Wheat Genetic Resources in Nepal

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ABSTRACT

Genetic diversity must be maintained and utilized for sustainable agriculture development. The amount of genetic diversity in the country depends on the number and diversity of the original ancestors involved in the creation of a germplasm pool, wild relatives and existing landraces. The objective of this research was to study the diversity of wheat gene pool present in the Nepalese bread wheat cultivars and landraces that could help for developing conservation and utilization strategy effectively. We examined the pedigrees of 35 Nepalese wheat cultivars and surveyed the literature for distribution of landraces and wild relatives of wheat. Cultivated landraces of spring and winter type, wild landraces and diploid species of wheat are found in Nepal. There are 35 improved wheat cultivars, 540 landraces and 10 wild relatives of wheat. Crosses between winter and spring wheat gene pools are far more common and offer a new source of diversity. Mexico, India and Nepal are the origin countries for 35 cultivars. In Nepal four cultivars were bred and developed using foreign landraces and maximum number of cultivars was developed in Mexico. Lerma 52, first improved cereal variety to be released in the history of cereal breeding in Nepal was released in 1960. A total of 89 ancestors originated in 22 different countries were used to develop these cultivars. Highest number of ancestors was from India. Ancestors of both *aestivum* and *durum* species having winter, spring and intermediate growth habit indicated the collection of wide gene pool. Most of the ancestors were *aestivum* (76.40%) and spring growth habit (57.31%). Modern varieties are replacing the landraces and improved old varieties resulted in the genetic erosion. Therefore, *in situ*, on farm and *ex situ* conservations are necessary for maintaining these genetic variations. Unutilization of local landraces in breeding program may be the major factor that causes to accelerate the genetic erosion. Gene pool from these landraces along with international gene pool could make towards success in developing high yielding cultivars with wide adaptability. In this study, cultivars and landraces surveyed represent a wide range of variation for different areas of origin and adaptation.

Key words: Ancestor, landrace, origin, wheat gene pool

INTRODUCTION

Wheat has been growing since time immemorial particularly in Far and Mid Western hills of Nepal. Mudwari (1999) reported many landraces and 10 wild relatives of wheat in Nepal. It is the third most important crop after rice and maize in Nepal. During mid 1960s the yield potential of dwarf high yielding varieties initiated a scope for raising wheat production in the country. Several exotic varieties were obtained through CIMMYT and USAID (NARC 1997). National Wheat Development Programme was established in 1972 to organize the research and development works on wheat as a commodity crop. Since then, there have been great achievement brought out by the consolidated efforts of wheat researchers, extension workers and farmers. So far there are 35 improved wheat cultivars and 90% of the wheat area is covered by modern wheat cultivars in Nepal (Bhatta et al 2000). Currently wheat is mainly used for bread and biscuits and is becoming more important in Nepalese economy.

Genetic diversity is necessary to derive different transgenic segregants suitable for different agro-ecology to meet the needs of farmers. Both the potential for long term genetic gain and the reduction of genetic vulnerability may depend on the genetic diversity present in the genetic base. The amount of genetic diversity presents depends on the number and diversity of the original ancestors involved in the creation of a germplasm pool and existing landraces. The level of genetic variation present in gene pools of most important crops has been analyzed by studying the pedigree relationship between cultivars. Kinship coefficients estimation of cultivars of oat (Souza and Sorrells 1989), soybean (Cox et al 1985a), winter wheat (Cox et al 1985b), rice (Dilday 1990) and barley (Martin et al 1991) has shown that a restricted number of ancestral genotypes account for a large proportion of the variation present in released cultivars. However Nepalese wheat cultivars possess great diversity because of using many ancestral genotypes to develop them (Joshi et al 2004). Richness on wheat taking into account the ancestors of cultivars and landraces should be assessed for effective conservation and utilization of wheat gene pools. Therefore we have focused here on landraces and its distribution in Nepal and countries from where genes were introduced through improved lines in Nepal.

METHODOLOGY

Literature related to wheat exploration, improved cultivars and Nepalese landraces were reviewed. Two sites, National Wheat Research Program (NWRP), Bhairawa and Plant Genetic Resources (PGR) Unit, Khumaltar were visited. PGR Unit has collected many wheat landraces from different parts of Nepal. Based on collection data landraces distribution were indicated in Nepal map. Frequency of wheat accessions collected from different districts and conserved in PGR Unit were computed. We examined the pedigrees of all 35 cultivars. Altogether 35 cultivars had been released in Nepal from 1960 to 2001. Most of the cultivars were introduced either from CIMMYT, Mexico or India. The pedigrees of all bread wheat cultivars were traced back to their ancestors that had no known relationship each other. The source of pedigrees and release dates for cultivars were Jain (1994), NARC (1997), Bland (2001), Skovmand et al (1997) and Skovmand et al (2000). Countries from where the genes introduced through the improved lines in Nepal were located in world map.

RESULTS AND DISCUSSION

The land in Nepal has the largest variations in altitude in the world. It lies between 26^o 22'N to 30^o 27'N and 80^o 4'E to 88^o 12'E. Elevation ranges from 60 to 8848m. Three types of land *Bari* (upland), *Khet* (lowland) and flat and fertile with good soil depths produce wheat indicating the diverse wheat genotypes adapted to different production environments. Wheat is grown as winter crop sown in October or November and harvested in March or April. It is also grown as a summer crop sown in April or May coming to fruition in September or October. Due to the varied agro-ecological diversity of the country, it is possible to plant same cultivar in both winter and summer season. Nepal is not original home for wheat but under the CGIAR system Nepal received a lot of wheat genotypes. In 1965, the Department of Agriculture launched a Grow more wheat campaign with the introduction of Mexican semi dwarf wheat resulted in a rapid expansion in wheat area and production.

Nepal is politically divided into five regions (Eastern, Central, Western, Mid Western and Far Western). Only two exploration missions have targeted wheat species in Western Nepal. Eighteen exploration programs were carried out in different parts of Nepal to collect different crops species. There are 63 landraces, which are differed by name and conserved in ABD (Table 1). These are collected from different altitude ranging from 720 to 3353 m. Farmer unit of description (FUD) is generally related to their phenotype and use value. FUD also indicates the level of diversity present in wheat gene pool. There may be many landraces that are genetically same but differed only by name or vise versa. These need to verify. ABD has 390 accessions of wheat landraces collected from all over the Nepal. These are conserved *ex situ* at medium term storage facility in Khumaltar, Kathmandu. Due to agro ecological differences Nepalese genotypes may contain unique genes. Dutch scientists who collected in around 1981, wheat in remote part of the Himalayan in Nepal has found material that is new and considerably different from germplasm already in gene bank anywhere in the world (Hawkes 1981). These genes if conserved properly could be enough to fulfill wheat diversity demand for developing wheat cultivars for next century.

Table 1. Different Nepalese wheat landraces and their cultivating area

SN	Landrace	District	Location	Altitude, m
1	Badi gahun	Bajura	Gadukhati-9	1768
2	Bangali gahun	Kalikot	Jubitha-7, Jubitha	1792
3	Bartole gahun	Baitadi	Patan	1372
4	Bhabri gahun	Mugu	Srinagar-5, Chaina	1960
5	Bhagere gahun	Baglung	Bhimpokhara	1565
6	Bhartole gahun	Baitadi	Gokuleswor-1, Kalchunde	720
7	Bhote gahun	Solukhumbu	Salleri	2408
8	Bhugari gahu	Bajura	Atichaul-1	1981
9	Bikase gahun	Darchula	Gokuleswor-3, Gokuleswor	750
10	Bikasi seto gahun	Sallyan	Dandagaon	1200
11	Bugoti	Bajura	Dogdi-6	1829
12	Bungoli	Bajhang	Kalukheti-8	1737
13	Chamdi gahun	Bajura	Gadukhati-9	1768
14	Dabde gahun	Jumla	Patrasi-7, Shelagarhigaon	2713
15	Dabdi gahun	Dandeldhura	Joishina	1585
16	Dabdikhane gahun	Dandeldhura	Matar gaon	
17	Dalkhane gahun	Kalikot	Mahadev-7, Sarkivada	1980
18	Dapche gahun	Dandeldhura	Bhel	1585
19	Daudi	Baitadi	Patan	1372
20	Daudi gahun	Baitadi	Shidheswor-8, Amarkholi	2070
21	Dhaule gahun	Baitadi	Gokuleswor-1, Kalchunde	720
22	Dho	Mustang	Kagbeni	2697
23	Dho/gahun	Mustang	Jharkot	3353
24	Dhu	Mustang	Khinga	3216
25	Dolkhe gahun	Khotang	Khalde	1402
26	Dudhe murilo	Rukum	Vulma	823
27	Gahun	Baglung	Dobira	1010
28	Gaile gahun	Bajura	Gadukhati-9	1768
29	Geru gahun	Mugu	Pina-5, Balagaon	2035
30	Gharelu gahun	Dandeldhura	Manara	1158
31	Hansa gahun	Myagdi	Benibagar	792
32	Jhirke	Bajhang	Majhigaon-8	1585
33	Jhuse gahun	Sallyan	Dandagaon	1100
34	Jhuse rato gahun	Kalikot	Mahadev-7, Sarkivada	1980
35	Keuma gahun	Solukhumbu	Chhulembu	2195
36	Lal gahun	Kanchanpur	Mahendra nagar-19	
37	Lalitpur local			
38	Lera rato gahun	Sallyan	Dandagaon	1200
39	Lere seto gahun	Sallyan	Tharmare	1160
40	Thaniya gahun	Jumla	Birat-9, Ludku	2390

SN	Landrace	District	Location	Altitude, m
41	Lunthung gahun	Taplejung	Lelep-5, Lunthum	1800
42	Mude gahun	Dandeldhura	Bhandare	1530
43	Mudlo gahun	Baglung	Gitapatha	1094
44	Mudule gahun	Arghakhanchi	Dhikura-2, Gairakot	1200
45	Mudulo gahun	Myagdi	Dhode	747
46	Murala gahun	Rolpa	Khumil	1500
47	Murulo rato gahun	Jajarkot	Gagane khola	2775
48	Nano gahun	Dandeldhura	Ghatal	1768
49	Paude gahun	Baitadi	Vasling-3, Gwane	2040
50	Pawai	Bajura	Kolti	2000
51	Peta gahun	Solukhumbu	Chhulembu	2195
52	Rani gahu	Bajhang	Majhigaon-8	1585
53	Rato gahun	Jajarkot	Risang	2850
54	Ratonal	Baitadi	Patan	1372
55	Ratonale	Baitadi	Patan-1	1372
56	Rupali gahun	Dandeldhura	Amargadhi-2, Dotighatal	1750
57	Sano gahun		Suda	
58	Sate gahun	Taplejung	Nankholyang-5, Myakha	900
59	Seto gahun	Rukum	Khara	
60	Talak gahu		Mahendra nagar	
61	Tari gaire	Bajura	Gadukhati-9	1768
62	Those gahun	Bajura	Gadukhati-9	1768
63	Thulo ghumche	Jajarkot	Danda gaon	2750

Source: Gupta et al 2000.

Nepal has many locally adapted wheat but any one has not been used or improved for developing Nepalese wheat cultivars. Such trends lead to genetic erosion. NWRP has maintained 150 landraces and ABD has 390 accessions of wheat. There may be duplicate accessions in these two places. Removing duplicate accessions and adding new one should be made continuously. Characterization, evaluation and utilization of these landraces in breeding program by NWRP and ABD could certainly enhance the wheat genes pool conservation. Landraces are mostly found in Western regions and only few locations of Central and Eastern regions (Figure 1) in Nepal. It is still unanswered why these landraces get popularized in remote areas e.g. Western Nepal. There are many important landraces in Western region. *Dabad Khani* is most popular local wheat suited to maize based cropping pattern in Western region. This distribution pattern could help to locate diverse wheat areas and to implement *in situ*, on farm conservation and exploration program. This pattern suggests that there are diverse wheat landraces adapted to different environments.

ABD has representative wheat landraces from 29 out of total 75 districts of Nepal (Table 2). Highest number of wheat accessions was collected from Dandeldhura (3.59% of total accessions) followed by Baitadi (3.33%), Bajura and Baglung. Dandeldhura, Baitadi, Bajura, Baglung and Achham may be the focal area in term of wheat landraces diversity. Due to the expansion of modern varieties these landraces are under threats of extinction. Extensive survey and duplication study of accessions could help to control genetic erosions and conservation cost. Many of these landraces are still grown by farmers and are the mixtures of white and brown coloured spike, amber and red coloured kernels, awned and awnless characters. These landraces have a wide range of natural adaptation to withstand varied abiotic and biotic conditions. In addition, these landraces have high tillering ability, withstand severe drought stress, have high protein content and longer seed dormancy. These are pure spring bread wheat types.

Some landraces with winter growth type have been reported in the northern high mountain area bordering Tibet, China. In addition to these, some diploid species have also been reported in the northern high mountains. Since these landraces are adapted to a small confined area, and wheat was considered a minor cereal until the middle of 20th century, there was no attempt to improve these landraces or the production practices. These landraces are generally grown under marginal lands under rainfed and low fertility conditions.

Table 2. Frequency and total accessions of wheat landraces collected from different districts of Nepal and conserved in Agriculture Botany Division Khumaltar

SN	District	Accession, n	Frequency, %	SN	District	Accession, n	Frequency, %
1	Achham	11	2.82	17	Khotang	3	0.77
2	Arghakhanchi	1	0.26	18	Manang	5	1.28
3	Baglung	12	3.08	19	Mugu	5	1.28
4	Baitadi	13	3.33	20	Mustang	9	2.31
5	Bajhang	6	1.54	21	Myagdi	6	1.54
6	Bajura	12	3.08	22	Nawalparasi	1	0.26
7	Dandeldhura	14	3.59	23	Panchthar	1	0.26
8	Darchula	4	1.03	24	Pyuthan	2	0.51
9	Doti	6	1.54	25	Rolpa	2	0.51
10	Gorkha	1	0.26	26	Rukum	6	1.54
11	Gulmi	2	0.51	27	Sallyan	5	1.28
12	Jajarkot	5	1.28	28	Solukhumbu	7	1.79
13	Jumla	6	1.54	29	Taplejung	2	0.51
14	Kalikot	5	1.28	30	Unknown	236	60.51
15	Kanchanpur	1	0.26				
16	Kaski	1	0.26		Total	390	

Thirty-five improved bread wheat varieties suitable to hills, plains and Western regions of Nepal are real efforts of researchers to be released during the period from 1960 to 2001. More numbers of crosses involving many parental lines in cultivars like Annapurna 2, Annapurna 4, Bhrikuti, LR64, RR21, NP884 and NP809 indicate the effort of scientists to collect value genes in single genotype. Four cultivars were released in 1997, which is the year of releasing highest number of cultivars. These cultivars were Achyut, Kanti, Pasang Lhamu and Rohini. Lerma 52, first improved cereal variety to be released in the history of cereal breeding in Nepal (Bland 2001) was released in 1960.

A total of 89 ancestors originated in 22 different countries were used to develop 35 cultivars (Table 4). Mexico, India and Nepal are the origin countries for 35 cultivars. In Nepal four cultivars had been originated and maximum number of cultivars was originated in Mexico. Ancestors of both *aestivum* and *durum* species having winter, spring and intermediate growth habit indicated the collection of wide gene pool.

Table 3. Improved bread wheat varieties released from 1960 to 2001 in Nepal

SN	Variety	Abbr†	Pedigree	Origin	Year released	Area of adaptation
1.	Achyut	ACH	CPAN168/HD2204	India	1997	Plains
2.	Annapurna1	ANNA1	KVZ/BUHO//KAL/BB	Mexico	1988	Hills
3.	Annapurna2	ANNA2	NAPO/TOB//8156/3/KAL/BB	India	1988	Hills
4.	Annapurna3	ANNA3	KVZ/BUHO//KAL/BB	Mexico	1991	Hills
5.	Annapurna4	ANNA4	KVZ/3/CC/INIA//CNO/ELGAU/4/SN64	Mexico	1994	Hills
6.	Bhrikuti	BK	CMT/COC75/3/PLO//FURY/ANA	Mexico	1994	Plains
7.	Bhairahawa Line1022	BL1022	PVN/ALD	Nepal	1991	Western Terai
8.	Bhairahawa Line1135	BL1135	QTZ/TAN	Nepal	1994	Plains
9.	Bhairahawa Line1473	BL1473	NL297/NL352	Nepal	1999	Plain & Hills
10.	Hybrid Delhi1982	HD1982	E5557/HD845	India	1975	Western Plains
11.	Kalyansona	KAL	PJ/GB55	Mexico	1968	Plains
12.	Kanti	KANTI	LIRA/FFN//VEE	Mexico	1997	Hills
13.	Kenya291	K291	NA‡	Kenya	1962	Hills
14.	Lerma52	L52	MTA/K324	Mexico	1960	Hills
15.	Lerma Rojo64	LR64	Y50/N10B//L52/3/2*LR	Mexico	1967	Hills
16.	Lumbini	LUM	E4871/PJ	India	1981	Plains
17.	Nepal Line251	NL251	WH147/HD2160//2*WH147	India	1988	Plains
18.	Nepal Line297	NL297	HD2137/HD2186//HD2160	India	1985	Plains
19.	Nepal Line30	NL30	HD832/BB	India	1975	Western Plains
20.	New Pusa799	NP799	NP 792	India	1962	Hills
21.	New Pusa809	NP809	DO/C518//SPP/NP114/3/WIS245	India	1962	Hills
22.	New Pusa835	NP835	NP760/RN	India	1962	Plains
23.	New Pusa852	NP852	KF/2*NP761	India	1962	Plains
24.	New Pusa884	NP884	KC6042/GUL//PLT/3/K58/N/4/NP755	India	NA†	Plains
25.	Pasang Lhamu	PAL	PGO/SERI	Mexico	1997	Hills
26.	Pitic62	PI	YT54/N10B 26.1C	Mexico	1967	Hills
27.	Rohini	ROH	PRL/TONI//CHIL	Nepal	1997	Plains
28.	Rust Resistant21	RR21	II53.388/AN/3/YT54/N10B/3/LR/4/B4946.A.4.18.2.IY/Y53//3*Y50	Mexico	1971	Hills & Plains
29.	S331	S331	LR64/HUAR	Mexico	1971	Hills & Plains
30.	Siddhartha	SID	HD2092/HD1962//E4870/3/K65	India	1983	Plains
31.	Sonora64	SN64	YT54/N10B//2*Y54	Mexico	1967	Hills
32.	Triveni	TRI	HD1963/HD1931	India	1982	Plains
33.	Uttar Pradesh262	UP262	S 308/BAJIO 66	India	1978	Plains
34.	Vaskar	VKR	TZPP/PL//7C	Mexico	1983	Mid-western Plains
35.	Vinayak	VIN	LC55	India	1983	Plains

† Abbr, Abbreviation. ‡ NA, Not available.
Source: NARC 1997.

Wheat genes from all regions of the world were introduced in Nepal through improved cultivars (Figure 2). Maximum ancestors were from India followed by USA and Kenya. Thanks to CGIAR, India, USA, Kenya, Australia and Argentina. Involvement of ancestors from 22 countries indicates the introduction of genes adapted to different geographic locations. Even though contributions of Nepalese wheat landraces in the world is not known, world contribution is recognized in wheat development in Nepal. A single landrace of each of eight countries have been used in developing wheat cultivars probably because of having value genes with them. It can be concluded that breeders can develop best varieties by reshuffling the genes from these wide collections.

Table 4. Ancestors of 35 Nepalese wheat cultivars and their origin

SN	Name	Abb†	Origin		Growth habit	Species
			Name	Abb		
1.	21931	21931	ISREAL	ISL	?	AESTIVUM
2.	36896	36896	ARGENTINA	ARG	?	AESTIVUM
3.	8A	8A	INDIA	IND	?	AESTIVUM
4.	8B	8B	INDIA	IND	?	?
5.	9D	9D	INDIA	IND	?	AESTIVUM
6.	AKAGOMUGHI	AGM	JAPAN	JPN	WINTER	AESTIVUM
7.	ALFREDO CHAVES 6.21	AC	BRAZIL	BRA	SPRING	AESTIVUM
8.	B4946.A.4.18.2.IY	B4946	?	?	?	?
9.	BONZA	BZA	COLOMBIA	COL	SPRING	AESTIVUM
10.	BREVOR	BVR	USA	USA	WINTER	AESTIVUM
11.	BUNGE NO 2	BN2	?	?	?	?
12.	BUTTON	BUTTON	?	?	?	AESTIVUM
13.	C13	C13	INDIA	IND	SPRING	AESTIVUM
14.	C209	C209	INDIA	IND	SPRING	AESTIVUM
15.	CARIANCA422	CAR422	CHILE	CHL	WINTER	AESTIVUM
16.	CENTENARIO	CTR	BRAZIL	BRA	SPRING	AESTIVUM
17.	CHRIS	CHR	USA	USA	SPRING	AESTIVUM
18.	CLEMENT	CMT	NETHERLANDS	NLD	WINTER	AESTIVUM
19.	CPAN1687	CPAN1687	INDIA	IND	SPRING	AESTIVUM
20.	DAVIS6301	D6301	USA	USA	?	AESTIVUM
21.	DEMOCRATE	DO	USA	USA	?	AESTIVUM
22.	EL GAUCHO	ELGAU	ARGENTINA	ARG	SPRING	AESTIVUM
23.	FEDERATION	FR	AUSTRALIA	AUS	SPRING	AESTIVUM
24.	FLORENCE	FLO	?	?	?	?
25.	FROCOR	FCR	BRAZIL	BRA	SPRING	AESTIVUM
26.	FUFAN17	FFN	CHINA	CHN	SPRING	AESTIVUM
27.	FURY	FURY	KENYA	KEN	SPRING	AESTIVUM
28.	GABO-AUS	GB	AUSTRALIA	AUS	SPRING	AESTIVUM
29.	GAZA	GAZA	EGYPT	EGY	SPRING	DURUM
30.	GENERAL URQUIZA	GU	ARGENTINA	ARG	SPRING	AESTIVUM
31.	HARD FEDERATION	HF	AUSTRALIA	AUS	SPRING	AESTIVUM
32.	HARDRED CALCATTA	HRC	INDIA	IND	SPRING	AESTIVUM
33.	HOPE	H44	USA	USA	?	AESTIVUM
34.	HYBRID DELHI845	HD845	INDIA	IND	SPRING	AESTIVUM
35.	IUMILLO	IU	USA	USA	SPRING	DURUM
36.	KANRED	KR	USA	USA	WINTER	AESTIVUM
37.	KAVKAZ	KVZ	RUSSIA	RSA	WINTER	AESTIVUM
38.	KENTANA48	KT48	MEXICO	MEX	SPRING	AESTIVUM
39.	KENYA C6042	KC6042	KENYA	KEN	?	?
40.	KENYA GOVERNER	KGV	KENYA	KEN	SPRING	AESTIVUM
41.	KENYA STANDARD	KS	KENYA	KEN	SPRING	?
42.	KENYA117A	K117A	KENYA	KEN	SPRING	AESTIVUM
43.	KENYA256	K256	KENYA	KEN	SPRING	?
44.	KENYA291	K291	KENYA	KEN	SPRING	AESTIVUM
45.	KENYA324	K324	KENYA	KEN	SPRING	?
46.	KENYA350-A-D9-C-2	KAD	KENYA	KEN	SPRING	?
47.	KENYA58	K58	KENYA	KEN	SPRING	AESTIVUM
48.	KHAPLI	KHP	INDIA	IND	SPRING	DURUM
49.	KLEIN ATLAS	KLAT	ARGENTINA	ARG	SPRING	AESTIVUM
50.	KLEIN RENDIDOR	KLRE	ARGENTINA	ARG	SPRING	AESTIVUM
51.	LA ESTANZUELA2787C	LAEST	**?**	?	?	?
52.	LC55	LC55	INDIA	IND	?	?
53.	LERMA ROJO	LR	MEXICO	MEX	SPRING	AESTIVUM
54.	MARNE DESPREZ	MD	FRANCE	FRA	WINTER	AESTIVUM

SN	Name	Abb†	Origin		Growth habit	Species
			Name	Abb		
55.	MARROQUI	MRQ	MOROCCO	MAR	SPRING	AESTIVUM
56.	MARSALL'S NO 3	MS-A	AUSTRALIA	AUS	?	AESTIVUM
57.	MCMURACHY	MCM	CANADA	CAN	SPRING	AESTIVUM
58.	MIDA-U	MIDA	USA	USA	SPRING	AESTIVUM
59.	MUNDIA	MUNDIA	INDIA	IND	?	?
60.	NAINARI60	NAI60	MEXICO	MEX	?	AESTIVUM
61.	NAPO	NAPO	COLOMBIA	COL	SPRING	AESTIVUM
62.	NARINO59	NAR59	COLOMBIA	COL	SPRING	AESTIVUM
63.	NEW PUSA773	NP773	INDIA	IND	SPRING	AESTIVUM
64.	NORIN10	N10	JAPAN	JPN	WINTER	AESTIVUM
65.	NP114	NP114	INDIA	IND	?	AESTIVUM
66.	OLESEN'S DWARF	ON	ZIMBABWE	ZIM	SPRING	AESTIVUM
67.	P4160E	P4160E	MEXICO	MEX	SPRING	AESTIVUM
68.	POLYSSU	PSSU	BRAZIL	BRA	SPRING	AESTIVUM
69.	QUINTZEL	QTZ	?	?	?	?
70.	RED FIFE	RF	CANADA	CAN	SPRING	AESTIVUM
71.	RED MACE	RM	GREAT BRITAIN	GBR	WINTER	AESTIVUM
72.	REITI	REITI	?	?	?	?
73.	S339	S339	INDIA	IND	SPRING	AESTIVUM
74.	SANTA ELENA	SE	USA	USA	SPRING	AESTIVUM
75.	SINVALOCHO MA	SCHOMA	ARGENTINA	ARG	SPRING	AESTIVUM
76.	SPALDING PROLIFIQUE	SPP	GREAT BRITIAN	GBR	?	AESTIVUM
77.	STEINWEDEL	SWD	AUSTRALIA	AUS	SPRING	AESTIVUM
78.	TEZANOS PINTOS RECOZ	TZPP	ARGENTINA	ARG	SPRING	AESTIVUM
79.	THEW	THEW	AUSTRALIA	AUS	WINTER	AESTIVUM
80.	TIMESTEIN	T	AUSTRALIA	AUS	SPRING	AESTIVUM
81.	TYPE1	TYPE1	PAKISTAN	PAK	?	DURUM
82.	TYPE9	TYPE9	PAKISTAN	PAK	?	AESTIVUM
83.	VERNAL EMMER	VN	RUSSIA	RSA	SPRING	DURUM
84.	WAGGA13	WG13	?	?	?	?
85.	WEIQUE	W	DEUTSCHLAND	DEU	WINTER	AESTIVUM
86.	WILHELMINE	WHM	NETHERLANDS	NLD	WINTER	AESTIVUM
87.	WILLET ERONO	WTE	USA	USA	SPRING	AESTIVUM
88.	WIS 245	WIS 245	?	?	?	?
89.	YAKTANA54	YT54	MEXICO	MEX	SPRING	AESTIVUM

† Abb, Abbreviation. ? Not known.

Use of 89 ancestors from 22 different countries represent the great diversity in built in 35 Nepalese wheat cultivars. Ancestors were with different growth habit eg spring (57.31%) and winter (13.48%). There were 76.40% *aestivum* and 5.62% *durum* ancestors species. Such diversity in species, origin and growth habit in ancestors have certainly enriched Nepalese wheat biodiversity.

Despite high yielding attributes of improved cultivars compared to those of local types improved varieties were found to be susceptible to diseases and lodging (Shrestha 1976). There are many examples of improved varieties gaining popularity within a short period of time but later become susceptible to biotic stresses. Such trend was not reported in landraces. In this study, cultivars surveyed represent a wide range of variation for different areas of origin and adaptation. This genetic diversity may be useful for further wheat improvement. The results of this study may help in the selection of the most diverse cultivars and greatly expand genetic variation for wheat improvement. Measurers of genetic diversity can be used to maximize the level of variation in segregating populations by intermating cultivars with greater genetic distance. Modern varieties are replacing the landraces and improved old varieties resulted in the genetic erosion. Therefore, *in situ*, on farm and *ex situ* conservations are necessary for maintaining the genetic variation in Nepalese wheat. Government, semi governmental and private agencies should take action to conserve and utilize wheat genetic variations present in Nepal.

Nepal being proximal to the secondary source of origin of wheat, might harbor the wheat relatives in addition to the so far recorded one species of *Aegiolopes* and nine species of *Agropyron*. Since wild germplasm is a valuable source for improving bread wheat productivity and durability, explorations on those wild relatives are suggested followed by their proper characterization and utilization in the breeding program. Gene pool from cultivated landraces of spring and winter type, wild landraces and diploid species of wheat along with international gene pool could make to success in developing high yielding cultivars with wide adaptability.

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