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Modern techniques and agronomic packages for hybrid rice cultivation in India

Praveen Pandey, Dinesh K. Tiwari

Department of Genetics and Plant Breeding, Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad, India.

Abstract. Rice is one of the most important cereal crops in the global food system providing energy, protein, and vitamins for about half of the world population. The population growth in most of the Asian countries, except China, continues to be around 2% per year. According to an estimate, for sustaining self-sufficiency, India must increase food production by at least 5 million tons and rice by 2 million tons every year. Hence it is very pertinent to critically consider whether the rice production can be further increased to keep pace with population growth. The use of high quality seeds and the introduction of hybrid rice cultivars make enough to feed the increasing population of the country. India is the second country next only to China to commercialize hybrid rice. Rice production practices is expected to continue to evolve to the changing challenges and needs of the times, when both the scientists and the rice growers will come up with innovations that seek to pursue rice self-sufficiency and global competitiveness. The dynamics of rice production and the factors that affect it are highly changeable. Crop yield mostly depends on crop management, agronomic practices and cultivation technology, the present review focuses on improved technology and proper crop management for hybrid rice cultivation in India.

Key Words: hybrid rice, production, crop management, agronomical practices.

Corresponding Author: P. Pandey, pandeypraveen1986@yahoo.com

Introduction

Rice is one of the most important crops in the global food system providing energy, protein, and vitamins for about half of the world population. It is grown in 114 countries across the world on 150 million hectare constituting nearly 11% of the world's cultivated land. Rice is grown under a wide diversity of climates, soils and production systems, faces to many biotic and abiotic stresses that vary according to site and geographical region (IRRI 1993). More than 90% of the rice is produced and consumed in Asia, which is a home for 60% of the earth's population (David 1991). At the current growth of population rice requirement increases dramatically and many nations are facing second-generation challenge of producing more rice at less cost in a deteriorating environment; hence, it is challenging task to ensuring food and nutritional security. The dynamics of rice production and the factors that affect it are highly changeable. Thus, improved technologies are required to bridge the gap to feed the increasing population. Therefore, enhancing productivity of rice through novel genetic approaches like hybrid rice was felt necessary. Hybrids offer better opportunity to break-through the yield ceilings of semi dwarf rice varieties (Virmani & Kumar 2004). Experience in China (Lin & Yuan 1980; Ma & Yuan 2003) and outside China, in IRRI (Virmani *et al* 1982; Virmani 1996, 2003), India (Mishra *et al* 2003), Vietnam (Hoan & Nghia 2003), the Philippines (Redona *et al* 2003), Bangladesh (Julfiquar & Virmani 2003), and several other countries clearly indicates that hybrid rice technology offers a viable option to meet this challenge.

The term "hybrid" is used to refer to the first filial generation of a cross between two genetically diverse parents. The commercial hybrid refers to a superior F1, which not only outperforms the better parent but also shows significant (at least 1t ha^{-1})yield superiority over the best high-yielding inbred variety of similar duration and possesses acceptable grain quality. India is key player in rice production in Asia, has also identified the possible heterosis or hybrid vigor which can contribute 15-25% yield increase over the currently available improved varieties. Hybrid varieties yield an average of 6.6 tons per hectare compared to 5 tons per hectare in case of varieties. Rice grown in China is more of 'japonica' type that becomes sticky upon cooking. Such rice is not accepted in India and hence adaptation to suit local conditions is one of the research imperatives. In India, the first rice hybrid was released in 1994. It was first introduced in the southern states of India and was quite well accepted. Subsequently it was slowly extended to the eastern parts of India. Hybrids with acceptable taste, moderately high head rice recovery, fluffy upon cooking, tolerant to major pests & diseases and high yield would be required in high volumes. Basmati rice hybrids with strong aroma, moderate head rice recovery, high grain elongation & fluffy upon cooking will be required in the premium market segment. Rice production practices and technologies either directly increases yield or affect production costs. The use of modern high-yielding varieties and the management of nutrients, pest and disease management, and water are technologies that directly contribute to higher yield.

Table 1.Top ten countries in the world, with the area, production and productivity of rice

Countries	Area (Million ha)	Production (Million tons)	Productivity (t/ha)
India	43.08	128.44	2
China	28.67	177.66	6.2
Indonesia	11.64	52	4.47
Bangladesh	10.69	37.63	3.52
Thiland	9.88	25.91	2.62
Vietnam	7.51	33.91	4.51
Mayanmar	6.32	22.38	3.54
Philippines	4.06	13.43	3.31
Brazil	3.37	11.07	3.28
Pakistan	2.34	6.91	2.54

The highest productivity of rice considered worldwide, is in many countries occupies very limited area, figured out in the above table. Therefore, appropriate agronomical management is necessary for obtaining the potential yield of the hybrid. Management practices differ from location to location and from season to season depending to local conditions. As cost of hybrid rice is combatively higher, it is very important to use the seed economically by following specialized nursery management and agronomic practices.

Planting Season

Sowing of hybrid seed should be adjusted in such a way that the crop is not exposed to extremely higher or low temperatures particularly at panicle initiation and flowering stages. The average temperature required throughout the life period of the crop ranges from 21-37^{0}C. At the time of tillering, the crop requires a higher temperature than for growth. Temperature requirement for blooming is in the range of 26.5-29.5^{0}C, at the time of ripening the temperature should be between 20-25^{0}C.

Table 2. Growing season of hybrid rice

Season	Sowing Period	Planting Period	Harvesting Time
Kharif	June 1st-3rd week	July 1st-3rd week	Sept-Oct
Rabi	November 2nd-4th week	December 2nd-4th week	March-April

Input Required

Seed rate recommended for hybrid rice is 15 kg/ha as compared to 40-50 kg /ha for the inbred varieties generally followed by farmers. Balanced use of organic and inorganic fertilizers is also very important to realize higher yields.

1. Hybrid rice seed 15 kg/ha
2. Green manure or Farm yard manure 5-10 tons/ha
3. Chemical fertilizers:
   - i. Nitrogen 120-150 kg/ha
   - ii. Phosphorus 40-60 kg/ha
   - iii. Potash 40-60 kg/ha
   - iv. Zinc (need based) 50-60 kg/ha of ZnSO4 once in three years

Nursery Management

As the cost of hybrid seed is higher, proper nursery management is very important to economize the cost of seed material, which is to be purchased afresh seed every season. Hence, space sowing of hybrid seed at the rate of 20-30 g/m^2 is recommended to obtain strong, healthy and multi tillered seedling in 20-25 days for planting.

Prepare wet beds of one meter width and convenient length with good drainage facility. Apply 250 kg of FYM, 1 kg nitrogen, 0.4 kg phosphorus and 0.5 kg potash per 100 m^2 nursery area. Soak 15-20 kg of hybrid seed for planting one hectare of field for 12-15 hours. Treat the pre soaked seeds with carbendazim (50% WP) about 4g/kg of seed. Incubate the seeds in gunny bags for 1-2 days for better sprouting. Sow this sprouted seeds sparsely and uniformly on well prepared seed beds. Total nursery area required for sowing 15-20 kg of seed is 750-1000 m^2. Maintain thin film of water without allowing the beds to dry at any time. Top dress the nursery beds after 15 days of sowing with 0.6-0.8 kg of nitrogen per 100 m^2 area. Appropriate plant protection measures may be taken, if necessary.

Main Field Management

Transplanting

Prepare main field thoroughly by repeated ploughing followed by puddling and apply the recommended dose of FYM two week before transplanting. Apply 50% of nitrogen, 75% of potash and complete dose of phosphorus one day before transplanting followed by thorough leveling. Transplanting 25-30 days old seedlings, 1-2 seedling per hill at 2-3 cm depth may be planted. The spacing of 20x10, 15x15 or 20x15 cm is essential to ensure a plant population of 45-50 hills per square meter area.

Weed Management

In line-planted or drilled rice, weeding can be done with a handhoe or with rotary weeders. In a broadcast-sown crop, weeds pose a major problem and hand-weeding is still practiced. The best time to weed the crop is three weeks after sowing or planting. Mix 2.5-3.0 kg of butachlor in 50-70 kg of sand and apply in one hectare area after 5-6 days of transplanting. Ensure an uniform level of 2 cm of water in field for 3-4 days. Need based hand weeding is recommended to ensure healthy crop.

Nutrient Management

Apply 25% of the recommended dose of nitrogen in the form of urea 30-35 days after planting and remaining 25% nitrogen and 25% potash at 70-75 days after transplanting at panicle initiation stage. The future use of controlled-release or slow release fertilizer will, however, depend on the economic feasibility. The future development in fertilizer use would consist in a judicious combination of organic and inorganic components as well as in biological N-fixation in an integrated nutrient-supply system.

Water Management

Maintain a thin film of water for initial 30 days and later increase the water level to 4-5 cm when the crop reach the maximum tillering stage so that emergence of late tillering can be suppressed. Drain out water completely 10 days before harvest.

Biotic stress

Biotic stress (disease and insect-pests) resistance of hybrids was determined by the resistance of their parental lines and evaluating whether this resistance was dominant or recessive. Hybrid vigor does not make rice hybrids more or less resistant than the parental lines. The most widely used WA-CMS system was not found associated with susceptibility to blast, bacterial blight, brown planthopper, and whitebacked planthopper. Nevertheless, the use of genetically diverse CMS systems is advocated to avoid potential genetic vulnerability of rice hybrids in the tropics where disease/insect pressure is high. Like other rice varieties, hybrid is also damaged by insect and diseases. Control measures for some of the common disease and insect pest are given below.

Table 3. Important diseases of rice and their control measures

Diseases	Control measures
Blast	Tricyclazole 75 WP Seed treatment (2 g/kg of seed), Spraying (0.6 g/liter)
Bacterial Leaf Blight	No chemical control
Sheath Blight	Validamycin 3L spray (2.5 mL/liter) or Hexaconazole 5EC spray (2 mL/liter) or Propiconazole 25 EC (1 mL/liter)
False smut	Chlorothalonil 75 WP spray (2 g/liter) or Propiconazole 25 EC (1 mL/liter) or Mancozeb 75 WP spray (3 g/liter)

Table 4. Important insect-pests of rice and their control measures

Insect-pests	Control measures
Stem Borer	Cartap spray 50 WP (0.3 kg a.i./ha) or Monocrotophos spray 36 WP (0.5 kg a.i./ha) or Chloropyriphos 20 EC (0.5 kg a.i./ha)
Brown Plant Hopper	Imidachloprid spray (25 g a.i./ha) or Thimethoxan spray 25 WG (25 g a.i./ha)
Leaf Folder	Cartep granules 4g (0.6 kg a.i./ha) or Cartep spray 50 SP (0.3 kg a.i./ha)
Gall Midge	Carbofuran or Forate granules 3 G (1.0-1.5 kg a.i./ha) or Chloropyriphos granules 10 G (1.0 kg a.i./ha)

Harvesting and Threshing

Timely harvesting prevents losses in yield because of the shedding of grains. The later stage of grain-ripening is a dehydration process and maturity is hastened when water is withdrawn from the field at the hardening stage of the grains. Drain out water from field when grains in the lowest portion of the panicle are in the dough stage (about 20 days from 50% flowering). Allow to grains to harden. Harvest 30-35 days after flowering when stalks still remain green to avoid grain shedding. Moisture content of paddy should be 20-24% at harvest. Thresh as early as possible preferably at a dry after harvest. Dry gradually under shade until the moisture content is brought down to 12-14% which ensures better milling quality and storage. Under good management conditions the hybrid can out yield the best high yielding varieties by 1.0-1.5 tones per hectare.

Grain Storage

It is crucial to properly store the produce. If moist paddy is stored, fungal attack will set in and this would lead to grain discoloration. Bad odour and bitter taste would also develop. For avoiding such defects, the controlled mechanical drying of paddy is a necessity. Storage of rice should be in the form of unmilled paddy. Bring down the grain moisture level up to 12-14%. Depending on quantity of grain to be stored, select a suitable storage structure (metallic/non-metallic) which is fairly air tight. Disinfest the storage structure with malathion 50 EC (1:100 dilution), about 3 liters of spray emulsion per 100 m^2 before filling in with grains.

If old empty gunny bags are to be reused, such bags are treated with malathion or immerse in boiling water for 15 to 20 minutes and dry it. Stalk the bags in systematic way on proper dunnage either on wooden crates or a foot thick layer of husk or straw, away from the walls. In advanced countries, mechanical devices and large-scale storage units are available and these facilities can be availed of on custom-service basis. Such a system can be adopted in this country. Alternatively, economical and effective storage structures, now available can be established at block or district levels.

Grain Quality

Acceptable grain quality of the commercial rice hybrids is essential to ensure profitability to hybrid rice farmers. Hybridity does not impair grain quality if the parents chosen to develop heterotic hybrids possess acceptable grain quality (Khush *et al* 1988). Therefore, a critical evaluation of parents for grain quality is necessary before using them in hybrid breeding. Similarly, hybrids showing strong heterosis for yield should be evaluated critically for grain quality before their release and commercialization.

Constraints and Future Challenges

Although tremendous progress has been made in research on the commercial utilization of heterosis in rice over the last 20 years, from a strategic point of view, the technology is still in its early stages and the high yield potential of hybrids has not yet been fully tapped. A possible strategy for the development of hybrid rice breeding could follow two phases.

i) Breeding methodology involving three approaches:

- Three-line method or CMS system;
- Two-line method or PGMS and TGMS system; and
- One-line method or apomixis system.

ii) Increasing the degree of heterosis in rice to increase yield potential using:

- Intervarietal hybrids;
- Intersubspecific hybrids;

- Distant hybrids (interspecific or intergeneric hybrids).
- If successful, each phase would signify a new breakthrough in rice breeding and would result in considerable yield increases.
- The yield of existing rice hybrids, including newly developed varieties, has stagnated for some years now meaning a plateau has been reached and, unless new methods and novel materials are found, it will be very difficult to increase yield potential further.
- There are only limited sources of male sterility-inducing cytoplasm (used for developing better CMS lines). Currently, about 85 percent of the A lines used in commercial production still belong to the "wild aborted" (WA) type. The dominant cytoplasmic-sterility situation of the WA type has a latent weakness that, over time, could make the hybrid rice vulnerable to a destructive pest.

Conclusions

Crop yield is a complex trait that is influenced by a number of component characters along with the environment directly or indirectly. Since the demand for rice is ever increasing and area available for expansion is limited, so it is challenging task to ensuring food and nutritional security to the country. Therefore, enhancing production and productivity of rice through novel genetic approaches like hybrid rice was felt necessary. Commercial exploitation of hybrid vigor is one of the most important applications of genetics in agriculture. It has not only contributed to food security, but has also benefited the environment. Hybrid rice production practices and technologies either directly increases yield or affect production costs. The high yield of hybrids is being combined with acceptable grain quality through appropriate breeding and selection of parental lines. Better agronomic approaches and nutrient and pest management strategies are being developed to maximize yield potential from hybrids.

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Authors

•Praveen Pandey, Department of Genetics and Plant Breeding, Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad - 224229, (U.P.) India. E-mail: pandeypraveen1986@yahoo.com

•Dinesh Kumar Tiwari, Department of Genetics and Plant Breeding, Narendra Deva University of Agriculture and

•Technology, Kumarganj, Faizabad - 224229, (U.P.) India. E-mail: dktiwari252003@yahoo.co.in

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