PHENOLOGICAL EFFICIENCY AND YIELD TRAITS OF RICE (*ORYZA SATIVA* L.) UNDER DIFFERENT MOISTURE REGIMES

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Abstract: Among the breeding lines R-RF-90, Mahamaya and MTU-1010 ranked relatively superior regarding there morpho- physiological and yield traits. Least reduction in yield was noticed in R-RF-89 and Vandana in rainfed and transplanted (TSD) condition. Mahamaya (57.88) exhibited maximum time to initiates the panicle followed by IR-64 (56.63). The maximum days taken to anthesis was recorded under rainfed condition (65.40) followed by irrigated (57.79) and transplanted (57.45). Mahamaya (68) exhibited maximum time to anthesis. Days to 50 % flowering was noticed maximum in rainfed condition (70.11) followed by irrigated (62.42) and transplanted (62.08). Direct sown (60.51) recorded minimum time to attain 50% flowering. Mahamaya (72.75) exhibited maximum time to days to 50 % flowering followed by IR-64 (71.38). Genotypes in direct sown condition (112.97) recorded more time to mature under different moisture regimes followed by irrigated (101.05) and rainfed condition (90.8). Rice genotypes in transplanted condition (88.25) exhibited minimum time to mature as compared to other moisture regimes. Mahamaya (110.13) exhibited maximum time to days to maturity followed by IR-64 (109.63). Among the breeding lines R-RF-90, Mahamaya and MTU-1010 ranked relatively superior regarding there morpho- physiological and yield traits. Least reduction in yield was noticed in R-RF-89 and Vandana in rainfed and transplanted (TSD) condition.

Keywords: Rice, Moisture regimes, Traits, *Oryza sativa*

INTRODUCTION

Rice is the most consumed cereal grain in the world, constituting the dietary staple food for more than half of the planet's human population. Rice is an integral part of creation myth and remains today as leading crop and most preferred food (Huke and Huke, 1997). Rice a member of the family Poaceae originated from South-East Asia and in the Asia, where more than 90% of world's rice is produced and consumed (Li and Xu, 2007) thus rice is immensely important to food security of Asia. About 23 million hectare of Asian rice area experienced present yield loss due to drought (Widawsky and O'Toole, 1990). More than 70 % of the rice area of Eastern India is rainfed even when the total rainfed is adequate, shortage at critical period reduced the yield . Since the rainfed ecosystem of Eastern India is highly variable and unpredictable, which can range from normal situation to severe drought condition, therefore identification of a stable genotype performing well under all the expected conditions under target population of environment is required. Pandey *et al.* (2005) observed that in Eastern India terminal drought is the most frequent type and severly affects the yield.

MATERIAL AND METHOD

The experimental site was located at Instructional cum-Research Farm, College of Agriculture, IGKV, Raipur (C.G.) during *kharif*, 2010. Raipur is situated in central part of Chhattisgarh and lies at latitude, longitude of 21°16' N, 81°26' E, respectively and 290.20 meters above mean sea level. It receives an average annual rainfall of 1326 mm (based on 80 years mean). The experiment was conducted in four different environment (Direct sown, transplanted (TSD), rainfed and irrigated) using SPD with two replications. The experimental details are as follows.

Experiment I	**Direct sown**	**Experiment II**	**Transplanted condition (TSD)**
Design	**: SPD**	Design	**: SPD**
Replications	**: 2**	Replications	**: 2**
Replication to replication distance	**: 1 m**	Replication to replication distance	**: 1 m**
Crop	**: Rice (*Oryza sativa* L.)**	Crop	**: Rice (*Oryza sativa* L.)**
Plot size	**: 3x1 mtr.**	Plot size	**: 3.80x0.60 mtr.**
Spacing (row to row)	**: 20 cm.**	Spacing	**: 20x20 cm.**

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Treatments	**: 48 genotypes**	Treatments	**: 48 genotypes**
Date of Sowing	**: 25th June, 2010**	Date of Sowing	**: 15th July, 2010**
Experiment III	**Rainfed condition**	**Experiment IV**	**Irrigated condition**
Design	**: SPD**	Design	**: SPD**
Replications	**: 2**	Replications	**: 2**
Replication to replication distance	**: 1 m**	Replication to replication distance	**: 1 m**
Crop	**: Rice (Oryza sativa L.)**	Crop	**: Rice (Oryza sativa L.)**
Plot size	**: 2.20x1.60 mtr.**	Plot size	**: 3x2 mtr.**
Spacing	**: 20x20 cm.**	Spacing	**: 20x20 cm.**
Treatments	**: 48 genotypes**	Treatments	**: 48 genotypes**
Date of Sowing	**: 24th June, 2010**	Date of Sowing	**: 18th June, 2010**

Experimental materials used for the study:

S. No.	Genotypes	S. No	Genotypes
1.	R-1838-RF-41	**25.**	R-RF-88
2.	R-1839-RF-42	**26.**	R-RF-80
3.	R-1837-RF-40	**27.**	R-RF-89
4.	R-RF-69	**28.**	R-RF-90
5.	IR70215-70-CPA	**29.**	R-RF-81
6.	Annnada	**30.**	R-RF-82
7.	MTU 1010	**31.**	R-RF-91
8.	IR-64	**32.**	R-RF-83
9.	Mahamaya	**33.**	R-RF-92
10.	Poornima	**34.**	R-RF-93
11.	Samleshwari	**35.**	R-RF-94
12.	Vandana	**36.**	R-RF-95
13.	Dagad deshi	**37.**	IR 84899-B-183-C
14.	Danteshwari	**38.**	IR 84899-B-185-C
15.	R-RF-84	**39.**	IR 72667-16-1-B-P
16.	R-RF-74	**40.**	R-RF-96
17.	R-RF-75	**41.**	R-RF-97
18.	R-RF-76	**42.**	R-RF-98
19.	R-RF-85	**43.**	R-RF-99
20.	R-RF-77	**44.**	R-RF-100
21.	R-RF-78	**45.**	R-RF-101
22.	R-RF-79	**46.**	R-RF-102
23.	R-RF-86	**47.**	R-RF-103
24.	R-RF-87	**48.**	R-RF-104

The size of each nursery beds were 1 x 25 cm drainage channel of 30 cm width was provided between the beds. The basal dose of fertilizers was given at the time of nursery bed preparation @ 80 kg N_2, 60 kg P_2O_5 and 40 kg K_2O ha^{-1}. The fertilizers were applied as per the requirement of crop. 80:60:60 kg ha^{-1} N: P: K were applied in the form of urea, DAP and MOP, respectively. After transplanting the soil was kept saturated until seedlings were get established in four sites *i.e.* direct sown, transplanted (TSD), rainfed and irrigated. In direct sown condition irrigation was not provided, in transplanted (TSD) condition water was not provided after 50% flowering, in rainfed site the irrigation was not provided until maturity and in irrigated site after establishment of seedling 5$\pm$2cm standing water was maintained throughout the growing period. Phenological parameters were days to panicle

initiation, days to anthesis, days to flowering, days to maturity. Experimental data were analyzed statistically adopting the technique of analysis of variance (ANOVA) for Split Plot Design (SPD). The level of significance was observed at 5 percent probability (Gomez and Gomez, 1984).

RESULT AND DISCUSSION

Phenological Parameters

Days to panicle initiation

In rainfed condition (55.13) rice genotypes took more time to initiate the panicle under different moisture regimes followed by direct sown (53.88) and transplanted condition (50.99) while in irrigated condition (40.58) rice genotypes took minimum time to initiates panicle. On the basis of average performance in four environments Mahamaya (57.88) exhibited maximum time to initiates the panicle followed by IR-64 (56.63). In all the genotypes variability in panicle initiation ranged between 45.50 to 57.88 days. However R-RF-91 (45.50) exhibited minimum period for panicle initiation. In few breeding lines delay in days to panicle initiation was observed in rainfed condition as compared to irrigated one. Similar findings were also reported by Anugus *et al.* (1993). Lilley and Fukai, (1994) have also correlated water deficit condition with phenological development and suggested that water deficit can only delay or advance the phenological phases.

Days to anthesis

The maximum days taken to anthesis was recorded under rainfed condition (65.40) followed by irrigated (57.79) and transplanted (57.45). The minimum was recorded under direct sown condition (55.92).On the basis of average performance in four environments Mahamaya (68) exhibited maximum time to anthesis. Genotype IR-64 (66.38) also showed comparable results with Mahamaya. In all the genotypes variability in anthesis ranged between 54.37 to 68 days. However R-RF-103 (54.37) exhibited minimum period for anthesis.

Days to 50 % flowering

The results clearly showed that days to 50 % flowering varied significantly due to different moisture regimes. Days to 50 % flowering was noticed maximum in rainfed condition (70.11) followed by irrigated (62.42) and transplanted (62.08). Direct sown (60.51) recorded minimum time to attain 50% flowering. On the basis of average performance in four environments Mahamaya (72.75) exhibited maximum time to days to 50 % flowering followed by IR-64 (71.38). In all the genotypes variability in days to 50 % flowering ranged between 58.38 to 72.75 days. However Vandana (58.38) exhibited minimum period for days to 50 % flowering.

Days to maturity

Genotypes in direct sown condition (112.97) recorded more time to mature under different moisture regimes followed by irrigated (101.05) and rainfed condition (90.8). Rice genotypes in transplanted condition (88.25) exhibited minimum time to mature as compared to other moisture regimes. On the basis of average performance in four environments Mahamaya (110.13) exhibited maximum time to days to maturity followed by IR-64 (109.63). In all the genotypes variability in days to maturity ranged between 98.50 to 110.13 days. However R-RF-69 (93.5) exhibited minimum period for days to maturity.

Table 1. Effect of different moisture regimes on phenological parameters of different rice genotypes

Treatments	Days to Panicle Initiation	Days to Anthesis	Days to 50% Flowering	Days to Maturity
Different Moisture Regimes				
M_1 – Direct Sown	53.88	55.92	60.51	112.97
M_2-Transplantad(TSD) Condition	50.99	57.45	62.08	88.25
M_3 –Rainfed Condition	55.13	65.40	70.11	90.80
M_4 – Irrigated Condition	40.58	57.79	62.42	101.05
SEm +	**0.11**	**0.56**	**0.63**	**0.09**
CD at 5%	**0.51**	**2.56**	**2.86**	**0.40**
Genotypes	**Mean**	**Mean**	**Mean**	**Mean**
V_1- R-1838-RF-41	49.63	55.75	60.88	98.38
V_2- R-1839-RF-42	50.75	59.75	63.38	95.75
V_3- R-1837-RF-40	51.00	60.63	65.00	96.63
V_4- R-RF-69	49.50	58.88	63.13	93.50
V_5- IR70215-70-CPA	50.75	59.75	63.75	96.38
V_6- Annnada	50.25	58.75	63.50	95.88

V_7- MTU 1010	53.13	64.88	69.25	102.50
V_8- IR-64	56.63	66.38	71.38	109.63
V_9- Mahamaya	57.88	68.00	72.75	110.13
V_{10}- Poornima	50.38	59.88	64.13	96.88
V_{11}- Samleshwari	53.13	61.63	65.88	102.63
V_{12}- Vandana	46.13	53.88	58.38	91.00
V_{13}- Dagad deshi	49.75	57.25	60.88	98.38
V_{14}- Danteshwari	52.88	58.50	63.38	97.75
V_{15}- R-RF-84	48.38	56.25	61.13	97.38
V_{16}- R-RF-74	49.75	57.50	62.50	97.13
V_{17}- R-RF-75	47.88	56.50	61.38	94.63
V_{18}- R-RF-76	48.50	58.63	63.13	93.75
V_{19}- R-RF-85	49.00	60.63	64.88	95.75
V_{20}- R-RF-77	51.25	58.88	63.00	96.13
V_{21}- R-RF-78	52.75	60.38	65.00	95.75
V_{22}R-RF-79	50.00	59.88	64.50	99.00
V_{23}- R-RF-86	48.88	60.50	65.00	100.13
V_{24}- R-RF-87	51.00	61.63	66.88	101.13
V_{25}- R-RF-88	48.63	56.50	61.88	96.88
V_{26}- R-RF-80	49.88	57.25	62.25	97.75
V_{27}- R-RF-89	49.88	58.13	63.38	98.00
V_{28}- R-RF-90	52.13	57.25	62.25	97.13
V_{29}- R-RF-81	49.50	58.50	63.13	98.75
V_{30}- R-RF-82	48.88	57.63	63.00	96.38
V_{31}- R-RF-91	45.50	58.50	63.38	96.88
V_{32}- R-RF-83	49.00	57.25	62.38	97.00
V_{33}- R-RF-92	47.50	60.25	64.25	97.75
V_{34}- R-RF-93	51.50	59.75	64.25	100.75
V_{35}- R-RF-94	53.38	60.38	65.13	101.13
V_{36}- R-RF-95	48.13	58.50	63.25	102.38
V_{37}- IR 84899-B-183-C	53.00	61.75	67.13	102.88
V_{38}- IR 84899-B-185-C	50.25	60.88	65.13	98.88
V_{39}- IR 72667-16-1-B-P	53.50	62.75	67.00	96.75
V_{40}- R-RF-96	46.13	58.63	63.38	95.38
V_{41}- R-RF-97	50.00	58.88	63.25	101.13
V_{42}- R-RF-98	52.50	60.50	64.25	97.00
V_{43}- R-RF-99	52.75	60.75	64.50	99.25
V_{44}- R-RF-100	47.25	56.375	60.63	96.75
V_{45}- R-RF-101	47.63	56.25	61.63	97.13
V_{46}- R-RF-102	47.75	57.875	62.75	99.50
V_{47}- R-RF-103	46.38	54.375	60.25	97.25
V_{48}- R-RF-104	46.75	55.12	60.12	98.12
SEm ±	**0.44**	**0.78**	**0.62**	**0.31**
CD at 5%	**1.24**	**2.19**	**1.75**	**0.87**
I (M x V)	**S**	**S**	**S**	**S**

Yield Determinants

The maximum number of panicle plant^{-1} was recorded in irrigated condition (14.41) which was significantly highest among different moisture regimes. In the same way transplanted condition (12.75) followed by rainfed condition (11.10) stands after irrigated ones. The lowest number of panicle plant^{-1} was recorded under direct sown condition (2.93). On the basis of mean value of number of panicle plant^{-1} (four environments) MTU-1010 (12.30) exhibited highest value of number of panicle plant^{-1}. However R-RF-82 (7.84) exhibited minimum value of number of panicle plant^{-1}.Highest test weight of rice seeds was obtained with rainfed condition (16.08 g) however it was statistically at par with irrigated condition (15.97 g). Lowest test weight was recorded under direct sown condition (14.65 g). R-RF-84 (19.33 g) followed by Mahamaya (18.01 g) exhibited highest value of test weight. However R-RF-102 (12.19 g) exhibited minimum value of test weight. The maximum number of grains panicle^{-1} was found under irrigated condition (131.43),

however it was statistically similar with direct sown condition (124.37). Under transplanted condition (84.06), it results lower number of grains panicle^{-1}. R-RF-95 (189.94) exhibited highest value of number of grains panicle^{-1}. However R-RF-83 (86.91) exhibited minimum value of number of grains panicle^{-1}. Among different moisture regimes, significantly maximum grain yield was recorded under irrigated condition (54.74 q ha^{-1}) which was statistically at par with rainfed condition (50.22), while minimum grain yield was obtained under direct sown condition (42.25).On the basis of mean value of grain yield (four environments) R-RF-69 (63.74 q ha^{-1}) similar with other six genotypes namely R-RF-78 (60.91 q ha^{-1}), R-RF-85 (35.44q ha^{-1}), R-1839-RF-42 (58.77 q ha^{-1}), R-1838-RF-41 (58.389 q ha^{-1}), IR-70215-70-CPA (57.34 q ha^{-1}) and R-RF-104 (56.28 q ha^{-1}) produced highest grain yield. However R-RF-86 (35.44 q ha^{-1}) exhibited minimum value of grain yield. Drought is a major cause of yield loss in rainfed rice. Stress caused mean yield reduction of 64 % across populations (Venuprasad *et al.*, 2007). Wide range of variability for yield attributing traits has been reported by other workers (Chauhan and Tandon, 1984; Singh *et al.*, 1984; Gomathinayagam *et al.*, 1990; Patil *et al.*, 1993). Maintenance of leaf water potential just prior to flowering is associated with higher panicle water potential, reduced delay in flowering time and reduced spikelet sterility and hence contributes to higher yield (Fukai *et al.*, 1999). Among different moisture regimes, significantly maximum biological yield of rice genotypes was recorded under irrigated condition (158.25 q ha^{-1}) followed by direct sown (124.51 q ha^{-1}) and rainfed condition (114.49 q ha^{-1}) whereas, minimum was obtained under transplanted conditions (97.43 q ha^{-1}). Samleshwari (153.82 q ha^{-1}) attained maximum value of biological yield followed by MTU-1010 (147.69 q ha^{-1}), IR-64 (146.47 q ha^{-1}), Mahamaya (146.35 q ha^{-1}) and IR-70215-70-CPA (145.77 q ha^{-1}). However R-RF-86 (100.66 q ha^{-1}) exhibited minimum value of biological yield. Amongst different moisture regimes genotypes in transplanted condition gave significantly maximum harvest index (47.18 %) of rice. The lowest harvest index was recorded in direct sown condition (34.72 %). R-RF-78 (51.68 %) and similar with R-RF-69 (49.32 %), R-1838-RF-41 (48.22 %), R-RF-85 (47.35 %), R-1839-RF-42 (46.90 %) and Vandana (44.35 %) exhibited highest value of harvest index. However R-1837-RF-40 (23.31 %) exhibited minimum value of harvest index.

Table 2. Effect of different moisture regimes on yield attributes of different rice genotypes

Treatments **Different Moisture Regimes**	**No. of Panicle plant^{-1}**	**No. of Grain Panicle^{-1}**	**Biological yield (q ha^{-1})**	**Grain yield (q ha^{-1})**	**Harvest Index (%)**	**Test Weight**
M_1 – Direct sown	2.93	124.37	124.51	42.25	34.72	14.65
M_2-Transplantad(TSD) Condition	12.75	84.06	97.43	46.03	47.18	15.58
M_3 –Rainfed Condition	11.10	98.86	114.49	50.22	43.92	16.08
M_4 – Irrigated Condition	14.41	131.43	158.25	54.74	34.75	15.97
SEm ±	**0.21**	**3.59**	**5.21**	**1.69**	**0.54**	**0.09**
CD at 5%	**0.94**	**16.15**	**23.46**	**7.61**	**2.43**	**0.41**
Genotypes	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**
V_1- R-1838-RF-41	11.33	104.69	121.76	58.39	48.22	15.45
V_2- R-1839-RF-42	10.31	109.20	127.86	58.78	46.90	16.99
V_3- R-1837-RF-40	11.14	119.88	127.81	52.74	41.80	14.90
V_4- R-RF-69	11.61	107.31	130.50	63.74	49.32	16.44
V_5- IR70215-70-CPA	11.33	114.64	145.77	57.34	40.19	15.79
V_6- Annnada	10.96	98.69	128.73	54.59	43.27	15.60
V_7- MTU 1010	12.30	104.58	147.69	52.66	37.57	16.23
V_8- IR-64	11.06	98.23	146.47	43.65	31.16	16.28
V_9- Mahamaya	11.16	140.03	146.35	51.51	35.74	18.01
V_{10}- Poornima	10.34	115.69	104.37	40.74	40.11	14.59
V_{11}- Samleshwari	8.86	144.24	153.82	51.55	34.38	12.91
V_{12}- Vandana	9.88	110.44	102.95	42.79	44.35	15.18
V_{13}- Dagad deshi	9.18	98.29	117.13	42.19	32.78	13.49
V_{14}- Danteshwari	10.36	99.44	114.79	40.50	37.75	15.14
V_{15}- R-RF-84	9.68	88.65	124.44	52.77	42.66	19.33
V_{16}- R-RF-74	9.49	94.44	133.56	45.43	34.82	14.43
V_{17}- R-RF-75	9.89	110.33	124.88	49.27	40.20	16.00
V_{18}- R-RF-76	10.61	115.65	125.55	49.64	40.12	17.69

V_{19}- R-RF-85	10.90	103.15	130.76	59.33	47.35	13.83
V_{20}- R-RF-77	10.09	120.06	121.58	50.37	41.85	16.74
V_{21}- R-RF-78	11.51	98.55	122.36	60.91	51.68	17.95
V_{22}R-RF-79	10.34	117.48	104.12	38.32	37.52	16.56
V_{23}- R-RF-86	10.34	101.69	100.66	35.44	36.37	12.79
V_{24}- R-RF-87	9.41	89.65	130.36	40.52	32.35	14.38
V_{25}- R-RF-88	11.54	110.53	122.95	50.81	41.90	15.89
V_{26}- R-RF-80	9.33	108.46	113.36	46.69	41.63	16.26
V_{27}- R-RF-89	10.34	120.13	103.08	39.24	38.00	15.78
V_{28}- R-RF-90	10.08	106.09	122.23	48.62	40.62	13.93
V_{29}- R-RF-81	9.58	128.79	118.11	43.82	38.00	14.85
V_{30}- R-RF-82	7.84	110.85	122.16	50.29	42.08	15.98
V_{31}- R-RF-91	8.74	125.66	118.24	41.30	36.99	16.18
V_{32}- R-RF-83	8.84	86.91	123.24	51.04	42.56	15.80
V_{33}- R-RF-92	9.26	100.21	125.19	50.82	41.71	14.61
V_{34}- R-RF-93	11.15	116.04	110.99	48.26	44.96	16.36
V_{35}- R-RF-94	10.65	96.66	123.32	48.60	40.26	17.15
V_{36}- R-RF-95	10.65	189.94	114.10	54.98	49.18	15.84
V_{37}- IR 84899-B-183-C	9.75	124.60	112.69	48.40	44.47	16.41
V_{38}- IR 84899-B-185-C	11.30	108.88	131.44	44.57	33.96	16.36
V_{39}- IR 72667-16-1-B-P	11.23	108.71	136.44	45.33	33.76	15.64
V_{40}- R-RF-96	11.56	91.20	111.62	45.73	41.60	16.69
V_{41}- R-RF-97	9.48	110.16	127.83	51.58	40.38	15.71
V_{42}- R-RF-98	10.07	99.18	137.82	43.22	34.52	13.89
V_{43}- R-RF-99	9.84	101.19	134.80	45.44	35.20	13.50
V_{44}- R-RF-100	10.38	91.93	103.85	41.22	40.17	15.51
V_{45}- R-RF-101	10.69	101.74	120.78	43.60	37.34	16.20
V_{46}- R-RF-102	9.14	113.79	124.23	41.02	33.30	12.19
V_{47}- R-RF-103	10.16	135.99	104.33	44.91	44.12	13.19
V_{48}- R-RF-104	10.54	99.03	139.10	56.29	41.65	16.88
SEm ±	**0.21**	**13.09**	**4.33**	**2.69**	**2.26**	**0.24**
CD at 5%	**0.60**	**36.53**	**12.08**	**7.52**	**6.31**	**0.67**
I (M x V)	**S**	**S**	**S**	**S**	**S**	**S**

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