iv) Susceptibility of parental lines to biotic stress

v) Non-availability of adequate quantity of nucleus and breeder seed of parental lines

vi) The genetic purity of certified and foundation seed of parental lines is not of desired level

vii) Lack of rolling plan for five years for seed multiplication.

viii) Poor integration of research, seed production and technology transfer.

15.4 Proposed plan for hybrid rice seed production for next 5 years *

i) Total area under rice (both wet and dry seasons) = 44 m ha

ii) Total present area under hybrids (2009) = 1.32 m ha (3.0%)

iii) Additional rice production due to area of hybrids = 2.0-2.5 m t

iv) Now area with 20 % national target for 5 years = 8.8 m ha

Requirement of certified/foundation/breeder/nucleus seed for covering 20% area under hybrid rice

Hybrid/parents	Seed requirement (t)	Area (ha)
Certified seed production		
1. Hybrid	132000 @ 15 kg/ha	88000 @ 15 q/ha
2. Female parent (A line)	1320 @ 15 kg/ha	880 @ 15 q/ha
3. Male parent (R line)	440 @ 5 kg/ha	176 @ 5 kg/ha
Foundation seed production		
1. Female parent (A line)	1320 @ 15 kg/ha	880 @ 15 q/ha
2. Maintainer Parent (B line)	440 @ 5 kg/ha	176 @ 3 q/ha
3. Male parent (R line)	440 @ 5 kg/ha	176 @ 3 q/ha
Breeder seed production		
1. Female parent (A line)	13.2 @ 15 kg/ha	8.8 @ 15 q/ha
2. Maintainer Parent (B line)	2.68 kg @ 5 kg/ha	1.05 @ 3 q/ha
3. Male parent (R line)	2.68 @ 5 kg/ha	1.05 @ 3 q/ha
Nucleus seed production The seed of each of the three parental lines (A,B,R) in hybrid seed production will be produced using paired crossing technique for attaining utmost purity and the quantity can be worked out as per need of breeder seed of each of the three lines planned above.		

***** Information (data) provided by Dr. M.P. Pandey, Vice-Chancellor, Indira Gandhi Agricultural University, Raipur (Chhattisgarh).

15.5 Potential areas for seed production of rice hybrids

Besides Andhra Pradesh, in 14 states/regions the rice hybrid seed production could be explored **(Table: 9).**

Table 1: Area under hybrid rice in different countries (2006)

Country	Area (ha)
India (2008)	14,00,000
Vietnam	8,00,000
Philippines	2,00,000
Mynmar	50,000
Indonesia	40,000
U.S.A	20,000
Others (Egypt, Sri Lanka, etc)	50,000

Table 2: List of rice hybrids released in India since 1994.

Sl. No	Hybrid	Duration (days)	Year of release	Developed by
1.	**APHR – 1****	130-135	1994	APRRI, Maruteru (ANGRAU), Hyderabad
2.	**APHR – 2****	120	1994	APRRI, Maruteru (ANGRAU), Hyderabad
3.	**MGR – 1 (CORH-1)****	110-115	1994	TNAU, Coimbatore
4.	**KRH – 1****	120-125	1994	VC Farm, Mandya, UAS, Bangalore
5.	**CNRH – 3****	120-125	1995	RRS, Chinsurah, West Bengal
6.	**DRRH – 1****	130	1996	Directorate of Rice Research, Hyderabad
7.	**KRH – 2***	125-130	1996	VC Farm, Mandya, UAS, Bangalore
8.	**Pant SankarDhan–1****	120	1997	GBPUA &T, Pantnagar
9.	**PHB –71***	130-135	1997	Pioneer Overseas Corporation, Hyderabad
10.	**CORH – 2****	125-130	1998	TNAU, Coimbatore
11.	**ADTRH – 1****	115	1998	TNRRI, Aduthurai (TNAU)
12.	**Sahyadri–1****	125-130	1998	RARS, Karjat (BSKKV)
13.	**Narendra Sankar Dhan–2****	125-130	1998	NDUA & T, Faizabad
14.	**PA–6201***	125-130	2000	Bayer Bio-Science, Hyderabad
15.	**PA–6444***	135	2001	Bayer Bio-Science, Hyderabad
16.	**PRH–10***	110-115	2001	IARI, New Delhi
17.	**PRH–122 R (Ganga)***	130	2001	Paras Extra Growth Seeds Ltd, Hyderabad
18.	**RH–204***	120-125	2003	Parry Monsanto Seeds Ltd, Bangalore
19.	**Suruchi***	130	2004	Mahyco Ltd, Aurangabad
20.	**Pant SankarDhan–3****	125-130	2004	GBPUA & T, Pantnagar
21.	**Narendra Usar Sankar Dhan–3****	130-135	2004	NDUA & T, Faizabad
22.	**DRRH–2***	115	2005	Directorate of Rice Research, Hyderabad
23.	**Rajlaxmi****	130-135	2005	Central Rice Research Institute, Cuttack

Sl. No	Hybrid	Duration (days)	Year of release	Developed by
24.	**Ajaya****	130-135	2005	Central Rice Research Institute, Cuttack
25.	**Sahyadri–2****	115-120	2006	RARS, Karjat (BSKKV)
26.	**Sahyadri–3****	125-130	2006	RARS, Karjat (BSKKV)
27.	**HKRH–1****	139	2006	RARS, Karnal (CCSHAU)
28.	**CORH–3****	115	2006	TNAU, Coimbatore
29.	**Indira Sona***	125-130	2006	IGKKV, Raipur
30.	**JKRH–401***	140	2007	JK Agriculture Genetics Ltd, Hyderabad
31.	**JRH–4****	116	2007	JNKVV, Jabalpur
32.	**JRH–5****	115	2007	JNKVV, Jabalpur
33.	**PA–6129***	120	2007	Bayer Bio-Science, Hyderabad
34.	**GK–5003***	128	2008	Ganga Kaveri Seeds Pvt. Ltd. Hyderabad
35.	**Sahyadri–4***	115-120	2008	RARS, Karjat (BSKKV)
36.	**JRH–8****	-	2008	JNKVV, Jabalpur
37.	**DRH–775***	97	2009	Methahelix Life Sciences, Pvt.Ltd, Hyderabad
38.	**HRI–157***	130-135	2009	Bayer Bio-Science, Hyderabad
39.	**PAC–835***	102	2009	Advanta India Ltd, Hyderabad
40.	**PAC–837***	97-103	2009	Advanta India Ltd, Hyderabad
41.	**NK–5251***	128	2009	Syngenta India Ltd., Secundrabad
42.	**DRRH–3***	131	2009	Directorate of Rice Research, Hyderabad
43.	**US–312***	125-130	2009	Seed Works International, Hyderabad

Source : Viraktamath *et al* (2010) “Hybrid Rice in India”, Bulletin No.47
Directorate of Rice Research, Rajendra Nagar, Hyderabad-500030.
*Hybrids released by State Variety Release Committee.
**Hybrids released by Central Variety Release Committee.

Table 3 : State wise rice hybrids released in India.

Sl. No.	State	Hybrids
1.	**Andhra Pradesh**	APHR-1, APHR-2, PHB-71, PA-6201, PA-6444, RH-204, Suruchi, DRRH-1, GK-5003, PAC-837, US-312, DRRH-3, NK-5251
2.	**Bihar**	KRH-2, PA-6201, Ganga, JKRH-401
3.	**Chhattisgarh**	Indra Sona, Suruchi, HRI-157, DRH-775, PAC-837
4.	**Delhi**	PRH-10
5.	**Gujarat**	Suruchi, KRI-157, PAC-835, PAC-837, DRRH-3, NK-5251
6.	**Goa**	KRH-2
7.	**Haryana**	PRH-10, Ganga, HKRH-1, PHB-71, RH-204, Suruchi, DRRH-2, Sahyadri-4
8.	**Karnataka**	KRH-1, KRH-2, PHB-71, PA-6201, PA-6444, RH-204, Suruchi, GK-5003, PAC-837, HRI-157, US-312, NK-5251
9.	**Maharashtra**	KRH-2, PA-6444, Suruchi, Sahyadri 1, Sahyadri-2, Sahyadri-3, Sahyadri-4, NK-5251
10.	**Madhya Pradesh**	PA-6201, JRH-4, JRH-5, JRH-8, HRI-157, DRRH-3
11.	**Orissa**	KRH-2, PA-6201, PA-6444, Ganga, Suruchi, Rajlaxmi, Ajya, JKRH-401, PAC-835, DRRH-3
12.	**Punjab**	PRH-10, Ganga, PHB-71, PA-6129, Sahyadri 1
13.	**Pondicherry**	KRH-2, PA-6129, HRI-157
14.	**Rajasthan**	KRH-2, RH-204
15.	**Tamil Nadu**	MGR-1, KRH-2, CORH-2, ADTRH-1, PHB-71, PA-6201, RH-204, DRRH-2, CORH-3, PA-6129, US-312, NK-5251
16.	**Tripura**	KRH-2, PA-6201, PA-6444
17.	**Uttar Pradesh**	KRH-2, Pant Sankar Dhan-1, Pant Shankar Dhan 3, Narendra Sankar Dhan-2, PHB-71, PA-6201, PA-6444, PRH-10, Ganga, Narendra Usar Sankar Dhan-3, Sahyadri-4, HRI-157, US-312, DRRH-3
18.	**Uttarakhand**	PA-6444, Ganga, RH-204,Pant Shankar Dhan 1, Pant Sankar Dhan-3, DRRH-2
19.	**West Bengal**	KRH-2, CNRH-3, PA-6201, DRRH-2, JKRH-401, Sahyadri-4, DRH-775, US-312
20.	**Jharkhand**	DRH-775
21.	**Jammu & Kashmir**	PA-837

Source : Viraktamath *et al* (2010) “Hybrid Rice in India” Bulleting No.47
Directorate of Rice Research, Rajendranagar, Hyderabad-500030.

Table 4 : Rice hybrids tolerant to abiotic stress conditions

Sl. No.	Abiotic Stress	Promising hybrids
1.	Rainfed upland	DRRH-2, Pant Sankar Dhan-1, Pant Sankar Dhan-3, KJTRH-4
2.	Salinity	DRRH-28, Pant Sankar Dhan-3, KRH-2, HRI-148, JRH-8, PHB-71
3.	Alkalinity	Suruchi (MPH-5401), PHB-71, JKRH-2000, CRHR-5, DRRH-2, DRRH-44
4.	Boro/Summer season	Rajlaxmi, CRHR-4, CRHR-32

Table 5 : Grain quality characteristics of rice hybrids released in India.

Sl. No.	Hybrid	Hulling (%)	Milling (%)	HRR (%)	KL (mm)	KB (mm)	L/B (ratio)	Grain Type	KLAC (mm)	ER	VER
1.	**APHR-1**	-	73.0	60.0	-	-	-	LS	-	-	-
2.	**APHR-2**	76-6	67.8	55.9	6.2	2.1	2.9	LS	10.2	1.6	3.8
3.	**MGR-1 (CORH-1)**	-	67.6	55.9	5.8	2.02	2.87	MS	9.2	1.58	4.5
4.	**KRH-1**	-	63.2	61.9	6.3	2.0	3.2	LS	9.3	1.5	-
5.	**CNRH-3**	77.6	70.3	51.7	5.8	2.3	2.6	MS	10.9	1.9	4.5
6.	**DRRH-1**	77.5	73.0	52.0	6.8	2.1	3.3	LS	11.3	1.7	5.3
7.	**KRH-2**	77.6	73.0	57.3	6.1	2.2	2.8	LB	12.3	2.0	4.7
8.	**Pant Sankar Dhan-1**	78.0	70.0	59.0	7.5	2.0	3.8	LS	9.7	-	5.3
9.	**PHB-71**	79.7	71.3	58.6	6.5	2.1	3.1	LS	12.4	1.9	4.7
10.	**CORH-2**	79.0	70.9	48.0	5.9	2.3	2.6	MS	11.3	1.9	4.7
11.	**ADTRH-1**	79.1	75.0	71.0	6.6	2.1	3.2	LS	11.4	1.7	5.0
12.	**Sahyadri 1**	-	67.6	51.5	6.9	2.1	3.25	LS	11.7	1.7	4.5
13.	**Narendra Sankar Dhan 2**	78.3	70.5	46.2	6.6	2.2	3.0	LS	11.7	1.8	5.0
14.	**PA-6201**	77.2	68.0	61.0	6.0	2.1	2.8	LS	10.9	1.8	5.2
15.	**PA-6444**	80.0	74.0	64.0	6.21	2.06	3.01	MS	-	-	-
16.	**PRH-10**	81.0	67.0	61.0	6.74	1.74	3.78	LS	1.78	1.76	-
17.	**PRH-122 (Ganga)**	80.0	74.5	68.5	6.79	2.09	3.24	LS	-	-	-
18.	**RH-204**	79.0	73.6	57.0	6.46	2.18	2.96	LS	-	-	5.2
19.	**Suruchi**	80.0	72.0	68.0	5.38	2.0	2.69	MS	-	-	-
20.	**Pant Sankar Dhan-3**	78.8	67.3	63.8	2.1	6.9	3.24	LS	11.9	1.72	3.9
21.	**Narendra Usar Sankar Dhan-3**	-	71.0	64.0	-	-	-	LS	-	-	-
22.	**DRRH-2**	75.0	73.0	63.0	6.5	1.92	3.4	LS	9.2	1.42	5.1

Sl. No.	Hybrid	Hulling (%)	Milling (%)	HRR (%)	KL (mm)	KB (mm)	L/B (ratio)	Grain Type	KLAC (mm)	ER	VER
23.	**Rajlaxmi**	80.0	72.0	60.3	7.44	1.98	4.37	LS	10.0	1.53	3.75
24.	**Ajaya**	80.0	72.0	62.0	7.22	2.04	4.4	LS	10.5	1.50	3.6
25.	**Sahyadri-2**	78.0	70.2	56.0	7.0	2.03	3.45	LS	-	-	-
26.	**Sahyadri -3**	78.0	74.5	60.2	7.51	2.20	3.38	LS	-	-	-
27.	**HKRH-1**	81.4	69.3	62.1	6.50	2.00	3.25	LS	-	-	-
28.	**JKRH – 401**	82.0	74.0	59.0	6.20	2.15	2.88	LB	-	-	-
29.	**CORH-3**	72.9	68.2	60.3	6.50	2.2	2.95	MS	-	-	4.3
30.	**Indira Sona**	-	78.7	55.0	7.10	2.05	3.43	LS	-	-	-
31.	**JRH – 4**	-	69.2	53.4	6.25	2.23	2.80	LB	-	-	5.3
32.	**JRH – 5**	-	68.4	53.0	6.63	2.15	2.96	LS	-	-	5.3
33.	**PA – 6129**	-	74.0	63.0	6.64	1.75	3.8	LS	-	-	-
34.	**GK – 5003**	-	73.0	68.0	6.30	1.85	3.3	LS	-	-	-
35.	**Sahyadri 4**	-	71.0	58.0	6.74	1.76	3.82	LS	-	-	-
36.	**JRH -8**	-	-	-	-	-	-	-	-	-	-
37.	**DRH – 775**	79.6	73.9	64.7	6.6	1.95	3.38	LS	-	-	-
38.	**HRI -157**	-	71.0	65.0	6.15	2.22	2.76	LB	-	-	-
39.	**PAC - 835**	-	72.4	59.6	5.92	2.05	2.96	MS	-	-	-
40.	**PAC – 837**	-	71.1	50.7	5.75	5.49	2.30	LB	-	-	-
41.	**NK – 5251**	79.0	73.0	66.8	6.00	1.95	3.10	LS	-	-	-
42.	**DRRH – 3**	80.2	71.7	67.3	5.28	2.00	2.64	MS	-	-	-
43.	**US – 312**	72.1	70.0	68.0	6.10	2.02	2.95	MS	-	-	-

Source : Viraktamath *et al* (2010): “Hybrid rice in India”, Bulletin No.47
Directorate of Rice Research, Rajendra Nagar, Hyderabad – 500030.

Table 6 : Disease and pest reaction of rice hybrids released in India

Sl. No.	Hybrid	Resistant to										
		BL	BLB	RTV	ShBL	BS	GLH	SB	BPH	WBPH	GM	LF
1.	APHR-1	-	MR	-	-	-	-	-	MR	-	-	-
2.	APHR-2	-	MR	-	-	-	-	-	-	-	-	
3.	MGR-1 (CORH-1)	-	-	R	-	-	R	MR	MR	MR	MR	-
4.	KRH-1	-	-	-	-	T	-	T	-	-	-	-
5.	CNRH-3	-	-	-	-	-	-	-	-	-	-	-
6.	DRRH-1	R	-	-	-	-	-	-	-	-	-	-
7.	KRH-2	R	-	-	-		-	T	R	R	-	-
8.	Pant Sankar Dhan-1	MR	MR	MR	-	MR	-	MR	MR	MR	-	-
9.	PHB-71	T	T	-	-	-	-	-	T	-	T	-
10.	CORH-2	MR	-	MR	-	-	-	-	-	MR	-	-
11.	ADTRH-1	-	-	-	-	-	-	MR	-	-	R	-
12.	Sahyadri 1	MR	-	-	-	-	R	-	-	-	-	-
13.	Narendra Sankar Dhan-2	R	R	-	-	R	R	-	R	-	-	-
14.	PA-6201	MR	-	MR	-	-	-	-	MR	-	-	-
15.	PA-6444	MR	-	MR	-	-	-	MR	MR	-	R	MR
16.	PRH-10	-	MR	MR	-	-	-	-	MR	-	-	MR
17.	PRH-122 (Ganga)	R	-	-	-	-	MR	MR	MR	MR	MR	MR
18.	RH-204	R	-	-	-	-	-	-	T	T	-	R
19.	Suruchi	R	-	-	-	-	-	-	-	MR	-	-
20.	Pant Sankar dhan-3	MR	MR	MR	-	MR	-	MR	MR	MR	-	-
21.	Narendra Usar Sankar Dhan-3	-	R	-	MR	-	MR	MR	MR	-	-	-
22.	DRRH-2	R	-	R	-	MR	-	-	-	MR	-	-
23.	Rajlaxmi	MR	MR	-	-	-	-	MR	MR	-	-	-

Sl. No.	Hybrid	Resistant to										
		BL	BLB	RTV	ShBL	BS	GLH	SB	BPH	WBPH	GM	LF
24.	Ajaya	MR	MR	-	-	-	-	MR	MR	MR	MR	-
25.	Sahyadri-2	MR	R	MR	-	-	-	-	-	-	-	-
26.	Sahyadri -3	R	MR	-	MR	MR	-	MR	MR	MR	-	R
27.	HKRH-1	R	-	-	-	MR	-	MR	-	-	-	-
28.	JKRH – 401	MR	-	MR	MR	MR	-	MR	-	MR	MR	MR
29.	CORH-3	T	-	T	-	-	T	-	T	T	-	-
30.	Indira Sona	MR	MR	-	-	-	-	-	-	-	R	-
31.	JRH – 4	R	-	-	-	-	-	-	T	T	R	T
32.	JRH – 5	R	-	-	-	-	-	-	T	T	-	T
33.	PA – 6129	R	-	-	-	MR	MR	-	-	-	R	-
34.	GK – 5003	R	-	R	MR	MR	-	-	-	MR	-	-
35.	Sahyadri – 4	MR	-	MR	-	-	-	T	T	T	T	-
36.	JRH -8	-	-	-	-	-	-	-	-	-	-	-
37.	DRH – 775	MR	-	MR	-	-	-	-	-	-	-	-
38.	HRI -157	-	-	MR	-	MR	-	-	-	-	-	-
39.	PAC - 835	R	MR	MR	-	-	-	-	-	-	-	-
40.	PAC – 837	R	-	MR	-	MR	MR	-	-	-	-	-
41.	NK – 5251	R	-	-	-	-	-	-	-	MR	-	-
42.	DRRH – 3	MR	-	MR	-	-	-	-	-	T	-	-
43.	US – 312	R	-	MR	-	MR	-	-	-	MR	R	-

Source : Viraktamath *et al* (2010): “Hybrid rice in India”, Bulletin No.47
Directorate of Rice Research, Rajendra Nagar, Hyderabad – 500030.

Table 7: Progressive increase in area and production of hybrid seed.

Year	Area (ha)	Seed production (q)
1995	195	2,000
1996	1,075	12,000
1997	1,485	18,000
1998	1,630	22,000
1999	1,660	25,000
2000	1,630	27,000
2001	1,625	29,000
2002	1,635	31,000
2003	2,865	40,000
2004	4,350	86,000
2005	6,800	1,25,000
2006	12,000	1,80,000
2007	13,000	1,95,000
2008	14,000	2,10,000
2009	20,000	3,00,000

Table 8: Economics of hybrid seed production in rice

Sl. No.	Particulars	Inputs and services	Cost of inputs/services (Rs./unit)	Total cost (Rs./ha)
1.	Seed cost of parental lines	(i) A line-15kg (ii) R line-5 kg	125/kg 60/kg	1875 300
2.	Certification Charges	Registration, inspection and processing	–	700
3.	Nursery raising	Preparation, sowing and maintenance - 4 labourers	100/labourer/day	400
4.	Fertilizers for Nursery	(i) DAP-25 kg (ii) Urea-15 kg (iii) Potash-15kg (iv) Organic manure-70kg (v) Zinc sulphate-2kg	10/kg 6/kg 5/kg 5/kg 30/kg	250 90 90 350 60
5.	Plant protectiion and irrigation in nursery raising	Need based	–	750
6.	Land preparation for main field	Tractor - 15 hrs.	400/hr	6000
7.	Fertilizations for main field	(i) DAP-150 kg (ii) Urea- 200kg (iii) Potash-100kg (iv) Organic manure-500kg (v) Zinc sulphate-40kg	10/kg 6/kg 5/kg 5/kg 30/kg	1500 1200 500 2500 1200
8.	Transplanting	30 labourers	100/labourer/day	3000
9.	Weeding	40 labourers	100/labourer/day	4000
10.	Supplementary Pollination	100 labourers	100/labourer/day	10000
11.	Roguing	36 labourers	125/labourer/day	4500

Sl. No.	Particulars	Inputs and services	Cost of inputs/services (Rs./unit)	Total cost (Rs./ha)
12	GA_3	90g	18/g	1620
13.	Spraying of GA_3	5 labourers	125/labourer/day	625
14.	Plant protection	Need based pesticides	—	500
15.	Irrigations	Need based number	—	1000
16.	Harvesting	(i) Male parent-15 labourers (ii) Female parent-50 labourers	100/labourer/day 100/labourer/day	1500 5000
17.	Threshing drying and bagging	50 labourers	100/labourer/day	5000
18.	Bags	15 (70 kg capacity)	30/bag	450
19.	Packing, tagging and transportation charges	—	—	1000
20.	Misc. expenses	—	—	500
	Total expenses	—	—	56460
	Yield and income	(i) Hybrid seed Raw seed = 15q Cleaned seed = 12.5q Undersized seed = 2.5q (ii) Grain yield = 5q	 7000/q 900/q 900/q	 87500 2250 4500
	Total income	—	—	94250
	Net income	—	—	37790
	Per kg cost of hybrid seed	—	—	45.15
	Per kg profit from hybrid seed	—	—	24.85

Table 9 : Potential areas for seed production of rice hybrids

Sl. No.	States	Districts/ region	Seasons
1.	**Andhra Pradesh**	Khammam, Warangal,Nijamabad, Kurnool,Nandyal and other regions having mild winter	*Rabi*
2.	**Assam**	*Boro* rice growing districts	*Rabi*/ Summer season
3.	**Bihar**	Katihar, Kishanganj, West Chamapran, Saharsa, Purnia, Supur, Araria, Darbhanga, Madhubani	*Rabi*/ Summer season
4.	**Chhattisgarh**	Dhamtari,Durg,Janjgir Champa	Summer season
5.	**Jharkhand**	*Boro* rice growing districts	*Boro* season
6.	**Karnataka**	Raichur, Bellary,Tumkur, Mandya, Mysore	*Kharif* and *Rabi*
		other districts having mild winters	*Rabi*
7.	**Madhya Pradesh**	Jabalpur Seoni, Balaghat Katni, Rewa	*Kharif* *Kharif* and *Rabi* *Kharif*
8.	**Maharashtra**	Kohlapur ,Nagpur ,Pune	*Kharif* and *Rabi*
9.	**Orissa**	*Boro r*ice growing regions	*Boro* / rabi season
10.	**Tamil Nadu**	Salem,Coimbatore	*Kharif* and winter
11.	**Uttaranchal**	Kashipur ,Bajpur ,Rudrapur	*Rabi*-cum-summer
12.	**Uttar Pradesh**	Gorakhpur ,Deoria ,Basti ,Shravasti	*Boro*/ summer
13.	**West Bengal**	Boro rice growing districts (Banka, purulia, West Midnapur, Howrah, New 24 Pargana, Jalpaiguri, Cooch Bihar)	Boro/ summer
14.	**Rajasthan**	Kota, Bundi,Banswara,Ganganagar	*Kharif*

The bulletin on **"Guidelines for seed production of hybrid rice"** embodies stepwise procedure for production of hybrid rice seed and a list and a features of rice hybrids developed so far by public and private sectors. The information contained in this bulletin will be of immense value to the seed producing and marketing agencies. It will be equally useful to the farmers as it will enable them to select most suitable hybrid for their agro-ecological conditions. This will have a positive impact on popularization of hybrid rice in the country.

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