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

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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), NL 1202 (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.
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_1/1/AE.SQ (224)//OPATA/7/PASTOR/MILAN/KAUZ/3/BAY 92 | 2016/17 |
| 5    | NL 1247   | KRICHAUFF/2*PASTOR/2*SOKOLL | 2016/17 |
| 6    | NL 1253   | PFAU/SERI.1B/AMAD/3/WAXWING/4/4AKURI/5/PFAU/SERI.1B/AMAD/3/AMAD/WAXWING | 2016/17 |
| 7    | NL 1254   | PFAU/SERI.1B/AMAD/3/WAXWING/4/4AKURI/5/PFAU/SERI.1B/AMAD/3/AMAD/WAXWING | 2016/17 |
| 8    | NL 1260   | BAJ #1/3/KIRITATI/HUW 253+ LR 3/PRINIA/4/KIRITATI/HUW 234 + LR 34/PRINIA | 2016/17 |
| 9    | NL 1328   | PICAFLOR #1/4/INQALAB 91*2/TUKURU/T.SELTA PI 348599/3/INQALAB 91*2/KUKUNA/5/KINGBIRD#1/1/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 6800211/3*PBW 343*2/KUKUNA | 2017/18 |
| 13   | NL 1311   | WBBL 4/OAX 93.24.35/WBLL 1/5/CROC_1/1/AE.SQ (205)/BOLR 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)/BCLN/6/WBLL 4/4BABEL/1B.1B*2/PRL/3/PASTOR/7/SUP 152 | 2017/18 |
| 15   | NL 1318   | PBW 343*2/KUKUNA/PBW 343*2/KUKUNA/3/IWA 6800211/2*PBW343*2/KUKUNA/4/PB W 343*2/KUKUNA/TUCUE #1 | 2017/18 |
| 16   | NL 1322   | SERI.1B//KAUZ/HEVO/3/AMAD/2/4/KIRITATI/2/6/BAY | 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\textsubscript{2}O\textsubscript{5}:K\textsubscript{2}O 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
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, 1999).

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/m² | 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    | 2625                |
| 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

F-test (Genotype )

| Genotype x Location | ns | ns | ns | ns | ns |

LSD (0.05)

| 5.26 | 4.35 | 13.5 | 83.77 | 12.9 |

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),
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 (2652 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 advanced 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       | 1815         | 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).
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/ m² | 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.
(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).
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.
DISCUSSION

There was a significant difference among the tested genotypes for most of the agromorphological 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/m², grains per spike and TGW. Wheat genotype NL 1307 also had the early maturity and relatively good yield 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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