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RESEARCH ARTICLE

# Reaction of rice (*Oryza sativa* L.) cultivars to blast population

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## SUMMARY

The research work was undertaken at College of Agriculture, Raipur, in association with College of Agriculture and Research Station, Ambikapur and Jagdalpur Chhattisgarh India, with the objectives of identifying functional resistance conferring genes in Chhattisgarh state, monitoring resistance in some genotypes/breeding lines and detecting variability in the blast population over the years. The experimental materials consisted of (a) a set of thirty one blast monogenic / differential lines along with seventy nine other genotypes including breeding lines, resistant and susceptible checks, were tested at blast 'hot spots' Ambikapur for three years (2007-2009) and Jagdalpur in 2007. The blast population in the Northern Hilly Region proved highly unpredictable and comprised of more than two highly virulent races. Breakdown of many resistant strains and genes occurred during the study, which could be attributed to changes in the frequency of pathogenic races prevailing over the years. Among the blast differential genes (monogenic lines) tested, only '*Pi-z$^5$*' gene consistently imparted complete resistance against the blast population in the Northern Hilly Region of Chhattisgarh, *Pi-z, Pi-9* and *Pi-k$^h$* provided variable level of resistance. On the other hand four genes *Pi-z$^5$*, *Pi-z, Pi-9* and *Pi-k$^h$* were functional in Bastar Plateau (Jagdalpur). The severity of blast disease was considerably higher at Ambikapur station than at Jagdalpur so only one centre (Ambikapur) could be reliably used to conduct screening trials. The race of the fungus at these two sites seems to be different. Eight strains *viz*., R 1518-762-3-564-1, R 1519-781-5-598-1, R 1540-1888-1278-1, R 1558-2423-3-1445-1, B 6441-FMR-6-0-0, F 7-10, IR42221-145-2-3-2 and 5173 showed consistently stable resistant reaction over the years.

**Key Words :** Rice, Blast, Resistance

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Rice is the staple food for more than half of the world's population. Demand for rice continues to increase due to the ever-increasing rice consumer base. However, the present rate of increase in rice production (2000-09) has slowed down (1.21%) compared with that of previous decades (2.49%) during 1970-79 and (1.70%) in 1990-2000, due to various biotic and abiotic stresses (Khush and Jena, 2009). Among the biotic stresses, blast disease is the most devastating disease in rice cultivation by causing maximum up to 90 per cent yield loss (Ramkumar *et al*., 2010). It is considered as a major constraint in rice production in different rice ecosystems ranging from irrigated (40-100%) to rainfed (70%) and upland rice area (63%) in major rice growing countries of the world, except in Australia (Vera Cruz *et al*., 2007).

With a view to manage the disease, the use of resistant cultivars with major resistance (R) genes still remains one of the most reliable methods. Identification and incorporation of different blast resistance genes with overlapping resistance spectra have long been main objectives of rice breeding programme worldwide (Wang *et al.*, 2007). However, because of either the rapid evolution of new pathogen races or the selection of a rare component of the pathogen population that is already virulent, resistance is rendered ineffective in many cultivars. Thus, breeding for more durable resistant cultivars, therefore, has become a priority in rice improvement.

Chhattisgarh state, considered as the 'rice bowl', has 3.61 million hectare under rice cultivation and a production of about 5.47 million tonnes (Anonymous, 2009b). The prevailing environment in some areas of Chhattisgarh such as Bastar Plateau and Northern Hilly Region favors the development of blast to epidemic proportions and has been considered as

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"hot spots" for the blast. Severe blast (S, >50%) was recorded in plateaus of Jharkhand and Chhattisgarh (Production – oriented survey report, 1994-2006) and that was higher than the plains in the same region (Variar, 2007). Though in Chhattisgarh some rice varieties and breeding lines, as sources of blast resistance, were identified (Persaud, 2006). However, a proper understanding of this disease is of utmost importance, thus, the study was carried out to identify the functional resistance conferring genes, detection of variability in the pathogen population.

## MATERIAL AND METHODS

The research work was carried out in the Department of Plant Breeding and Genetics, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur, Chhattisgarh. Collaboration was made with College of Agriculture and Research Station Ambikapur and Jagdalpur to facilitate screening against blast. The studies were extended over a period of three cropping seasons *viz*., wet season (*Kharif*) 2007, 2008 and 2009. The experimental materials consisted of (a) a set of thirty one blast monogenic / differential lines along with seventy nine other genotypes including breeding lines, resistant and susceptible checks, were tested at blast 'hot spots' Ambikapur for three years (2007-2009) and Jagdalpur in 2007. The experiment was conducted under field conditions. All the standard agronomic practices were followed during cultivation of the crop. Screening techniques employed as uniform blast nursery (UBN) test procedure (Ou, 1965). Evaluation was done about 30-35 days after seeding, when susceptible check reached 9 score, using the standard evaluation system (SES) based on a 0-9 scale as given by International Network for Genetic Evaluation of Rice, INGER (1996). For the genetic studies score up-to 3 were kept as resistant while score 4 and 5 were clubbed with susceptible.

## RESULTS AND DISCUSSION

The experimental findings obtained from the present study have been discussed in following heads:

**Rice blast screening:**

Blast monogenic lines and new rice genotypes were screened along with eight susceptible checks (Mahisugandha, Dubraj, Poornima, Danteshwari, Swarna, Mahamaya, Cheptigurmatia, and HR12) against blast population over the years 2007-2009 at Ambikapur and at Jagdalpur in 2007 only. The primary aim was to identify effective resistance conferring blast genes in Chhattisgarh. The reaction of these genes over the years and the different locations are given in Table 1 and 2. Highly susceptible reaction (score 9) was consistently observed for all four checks over the years and locations. This served as a benchmark for the reliability of reaction of the test entries.

Of the thirty-one monogenic lines tested at Ambikapur during *Kharif* 2007 only IRBL 9, IRBL 10, IRBL 22, IRBL 31 and IRBL 8 possessing the genes *Pi-z*, *Pi-z$^5$*, *Pi-9*, *Pi-z$^5$* and *Pi-k$^h$*, respectively provided resistance (score 1 and 3), while the remaining 26 lines / genes proved highly susceptible and same as the checks. During *Kharif* 2008, resistant reaction was recorded for four entries *viz*., IRBL 10, IRBL 31 (both possessing *Pi-z$^5$* gene), IRBL 22 *(Pi-9)* and IRBL 9 *(Pi-z)* (score 1 and 3), while IRBL 8 (*Pi-k$^h$*) was moderately resistant and all other entries were highly susceptible (score 9). But only two blast monogenic lines *viz*., IRBL 10, IRBL 31 (both possessing *Pi-z$^5$* gene) were recorded resistant reaction (score 3) and other three monogenic lines IRBL 9 *(Pi-z)*, IRBL 22 *(Pi-9)* and IRBL 8 *(Pi-k$^h$)* were found moderately resistant (score 5) at Ambikapur during the *Kharif* 2009. Thus, the *Pi-z$^5$* gene should be utilized in developing blast resistant varieties for the Chhattisgarh state. This gene is providing durable and stable resistance in the region. Identification of functional blast resistance gene (s) for a particular region is a prerequisite for their meaningful deployment (Shridhar *et al*., 1999).

Overall, twenty nine new genotypes *viz*., IR 64, R 1013-2307-1-1, R 1124-91-2-73, R 1250-1557-1-895-1, R 1448-578-2-473-1, R 1470-345-338-2-1, R 1518-762-3-564-1, R 1519-769-2-574-1, R 1519-778-2-590-1, R 1519-781-5-598-1, R 1519-784-1-599-1, R 1539-1785-1-1263-1, R 1540-1888-1278-1, R 1543-1966-1-1290-1, R 1551-2169-1-1354-1, R 1558-2419-2-1442-1, R 1558-2423-3-1445-1, R 1559-2425-2-1449-1, R 1559-2427-1-1450-1, R 1559-2427-2-1451-1, R 1560-2442-1-1456-1, R 1723-2271-1-1404-1, B 6441-FMR-6-0-0, F 7-10, IR 42221-145-2-3-2, 5173, Abhaya, G 95-02 and BR 240 proved to be resistant over the years (2007-2009) at Ambikapur and in 2007 at Jagdalpur.

The Colombian cultivar 5173 has *Pi-z$^5$* gene (Mackill and Bonman, 1992), proved highly resistant with scores of 1 over the three years testing at Ambikapur. Also score of 1 and 3 was observed right through from 2007-2009 for monogenic lines IRBL 10 and IRBL 31 that are representatives of *Pi-z$^5$* gene and both the lines were derived from C101 A51. The reason why 5173 showed better (less) score than all these NIL's is possibly due to additional effective minor genes / QTL's that may be present in cultivar 5173 which supported the resistance of gene *Pi-z$^5$*. The same may be the case with IR42221-145-2-3-2 that possess *Pi-z$^5$* gene.

The gene present in Guyanese strains B 6441-F-MR-6-0-0 (*Pi-48*), F 7-10 (*Pi-49*) were reported to be new blast resistant gene (Persaud, 2006). Both showed highly resistant score of 1, so they can be used as new donors for the blast resistant gene. F 7-10 has extra-long slender grain and high production potential. The other two Guyanese strains BR 240 and G 95-02 were also imparting resistance of variable level.

This study was intended in developing a comprehensive understanding of the mode of inheritance, the allelic relationships of the resistance conferring genes in donors in Chhattisgarh along with the functional resistance genes for the region are identified, the variation in the fungus population has been detected. This study would enable the breeders and

**Table 1: Reaction of blast in monogenic lines at Ambikapur and Jagdalpur**

| Sr. No. | Entry No. | Designation | Target gene | Blast score | | | |
|---|---|---|---|---|---|---|---|
| | | | | Ambikapur | | | Jagdalpur |
| | | | | *kh*.2007 | *kh*.2008 | *kh*.2009 | *kh*.2007 |
| 1. | IRBL 1 | IRBLa-A | *Pi-a* | 9 | 9 | 9 | 9 |
| 2. | IRBL 2 | IRBLa-C | *Pi-a* | 9 | 9 | 9 | 9 |
| 3. | IRBL 3 | IRBLi-F5 | *Pi-i* | 9 | 9 | 9 | 9 |
| 4. | IRBL 4 | IRBLks-F5 | $Pi\text{-}k^{s}$ | 9 | 9 | 9 | 9 |
| 5. | IRBL 5 | IRBLks-S | $Pi\text{-}k^{s}$ | 9 | 9 | 9 | 9 |
| 6. | IRBL 6 | IRBLk-ka | *Pi-k* | 9 | 9 | 9 | 9 |
| 7. | IRBL 7 | IRBLkp-K60 | $Pi\text{-}k^{p}$ | 9 | 9 | 9 | 9 |
| 8. | IRBL 8 | IRBLkh-K3 | $Pi\text{-}k^{h}$ | 3 | 5 | 5 | 3 |
| 9. | IRBL 9 | IRBLz-Fu | *Pi-z* | 1 | 3 | 5 | 1 |
| 10. | IRBL 10 | IRBLz5-CA | $Pi\text{-}z^{5} = Pi\text{-}2(t)$ | 1 | 1 | 3 | 1 |
| 11. | IRBL 11 | IRBLzt-T | $Pi\text{-}z^{t}$ | 9 | 9 | 9 | 9 |
| 12. | IRBL 12 | IRBLta-K1 | *Pi-ta = Pi-4(t)* | 9 | 9 | 9 | 9 |
| 13. | IRBL 13 | IRBLta-CT2 | *Pi-ta* | 9 | 9 | 9 | 9 |
| 14. | IRBL 14 | IRBLb-B | *Pi-b* | 9 | 9 | 9 | 9 |
| 15. | IRBL 15 | IRBLt-K59 | *Pi-t* | 9 | 9 | 9 | 9 |
| 16. | IRBL 16 | IRBLsh-S | *Pi-sh* | 9 | 9 | 9 | 9 |
| 17. | IRBL 17 | IRBLsh-B | *Pi-sh* | 9 | 9 | 9 | 9 |
| 18. | IRBL 18 | IRBL1-CL | *Pi-1* | 9 | 9 | 9 | 9 |
| 19. | IRBL 19 | IRBL3-CP4 | *Pi-3* | 9 | 9 | 9 | 9 |
| 20. | IRBL 20 | IRBL5-M | *Pi-5(t)* | 9 | 9 | 9 | 9 |
| 21. | IRBL 21 | IRBL7-M | *Pi-7(t)* | 9 | 9 | 9 | 9 |
| 22. | IRBL 22 | IRBL9-W | *Pi-9* | 1 | 3 | 5 | 1 |
| 23. | IRBL 23 | IRBL12-M | *Pi-12(t)* | 9 | 9 | 9 | 9 |
| 24. | IRBL 24 | IRBL19-A | *Pi-19* | 9 | 9 | 9 | 9 |
| 25. | IRBL 25 | IRBLkm-Ts | $Pi\text{-}k^{m}$ | 9 | 9 | 9 | 9 |
| 26. | IRBL 26 | IRBL20-IR24 | *Pi-20* | 9 | 9 | 9 | 9 |
| 27. | IRBL 27 | IRBLta2-Pi | $Pi\text{-}ta^{2}$ | 9 | 9 | 9 | 9 |
| 28. | IRBL 28 | IRBLta2-Re | $Pi\text{-}ta^{2}$ | 9 | 9 | 9 | 9 |
| 29. | IRBL 29 | IRBLta-CP1 | *Pi-ta* | 9 | 9 | 9 | 9 |
| 30. | IRBL 30 | IRBL11-Zh | *Pi-11(t)* | 9 | 9 | 9 | 9 |
| 31. | IRBL 31 | IRBLz5-CA(R) | $Pi\text{-}z^{5}$ | 1 | 1 | 3 | 1 |
| 32. | Mahisugandha | Check | - | 9 | 9 | 9 | 9 |
| 33. | Dubraj | Check | - | 9 | 9 | 9 | 9 |
| 34. | Swarna | Check | - | 9 | 9 | 9 | 9 |
| 35. | Poornima. | Check | - | 9 | 9 | 9 | 9 |
| 36. | HR 12 | Check | - | 9 | 9 | 9 | 9 |
| 37. | Mahamaya | Check | - | 9 | 9 | 9 | 9 |
| 38. | Cheptigurmatia | Check | - | 9 | 9 | 9 | 9 |
| 39. | Danteshwari | Check | - | 9 | 9 | 9 | 9 |

*Kh.* = *Kharif* season

**Table 2: Reaction of genotypes screened over the years to monitor resistance and detecting variability**

| Sr. No. | Genotype | Blast score | | | |
|---|---|---|---|---|---|
| | | Ambikapur | | | Jagdalpur |
| | | *kh.* 2007 | *kh.* 2008 | *kh.* 2009 | *kh.* 2007 |
| 1. | IR-64 | 1 | 3 | 3 | 1 |
| 2. | MTU 1065 | 7 | 7 | 7 | 5 |
| 3. | MTU 1075 | 7 | 7 | 9 | 5 |
| 4. | OR 1898-18 | 9 | 9 | 9 | 7 |
| 5. | R 714-5-55-2-1 | 3 | 5 | 5 | 5 |
| 6. | R 979-67-2-44-1 | 5 | 7 | 7 | 5 |
| 7. | R 979-1528-2-1 | 3 | 5 | 5 | 7 |
| 8. | R 1013-2307-1-1 | 1 | 3 | 3 | 3 |
| 9. | R 1022-1803-1-1 | 3 | 5 | 5 | 5 |
| 10. | R 1027-2238-3-1 | 3 | 5 | 5 | 7 |
| 11. | R 1060-30-2-41-1 | 3 | 5 | 5 | 3 |
| 12. | R 1124-69-1-45-1 | 3 | 5 | 5 | 5 |
| 13. | R 1124-91-2-73 | 3 | 3 | 3 | 3 |
| 14. | R 1130-80-1-52-1 | 3 | 7 | 7 | 5 |
| 15. | R 1207-257-5-1 | 3 | 3 | 5 | 7 |
| 16. | *R 1219-650-2-314-1* | 5 | 7 | 7 | 7 |
| 17. | R 1238-692-820-1-1 | 3 | 7 | 7 | 5 |
| 18. | R 1238-1820-1-1 | 3 | 5 | 7 | 5 |
| 17. | R 1240-913-2-1031-1 | 3 | 3 | 7 | 3 |
| 20. | R 1240-927-3-1056-1 | 5 | 7 | 5 | 5 |
| 21. | R 1247-1936-1-1 | 1 | 5 | 5 | 3 |
| 22. | R 1248-1489-2-822-1 | 9 | 9 | 9 | 7 |
| 23. | R 1250-1557-1-895-1 | 1 | 3 | 3 | 3 |
| 24. | R 1262-1667-1-1 | 1 | 5 | 5 | 3 |
| 25. | R 1262-1668-2-1 | 1 | 5 | 5 | 5 |
| 26. | R 1264-1670-1-1 | 3 | 3 | 5 | 5 |
| 27. | R 1327-483-1-1 | 7 | 7 | 7 | 3 |
| 28. | R 1448-153-65-2-1 | 9 | 7 | 7 | 3 |
| 29. | R 1448-578-2-473-1 | 3 | 1 | 3 | 3 |
| 30. | R 1454-87-50-4-1 | 7 | 7 | 7 | 5 |
| 31. | R 1454-171-96-1 | 7 | 7 | 9 | 7 |
| 32. | R 1456-199-3-180-1 | 5 | 3 | 5 | 3 |
| 33. | R 1462-243-100-7-1-1 | 5 | 7 | 7 | 7 |
| 34. | R 1470-345-338-2-1 | 3 | 3 | 3 | 1 |
| 35. | R 1473-529-249-4-1 | 1 | 1 | 3 | 7 |
| 36. | R 1475-468-564-2-1 | 3 | 5 | 5 | 5 |
| 37. | R 1493-625-3-499-1 | 3 | 5 | 3 | 3 |
| 38. | R 1502-643-784-1-1 | 3 | 3 | 5 | 3 |
| 39. | R 1518-762-3-564-1 | 1 | 1 | 3 | 1 |
| 40. | R 1518-767-4-569-1 | 1 | 5 | 5 | 3 |
| 41. | R 1519-769-2-574-1 | 1 | 3 | 3 | 1 |
| 42. | R 1519-773-5-583-1 | 3 | 3 | 3 | 7 |

*Table 2: Contd…………..*

Table 2: Contd………….

| | | | | | |
|---|---|---|---|---|---|
| 43. | R 1519-778-2-590-1 | 1 | 3 | 3 | 3 |
| 44. | R 1519-781-5-598-1 | 1 | 1 | 3 | 1 |
| 45. | R 1519-784-1-599-1 | 1 | 1 | 3 | 3 |
| 46. | R 1520-936-1-811-1 | 9 | 7 | 9 | 3 |
| 47. | R 1528-1139-3-1003-1 | 3 | 5 | 5 | 7 |
| 48. | R 1529-1166-1-1020-1 | 3 | 3 | 3 | 7 |
| 49. | R 1529-1183-1-1041-1 | 1 | 1 | 3 | 5 |
| 50. | R 1529-1183-3-1043-1 | 1 | 1 | 3 | 5 |
| 51. | R 1530-1194-2-1061-1 | 1 | 3 | 5 | 5 |
| 52. | R 1537-1566-1-1210-1 | 3 | 5 | 5 | 7 |
| 53. | R 1538-1614-1-1221-1 | 3 | 5 | 5 | 9 |
| 54. | R 1539-1785-1-1263-1 | 1 | 3 | 3 | 3 |
| 55. | R 1540-1888-1278-1 | 1 | 1 | 1 | 3 |
| 56. | R 1543-1966-1-1290-1 | 3 | 3 | 3 | 3 |
| 57. | R 1551-2169-1-1354-1 | 3 | 3 | 3 | 3 |
| 58. | R 1558-2419-2-1442-1 | 3 | 3 | 3 | 3 |
| 59. | R 1558-2423-3-1445-1 | 1 | 1 | 1 | 3 |
| 60. | R 1559-2425-2-1449-1 | 1 | 1 | 3 | 3 |
| 61. | R 1559-2427-1-1450-1 | 1 | 1 | 3 | 3 |
| 62. | R 1559-2427-2-1451-1 | 1 | 3 | 3 | 3 |
| 63. | R 1560-2442-1-1456-1 | 1 | 3 | 3 | 3 |
| 64. | R 1723-2271-1-1404-1 | 1 | 3 | 3 | 3 |
| 65. | B 6441-FMR-6-0-0 | 1 | 1 | 1 | 1 |
| 66. | F 7-10 | 1 | 1 | 1 | 1 |
| 67. | IR 42221-145-2-3-2 | 1 | 1 | 1 | 1 |
| 68. | 5173 | 1 | 1 | 1 | 1 |
| 69. | Abhaya | 1 | 3 | 3 | 1 |
| 70. | G 95-02 | 1 | 3 | 3 | 1 |
| 71. | BR 240 | 1 | 3 | 3 | 1 |
| 72. | Mahisugandha | 9 | 9 | 9 | 9 |
| 73. | Dubraj | 9 | 9 | 9 | 9 |
| 74. | Swarna | 9 | 9 | 9 | 9 |
| 75. | Poornima | 9 | 9 | 9 | 9 |
| 76. | HR 12 | 9 | 9 | 9 | 9 |
| 77. | Mahamaya | 9 | 9 | 9 | 9 |
| 78. | Cheptigurmatia | 9 | 9 | 9 | 9 |
| 79. | Danteshwari | 9 | 9 | 9 | 9 |

*kh* = *Kharif* season, ch =susceptible check

pathologist to have a greater insight into the nature of the genetic interactions between the blast fungus and its host. The stability of resistance conferring genes in given rice cultivar is determined by how the blast pathogen changes and the way the resistance is deployed (Ahn, 1994). Thus, the ability of the breeders to develop varieties with effective durable blast resistance for the region is likely to be enhanced with the results obtained in this study.

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