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ASSESSMENT OF CROP PHENOLOGY AND GENOTYPE RESPONSE UNDER UNPREDICTABLE WATER STRESS ENVIRONMENTS OF UPLAND RICE

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ABSTRACT

The investigation was carried out in S.G. College of Agriculture & Research Station, Jagdalpur, Chhattisgarh to identify promising genotypes and formulate phenological relationships at phenotypic and genotypic levels and assess the impact of uncertain weather parameters reference to water stress during Kharif 2013 and 2014. Days to flowering was found to be most senstive for erratic rainfall pattern over the years. In Kharif 2013, where lower rainfall was received during vegetative shifting phase all the genotypes flowered before 85 DAS where as it was extended to 100 DAS in next experiment year. In Sahbhagidhan spikelet per panicle was observed to be 103 in Kharif 2013, while it was reduced to 83 in Kharif 2014. Similer reduction was observed in genotype IR-833-B-B-141-1, where spikelet number was reduced to 65 from 85 with harvest index of 40.25 %. It shows that genotype resistant to water stress at perticular growth stage, may not perform parallaly under nonstress environments. Sahbhagidhan, the check variety had optimum plant height (92.5cm), panicle length (21.60cm), high spikelet per panicle (93) and spikelet fertility (94.5%) but had lesser number of panicles per unit area (227), lower harvest index (35.75%) and reduced grain yield. Among the entries evaluated, IR-83381-B-B-137-3, IR-86857-46-1-1-2 and IR-84857-46-1-1-6 were found to be promising for rainfed breeding programmes as parent material.

Keywords: Upland rice, erratic rainfall, crop phenology, Spikelet fertility

INTRODUCTION

Rice is cultivated in highly diverse situations that range from flooded wetland to rainfed dryland (Degenkolbe *et al.,* 2009). Irrigated rice, which accounts for 55% of the global rice area, provides 75% of production and consumes about 90% of the freshwater resources, used for agriculture in Asia (Sandhu *et al.,* 2013). Since, water requirement for rice cultivation is quite higher i.e. 2500 litres to produce 1 kg of grain (Bouman *et al.,* 2007), and is expected that rice production will be decreased due to water stress in many Asian countries (Shrawan *et al.,* 2012; Guimarães *et al.,* 2013), affecting more than 19 million ha (Lifitte *et al.,* 2006). Higher water requirement is probably due to large area of lowland long durational irrigated rice. Thus it's necessary to opt for varieties requiring limited water (Motsumoto *et al.,* 2014) to sustain food security in climate change era. Upland rice encompasses 12% of global rice production area in the lowest yielding ecosystem, produced by poorest farmers with 0.5 ha average operational holdings. Due to subtle selection over long period of time, upland rice has become drought tolerant potential crop and harbors great genetic potential for future water limited rice. It has also precious traits like high pestilent insect resistant possibility and short growing season. Therefore, in present investigation, 18 new genotypes were tested for upland ecology, to estimate the impact of water stress on yield and identify promising genotypes for future rainfed rice research.

MATERIALS AND METHODS

The experiment was undertaken under entirely rainfed conditions during *Kharif* 2013 and 2014 at Upland Rice Breeding Block of S. G. College of Agriculture and Research Station, Jagdalpur, Chhattisgarh with 18 genotypes. A true upland simulation model was developed by choosing experimental plot where no water accumulates and complete rainfed treatment was given during entire crop growth cycle. Sowing was completed by just onset of monsoon by direct seeding in agronomically standardized geometry in 10sq M plot with three replications. Trench was made in periphery of experimental plot to avoid no water accumulation. The data was recorded for 10 quantitative characters namely days to flowering, crop duration, plant height, and panicles per M^2, panicle length, spikelets per panicle, spikelet fertility, grain yield, biological yield and harvest index. The mean over replication of each character were subjected to statistical analysis. For statistical analysis software Window State Version 9.1 was used.

RESULTS AND DISCUSSION

Crop phenology under unpredictable water stress

The potential of upland ecology for rice production is limited by occasional cessation of rainfall, spanning for days to weeks (Kamoshita *et al.,*

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2008; Abarshahr *et al.*, 2011). Occurrence of water stress at vegetative state has relatively lower negative impact on grain yield than occurrence at the reproductive stage where grain yield is reduced by up to 30 percent (Nassir and Adewusi, 2012). Days to flowering was found to be most senstive for erratic rainfall pattern over the years. In *Kharif* 2013, where lower rainfall was received during vegetative shifting phase all the genotyeps flowered before 85 DAS (Table 1). While in next experimental year, where comperatively higher rainfall occurred the same genotypes bloomed till 100 DAS. The results indecates that water scaricity at late vegetative state alters the available moisture to reproductive units immidiatly and plant is moult to flower. The biophysical mechanism is further clarified by crop duration which is shifted accordingly as well (115 DAS to 125 DAS in 2013 and 2014 respectively). Maximum altertaion for flowering and crop duaration was recorded in sahbhagidhan indecating sensitivity of genotypes with altering moisture level. While, genotype, IR-84887-B-15 (112 & 113), IR-86857-46-1-1-2 (112 & 113) was found to be least affected sowing considerable physiological buffer in stress tolerance. During the late season water stress, the capacity of assimilate transmission into seeds increases and is considered as useful physiological phenomenon under drought stress conditions (Singh *et al.*, 2003). Moreover, the amounts of assimilate transferring from stems and leaves to filling grains will increase parallel with drought stress (Kumar *et al.*, 2006). Therefore, crop should surpass at least milking and soft dough stage prior to soil surface begins to dry. For plant height (90 & 89 cm), panicles per M^2 (271 and 268), panicle length (21.9 and 19.9 cm) no significant deviation was observed over the years . In *Sahbhagidhan* spikelet per panicle was observed to be 103 in *Kharif* 2013, while it was reduced to 83 in *Kharif* 2014. Similer reduction was observed in genotype IR-833-B-B-141-1, where spikelet number was reduced to 65 from 85. It shows that genotype resistant to water stress at perticular growth stage, may not perform parallaly under nonstress environments. However, these results were further become partially attractive when grain yield and harvest index was compared and despite morphologiocal alteration, grain yield was higher in 2014. The similer results have been oberservd by Fukai *et al.* (2008) and Guimaraes *et al.* (2013) for yield and reproductive components. However, entry IR-86857-46-1-1-2, R-RF- 95 and R-RF-45 exhibited higher performance in stress year indecating the suitability under stress but may not be promising under normal rainfall.

Table 1: Response of genotype to variable stress levels (Kharif 2013 and 2014)

Genotypes	**Days to Flowering**		**Crop Duration**		**Plant Height (cm)**		**Panicles Per M^2**		**Panicle Length (cm)**	
	E 1	**E 2**	**E 1**	**E 2**	**E 1**	**E 2**	**E 1**	**E 2**	**E 1**	**E 2**
R-RF-69	79	83	107	111	87	76	276	229	19.5	18.8
R-RF-84	78	89	109	119	85	77	262	238	20.0	18.6
R-RF-95	76	80	107	110	80	76	276	285	22.0	21.4
R-RF-65	81	90	114	120	88	97	242	301	22.0	20.5
IR 84887-B-15	78	85	112	113	111	102	278	267	23.0	21.1
IR 83929-B-B-132-2	79	87	108	116	100	102	238	146	23.5	20.6
IR 86857-46-1-1-2	82	89	112	117	88	86	251	294	23.0	20.2
R-RF-45	82	90	111	117	107	104	319	334	23.0	19.7
PM 6004	82	87	112	116	100	105	283	270	23.0	20.5
IR 83381-B-B-137-3	83	90	110	121	104	99	328	316	22.0	18.7
Sahbhagidhan	78	90	107	120	89	97	250	205	22.5	20.7
IR 88287-677-60-3	83	91	113	120	76	89	328	316	21.5	20.9
IR 84852-B-12-1-4	83	91	116	121	85	97	303	338	21.0	20.9
IR 88287-677-53-3	84	92	113	120	90	76	291	285	19.0	17.8
IR 83383-B-B-141-1	85	98	115	126	94	72	218	264	22.5	18.0
IR 84859-B-41-1-2	84	92	115	121	84	83	228	256	20.5	18.6
IR 86857-46-1-1-2	81	83	112	113	75	84	205	266	22.5	19.2
R-1570-2649-1-1546-1	84	92	117	120	87	88	313	222	24.0	22.0
Mean	81	88	111	117	90	89	271	268	21.9	19.9
C.V.	1.18	0.94	1.22	1.14	7.59	6.39	9.44	10.74	5.84	4.91
F Prob.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00
S.E.M.	0.67	0.58	0.96	0.95	4.84	4.03	18.12	20.38	0.90	0.69
C.D. 5%	2.01	1.75	2.86	2.82	14.38	11.97	53.85	60.56	2.69	2.05
C.D. 1%	2.75	2.39	3.92	3.86	19.71	16.40	73.78	82.97	3.68	2.81

Where: E 1 = Kharif 2013; E2 = Kharif 2014

Table 1: Continues…

Genotypes	Spikelets Per Panicle		Spikelet Fertility (%)		Grain Yield (kg/Plot)		Biological Yield (kg/Plot)		Harvest Index (%)	
	E 1	**E 2**	**E 1**	**E 2**	**E 1**	**E 2**	**E 1**	**E 2**	**E 1**	**E 2**
R-RF-69	73	65	84.50	88.00	2.20	2.00	6.13	4.94	36.00	40.50
R-RF-84	75	67	88.50	91.00	1.99	2.40	4.63	5.08	43.00	47.00
R-RF-95	83	69	85.50	89.00	2.50	2.27	9.03	6.90	28.00	32.50
R-RF-65	84	80	87.00	92.50	2.03	3.13	4.50	6.25	45.00	50.00
IR 84887-B-15	88	82	87.50	91.50	2.68	2.80	7.09	6.40	37.50	44.00
IR 83929-B-B-132-2	89	90	90.50	94.00	2.38	2.40	6.07	5.60	39.00	42.50
IR 86857-46-1-1-2	86	78	87.00	91.00	2.80	2.37	7.59	5.73	37.00	41.50
R-RF-45	86	82	89.00	92.00	2.64	2.40	9.71	7.47	27.50	32.00
PM 6004	87	89	93.50	97.00	2.93	2.87	7.25	6.40	40.50	44.50
IR 83381-B-B-137-3	82	79	92.50	96.50	2.59	2.67	8.15	7.20	32.50	36.50
Sahbhagidhan	84	103	93.50	95.50	1.87	1.89	5.56	5.07	34.00	37.50
IR 88287-677-60-3	81	71	87.00	91.50	1.47	1.89	4.42	5.01	33.00	38.00
IR 84852-B-12-1-4	80	63	91.50	93.50	2.00	2.73	6.68	7.46	30.50	36.00
IR 88287-677-53-3	72	61	89.50	93.00	1.94	1.94	7.33	7.27	26.50	27.50
IR 83383-B-B-141-1	85	66	89.50	92.50	1.54	1.45	5.60	4.60	27.50	31.50
IR 84859-B-41-1-2	77	77	86.00	94.00	2.20	2.89	6.09	6.99	36.00	41.00
IR 86857-46-1-1-2	85	72	81.00	88.00	2.25	2.93	6.44	7.20	35.00	41.00
R-1570-2649-1-1546-1	91	81	87.50	92.50	1.87	2.12	7.14	6.64	26.00	32.00
Mean	82	76	88.39	92.39	2.21	2.40	6.63	6.23	34.14	38.64
C.V.	5.25	8.10	2.87	1.69	13.71	15.52	17.04	8.38	8.21	7.77
S.E.M.	3.06	4.36	1.79	1.10	0.21	0.26	0.79	0.37	1.98	2.12
C.D. 5%	9.09	12.96	5.33	3.28	0.63	0.78	2.37	1.09	5.89	6.31
C.D. 1%	12.45	17.76	7.30	4.49	0.87	1.07	3.25	1.50	8.07	8.64

Genotypic response to rainfed treatment

In present investigation, entry R-RF-95 flowered earliest among all (75 and 79 DAS) (*Kharif* 2013 and 2014 respectively) and accordingly had smallest plant height (106 and 76 cm). It recorded 275 and 285 panicles per square meter with 20 and 21.4 cm average panicle size. However, number of spikelet was less per panicle (82 and 68) and spikelet fertility was 85.5 and 89 percent. Genotype PM-6004 recorded maximum grain yield (2.9 and 2.86 kg/plot) with comparative higher spikelet fertility (93.50 and 97 %) and 42.5 percent harvest index. Entry IR-84887-B-15 with 106.25 cm plant height, 272 panicle per unit area, 84 grain per panicle and 89.25 percent spikelet fertility, yielded 2.74 kg/plot. The harvest index was 40.25 percent. Sahbhagidhan, the check variety, has optimum plant height (92.5cm), panicle length (21.60cm), high spikelet per panicle (93) and spikelet fertility (94.5%) but had lesser number of panicles per unit area (227) and lower harvest index (35.75%) reduced the grain yield. Among the entries evaluated, IR-83381-B-B-137-3, IR-86857-46-1-1-2 and IR-84857-46-1-1-6 found to be promising for rainfed breeding programmes as parent material. Hence, if soil moisture begins declining after soft dough stage, crop will finish its growth without significantly alteration in grain yield. However, when stress is imposed at milking and hard dough stage, spikelet fertility and chaffiness (Botwright, 2008; Yue *et al.*, 2012) will reduce the final yield (Yang and Zhang, 2006).

Present study reveals that beyond the most appropriate agronomic practices that enable plants to better use soil water, need is bred for genotypes with greater capacity to adapt under irregular rainfall and able to maintain better plant water status, especially when stress occurs around flowering and grain formation, since leaf and panicle water potential are very highly associated with panicle exertion and anther dehiscence. It can be concluded that, while undertaking upland breeding, panicles per unit area, number of spikelet per panicle, spikelet fertility and harvest index are important secondary yield parameters. Under monsoon seizing drought spikelet fertility should be above average while maintaining harvest index maximum.

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