Website : www.asthafoundation.in
Frontiers in Crop Improvement
Vol 9 : 1-5 (January-2021) Print ISSN : 2393-8234 Online ISSN : 2454-6011
Astha Foundation, Meerut (U.P.) India

Evaluation of Cold Tolerant Promising Rice Genotypes for High Hills of Nepal

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Abstract

Rice is the staple food crop of Nepal and high hill shares nearly 5% of its total cultivated area. To develop cold tolerant promising rice varieties better than the existing ones, a series of trials namely observation nursery trial, initial evaluation trial, coordinated varietal trial and farmer's field trial were conducted at National Plant Breeding and Genetics Research Center, Khumaltar, Lalitpur in 2019 and earlier years. Seeds were sown at the 2st week of June and 25 days old seedlings were transplanted in the field so as to synchronize the flowering time with cold temperature. Plants were maintained with 15 cm x 20 cm spacing and recommended dose of fertilizers 80:30:30 kg/ha NPK were supplied. All other agronomic practices like fertilization, weeding, and irrigation were maintained at appropriate time. The best promising genotypes selected for 2020 were NR11121-B-B-17-5-7-3, IR13K190, NR10859-1-7-2-1, NR10682-B-B-B-3, NR 11121 B-B-17-5-3, and NR 11121 B-B-17-5-7-1. Two genotypes which performed better than the check Chandannath-3 at field conditions were promoted in farmer's field trial from coordinated varietal trial and the rest four genotypes of farmer's field trial 2019 were repeated in 2020. These two promising genotypes were proposed for variety release for high hills of Nepal.

Key words : *Cold tolerant, high hill, promising genotypes, rice, Oryza sativa.*

Introduction

Rice is a major staple food crop of Nepal which contributes 20% to agriculture gross domestic product (AGDP) and nearly 7% to gross domestic product (GDP) of the country (1,2). It supplies more than 50% calories to the whole Nepalese population. It is cultivated in around 70% in terai, 25% in hills and around 5% in high hills regions of Nepal (1). Though high hill has small coverage area of cultivation, it plays significant role to boost food security in high hill regions.

Rice was transplanted in nearly 42.64% of total land and contributed 50.75% of the total production of cereal crops in 2019/20 (1). Rice has both economic and cultural importance as it is deeply engraved in the tradition and culture of the country where it is offered to bring good health and prosperity to family members in many auspicious occasions. The significance of rice extends beyond life for Hindu and Buddha communities with offerings given to the departed soul. Though rice is major economic vehicle in Nepalese agriculture, its productivity is still low and farmers have very limited alternatives to choose best variety for their agro-ecological zones. Because of this fact, many farmers still grow either local landraces (good taste and cooking quality) or available released varieties, most of which are medium and coarse type and unliked by many because of their taste. Thus an ideal type rice variety is in need which should have good cooking quality, better in taste and has high productivity (2).

Nepal cultivates rice in diverse agro-ecosystems i.e. from 60 masl in the terai to 3050 masl in Chhumchaur Jumla, the highest place of rice growing in the world (3). Rice was cultivated in about 1.45 million ha with 5.55 million production and a productivity of about 3.8 ton/ha in 2019/20 (1). High hill accounts about 5% of the total rice area but the productivity is low compared to national average productivity due to many biotic, abiotic and other constraints. Rice area and production of this region is highly dependable on prevailing monsoon pattern. Generally farmers prepare rice seed bed in regular time and wait for monsoon to transplant the crop. A late monsoon compels farmers to transplant older seedlings which translate into yield losses due to prolonged maturity and cold injury during reproductive stage.

National Plant Breeding and Genetics Research Center (NPBGRC), Khumaltar, Lalitpur has mandate to test and propose rice varieties for mid and high hills of the country. Thus this center focusses on testing of several cold tolerant genotypes in high hill regions. Few cold tolerant varieties have been released and still promising rice varieties are on the test at field level. The main objective of high hill based trial is to develop and evaluate cold tolerant promising rice varieties that suits the high hills region of Nepal.

Materials and Methods

Rice varietal development is a continuous program. Thus to develop high hill rice variety, a number of rice trials were

Received : January-2020; Revised : January-2020; Accepted : January-2021

Table-1 : Performance of high hill rice genotypes in coordinated varietal trial/JSVT at National Plant Breeding and Genetics Research Center, Khumaltar Lalitpur, 2019.

S.No.	Treatments	DTF	DTM	PHT	PNL	TILN	FGN	FGNW	SGN	GYLD
1.	NR 682-B-B-B-3	82	126	134.47	20.73	16	99	3	29	3313
2.	IR1367(YEONGSON)	87	135	87.53	21.33	17	69	2	77	2334
3.	PR29399-B-2-2-1	82	127	135.60	22.40	12	111	3	30	4188
4.	NR 11121 B-B-17-5-7-1	83	125	129.33	22.67	14	96	2	45	4231
5.	NR10838-B-B-4	96	131	123.27	24.67	15	117	3	51	1678
6.	NR 11121 B-B-23-7-2	94	131	106.00	21.73	15	119	3	49	2869
7.	NR 11121 B-B-17-5-3	91	130	129.40	25.47	13	107	3	33	4280
8.	NR 11121 B-B-17-9-5-3-1	95	135	114.27	21.67	14	100	2	53	2665
9.	NR 11121-B-B-17-3-1-2	86	129	121.33	21.07	14	59	2	21	2868
10.	NR 11341-B-B-32-2	88	132	131.80	21.27	15	93	2	21	2625
11.	NR11341-B-B-30	93	134	153.93	22.80	11	107	3	45	2687
12.	Chandannath-3	82	126	151.40	22.67	13	127	3	44	3775
	Mean	88	130	126.53	22.37	14	100	2	42	3126
	CV (%)	3.57	1.61	2.89	4.33	19.19	24.27	24.74	43.22	20.94
	p value	0	0	0	0.0001	0.3542	0.0825	0.0489	0.0411	0.0008
	Std Err	2.57	1.71	2.99	0.7911	2.21	99.36	2.52	73.28	534.48

(**Abbreviations :** DTF: Days to flowering; DTM: Days to maturity; PHT: Plant height (cm); PNL: Panicle length (cm); TILN: Tillers number per hill; FGN: Fertile grain number per panicle; FGNW: Fertile grain weight per panicle; SGN: Sterile grain number; GYLD: Grain yield in Kg/ha)

Table-2 : Performance of high hill rice genotypes in coordinated varietal trial/JSVT at National Plant Breeding and Genetics Research Center, Khumaltar Lalitpur, 2020.

S.No.	Treatment	DTF	DTM	PHT	PANL	TILN	FGN	FGWT	SGN	GYLD
1.	NR29399-B-2-2-1	73	109	120.5	22.73	15	81	2.17	27	4716
2.	NR 682-B-B-B-3	73	102	128.3	21.33	13	85	2.4	22	4533
3.	NR 11121-B-B-17-3-1-2	76	108	125.9	23	13	89	2.16	17	5074
4.	NR 11341-B-B-32-2	76	106	124.5	22.2	15	76	1.62	16	4587
5.	NR11341-B-B-30	79	111	147.0	23.87	14	89	2.11	39	4283
6.	NR10838-B-B-4	71	104	130.3	24.13	16	107	2.47	47	5025
7.	NR 11121 B-B-23-7-2	78	104	125.1	23.67	20	94	2.01	32	3603
8.	NR 11346-B-B-15-1-2	76	102	133.9	23.6	12	81	2.1	83	4057
9.	NR 11345-B-B-14-1-2	71	100	135.5	23.13	11	106	3.67	66	6941
10.	NR 11345-B-B-30-3-1	71	102	136.5	22.8	13	120	3.37	44	5443
11.	NR 11366-B-B-26-3-2	73	102	126.8	23.93	14	85	1.97	46	4332
12.	Chandannath 3	71	106	150.4	23.33	14	76	1.89	55	5331
	Mean	74	105	132.07	23.14	14.22	90	2.33	41	4827
	CV (%)	2.43	3.66	9.76	7.47	19.12	20.81	24.5	51.65	16.04
	p value	0	0.0503	0.1986	0.7689	0.0785	0.171	0.0075	0.022	0.0048
	StdErr	1.47	3.12	10.52	1.41	2.2	15.39	0.465	17.36	632.2

(**Abbreviations :** DTF: Days to flowering; DTM: Days to maturity; PHT: Plant height (cm); PNL: Panicle length (cm); TILN: Tillers number per hill; FGN: Fertile grain number per panicle; FGNW: Fertile grain weight per panicle; SGN: Sterile grain number; GYLD: Grain yield in Kg/ha)

used to test certain genotypes for high hills. These high hill genotypes must have cold tolerant ability so that it could perform its best in high hill regions. Thus to test these genotypes in mid hill, a cold tolerant environment is necessary during rice heading and flowering stage. To synchronize the flowering time with cold environment, delayed sowing was done and thus seed was sown at 2nd week of June and they were transplanted after 25-28 days of sowing. Farmer's field trial (FFT) and Jumla selection varietal trial (JSVT) or CVT trial were grown with a plot size of 2 m^2 and 9 m^2 respectively. Spacing was maintained as 15 cm x 20 cm. Fertilizer was recommended as 80:30:30 kg\ha NPK. Nitrogen was applied at split dose, i.e. 50% during transplanting, and the remaining was divided into

Table-3 : Comparison of grain yield of common genotypes of coordinated varietal trial 2019 and 2020.

S.No.	Treatment	GYLD in 2019	GYLD in 2020	Average of 2019 and 2020 (kg/ha)
1.	NR29399-B-2-2-1	4188	4716	4452
2.	NR 682-B-B-B-3	3313	4533	3923
3.	NR 11121-B-B-17-3-1-2	2868	5074	3971
4.	NR 11341-B-B-32-2	2625	4587	3606
5.	NR11341-B-B-30	2687	4283	3485
6.	NR10838-B-B-4	1678	5025	3352
7.	NR 11121 B-B-23-7-2	2869	3603	3236
8.	Chandannath 3	3774	5331	4553
	Average yield (kg/ha)	3000	4644	3822

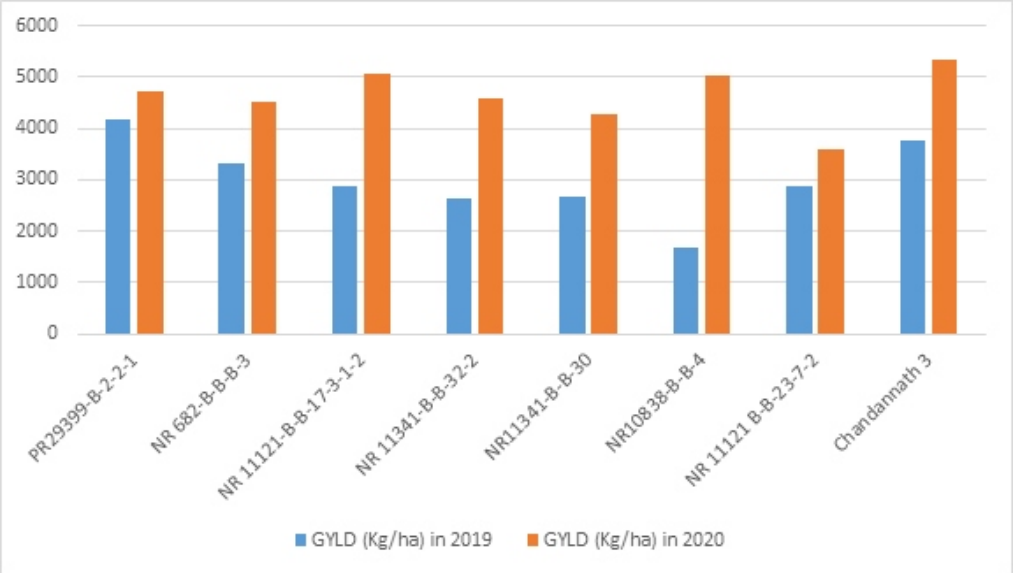

Fig.-1 : Comparison of grain yield of high hill rice genotypes in CVT trial 2019 and 2020.

two parts and applied at maximum tilering stage and during flowering stage. Phosphorus and potash applied as basal dose during last field preparation for transplanting. Manual weeding was done at maximum tillering stage. Major quantitative traits data i.e. days to flowering, days to maturity, plant height, number of fertile grain per panicle, number of sterile grain per panicle, effective tiller per hill, straw weight etc. were recorded for evaluation of the genotypes. These data were taken following standard evaluation system of rice (SES) IRRI protocol (www.irri.org).

JSVT trial replicated thrice and consisted 12 genotypes along with a standard check Chandannath-3. Similarly, FFT trial had three replications and each replicated trial consisted five genotypes along with a standard check Chandannath-3. These trials were conducted for the year 2019 and 2020.

Results and Discussion

Rice genotypes and its traits were found significantly different from each other in coordinated varietal trial 2019 (Table-1). Maximum grain yield recorded in NR 11121 B-B-17-5-3 (4280 kg/ha) followed by NR 11121 B-B-17-5-7-1 (4231 kg/ha) and PR29399-B-2-2-1 (4188 kg/ha) whereas standard check Chandannath-3 has yield only 3775 kg/ha. But shortest days to maturity was found in NR 11121 B-B-17-5-7-1 (125 days) and longest days to maturity observed in IR1367(YEONGSON) and NR 11121 B-B-17-9-5-3-1 (135 days). Similarly, grain yield was recorded maximum in NR 11345-B-B-14-1-2 (6941 kg/ha) followed by NR 11345-B-B-30-3-1 (5443 kg/ha), NR 11121-B-B-17-3-1-2 (5074 kg/ha) and NR10838-B-B-4 (5025 kg/ha) in 2020 (Table-2). In the same way, longest days to maturity was obtained in NR29399-B-2-2-1 (109 days) and shortest maturity days was obtained in NR 11345-B-B-14-1-2 (100 days). The common genotypes of CVT/JSVT trials of 2019 and 2020 were considered and its average yield calculated. The average yield of the year 2020 (4644 kg/ha) was found significantly higher than 2019 (3000 kg/ha). But maximum grain yield was obtained in NR29399-B-2-2-1 (4452 kg/ha) followed by NR 11121-B-B-17-3-1-2 (3971 kg/ha) and NR 682-B-B-B-3

Table-4 : Performance of high hill promising rice genotypes in farmer's field trial at National Plant Breeding and Genetics Research Center, Khumaltar Lalitpur, 2019.

S. No.	Treatment	DTM	PHT	PANL	TILN	FGN	GYLD (kg/ha)
1.	NR11121-B-B-17-5-7-3	132	149	25.4	17	63	3373
2.	IR13K190	130	133	22.93	17	93	3192
3.	NR10859-1-7-2-1	138	137	22.07	16	75	2936
4.	NR10682-B-B-B-3	127	146	21.33	15	99	2941
5.	Chandannath-3	131	133	23.27	15	89	3424

(**Abbreviations :** DTF: Days to flowering; DTM: Days to maturity; PHT: Plant height (cm); PNL: Panicle length (cm); TILN: Tillers number per hill; FGN: Fertile grain number per panicle; FGNW: Fertile grain weight per panicle; SGN: Sterile grain number; GYLD: Grain yield in Kg/ha)

Table-5 : Performance of high hill promising rice genotypes in farmer's field trial at National Plant Breeding and Genetics Research Center, Khumaltar Lalitpur, 2020.

S.No.	Treatment	DTM	PHT	PANL	TILN	FGN	GYLD
1.	NR11121-B-B-17-5-7-3	100	166	28	16	49	4470
2.	IR13K190	106	158	25.6	12	106	6753
3.	NR10859-1-7-2-1	106	157	23.6	13	75	5656
4.	NR10682-B-B-B-3	100	150	21.6	13	86	4795
5.	Chandannath-3	100	146	23.8	12	99	5733

(**Abbreviations :** DTF: Days to flowering; DTM: Days to maturity; PHT: Plant height (cm); PNL: Panicle length (cm); TILN: Tillers number per hill; FGN: Fertile grain number per panicle; FGNW: Fertile grain weight per panicle; SGN: Sterile grain number; GYLD: Grain yield in Kg/ha)

Table-6 : Comparison of promising high hill rice genotypes in 2020 and 2019.

S.No.	Treatment	GYLD in 2020	GYLD in 2019	Average of 2019 and 2020 (kg/ha)
1.	NR11121-B-B-17-5-7-3	4471	3373	3922
2.	IR13K190	6754	3192	4973
3.	NR10859-1-7-2-1	5657	2936	4296
4.	NR10682-B-B-B-3	4795	2941	3868
5.	Chandannath-3	5733	3424	4579
	Average yield	5482	3173	4328

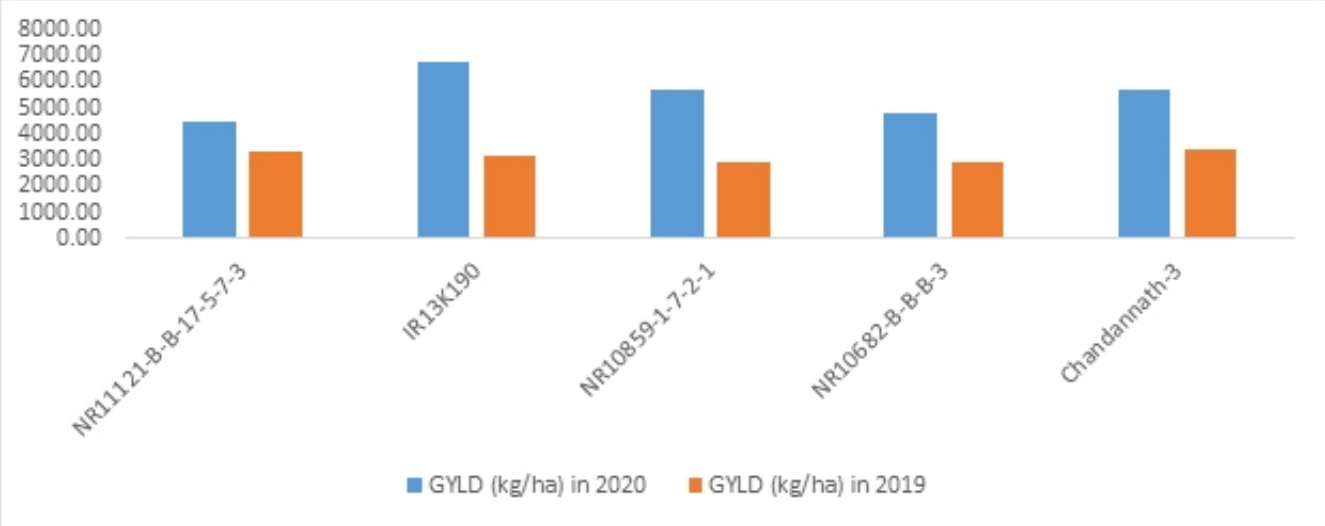

Fig.-2 : Comparison of grain yield of high hill rice genotypes in FFT trial 2019 and 2020.

(3923 kg/ha) whereas standard check Chandannath has average yield of 4553 kg/ha (Table-3; Figure-1).

Combined yield analysis of CVT trial showed that only one genotype NR29399-B-2-2-1 was promising than the standard check Chandannath-3 and therefore, this genotype was promoted to FFT trial as a promising genotype. The rest genotypes were either discarded or repeated in JSVT trial for the next year.

Five genotypes performance were observed in farmer's field trial in both the year 2019 and 2020 along with a standard check Chandannath-3. NR10682-B-B-B-3 (127 days) had shortest days to maturity and NR10859-1-7-2-1 (138 days) had longest days to maturity but both genotypes yield were significantly lower than Chandannath-3. NR11121-B-B-17-5-7-3 (3373 kg/ha) had yield at par with Chandannath-3 (3424 kg/ha) and considered best performing genotypes in 2019 (Table-4). Similarly, IR13K190 (6753 kg/ha) performance was excellent and had maximum grain yield than the other promising genotypes NR10859-1-7-2-1 (5656 kg/ha), NR10682-B-B-B-3 (4795 kg/ha) and NR10682-B-B-B-3 (4795 kg/ha) in 2020 (Table-5).

Two years combined yield analysis of high hill promising rice genotypes showed IR13K190 (4973 kg/ha) had maximum grain yield followed by NR10859-1-7-2-1 (4296 kg/ha), NR11121-B-B-17-5-7-3 (3922 kg/ha) and NR10682-B-B-B-3 (3868 kg/ha) respectively. Standard check Chandannath-3 had grain yield 4579 kg/ha which was lower than IR13K190 and higher than other three genotypes (Table-6, Figure-2).

Two promising genotypes IR13K190, and NR10859-1-7-2-1 were found better than the check Chandannath-3 and therefore these genotypes were prepared to propose for general cultivation of high hill regions of Nepal. The similar process is conducted to select mid hill rice genotypes where Khumal-12 (NR 10490) and Khumal-14 (NR 10676) were found promising and proposed for mid hill based people of Nepal (4, 5, 6). Only those genotypes were promoted which had been found high yielding and disease resistant to leaf and neck blast since blast is a severe problem in hills of Nepal (7).

Varietal development is a continuous process. Many varieties which are released could get deterioration after few years and this might be due to certain disease and pest susceptibility or due to genetic unstability. Nepal has released 7 high hill rice varieties (Chandannath-1, Chandannath-3, Machhapuchhre-3, Chhomrong local, Lekali-1 and Lekali-3) and among them only 4 varieties (Chandannath-1, Chandannath-3, Lekali-1 and Lekali-3) are cultivated widely (8). The rest varieties might be unliked by farmers with the development of new rice varieties.

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