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ARTICLE
Wheat Varietal Investigation for the Hill Region of Nepal

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ABSTRACT

Multilocation testing of the Coordinated Varietal Trial for Mid-hill and High Hill (CVT-MHH) of wheat genotypes were conducted at different hill research stations of Nepal Agricultural Research Council (NARC) during the normal planting season of 2012-13 and 2013-14. Twenty genotypes including two check varieties were included in Randomized Complete Block (RCB) design with three replications in the experiment. Data on the different yield attributing traits were recorded. Highly significant difference (p<0.01) among the genotypes for the days to heading, days to maturity, plant height, thousand grain weight and grain yield was observed in 2012-13. Wheat genotype BL 4061 had the highest grain yield with 3802 kg/ha followed by NL 1153 (3736 kg/ha), NL 1159 (3733 kg/ha), NL 1154 (3674 kg/ha) and NL 1156 (3462 kg/ha). In 2013-14 also a highly significant difference among the genotypes for all the recorded traits was observed and these genotypes were stable for the yield and yield attributing traits. The most promising genotype for the grain yield was NL 1153 (5816 kg/ha) followed by NL 1178 (5760 kg/ha), NL 1156 (5454 kg/ha), NL 1159 (5259 kg/ha) and NL 1179 (5075 kg/ha). From the yield and other yield attributing trait wheat genotypes NL 1055, NL 1153, NL 1159, NL 1156 and NL 1179 need to be tested under farmers' field for further confirmation and release as variety.

1. Introduction

Wheat is the third major cereal crop after rice and maize in Nepal. Wheat is grown from Terai to high mountain region and consumption of wheat in recent years is increasing day by day. In Nepal wheat has covered the area of 703992 ha with the production of 2,005,665 metric tons and productivity of 2849 kg/ha [15]. The Mid-hills and high hills represent 32% of the total production and 43% of the area. The area under wheat production in mid and high hills was 317458 ha and production was 598243 metric tons with the average productivity of 2047 kg/ha (MOAD, 2017) [14]. The low level of productivity in hills and high hills is mainly due to difficulty in the availability of improved varieties on one hand and occurrence of disease on the other. Yield gaps are generally associated with the lack of adoption of recommended technologies [8]. Since there is little scope for increasing land area under wheat, the major challenge will be to break the yield barrier by pragmatic genetic and developmental approaches [3]. It is very crucial to increase the grain yield to meet the current and future demands of food. Development of the

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high yielding varieties for the hills of Nepal is important to meet the required production and food security of that region.

Nepal has a wide variety of climatic condition due to the topographical differences within short north-south span of the country. About 70 to 90% of the rainfall occurs during the summer monsoon months (June to September) in Nepal and the rest of the months are almost dry. Wheat is cultivated during the dry winter period and therefore, supplementary irrigation plays a vital role in its cultivation. Varieties of wheat have been developed to suit the local climatic conditions. Due to the availability of improved seeds, modern cultivation practice and a supplementary irrigation; the wheat cultivation has increased substantially throughout Nepal in the recent years [16].

Improvement and selection of high input, stress responsive and wide adaptive wheat genotypes with preferred traits are necessary to increase production and productivity for ensured food security [4]. Existing varieties are not sufficient to increase sustainable production and productivity due to climate change, disease outbreak, population growth, decreasing land and other resources. Because of the fast rate of urbanization, transport system development, growing industry and changing food habits of the people, quantity and quality improvement in wheat is the urgent need of the country. Therefore, with the objective to develop high yielding varieties with other desirable traits for hilly region, Coordinated Varietal Trials were conducted at different locations representing hill environments of the country.

2. Materials and Methods

Multilocation testing of wheat genotypes was done at five different agricultural research stations. Planting was done in normal wheat season (November) of 2012-2013 and 2013-2014 in Agriculture Botany Division, Khumaltar; Horticulture Research Station, Dailekh; Agriculture Research Station, Pakhribas; Hill Crop Research Program, Dolakha and Agriculture Research Station, Jumla (Table 1). Selected genotypes from the CIMMYT nurseries and yield trials and newly developed genotypes through hybridization at Bhairahawa and Agricultural Botany Division, Khumaltar were included in the CVT-MHH. Twenty genotypes including two check varieties, *Dhaulagiri* and *WK 1204* were used in the experiment. Randomized Complete Block (RCB) design with three replications was used. Arrangement of the treatments was with four genotypes in the rows and five genotypes in the column. The distance between the rows was 25 cm. The area of each experimental unit was six square meter witheight rows of three meter length.

Data on quantitative characteristics like days to heading (DH), days to maturity (DM), plant height (PH), Grains per Spike (GPS), thousand grain weight (TGW), Spikes per meter square (SPMS) and grain yield (GY) were recorded. Data were analyzed utilizing ANOVA technique on Gen-stat program [22].

Table 1. Details of the Experiment conducted locations in 2012-13 and 2013-14

S.N.	Research Stations	Address	Geographical Position	Altitude (meters above sea level)
1	Agriculture Research Station (ARS)	Pakhribas, Dhankuta	27°05’ N 87°14’E	1889
2	Hill Crop Research Program (HCRP)	Kabre, Dolakha	27°38’ N 86°08’E	1733
3	Agriculture Botany Division (ABD)	Khumaltar, Lalitpur	27°39’ N 85°19’E	1321
4	Horticulture Research Station (HRS)	Kimugaun, Dailekh	28°50.83’ N 081°43.3’ E	1255

3. Results and Discussion

A highly significant difference ($p < 0.01$) among the tested genotypes was observed for all the traits in 2012-13 and 2013-14. Location specific variation for the tested genotypes for all traits was non-significant (>0.05) in 2012-13 (Table 2). In 2013-14 also a highly significant difference among the tested genotypes was observed for all the recorded traits and the genotypes were stable for the yield and yield attributing traits (Table 3). Genotypically plant height, grains per spike and 1000-grain weight were positively and significantly correlated with grain yield while highly significantly associated phenotypically [12]

3.1 Days to Heading

The stage from partial to full appearance of spike is also called ear emergence or heading [1]. In this study, there was a significant difference among the tested genotypes for days to heading in 2012-13. The most early genotype in heading days was NL 1055 (108) followed by NL 1082 (109), NL 1153 (109), BL 4241 (110), NL 1118 (111) and NL 1117 (112) in 2012-13 (Table 2). The 12 genotypes were earlier than the mean days to heading and 10 genotypes were earlier than the check varieties Dhaulagiri and WK 1204. Similarly, a highly significant difference among the tested genotypes was observed for days to heading in 2013-14 (Table 3). Check variety Dhaulagiri was the earliest genotype with 122 days to heading which

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was followed by NL 1084 (123), NL 1055 (124), NL 1185 (125), BL 4423 (126), and NL 1120 (129) (Table 3). The result with the highly significant difference among the genotypes for days to heading is in agreement with the Subedi *et al*. [20] in the study of the genotypic performance in the hills of Nepal.

3.2 Days to Maturity

Physiological maturity is usually defined as the time when the flag leaf and spikes turn yellow [9]. Asignificant difference among the tested genotypes for days to maturity was observed in 2012-13 (Table 2). The most early maturing genotype was BL 4291 (156) followed by NL 1055 (157), NL 1082 (159), NL 1118 (160), BL 4278 (160), WK 2164 (161) and NL 1156 (161). Seven genotypes matured earlier than the mean days to maturity in 2012-13. Similarly a highly significant difference was observed in 2013-14 for the days to maturity. In 2013-14, the earliest maturity was observed in NL 1055 with 173 days followed by Dhaulagiri (175), NL 1184 (176), NL 1082 (177), WK 2183 (177), NL 1180 (178), WK 2182 (178) and NL 1179 (179) (Table 3). These observations are similar with the result obtained by Pandey et al. [18].

3.3 Plant Height

The plant height was determined by measuring the distance between the base of the stem and the top of the spike excluding awns. Both grain and plant height are important objectives for any wheat breeding program because grain provides energy, protein and dietary fiber in human nutrition while the height can increase the straw yield which becomes the important forage for livestock. Therefore, breeding for plant height as well as grain yield is the foremost challenges for a wheat breeder. Plant height, number of grains per spike, thousand grain weight, biological yield and grain yield contribute equally to average grain yield of wheat crop (Khan, 2016)[13]. Highly significant difference among the tested genotypes for plant height was observed in both years. There was non-significant GXE interaction (Table 2 and Table 3). The shortest plant height was observed in NL 1160 with 72 cm followed by WK 1204 (73 cm), NL 1117 (76 cm), and NL 1118 (76 cm). Eleven genotypes were shorter than the mean genotypes in 2013-14. Similarly, in 2013-14 the shortest plant height was in NL 1185 with 85 cm followed by WK 2123 (86), WK 1204 (87), NL 1055 (89), NL 1082 (89), WK 2182 (90) and NL 1179 (92). Eleven genotypes had lower height than the mean (Table 3). This finding is similar to the previous findings obtained by Gautam *et al.*[6].

Table 2. Combined analysis of different traits evaluated in 2012-13 in CVT-MHH at Khumaltar and Pakhribas

Genotypes	DH	DM	PH	SPMS	TGW	GY
BL 4061	114	163	85	274	42	3802
NL 1055	108	157	81	278	34	3205
NL 1078	114	162	81	195	39	3235
NL 1082	109	159	83	224	40	3457
NL 1117	112	162	76	332	33	3053
NL 1118	111	160	76	306	33	3275
NL 1120	112	163	84	253	41	3170
WK 1581	127	161	100	244	38	3110
BL 4278	112	160	85	213	35	3188
BL 4291	110	156	83	274	33	2339
NL 1153	109	164	92	224	44	3736
NL 1154	115	161	85	224	41	3674
NL 1156	113	161	84	229	41	3462
NL 1157	115	163	84	253	36	2969
NL 1159	115	163	84	235	40	3733
NL 1160	115	162	72	245	35	3186
NL 1161	112	162	79	264	36	3256
WK 2164	112	161	82	235	32	3366
Dhaulagiri (Check)	113	164	80	223	37	2868
WK 1204 (Check)	115	164	73	262	37	3287
GM	113	161	82	249	37	3269
F-test (E)	*	**	**	**	**	**
F-Test (EXL)	ns	ns	ns	ns	ns	ns
LSD (0.05)	9.44	2.64	5.57	45.82	3.76	444.04
CV (%)	8.8	1.6	6.8	14.4	10	8.6

Notes:
*Where GM= Grand Mean, E= Entry (Genotype), L= Location, 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 <0.05) ns = non-significant difference among the tested genotypes (where, p > 0.05).*

3.4 Spikes per meter Square

Highly significant difference among the tested genotypes in both years was observed for the number of spikes per meter square. There was no GXE interaction observed. Spikes per meter square indicate the tillering capacity of the crop and the plant population in the experiment. The highest number with 332 spikes per meter was observed in NL 1117 followed by NL 1118 (306), NL 1055 (278)

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and BL 4291 (274). Ten genotypes had higher spikes per square meter than the mean in 2012-13 (Table 3). In 2013-14 the highest number of spikes per square meter was observed in WK 2134 (343) followed by NL 1179 (321), WK 2123 (303), NL 1185 (299), NL 1055 (294), WK 2183 (292), WK 2180 (291). Ten genotypes had higher SPMS than the grand mean (279). The present result coincides with those of Thapa *et al.*[21].

3.5 Grains per Spike

It has generally been observed that high yield in bread wheat varieties is associated with the increasing number of grains spike (Ashebr *et al.*., 2020)[2]. The observation was not taken for the grains per spike in 2012-13 (Table 2). The tested wheat genotypes were significantly different for grains per spikewith non-significant GE interaction, indicating variation among genotypes with no effect of location. Our result for the grains per spike has been supported by the result of Ilyas and Mohammad [10]. In the 2013-14, the number grains per spike was observed in NL 1082 (53) and NL 1153 (53) which was followed by WK 2183 (52), BL 4460 (50) WK 1204 (49), NL 1178 (48), WK 2180 (47) and NL 1156 (47) (Table 3). Nine genotypes had higher grains per spike than the mean of 46 grains.

3.6 Thousand Grain Weight

The thousand grain weight was the highest in NL 1153 with 40 g followed by BL 4061 (41), NL 1120 (41), NL 1156 (41), NL 1154 (41), NL 1082 (40), NL 1159 (40) and NL 1078 (39). Nine genotypes had the higher thousand grain weight than the mean and both of the check varieties Dhaulagiri and WK 1204 (Table 2). Highly significant difference among the tested genotypes was observed and there was no GXE and the variation among the genotypes for the grain weight was due to the genotypic variation. The highest TGW was in NL 1178 (59) in 2013-14 followed by NL 1153 (58), BL 4423 (58), NL 1184 (58), Dhaulagiri (57), NL 1156 (57) and NL 1183 (57) (Table 3). Eleven genotypes had the higher TGW than the mean of 54 g. This result is similar to the result obtained by Gautam *et al.*. [6]and Pandey et *al.*., (2020).

3.7 Grain Yield

Highly significant difference among the tested genotypes for grain yield was observed. Wheat genotype BL 4061 had the highest grain yield of 3802 kg/ha followed by NL 1153 (3736 kg/ha), NL 1159 (3733 kg/ha), NL 1154 (3674 kg/ha), NL 1156 (3462 kg/ha) and NL 1082 (3457 kg/ha). Nine genotypes had higher grain yield than the grand mean (3269 kg/ha) and seven had the higher yield than the checks. The highest GY in 2013-14 was in NL 1153 (5816) followed by NL 1178 (5760), WK 2123 (5475), NL 1156 (5454), NL 1159 (5259), NL 1179 (5075) and WK 1204 (5035). Nine genotypes had the higher grain yield than the mean yield. In our experiments there were significant differences among the genotypes for grain yield which are in agreement with Sharma [19]; Kamat [11]; Ginkel et al. [7]; Dwivedi *et al.* [5] and Pandey *et al.* [17].

Table 3. Summary of combined analysis in CVT-MHH across 4 locations (Dolakha, Pakhribas, Khumaltar and Dailekh) in 2013-14

Genotypes	DH	DM	PH	GPS	SPMS	TGW	GY (kg/ha)
NL 1153	130	184	108	53	259	58	5816
NL 1178	134	181	96	48	284	59	5760
WK 2123	135	180	86	46	303	48	5475
NL 1156	133	181	94	47	277	57	5454
NL 1159	137	182	96	44	260	55	5259
NL 1179	132	179	92	43	321	54	5075
WK 1204 (Check)	137	182	87	49	287	53	5035
NL 1185	125	181	85	42	299	49	4937
WK 2182	132	178	90	45	259	56	4917
WK 2180	134	180	94	47	291	55	4897
NL 1183	131	180	89	46	262	57	4895
NL 1180	129	178	91	38	267	55	4829
NL 1184	123	176	98	47	241	58	4710
WK 2134	138	181	93	37	343	48	4605
NL 1082	125	177	89	53	258	50	4486
NL 1055	124	173	89	46	294	50	4480
BL 4460	134	181	96	50	247	51	4475
WK 2183	134	177	91	52	292	51	4441
BL 4423	126	180	92	40	254	58	4435
Dhaulagiri (Check)	122	175	95	42	283	57	4283
GM	130.6	179.3	92.53	45.72	279	53.88	4913
P value (Genotype)	**	**	**	**	**	**	**
P value (Genotype X Environment))	*	ns	ns	ns	ns	ns	ns
LSD (0.05)	3.1	2.4	8.08	5.9	41.9	5	685
CV (%)	3	1.7	10.8	14.2	13.6	11.6	14

Note:
*Where GM= Grand Mean, E= Entry (Genotype), L= Location, 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 <0.05). ns = non-significant difference among the tested genotypes (where, p > 0.05).*

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4. Conclusion

There was a highly significant difference ($p < 0.01$) among the tested genotypes for days to heading, days to maturity, plant height, spikes per meter square, number of grains per spike, thousand grains weight and grain yield in both years. This indicates the presence of sufficient variability among the tested genotypes and provides a good opportunity for wheat improvement program. There was no significant GXE indicates these genotypes are stable for the observed traits. The most promising genotypes with higher grain yield, more number of grains per spike, bolder grain size, early days to heading and maturity were identified from the varietal investigation. From the analysis of yield and other yield attributing trait wheat genotypes NL 1055, NL 1153, NL 1159, NL 1156 and NL 1179 need to be tested under farmers' field for further confirmation and release as variety.

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