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HEADING AND SPIKELET FERTILITY IN COLD TOLERANT RICE GENOTYPES AS INFLUENCED BY ENVIRONMENTS IN HIGH ALTITUDE AREA

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Eighty-eight cold tolerant rice germplasm consisting of *indica, japonica* and *javanica* types were evaluated in direct seeded, rainfed, upland condition at three sowing dates (SD) in high altitude area of Garhwal Himalayas. Heading time was not significantly altered by the first (24 April) or the Second (28 May) SD, but very few lines flowered in the third SD (28 June). Heading time was reduced by 2-37 days in the third SD. About 64% lines showed head emergence while, 28% lines bore fertile spikelets. *Japonica* and Javanica types showed increased head emergence and spikelet fertility. Average spikelet fertility was, in general, more in the cloudy conditions during anthesis, as compared to that of the first SD (3.64%) indicating not only the possible role of low temperature in influencing this character but also of other factors as well. High spikelet sterility in some early maturing lines vindicated this fact further.

Key words : Rice, germplasm, cold tolerant, environmental influence

Direct seeded upland rice is extensively cultivated in the hills of Uttar Pradesh, India. The crop is generally sown from end of March to April (Spring rice) and harvested in September-October depending on altitude. Transplanted rice is raised from May end to mid June, about a month earlier as compared to that of the plains. May-June sown direct seeded upland rice is also gaining importance in some sporadic pockets in recent years with the release of suitable improved varieties for this specific condition with a view to increase cropping intensity.

In high altitude areas cold temperature induced spikelet sterility is a common phenomenon. Early maturing cultivars are expected to perform better as they can escape cold temperature stress during the grain formation stage. However, it was observed that contrary to expectations, even early maturing lines do not always show high spikelet fertility. Therefore, the present

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investigation was carried out to find out the role of other environmental factors on heading time and spikelet sterility in a number of cold tolerant rice genotypes.

MATERIALS AND METHODS

Eighty eight cold tolerant rice lines received from the International Rice Research Institute, Manila, Philippines including three local checks were evaluated at three sowing dates (SD) viz., 24 April, 28 May and 28 June during 1991. The material consisted of 34 *indica* Early, 13 *indica* Medium, 39 *Japonica* and 2 *javanica* lines. The lines were raised at the experimental farm, G.B. Pant University of Agriculture and Technology, Hill Campus Ranichauri in Tehri Garhwal Himalayas situated between 30° - 15′N and 78° - 30′ E at an altitude of 2150 m above msl in upland, dry seeded, rainfed condition. Seeds of the first sowing date germinated a few days later (1-5 May) due to insufficient soil moisture at the time of sowing. Therefore, observation on heading time was calculated from the date of germination of seeds. Plot size consisted of single 2 m long rows, spaced 20 cm apart, with inter-plant distance of 8-10 cm. Observations on heading time and spikelet fertility were recorded in three sowing dates while those on plant height and tillering ability could be recorded in the first sowing date only. For calculating spikelet fertility percentage, number of filled or semi-filled grains and empty grains were separated and counted in all the earheads in a line and expressed as percentage. Data on related important weather parameters were recorded during the crop growing period.

RESULTS AND DISCUSSION

A persual of the data (Table 1) revealed that only about 64 per cent lines (56) showed head emergence, while only 28 per cent lines (25) bore fertile spikelets pooled over all the sowing dates. *Japonica* and *javanica* groups showed increased head emergence and spikelet fertility as compared to *indica* lines showing better cold tolerance ability. In general, heading time was not significantly altered either by the first or the second SD as most of the cultures showed little difference in head emergence with respect to these two SDs. Although very few lines flowered in the third SD, heading time was reduced by 2-37 days in the third sowing date. The reduction was more pronounced in the *japonica* lines that are known to be photosensitive.

Spikelet fertility was, in general, more in the second SD (average 5.87%) as compared to that of the first SD (average 3.64%) indicating not only the role of low temperature but also of other factors in influencing this character. The details of important weather parameters recorded during the crop season

Table 1. Heading time and spikelet fertility of cold tolerant rice lines at three sowing dates at Hill Campus during 1991

Entry	Heading time (days)			Plant height (cm)	Spikelet fertility (%)			Tillering ability[a]
	I[b]	II	III	I	I	II	III	I
INDICA : EARLY								
CALIFORNIA BELLE (ACC 66836)	110	112	-[c]	75	0	0	-	7
CHINA 1039	112	108	-	54	0	0	-	7
DUBOVKSY 129	-	-	-	42	-	-	-	7
GASMAL 89 (ACC 29325)	-	-	-	89	-	-	-	7
IB 20	-	-	-	77	-	-	-	9
IB 42	180	-	-	42	0	-	-	9
IR 18502-PL P4 -3-3-3-1-1	116	118	-	62	0	0	-	5
IR 20654-R-R-R-15-1-B	-	-	-	55	-	-	-	3
IR 25884-94-3-2	-	-	-	58	-	-	-	7
KAEU N 101	95	99	-	86	0.5	0.5	-	9
KALIN	102	105	100	65	0	0	0	9
K 39-96-1-1-1-2	112	113	102	66	0	0	0	7
MILYANG 77 (CHILSEONGBYEO)	-	-	-	36	-	-	-	9
RP 1442-4-6-1-1-1	112	115	-	76	0	0	-	9
RP 1681-1701-4204	-	-	-	76	-	-	-	9
RP 1888-4259-1529-126	116	116	-	55	0	0	-	7
RP 2420-111-21-2-4	-	-	-	60	-	-	-	7
RP 2421-100-2-3-2	181	-	-	70	0	-	-	9
SPTLR 81346-PTG-B3-53-5-2-1	-	-	-	71	-	-	-	5
SPTLR 81366-PTG-16-2-3-3-1	-	-	-	68	-	-	-	9
SPTLR 81399-PTG-17-1-2-1-1	-	-	-	55	-	-	-	7
SPTLR 82078-PTG-B3-24-1-1	-	-	-	42	-	-	-	5
SUWEON 325 (JUNGWEONBYEO)	184	-	-	32	0	-	-	9
SUWEON 332 (YONGMOONBYEO)	-	-	-	47	-	-	-	7

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Entry	Heading time (days)			Plant height (cm)	Spikelet fertility (%)			Tillering ability[a]
	I[b]	II	III	I	I	II	III	I
SUWEON 333 (YONGJUBYEO)	-	-	-	42	-	-	-	9
THIMPU MAAP	120	125	-	113	0	0	-	9
TOKAMBANO 669	135	135	-	82	0	0	-	5
T3	-	-	-	70	-	-	-	7
UGEY MAP (ACC 72530)	-	-	-	75	-	-	-	7
VL DHAN 16	-	-	-	74	-	-	-	9
VL DHAN 163	110	112	-	75	0	0	-	9
VL DHAN 206	115	110	-	85	0	0	-	5
WANGDI MAP (ACC 725291)	-	-	-	81	-	-	-	5
88-2165-7	115	118	-	75	-	-	-	9
INDICA : MEDIUM								
CN 880-1-2/1	-	-	-	60	-	-	-	7
CN 880-24-1/3	-	-	-	54	-	-	-	7
CN 881-5-1/1	-	-	-	54	-	-	-	9
HAO-HAI-HUAN (ACC 66984)	-	-	-	80	-	-	-	9
IB 15A	-	-	-	52	-	-	-	9
IB 23	-	-	-	75	-	-	-	9
IR 1552	-	-	-	48	-	-	-	9
IR 40094-1-4-3	-	-	-	66	-	-	-	9
SPTLR 81366-PTG-18-1-3-3-1	-	-	-	80	-	-	-	9
136 (ACC 66986)	118	120	-	79	0	0	-	9
RANICHAURI LOCAL	110	112	97	81	0	0	0	5
SAONLI LOCAL	113	115	-	91	0	0	-	5
JAGDHAR LOCAL	120	120	-	91	-	-	-	9
JAPONICA :								
BARKAT (K 78-13)	122	128	-	90	0	0.1	-	7
E WAN NO. 5	-	-	-	62	-	-	-	9
HOA VANG THAI BINH	-	-	-	56	-	-	-	7
HR 5824-B-3-2-3	112	115	93	77	0	1	0	7
HR 6419-B-42-2	110	110	-	74	0	0	-	7

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Entry	Heading time (days)			Plant height (cm)	Spikelet fertility (%)			Tillering ability[a]
	I[b]	II	III	I	I	II	III	I
HR 7896-ACB7	115	115	-	62	0	0	-	9
HSA 255	110	112	95	86	2	30	0	9
HSC 19	112	110	95	66	2	20	0	9
HSC 236	108	115	-	81	0	2	-	9
HSC 55	110	112	97	65	1	1	0	9
HŞC 6	112	110	97	86	0.5	10	0	7
HSL 303	108	108	97	80	5	2	0	7
HSL 447	105	105	-	80	0.5	5	-	9
H 247	120	120	-	56	0	1	-	7
H 433	102	110	-	94	10	2	-	9
H443	102	110	-	94	10	2	-	9
H 447	100	102	-	74	0	2	-	9
H 448	110	112	-	72	2	0.1	-	9
H 467	110	110	-	53	2	5	-	9
H 473	112	120	87	63	2	0	-	9
H 491	130	135	98	88	1	0	0	9
IRI 384	-	-	-	52	-	-	-	9
IR 47686-6-2-2-1	140	145	-	88	0	0	-	9
JINBU 8	-	-	-	80	-	-	-	9
JINBU 9	115	125	-	82	0	0	-	9
MENG-LI-WANG-GU (ACC 66985)	120	125	-	71	2	0.1	-	7
MULYANG 54 (GAYA BYEO)	125	115	-	69	2	0.1	-	7
MILYANG 93 (SANGNAMBATBYEO)	125	130	-	72	0	0	-	5
MOH TSIJU (ACC 01249)	-	-	-	87	-	-	-	7
SR 11451-T 204	130	135	-	72	0.1	0	-	9
SR 11842-91-4-3	132	135	-	81	0	0	-	7
STEJAREE 45	100	102	-	72	25	32	-	5
SUWEON 222	125	130	-	83	0	0	-	9
SUWEON 345	120	135	-	60	0	0	-	7
TK 5331-R-R-R-R-28-1	135	135	-	58	0	0	-	7

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Entry	Heading time (days)			Plant height (cm)	Spikelet fertility (%)			Tillering ability[a]
	I[b]	II	III	I	I	II	III	I
YR 6488-ACP39	125	145	-	69	0	0	-	5
80007-TR210-14-1-1	130	135	-	105	2	0	-	1
80018-TR161-7-1-1	125	125	-	95	1	.5	-	5
80023-TR166-2-1-4	130	124	-	85	0	0	-	9
JAVANICA:								
NEP THAP	132	-	-	79	0.5	-	-	9
PLOVDIV	121	115	-	80	-	1	-	7

[a]Scored in 1-9 scale following Standard Evaluation System for Rice, IRRI at growth stage 8-9.
[b]I = 24 April, II = 28 May and III = 28 June sowing dates.
[c]No head emergence.

are given in Table 2. The average sunshine hours during August and September were only 3.1 and 5.8 hrs per day as against the maximum possible sunshine hours of 13.2 and 12.4, respectively. The number of sunny days was also the lowest (12 days) during August. The active period of anthesis in the first SD was from July end to late August while in the second SD, it was from August end to middle of September. Thus coincidence of uninterrupted rainy or overcast conditions with anthesis in the first SD could be an important factor contributing to reduced spikelet fertility. The lines in the second SD, though experienced comparatively lower temperature during anthesis, showed increased spikelet fertility as they escaped continuous rainy or cloudy conditions during

Table 2. Important weather parameters during the crop season 1991 at Ranichauri (UP)

Month	Temperature C		No. of rainy days	No. of sunny days*	Average sunshine hours	Maximum possible sunshine hours
	Max.	Min.				
April	21.0	8.5	5	23	8.9	12.9
May	26.1	13.3	6	19	10.1	13.7
June	24.5	14.4	12	15	8.7	14.1
July	24.0	16.4	7	17	5.9	13.9
August	22.3	15.7	19	12	3.1	13.2
September	22.0	14.9	8	15	5.8	12.4
October	20.8	10.3	0	16	8.8	11.5
November	15.4	5.7	1	21	6.7	10.6

*Number of days having sunshine hours equal to or more than the average monthly sunshine hours.

this critical period. This may also explain the reduced spikelet fertility observed in some early flowering lines like KAEU N 101 and also the differential spikelet fertility shown by some lines at different sowing dates.

Air temperatures, at later stages of plant growth, are known to affect percentages of unfertilized spikelets and percentages of ripened grains (Bhuiyan and Galag, 1989). Thus spikelet fertility or sterility has often been used as an indicator of cold tolerance or susceptibility (Satake *et. al.*, 1969; Kaw, 1991). But relying on spikelet fertility alone as a measure of cold tolerance may at times be misleading as revealed by this study. Spikelet sterility induced by low radiation caused by uninterrupted rainy or cloudy conditions particularly during reduction division and anthesis should be carefully separated from the induced by cold temperature in high altitude areas to arrive at clearcut conclusions. The same is corroborated by Yoshiba (1981) also who observed that unfavorable weather during reduction division and anthesis, cultural practices like high plant density and low radiation during post-flowering stage reduce the number of filled grains per panicle.

The cultivar Stejaree 45 showed high and almost uniform spikelet fertility in both the first (25%) and the second (32%) SD. Three local cultivars collected from nearby mid altitude (1200-1500 m above msl) areas showed complete spikelet sterility though in other seasons they had shown reasonable seed setting (data not presented). This suggests that a more critical analysis is required on the role of weather variables on spikelet sterility/fertility over the seasons encompassing different altitudes.

Plant height and tillering ability, the important parameters of plant growth, recorded only in the first SD showed wide variations. Plant height ranged from 32 cm for Suweon 325 to 113 cm for Thimpu Maap. Though most genotypes in general showed poor tillering ability (score 7-9), the *japonica* line 8007-TR 210-14-1-1 showed excellent performance (score 1) with respect to this character.

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