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Research Article

Evaluation of bread wheat genotypes under rain-fed conditions in Terai districts of Nepal

Deepak Pandey[1], Khem Raj Pant[1], Biswas Raj Bastola[1], Rabin Giri[2], Suman Bohara[3], Shankar Shrestha[4], Govinda Bahadur Hamal[5] and Jiban Shrestha[6]

[1]National Wheat Research Program, Bhairahawa, Rupandehi, Lumbini Province, Nepal
[2]Directorate of Agricultural Research (DoAR), Bhagetada, Doti, Sudurpashchim Province, Nepal
[3]Directorate of Agricultural Research (DoAR), Khajura, Banke, Lumbini Province, Nepal
[4]National Sugarcane Research Program, Jitpur, Bara, Province No. 2, Nepal
[5]National Maize Research Program, Rampur, Chitwan, Bagmati Province, Nepal
[6]National Plant Breeding and Genetics Research Centre, Khumaltar, Lalitpur, Bagmati Province, Nepal
*Correspondence: dpandey5@yahoo.com
*ORCID: https://orcid.org/0000-0002-1618-9288
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ABSTRACT

Thirty four percent of the total wheat cultivated area is under rain-fed condition in Nepal and that of the Terai is nineteen percent. The objective of this study was to develop drought tolerant and high yielding varieties of wheat for timely sown rain-fed environments. Coordinated Varietal trial (CVT) was carried out in normal wheat growing season during 2016/17 and 2017/18. The research was conducted at five locations (Rampur, Bhairahawa, Doti, Jitpur and Nepalgunj) of five research stations of Nepal Agricultural Research Council (NARC) throughout the Terai region in alpha lattice design with two replications. Data on different yield attributing traits were recorded. In the CVT-TTL 2016/17 highly significant difference ($p<0.01$) among the genotypes was found for days to heading, days to maturity, plant height, number of grains per spike and thousand kernel weight and significant difference ($p<0.05$) for grain yield. The highest grain yield was observed in NL 1326 (2954 kg/ha) which was followed by NL 1327 (2819 kg/ha), NL 1211 (2719 kg/ha), NL1202 (2683 kg/ha), BL 4707 (2654 kg/ha) and BL 4708 (2652 kg/ha). Similarly, in CVT-TTL 2017/18, highly significant difference ($p<0.01$) among the genotypes was observed for the days to heading, days to maturity and plant height and non-significant different for number of grains per spike, grain yield and TGW. However, Genotype by Environment (G x E) was found highly significant ($p<0.01$) for the days to heading, plant height, grain yield and TGW and significant different ($p<0.05$) for number of grains per spike. The highest grain yield was obtained in NL1322 (2305 kg/ha) which was followed by NL1369 (2287 kg/ha), NL 1202 (2205 kg/ha), BL 4708 (2197 kg/ha) and BL 4820 (2118 kg/ha). Among these tested genotypes BL 4708, NL 1202, NL 1211, NL 1307, NL 1327 and NL 1369 are recommended for the coordinated farmer's field trial for further verification and release as variety.

Keywords: Environment, genotype, rain-fed, Terai, wheat, yield

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INTRODUCTION

Future global food security will require agricultural production in 2050 to be 60% more than it was in 2010 to progress at the same speed with global population growth and food consumption patterns (Alexandratos & Bruinsma, 2012). One promising way for increasing grain production is by bridging the gap between yields currently achieved on farms and those that can be achieved by using the best-adapted crop cultivars and production practices (van Ittersum *et al*., 2013). Currently, about 95% of the wheat grown worldwide is hexaploid bread wheat, with most of the remaining 5% being tetraploid durum wheat. The latter is more adapted to the dry Mediterranean climate than bread wheat and is often called pasta wheat to reflect its major end-use (Shewry, 2009). Globally, about 37% of wheat growing areas are semi-arid in which available limited soil moisture constitutes a major problem in wheat production. Thirty four percent of the total wheat cultivated area is under rain-fed condition in Nepal and that of the Terai is 19% (ABPSD, 2017).

Rain-fed conditions provide the selection environment for drought tolerance (Drikvand *et al*., 2012). Breeding strategies for drought tolerance improvement include choice and classification of the testing environment, water stress management and characterization, and use of phenotyping traits with high heritability (Monneveux *et al.*, 2009). Significant management gaps have been observed between attainable and actual yields of rain-fed wheat. Genetic selection with optimal crop management could increase yields of wheat, barley, and canola significantly under rain-fed conditions (Chapagain & Good, 2015).

Wheat varieties Bhrikuti, Aditya, and Vijay were released in 1994, 2009 and 2010 respectively as an option for rain-fed condition for Terai (Pandey *et al.*, 2019). This reflects the choice is limited. In a study in China, under rain-fed-only conditions, the management efficiency of wheat production was higher in many regions than cases with full irrigation (Terjung *et al*., 2014). In the changed climate, increased temperature would cause reduction in wheat yield to the extent of 4, 32 and 61% in the mid-century periods between 2021–2030, 2031–2040 and 2041–2050, respectively, by increasing water stress and decreasing utilization efficiency of photosynthetically active radiation. The decreases in crop water productivity would be 40, 56 and 76%, respectively, which are caused by decreased yield and increased ET (Vashishth *et al*., 2013).

This research was conducted to develop superior wheat genotypes under rain-fed area environment of Nepal. To identify the high yielding variety for rain-fed environment different multilocation national screening nurseries and yield trials and some International Screening nurseries and yield trials were conducted every year.

MATERIALS AND METHODS

Experimental site

With the objectives of wheat variety development for the rain-fed condition of Terai region of Nepal Coordinated Varietal Trial were conducted in five different locations. The detail of the experimental site with geographical position, altitude and general soil characteristics is given in the Table 1.

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Table 1: Geographical details of the research conducted sites

S.N.	Location	Address	Geographical position	Altitude (m.)	General Soil Character
1	National Wheat Research Program	Bhairahawa, Rupandehi	27º32' N 83º25'E	105	Silt Loam
2	National Maize Research Program	Rampur, Chitwan	27º39' N 84º21'E	188	Sandy loam
3	Directorate of Agricultural Research	Lumbini Province, Khajura, Banke	28º06' N 81º35'E	151	Sandy loam
4	National Sugarcane Research Program	Jitpur, Bara	27º07' N 84º57'E	95	Silt Loam
5	Directorate of Agricultural Research,	Sudurpashchim Province, Bhagetada, Doti	29º15' N 80º56'E	534	Sandy loam

Plant materials

Twenty wheat genotypes including three check varieties *Bhrikuti, Gautam* and *RR21* were used. These genotypes were selected from the promising genotypes from the Initial Evaluation Trial (IET) and some genotypes were selected from the Coordinated Varietal Trial (CVT) of the previous year. These materials were taken as NL (Nepal Line) series from the nurseries and yield trials of the CIMMYT conducted at NWRP, Bhairahawa. The BL (Bhairahawa Line) series were from the advanced homozygous materials from the hybridization program of Bhairahawa. The name of the genotypes with their cross pedigree and the trial conducted year in CVT-TTL have been given in Table 2.

Table 2: Cross pedigree of the genotypes tested in CVT-TTL in different years

S.N.	Genotypes	Pedigree	Year
1	BL 4335	BL 2030/BL 2775	2016/17
2	NL 1207	SOKOLL*2/TROST	2016/17
3	NL 1211	W15.92/4/PASTOR//HXL 7573/2*BAU/3/WBLL 1	2016/17
4	NL 1244	BOW/VEE/5/ND/VG 9144//KAL/BB/3/YACO/4/CHIL/6/CASKOR/3/CROC_1/AE.SQ (224)//OPATA/7/PASTOR//MILAN/KAUZ/3/BAV 92	2016/17
5	NL 1247	KRICHAUFF/2*PASTOR//2*SOKOLL	2016/17
6	NL 1253	PFAU/SERI.1B//AMAD/3/WAXWING/4/AKURI/5/PFAU/SERI.1B//AMAD/3/WAXWING	2016/17
7	NL 1254	PFAU/SERI.1B//AMAD/3/WAXWING/4/AKURI/5/PFAU/SERI.1B//AMAD/3/WAXWING	2016/17
8	NL 1260	BAJ #1/3/ KIRITATI//HUW 253+ LR 34/PRINIA/4/KIRITATI//HUW 234 + LR 34/ PRINIA	2016/17
9	NL 1328	PICAFLOR #1/4/INQALAB 91*2/TUKURU//T. SPELTA PI 348599/3/INQALAB 91*2/KUKUNA/5/KINGBIRD#1//INQALAB 91*2/TUKURU	2016/17
10	BL 4818	NL 971/NL 1082	2017/18
11	BL 4820	NL 971/NL 1082	2017/18
12	NL 1298	SUP 152/3/IWA 8600211//2*PBW 343*2/KUKUNA	2017/18
13	NL 1311	WBLL 4//OAX 93.24.35/WBLL1/5/CROC_1/AE. SQ (205)//BORL 95/3/PRL/SARA//TSI/VEE #5/4/FRET 2	2017/18
14	NL 1317	NAC/TH. AC.//3*PVN/MIRLO/BUC/4/2*PASTOR/5/T. DICOCCON PI 94624/AE.SQ (409)//BCN/6/WBLL 4//BABAX. 1B.1B*2/PRL/3/PASTOR/7/SUP 152	2017/18
15	NL 1318	PBW 343*2 /KUKUNA//PBW 343*2/KUKUNA/3/IWA8600211//2*PBW343*2/KUKUNA/4/PBW 343*2/KUKUNA//TECUE #1	2017/18
16	NL 1322	SERI.1B//KAUZ/HEVO/3/AMAD*2/4/KIRITATI*2/6/BAV	2017/18

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		92//IRENA/ KAUZ/3/HUITES/4/T. SPELTA PI 348764/5/ BAV 92//IRENA/KAUZ/3/HUITES	
17	NL 1368	OASIS/SKAUZ//4*BCN/3/2*PASTOR/4/T. SPELTA PI348449/5/BACEU#1/6/WBLL1*2/CHAPIO	2017/18
18	NL 1369	T. DICCOCON CI 9309/AE. SQUARROSA (409) //MUTUS /3/ 2*MUTUS	2017/18
19	BL 4699	BL 3235/WBLL 1*2/3/WEAVER/OCI//BORL 95	2016/17 and 2017/18
20	BL 4707	BL 3629/KIRITATI//SERI/RAYON	2016/17 and 2017/18
21	BL 4708	BL 3629/KIRITATI//SERI/RAYON	2016/17 and 2017/18
22	NL 1202	NAC/TH.AC//3*PVN/3/MIRLO/BUC/4/2*PASTOR/5/KACHU/6/ KACHU	2016/17 and 2017/18
23	NL 1307	ROLF07/4/BOW/NKT//CBRD/3/ CBRD/5/FRET2/TUKURU//FRET2	2016/17 and 2017/18
24	NL 1325	KVZ/PPR 47.89C//FRANCOLIN #1/3/2* PAURAQ/4/PBW 343*2/KUKUNA*2//FRTL/PIFED	2016/17 and 2017/18
25	NL 1326	PICUS/3/KAUZ*2 BOW//KAUZ/4/KKTS/5/T. SPELTA PI 348530/6/2*FRANCOLIN #1/7/2* WBLL 1/KUKUNA//TACUPETO F2001/3/BAJ #1	2016/17 and 2017/18
26	NL 1327	MELON//FILIN/MILAN/3/FILIN/5/CROC_1/AE.SQUARROSA (444)/3/T.DICOCCON PI94625/AE.SQUARROSA (372)//3*PASTOR/4/T.DICOCCON PI94625/AE.SQUARROSA (372)//3*PASTOR/6/ATTILA/3*BCN//BAV92/3/ TILHI/5/ BAV92/3/PRL/SARA//TSI/VEE#5/4/CROC_1/AE.SQUARROSA (224)//2*OPAT	2016/17 and 2017/18
27	RR 21	1154-388/AN/3/YT54/NIOB/RL64	2016/17 and 2017/18
28	BHRIKUTI	CMT/COC 75/3/ PLO//FURY/ANA 75	2016/17 and 2017/18
29	GAUTAM	SIDDHARTHA/NING8319/NL 297	2016/17 and 2017/18

Experimental design and treatment details

Twenty wheat genotypes including three check varieties were planted in Alpha lattice design with two replications. Each replication had five blocks consisting of four plots. The plot size was 10 square meter (10 rows of four meter length). The spacing maintained was 25 cm between the rows.

Cultural practice

Seeding was done on the third to fourth week of November in all locations. The seed rate was 120 kg/ha. The fertilizer was applied @ 60:30:20 N: P_2O_5:K_2O kg/ha. All fertilizer was applied as the basal dose.

Data observation

Observations on quantitative characteristics like days to heading (DH), days to maturity (DM), plant height (PH), Grains number per Spike (GNPS), thousand grains weight (TGW) and Spikes per meter square (SPMS) and grain yield (GY) were measured and collected.

Statistical analysis

Data entry and processing was carried out using Microsoft Office Excel 2007. Analysis of variance (ANOVA) and mean estimation were done with the software- R Studio (R version

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4.0.2).The significant differences between varieties were determined using the least significant difference (LSD) test at 1% or 5% level of significance (Gomez & Gomez, 1984; Shrestha, 2019).

RESULTS AND DISCUSSION

RESULTS

The analysis of variance showed, highly significant difference among genotypes for days to heading, days to maturity, plant height, number of grains per spike and thousand grain weight. Likewise, significant difference for grain yield and non significant difference among genotypes for number of spikes per meter square was obtained during 2016/17 (Table 3).

Table 3: Combined means of agronomic traits in CVT-Rain-fed environment across five locations (NWRP-Bhairahawa, NMRP-Rampur, NSRP-Jitpur, DoAR-Nepalgunj and DoAR-Doti) in 2016/17

S.N.	Genotypes	DH (days)	DM (days)	PH (cm)	No. of Spikes/m^2	Number of Grains/Spike	TGW (g)	Grain Yield (kg/ha)
1	BL 4335	77	124	89.4	228	35	47.8	2413
2	BL 4699	79	128	95.3	240	40	46.4	2559
3	BL 4707	80	128	90.1	229	42	43.8	2654
4	BL 4708	79	126	85.7	254	40	47.5	2652
5	NL 1202	80	127	87.3	219	44	45.2	2683
6	NL 1207	85	131	82.8	224	43	41.8	2415
7	NL 1211	81	127	87.3	219	41	48	2719
8	NL 1244	80	128	87	252	48	41.4	2338
9	NL 1247	81	129	86.3	252	39	40.1	2393
10	NL 1253	77	125	81.2	224	42	44.3	2629
11	NL 1254	76	127	81.1	232	46	42.9	2465
12	NL 1260	77	125	82.5	219	46	39.5	2331
13	NL 1307	80	129	82.6	204	45	45.9	2288
14	NL 1325	78	128	83.1	226	44	42.6	2600
15	NL 1326	73	124	87.9	273	47	38.3	2954
16	NL 1327	79	129	85.1	225	47	43.7	2734
17	NL 1328	80	127	81	218	43	42	2294
18	RR 21	76	128	86.8	232	39	44.2	2229
19	BHRIKUTI	76	126	79.7	235	44	44.7	2489
20	GAUTAM	77	128	87	202	46	45.5	2379
Grand Mean		78	127	85.5	230	43	43.8	2511
F-test (Genotype)		**	**	**	ns	**	**	*
Genotype x Location		ns	**	ns	ns	ns	**	ns
LSD (0.05)		5.26	4.35	13.5	83.77	12.9	7.62	840.69
CV (%)		3.42	1.74	8.06	18.55	15.31	8.88	17.08

*Where, LSD= Least Significant difference, CV = Coefficient of Variation, *Indicates significant difference among the tested genotypes (where, p is> 0.01 to 0.05). **indicates the highly significant difference among the tested genotypes (where, p is <0.01). ns = non-significant difference among the tested genotypes (where, p > 0.05).*

The days to heading ranged from 73 to 85 days with mean days to heading of 78 days. Similarly days to maturity ranged from 124 to 131 days with mean days to maturity of 127 days. The TGW observed was highest in the NL 1211(48 g) followed by BL 4335 (47.8 g), BL 4708 (47.5 g), NL 1307 (45.9 g), Gautam (45.5 g), NL 1202(45.2 g) and NL 1327(43.0 g). Similarly, the grains per spike was highest in the NL 1244 (48) followed by NL 1327 (47),

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NL 1326 (47), NL 1254 (46), NL 1260 (46), NL 1307 (45) and NL 1202 (44). The average grain yield was found 2511 kg/ha. The highest grain yield was observed in NL 1326 (2954 kg/ha) followed by NL 1327 (2819 kg/ha), NL 1211 (2719 kg/ha), NL 1202 (2683 kg/ha), BL 4707 (2654 kg/ha), BL 4708 (26 52 kg/ha), NL 1253 (2629 kg/ha), NL 1325 (2600 kg/ha) and BL 4699 (2559 kg/ha). The Check variety Bhrikuti yielded 2489 kg/ha (Table 3).

In 2016/17, the highest mean grain yield of the tested genotypes was observed at Rampur, Chitwan (3877 kg/ha). Similarly, the lowest was observed at Jitpur, Bara (1508 kg/ha) (Table 4). Significant difference among the tested genotypes was observed for grain yield at Bhairahawa, Rampur, Khajura and Doti whereas that of the Jitpur was non-significant (Table 4).

Table 4: Grain yield (kg/ha) of advance wheat genotypes in different locations (Bhairahawa, Nepalgunj, Doti, Jitpur and Rampur) in CVT rain-fed environment in 2016/17

S. N.	Genotypes	NWRP, Bhairahawa	DoAR, Banke	DoAR, Doti	NSRP, Jitpur	NMRP, Rampur
1	BL 4335	1471	3432	2191	1112	3688
2	BL 4699	1947	3056	2677	2000	4082
3	BL 4707	1573	2999	2523	1752	3765
4	BL 4708	1511	2978	2451	1642	4173
5	NL 1202	1590	3365	2707	1528	3840
6	NL 1207	1356	2328	2286	1303	4060
7	NL 1211	1769	3627	2904	1396	4058
8	NL 1244	1700	2420	2265	1608	4083
9	NL 1247	1353	2845	2755	1157	3684
10	NL 1253	1472	2786	2674	1706	4083
11	NL 1254	1365	3408	2758	1490	4172
12	NL 1260	1208	2191	2651	1162	4183
13	NL 1307	1822	3606	2715	1055	3210
14	NL 1325	1210	4173	2796	1617	3573
15	NL 1326	1692	4185	2915	2064	4282
16	NL 1327	1935	2953	2977	1222	4376
17	NL 1328	1368	3296	2131	1616	3526
18	RR 21	1262	2078	2513	1468	3083
19	BHRIKUTI	1634	2498	1941	1945	4004
20	GAUTAM	1358	3364	2365	1326	3620
Grand Mean		1540	3079	2560	1508	3877
F-test		*	*	*	ns	*
LSD (0.05)		336.5	786.27	554.99	621.27	540.63
CV (%)		14.8	14.9	13.6	16.2	12.8

*Where, LSD= Least Significant difference, CV = Coefficient of Variation, *Indicates significant difference among the tested genotypes (where, p is> 0.01 to 0.05). **indicates the highly significant difference among the tested genotypes (where, p is <0.01). ns = non-significant difference among the tested genotypes (where, p > 0.05).*

Highly Significant difference among the genotypes was observed for the days to heading, days to maturity and plant height and non-significant difference among the genotypes was found for number of grains per spike, grain yield and TGW. However, Genotype by Environment (G X E) was found highly significant for the days to heading, plant height, grain yield and TGW and significant difference for number of grains per spike during 2017/18(Table 5).

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Table 5: Combined means of agronomic traits in CVT-Rainfed environment across three locations (NWRP-Bhairahawa, NMRP- Rampur and DOAR-Doti) in 2017/18

S.N	Genotypes	DTH (days)	DTM (days)	PH (cm)	No. of Spikes/ m^2	No. of Grains per Spike	TGW (g)	Grain Yield (kg/ha)
1	BL 4699	82	118	77	197	40	41.1	2065
2	BL 4707	81	116	71	181	35	35.7	1904
3	BL 4708	78	116	74	190	37	37.5	2197
4	BL 4818	87	119	79	239	39	40.1	2046
5	BL 4820	86	120	77	193	42	40.2	2118
6	NL 1202	82	119	73	176	36	39.9	2205
7	NL 1298	76	116	66	208	40	37.3	1817
8	NL 1307	84	119	70	205	42	40.7	1976
9	NL 1311	86	120	71	173	38	40.5	1764
10	NL 1317	82	118	70	201	37	37.4	1746
11	NL 1318	83	118	76	214	38	38.5	2030
12	NL 1322	84	119	71	211	37	39.9	2305
13	NL 1325	81	119	69	187	39	38.0	1847
14	NL 1326	78	118	71	240	38	33.0	1853
15	NL 1327	81	118	73	185	37	40.9	1800
16	NL 1368	88	123	70	209	39	33.1	1890
17	NL 1369	80	117	69	195	37	37.6	2287
18	RR 21	79	117	75	210	39	35.0	1851
19	BHRIKUTI	82	119	67	191	44	37.0	2024
20	GAUTAM	81	119	73	172	47	40.1	1996
Grand Mean		82.1	118.3	72.2	198.9	39.1	38.2	1986.2
LSD (0.05)		3.85	2.50	5.24	47.96	10.75	6.16	555.25
CV (%)		1.4	1.5	3.6	17.9	11.4	5.9	14.4
F-Test (Genotypes)		**	**	**	ns	ns	Ns	ns
F-test (Genotypes x Location)		**	ns	**	ns	*	**	**

*Where, LSD= Least Significant difference, CV = Coefficient of Variation, *Indicates significant difference among the tested genotypes (where, p is> 0.01 to 0.05). **indicates the highly significant difference among the tested genotypes (where, p is <0.01). ns = non-significant difference among the tested genotypes (where, p > 0.05).*

The heading date among the tested genotypes ranged from 76 to 88 days. The days to maturity ranged from 116 to 123 days and plant height was ranged from 66 cm to 79 cm among tested entries (Table 5).Wheat genotypes BL 4708, NL 1298 and BL 4707 were the early maturing genotype with 116 days of maturity followed by NL 1369 (117 days) and NL 1327 (118 days).The TGW ranged from 33 to 41 grams with mean value of 38.2 g. The highest thousand grain weight was observed in the BL 4699 with 41.1 g followed by NL 1327 (40.9 g), NL 1307 (40.7 g), NL 1311(40.5g), BL 4820 (40.2g), BL 4818 (40.1g) and NL 1202 (39.9g).The grain yield ranged from1746 to 2305 kg/ha with average value of 1986 kg/ha. The highest grain yield was observed in NL1322 (2305 kg/ha), followed by NL1369

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(2287 kg/ha), NL 1202 (2205 kg/ha), BL 4708 (2197 kg/ha) and BL 4820 (2118 kg/ha) in CVT-TTL in 2017/18 (Table 5).

In biplot analysis, the genotypes NL 1326, NL 1318, NL 1368, NL 1327, BL 4818, BL 4699 and NL 1311 were found highly stable in all locations. Under Doti and Bhairahawa condition genotypes BL 4818, BL 4820, NL 1307, NL 1322, NL 1369 and BL 4708 performed better than others. Similarly, under Rampur condition wheat genotype NL 1202 and BL 4699 performed well (Figure 1).

In 2017/18 the highest mean grain yield was observed at Rampur and that was followed by Doti. Similarly, in these locations significant difference among the genotypes was observed for the grain yield. In Bhairahawa the difference among the genotypes for the grain yield was non-significant (Table 6).

Table 6: Grain yield (kg/ha) of advance wheat genotypes in different locations (NWRP-Bhairahawa, NMRP-Rampur and DOAR-Doti) in CVT rain-fed environment in 2017/18

S.N.	Genotypes	NWP, Bhairahwa	DoAR, Doti	NMRP, Rampur
1	BL 4699	1057	1096	4227
2	BL 4707	1146	698	4045
3	BL 4708	1043	1340	3948
4	BL 4818	1376	1184	3569
5	BL 4820	1393	1209	3662
6	NL 1202	1269	1115	4381
7	NL 1298	1095	786	3523
8	NL 1307	959	1663	3247
9	NL 1311	876	1278	3128
10	NL 1317	1193	1335	2526
11	NL 1318	1116	944	3993
12	NL 1322	1454	1699	3724
13	NL 1325	957	1405	3365
14	NL 1326	1145	1150	3389
15	NL 1327	1271	1216	2930
16	NL 1368	1056	1066	3683
17	NL 1369	1359	1278	4159
18	RR 21	781	1023	3488
19	BHRIKUTI	1270	868	4059
20	GAUTAM	1109	996	3854
Grand Mean		1146	1167	3645
F-Test (Genotype)		ns	*	*
LSD Value (0.05)		403.5	416.46	877.9
CV (%)		13.4	16.8	11.3

*Where, LSD= Least Significant difference, CV = Coefficient of Variation, *Indicates significant difference among the tested genotypes (where, p is> 0.01 to 0.05). **indicates the highly significant difference among the tested genotypes (where, p is <0.01). ns = non-significant difference among the tested genotypes (where, p > 0.05).*

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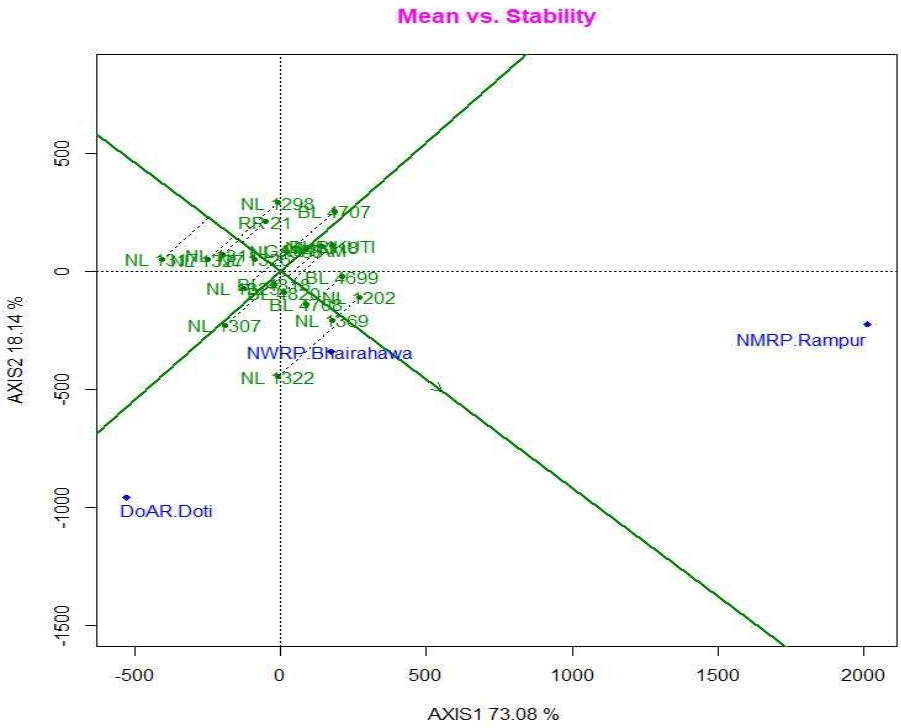
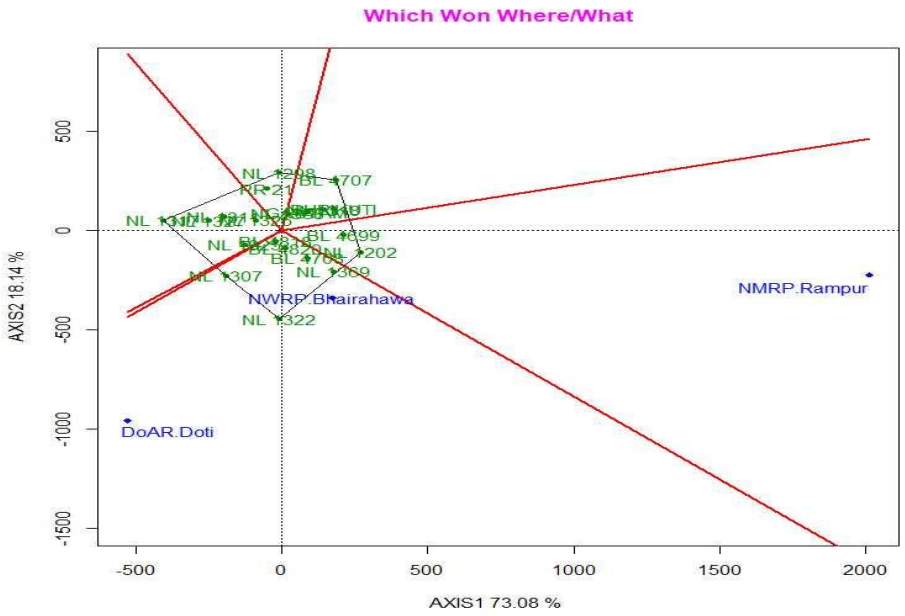


(a)



(b)

Figure 1: (a) "Mean Vs Stability" view of GGE biplot and (b)"Which won where" based on the G × E data of grain yield of advanced wheat genotypes in different locations (Bhairahawa, Rampur and Doti) in 2017/18. *The data were not transformed ("Transform = 0"), not scaled ("Scaling = 0"), singular value partitioning ("SVP" = GH, column matrix preserving) and were tester-centered (G+GE). It represents 91.22 percent of the total G+GE.*

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DISCUSSION

There was a significant difference among the tested genotypes for most of the agro-morphological traits studied which are similar to the finding reported by Sharma (1994), Khan *et al.* (2015) and Baloch *et al.* (2013). Significant difference among the tested genotypes for the grain yield was observed under rain-fed condition in a study conducted in Pakistan (Raza, 2017) which is in accordance with that of the result of CVT under rain-fed in 2016/17. Based upon the grain yield and yield attributing traits, best genotypes need to be selected and promoted to coordinated farmer's field trial (CFFT). From the CVT-TTL (2016/17) eight genotypes BL 4699, BL 4707, BL 4708, NL 1202, NL 1307, NL 1325, NL 1326 and NL 1327 are recommended to retain in the CVT-TTL (2017/18) (NWRP, 2018). Outstanding result for the NL 1202, BL 4707 and BL 4708 was obtained also in 2015/16 under the rain-fed condition (Pandey *et al.*, 2017). Similarly, excellent performance of the NL 1202 was observed also in the western Terai region (Tripathi *et al.*, 2017). Three genotypes BL 4335, NL 1211 and NL 1307 are recommended for testing in coordinated farmers' field trial in next season. Similarly, in 2017/18 a highly significant difference and wide range of variation for all characters indicated the presence of sufficient variability among the genotypes. Similar results were also reported by Alam *et al.* (2013) and Desheva and Cholakov (2014).The winning cultivars are detected using features of GGE biplot analysis (Voltas *et al.*, 2005).The best performing stable wheat genotypes NL 1327 and BL 4818 have been identified using the technique. From the CVT-TTL (2017/18), seven genotypes (BL 4818, BL 4820, NL 1318, NL 1322, NL 1368 and NL 1369) were retained for the CVT-TTL (2018/19) and three genotypes (BL 4699, NL 1307 and NL 1327) were promoted to the coordinated farmers' field trial (NWRP, 2018). NL 1307, NL 1317, and NL 1302 have the good combination of highest spikes/m^2, grains per spike and TGW. Wheat genotype NL 1307 also had the early maturity and relatively good yielded in testing locations of western Nepal (Yadav *et al.*, 2019). Earliness coupled with high yield of genotypes under rain-fed environment is desirable in crop improvement. According to Mwadzingeni *et al.* (2016) and Dodig *et al*. (2012) earliest and shortest genotypes can yield high under stress condition by producing high tiller number and high thousand kernel weight. Ehdaie *et al*. (2006) and Reynolds *et al.* (2006) reported water soluble carbohydrate of stem contributed grain growth when canopy photosynthesis is inhibited under water limiting condition. Based upon the overall performance of wheat genotypes BL 4708, NL 1202, NL 1211, NL 1307, NL 1327 and NL 1369 are recommended to retain in Coordinated Farmer's Field Trial for the better conformation in the farmers' field for the release as variety.

CONCLUSION

Rain-fed condition provides the selection environment for drought tolerance. A highly significant difference and wide range of variation for all characters indicated the presence of sufficient variability among the genotypes. Stability analysis has further confirmed the adaptation of the genotypes to a particular environment. Among these tested genotypes BL 4708, NL 1202, NL 1211, NL 1307, NL 1327 and NL 1369 are recommended for the coordinated farmer's field trial for further verification and release as variety.

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Authors' contributions

D. Pandey, K. R. Pant, R. Giri, S. Bohara, G. B. Hamal and S. Shrestha involved in the conduction of the research. D. Pandey and K. R. Pant recorded and analyzed the data. J. Shrestha helped in analysis of data. All authors approved the final version of articles to be published.

Conflict of interest

The authors declare no conflicts of interest regarding publication of this manuscript.

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