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Review paper

Diversity, conservation and utilization of grain legumes: A potential source for food and nutritional security in Nepal

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ABSTRACT

Grain legumes are precious crops of Nepal in terms of the dietary protein supplement ample concentration of micronutrients, and role in crop intensification and ameliorating soil fertility. About 11% of the cultivated area is occupied by grain legumes that include lentil, chickpea, grasspea, fieldpea, fababean, pigeonpea, soybean, blackgram, horsegram, ricebean, cowpea, and mungbean. About 100 genera and 379 species of legumes are distributed in diverse agroecological zones ranging from terai to the alpine region of Nepal, with growth habits ranging from annual to perennial shrubs. Out of the 379 species of legumes which include grain, vegetable, and forage legumes, 262 are native, and 20 species belonging to the sub-group Papilionacae are used as food legumes. Highest food legume species diversity has been recorded in *Macrotyloma* (34 spp.), followed by *Crotalaria* (18 spp.), *Vigna* (15 spp.), *Lathyrus* (7 spp.), *Vicia* (6 spp.), *Cajanus* (5 spp.), *Trigonella* (5 spp.) and *Phaseolus* (4 spp.). Other genus having 1-3 species includes *Cicer* (3 spp.), *Mukuna* (3 spp.), *Glycine* (2 spp.), *Canavila* (2 spp.), *Pisum* (2 spp.), *Lablab* (2 spp.), *Pachyrrhizus* (1 sp.), *Psophocarpus* (1 sp.), *Lens* (1 sp.) and *Cyamopsis* (1 sp.). Research on grain legumes was initiated in 1976 and a systematic collection of grain legume landraces was done in 1987 by the Grain Legumes Research Program (GLRP). Past collection missions organized in collaboration with the International Development Research Centre (IDRC), the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), the International Center for Agricultural Research in the Dry Areas (ICARDA), and other institutes have resulted in the collection of 1107 landraces and provided an opportunity for their inclusion in the variety improvement program. National Agricultural Genetic Resources Center (NAGRC) has conserved 2936 landraces of different legumes, 951 landraces have been kept in gene banks of ICARDA center, while GLRP Khajura has active collections of 218 landraces and 627 exotic germplasm of various legume crops. Varietal improvement programs resulted in the development of 51 varieties, while 6 varietes were registered and two varieties were de-notified in food legumes (lentil, chickpea, soybean, cowpea, black gram, mungbean, pigeon pea, rice bean, faba bean, grass pea, and kidney bean).

Key words: Agrobiodiversity, Fabaceae, Grain legumes

INTRODUCTION

Nepal has a diverse climatic, geographical variation, and diverse culture. Three agroecological zones i.e. Tarai, Mid Hill, and High Hill experience a wide range of climates from tropical to temperate and arctic. The variation is mainly attributed to immense changes in elevation from 60 to 8848 masl. The wide variation in the agro-climatic condition of the country within a short range allows several species of grain legumes to be grown in the country. The Fabaceae family comprises more than 650 genera and about 18,000 species, thereby constituting the third-largest family of flowering plants (Polhill and Raven, 1981). About 100 genera and 379 species of legumes are widely distributed from Terai to the alpine region of Nepal (www.Ffloras.org.). Out of the 379 species, 262 are native and the other species are either introduced or unknown (Shrestha, 1994). Twenty species under the Papilionacae subfamily are used as pulses or grain legumes (Shrestha, 1994; Regmi, 1996), while some species like *Pachyrrhizus, Psophocarpus or Crotalaria* are used for tubers, pods, or flowers, respectively.

Grain legumes under the subfamily papilionacae are important crops of Nepal in terms of their contribution to the dietary protein supply to the people and maintenance of soil fertility through symbiotic nitrogen fixation. These crops occupy 10.75% of the total cultivated area of the country. Among cultivated legumes, lentil occupies a prominent place in terms of area and production. Pulse crops such as chickpea or gram (*Cicer arietinum* L.), pea (*Pisum sativum* L.), lentil (*Lens culinaris* subsp. *culinaris* Medikus), grasspea or lathyrus (*Lathyrus sativus* L.) and faba bean or broad bean (*Vicia faba* L.) are grown during winter months mostly in rotation with rice in residual soil moisture, while soybean (*Glycine max* (L.)) Merrl., cowpea (*Vigna unguiculata* (L.) Walp), mungbean or green gram (*Vigna radiata* (L.) Wilczek), black gram or mash (*Vigna mungo* (L.) *Hepper*), pigeon pea (*Cajanus cajan* (L.) Millsp.), horse gram or Kulthi (*Macrotyloma uniflorum (Lam.)* Verdc,. common bean or rajma or rajmash (*Phaseolus vulgaris* L.) and ricebean (*Vigna umbellata* (L.) Ohwi and Ohashi) are grown as sole crop or intercrop with maize or on bund during summer or spring or autumn seasons depending upon varieties and agro-ecological zones. Although the Food and Agriculture Organization (FAO) defines soybean as an oil crop, it is still the food crop in mountainous regions where it plays an important role in the maize-based farming system and provides dietary protein to rural people. In FAO statistics, dry bean includes *Phaseolus* spp. and *Vigna* spp. (except cowpea) and pulse crops of minor relevance such as lablab or hyacinth bean (*Lablab purpureus* (L.) Sweet, sword or jack bean (*Canavalia* spp.), winged bean (*Psophocarpus tetragonolobus*), guar bean (*Cyamopsis tetragonolaba*), yam bean (*Pachyrrhizus erosus* L.) etc. are also being grown in Nepal. Other summer pulses of minor importance are lima or butter bean (*Phaseolus lunatus L.*); adzuki bean (*Vigna angularis* Ohwi & H. Ohashi); scarlet runner bean (*Phaseolus coccineus* L.); moth bean or haricot bean (*Vigna aconitifolius (Jacq.) Marechal*); tepary bean (*Phaseolus acutifolius*), Kause simi or velvet bean (*Stizolobium* spp.) and other *Vigna* spp (Akibode and Maredia 2011). Horsegram and rice bean are underutilized species in Nepal (ANBTRACO 2006). This review article discussed the diversity, conservation, and utilization of grain legumes as a potential source of food and nutritional security in Nepal.

GRAIN LEGUMES SPECIES

In Nepal, different grain legume species are grown (Table 1) which has been discussed below.

Cajanus

The *Cajanus cajan* (L.) Millsp is the cultvited species of the genus *Cajanus* having chromosome number 2n = 2x=22 along with a genome size of 845 Mbp (Greilhuber and Obermayer, 1998). It is an important grain legume in drier areas of central and mid-western terai, and it is a new introduction in the midhills. It covers about 5% of the total area and production in Nepal (MoAC 2013). This crop can be grown in wasteland, terraces, bunds, and in agroforestry systems. It has multiple uses as food, fuel, fodder, soil fertility improvement, and reducing soil degradation in sloppy land. In general, mono-crop of pigeon pea is taken in dry areas of western terai, while bund planting is popular in central and eastern terai. Mixed cropping pigeon pea with maize, sorghum, or sesame is popular among farmers in the Terai.

Seven wild species *Atylosia elongate* Benth., *Atylosia mollis* Benth., *Atylosia scarabaeoides, Atylosia volubilis* (Blanco.) Gamble. and *Atylosia cajanifolia* (Haines) Maesen. have been reported in Nepal. Wild pigeonpea, *Atylosia* spp;. syn. *Cajanus scaraboides L.,* often with tendrils intertwined with other shrubs/grasses with bright yellow flowers and small pubescent pods are found growing from terai to high hills in wastelands and forests. *Atylosis* elongate Benth, *A. scarabeeoides* (L) Benth, and *A. molis* Benth. have been found in Kakani (Shrestha and Shrestha, 1996).

Canavalia

Two cultivated species *Canavalia ensiformis* (L.) DC., and *Canavalia gladiate* (Jacq.) *DC.* have been reported. Both these species have a diploid 2n=2x=22 chromosomes. Seeds are edible and other plant parts are used as fodder. The species are distributed in the midhills to high hills.

Crotalaria

One species *Crotalaria juncea* L. is grown extensively as a green manure crop and leaves, tender twigs, and flowers are consumed as vegetables. It has a diploid chromosome number 2n=2x=16. Eighteen species have been found in Nepal, which are distributed from Terai to high hills.

Cicer

Chickpea *(Cicer arietinum* L.) is a popular winter crop in Nepal. It is a diploid with 2n=2x=16 chromosomes and a genome size of approx. 750

Table 1. Cultivated grain legume species and their wild relatives in Nepal

Genus	English Name	Nepali Name
Cajanus		
Cajanus cajan (L.) Millsp.	Pigeonpea	Rahar
Atylosia elongate. Benth., *Mollis* Benth., A. *scarabaeoides* L., *A. volubilis* (Blanco) Gamble, *A. cajanifolia* (Haines) Maesen	Wild pigeonpea	Jungali rahar
Canavalia		
Canavalia ensiformis (L.) DC.	Jackbean	Khunde simi
Canavalia gladiate (Jacq.) *DC.*	Swordbean	Tarbare simi
Crotalaria		
Crotalaria juncea L.	Sunhemp	Sanai, Chinchine
Cicer		
Cicer arietinum L.	Chickpea	Chana
Cicer microphyllum Benth., *C Jaquemonte* Jaub.et Spach.	Wild chickpea	Jungali chana
Cyamopsis		
Cyamopsis tetragonoloba (L.) Taub., syn. *Cyamopsis psoralioides* L.	Cluster bean	Juppe simi
Glycine		
Glycine max (L.) Merrl.	Soybean	Bhatmas
*Neonotonia wightii (*Arn.*)* Lockey	Bhatmashe	Bhatmase
Lablab		
Lablab purpureus (L.) Sweet, syn. *D. lablab* (L.)	Lablab bean	Tate simi
Lathyrus		
Lathyrus sativus L	Grasspea	Khesari, Latara
Lathyrus aphaca L.	Wild	Pili matari
Lathyrus odoratus L.	Lathyrus pea	Kerauful
Lathyrus pratens L., *L sphericus* Retz., *L humilis* (Ser.) Fischer ex. Spreng	Wild	-
Lens		
Lens culinaris subsp. culinaris Medik.	Lentil	Musuro
Macrotyloma		
Macrotyloma uniflorum (Lam.) Verdc.	Horsegram	Gahat
Desmodium gangeticum DC.	Wild	Gahate ghas
Mucuna		
Mucuna pruriens (L.) DC., syn. *Mucuna cochinchinense* (Lour.) A. Chev., syn. *Dolichos pruriens* L., syn. *Stizolobium pruriens* Brown	Velvet bean	Kause simi
Mucuna macrocarpa Wall., *M. nigricans* (Lour.) Steud	Velvet bean	Kause simi
Pachyrrhizus		
Pachyrrhizus erosus (L.) Urb.	Yambean, Potato bean	Kesour, Misrikand
Phaseolus		
Phaseolus vulgaris L.	French bean, Common bean	Ghui Simi, Dal simi, Asare simi
Phaseolus acutifolius L.	Tepary bean	Simi
Phaseolus coccineus L.	scarlet runner bean	Simi
Phaseolus lunatus L.	Lima bean, butter bean	Simi
Pisum		
Pisum sativum L.	Pea	Matar Kerau
Pisum sativum arvense (L.) Poir.	Pea	Sanu Kerau
Psophocarpus		
Psophocarpus tetragonolobus (L.) DC.	Winged bean	Pate simi
Trigonella		
Trigonella foenicum graecum L.	Fenugreek	Methi
Trigonella emodii Benth., *T gracilis* Benth., *T curniculata* (L.) L., *T pubescens* Edge ex. Baker	Wild Fenugreek	Methijhar

Vigna		
Vigna aconitifolius (Jacq.) Marechal	Mothbean	Kulthi
Vigna angularis (Willd.) Ohwi. & H. Ohashi	Adzuki bean	Ratomas Maslahari
Vigna mungo (L.) Hepper Wild	Blackgram	Mas
Vigna radiata (L.) Wilczek.	Mungbean	Mugi
Vigna umbellata (Thumb.) Ohwi and Ohashi	Ricebean	Mashyang, Siltung
Vigna unguiculata (L.) Walp.	Cowpea	Bodi
Vigna unguiculata (L.) Walp. var. *sesquipedalis* (L.) H. Ohashi	Yardlong bean	Tane bodi
Vigna nepalensis Tateishi & N. Maxted	Wild Cowpea	Bodi
Vigna unguiculata var. *catjang* (Burm.) Walp.)	Cowpea	Bodi
Vigna unguiculata var. *unguiculata*	Cowpea	Bodi
Vigna vexillata (L.)	Zombi pea	-
Vigna vexillata var. *augustifolia* Schumach. & Thonn.)	-	-
Vicia		
Vicia faba L. var. eu *faba major*	Broad bean	Bakula (sano)
Vicia faba L. Var. eu faba minor	Broad bean	Bakula (thulo)
Vicia augustifolia L.	Broad beans (wild)	Rahariya simi
Vicia himalensis (Camb.) (Benth.)	Broad beans (wild)	Kutuli kosa
Wild species		
Vicia hirsuta (L.) Gray	Vetch	Aakata
Vicia bakeri Ali	Vetch	Kutuli kosa
Vicia tetrasperma Moench.	Vetch	Munmun
Vicia rigidula Royle.	Vetch	Kutuli kosa
Vicia tenufolia Roth.	Vetch	Kutuli kosa

Mbp (Arunugantham and Earle, 1991) The crop covers about 3% of the total area and production of grain legumes in Nepal (MoAC 2013). It is mostly consumed as whole seed (boiled, roasted, parched, fried, steamed, sprouted etc.), dal (decorticated split cotyledons boiled and mashed to make a soup), or as dal flour (*besan*). Plucking tender leaves and twigs are used traditionally as green vegetables among some communities in the Terai. Seed is a good source of protein (18-22%), carbohydrates (52-70%), fat (4-10%), minerals (calcium, phosphorus, iron) and vitamins. Its straw has also good forage value. The cultivated species is divided into two distinct types *Desi* and *Kabuli*. Desi types are small with pink flowers and gray to brown testa or seed coat, whereas the Kabuli types are larger and white-seeded and have white flowers, and are more susceptible to insect pests. Two wild species *Cicer microphyllum* Benth. ,and *Cicer jaquemonte* Jaub.et Spach. have been reported in the western high hills of Nepal.

Cyamopsis

Cluster bean (*Cyamopsis tetragonoloba* [L.] Taub.), commonly known as guar is used as fodder, vegetable, and green manure. In recent times it has become a major industrial crop due to the need for the guar galactomannan/gum present in the endosperm of its seeds. Guar gum is useful in various industries like paper, textiles, petroleum, drilling, pharmaceutics, food, cosmetics, explosives, etc. Guar is a drought-resistant, hardy, deep-rooted annual legume. In India, the crop is mainly grown in the dry habitats of Rajasthan, Haryana, Gujarat, Punjab, and to a limited extent in Uttar Pradesh and Madhya Pradesh. Outside India, guar is grown in Pakistan, South Africa, Brazil, Nepal, Australia, and Oklahoma planes of North Texas in the USA. Guar is a cultivated crop not found in wild conditions and hence its available landraces are the main source of genetic variability.

Guar is strictly a self-pollinated diploid legume with chromosome number 2n =14 and a genome size ~ 2.45 Giga Bases/C. Cross-pollination is prevented due to the cleistogamous nature of flowers. Thus, the heterosis available is reduced, which makes commercial hybrid seed production difficult and non-economical. This limiting factor of the yield gap can be overcome by the production of improved varieties of guar through molecular marker-based selection and breeding programs.

Glycine

Soybean (*Glycine max* L. Merril.) has a diploid chromosome number 2n=2x=40 along with a genome size 1100 Mbp. It is an important legume

of midhills which contributes 80% to total soybean area and production in the Neapl country. However, soybean is becoming popular as the sole crop in Terai and inner Terai due to the high yield potential and high demand for soya meal in the poultry industry. Seed contains 45-50% protein, and 20% oil and is rich in vitamins B, C, E, and minerals. It can be used as a good supplemental food with cereal, especially in underdeveloped countries where the majority population suffers from malnutrition. Soybean has a very diverse utilization as the seed is used to prepare baby food and food for diabetic patients, green pods are used as green vegetables, and dry seeds are roasted or fried and eaten as snacks. Soybean oil is cholesterol-free, and widely used for cooking and in the production of vegetable ghee. Cake and meal are utilized for preparing various livestock and poultry feeds. Green foliage can be used as green manure and as a fodder crop. The species *Neonotonia wightii (*Arn.*)* Lackey called Bhatamase in Nepali is grown as a fodder crop from Terai to the hills.

Lablab

Lablab or hyacinth bean also called Hiunde simi or Tate simi in Nepali is an annual legume. The crop is grown from terai to the high hills in frost-free season. The green pods of various sizes and shapes are consumed as vegetables. Only one species (*Lablab purpureus* (L.), Sweet, Syn. *Dolichos lablab* (L). *Dolichos purpureus* (L.), *Lablab vulgaris* (Savi), is reported in Nepal. It is self-fertilized with chromosome number 2n=22 and 24 with a genome size of 367 Mbp. Fodder types are extensively grown in various altitudes.

Lathyrus

Grass pea (*Lathyrus sativus* L.) also known as Kheshari, Latara, or Matara in local languages is adapted to both drought and excess soil moisture conditions (Adhikari *et al.,* 1987). Grass pea is an important food item. It is a diploid species (2n = 14; genome size of ~8.2 Gb, Bennett, and Leitch 2012) with a great potential for expansion in dry areas or zones that are becoming more drought-prone (Hillocks and Maruthi, 2012). This species has been also recognized as a potential source of resistance to several important diseases in legumes (Vaz Patto and Rubiales, 2014). Most often it is used as dal aqueous slurry cooked with spices, atta (flour boiled in water), and satu (roasted flour mixed with water). It is often used as an adulterant to chickpea and pigeon pea dal or flour (Bharati and Neupane, 1989). The young plant is used as a leafy vegetable, eaten with rice meal. They are also rolled and dried for off-season use as a vegetables (Bharati and Neupane, 1989). Fodder is a valuable livestock feed. Fresh biomass yields of 5-6 t/ ha in addition to 1.8 t/ha of seed yields of local varieties have been reported (Neupane, 1996). Despite its multiple uses, the area and production are reduced drastically primarily due to discouragement in its consumption as the Nepal government imposed a ban on the marketing of grasspeas since 1991 (NGLRP 1998). Dietary intake of large quantities over a longer period is believed to cause neurological disorder (*Lathyrus*) due to the presence of neurotoxin, ODAP (*N-oxalyl-L*-2,3-*diaminopropionic acid*). ODAP content in local varieties is high and ranges from 0.6-0.8 %.

Five wild relatives of grasspea have been reported in Nepal. *Lathyrus aphaca* L. (Pili matri) annual herb with yellow flowers, reported from Terai used as fodder. *Lathyrus odoratus* L. also called sweet pea (Kerauphul in Nepali) is a wild form of lathyrus (Campbell, 1977) grown as an ornamental plant in the home garden. Other species are *Lathyrus pratens* L.; *Lathyrus sphericus* Retz, *Lathyrus humilis* (Ser.) Fischer ex. Spreng.

Lens

Lentil (*Lens culinaris* subsp. *culinaris* Medikus) is a self-pollinated and diploid 2n=14 crop with a genome size of ~4 Gbp. It is locally known as *Musuro*, and is a major grain legume accounting for about 62.5% of area and production under grain legume in Nepal. The increasing trends in area, production, and productivity are due to the availability of production technologies and its remunerative export market (small seed red lentils fetch higher prices in Bangladesh), breeding lines and technical support from international centers, area expansion in new areas (introduction in mid hills and cultivation in rice fallow) and reducing area under grass pea due to ban on its marketing (NGLRP 2008). Although local landraces of lentils (mostly black seeded) have been grown in high altitudes, improved varieties have been introduced in recent years in hills (5% area) where productivity is high due to longer growing seasons and fewer diseases. Lentil dhal consumption is on the rise as the cooking time is the shortest compared to other grain legumes. Lentil seed contains about 20-25% protein and is a rich source of Fe, Zn, and vitamins. Anemia (Fe deficiency) is common in young women and children worldwide. Fe requirements vary from 0.23-0.55 mg/day in children to 0.35-0.55

mg/day in adults (FAO 2004). Fe and Zn content in seed ranged from 64-127 mg/100 g and 35-88 mg/100 g, respectively (NGLRP 2006, 2008). Lentil cultivars grown in Nepal belong to *microsperma* types characterized by small seeds, plant parts are covered with white hairs and red cotyledons, whereas the *macrosperma* types introduced from the Mediterranean region are bold-seeded, have no pubescence in the plant parts and have yellow cotyledons.

Macrotyloma

Horsegram (*Macrotyloma Uniflorum* (Lam.) Verdc. syn. *Doluchos biflorus* L., *Dolichos uniflorus* Lam.) is a diploid chromosome number 2n=2x=20, 22, 24 with a genome size of 400 Mbp. It is also called gahat in Nepali is an important legume crop grown from Terai to the hills. In the hills, it is grown in a maize-based system and as a sole or a mixed crop in the Terai. Soup prepared from its seeds is consumed in the winter months and is traditionally used for the removal of kidney stones. Differences in the color of seed testa e.g. light red, brown, grey-black, or mottled, and seed size have been observed in landraces. The genus has 34 wild species including *Desmodium gangeticum* DC. widely used as a fodder crop (www.Ffloras.org.).

Mucuna

Mucuna prurience (L.) DC., Syn. *Mucuna cochinchinense* (Lour.) A. Chev., syn. *Dolichos pruriens* L. called velvet bean is an annual climbing legume. It is one of the most important medicinal plants. It is used to treat many ailments but is widely used for the treatment especially for Parkinson's disease because of the presence of 3,4-dihydroxyphenylalanine (L-dopa) in it. Velvet bean pods and plant parts possess dense hairs which give a stinging effect on the touch. It is used as fodder for animals, and green manure and the seeds can be consumed after properly cooking. Three species have been reported from Nepal.

Pachyrrhizus

Yam bean (*Pachyrrhizus erosus* L) is called Mishrikand or Kesour and is grown in the central Terai. It is a diploid with basic chromosome number 2n=2x=22. The edible part of is tuber is eaten raw after peeling out the skin. Seeds are poisonous and have insecticidal properties. Yambean is particularly used during Saraswoti Pooja by women devotees. Despite its high content of carbohydrates in the form of dietary fiber, it is a neglected crop. The tubers have 86–90% water, trace amounts of protein and lipids. Its sweet flavor comes from the oligofructose inulin (also called fructooligosaccharide) which is a pre-biotic, and is very low in saturated fat, cholesterol, and sodium.

Phaseolus

The genus consists of 4 species Kidneybean (*Phaseolus vulgaris* L.) also known as *Simi, Rajma, or* French bean, *Phaseolus acutifolius*, *Phaseolus coccineus L.* and *Phaseolus lunatus* L. *Phaseolus vulgaris* L is a diploid 2n=2x=22 with genome size of 576 Mbp. The indeterminate long-duration type of Kidney bean **i**s grown during summer in mid/high hills and the determinate early maturity type is grown during winter months (post rainy) in terai. It is an important cash-generating legume in Jumla and adjoining hilly districts, and Mustang where mixtures of landraces with different sizes and seed coat patterns are harvested and sold in the market. In Chitwan, Nawalparasi, Makwanpur, and Rupendehi districts, varieties PDR 14 and Hetaude are popular under rice or maize-based cropping systems with partial irrigation. The area under *rajma* is in increasing trends due to ease in marketing and good returns.

Pisum

Field pea (*Pisum sativum* L.) is an important crop and can be grown successfully in the Terai (<100 m) during winter to high mountains (3000 m) during summer months. It is also diploid 2n=2x=14 along with a genome size of about 4,500 Mb (Jain *et al.,* 2014). A great variation in seed size and seed color is observed in local field peas. Green peas are important as green vegetables. *Pisum sativum arvense* (L.) Poir called small pea is extensively grown in the Kathmandu area in a rice-based system.

Psophocarpus

Winged bean *Psophocarpus tetragonolaba* (L.) DC. is an annual legume grown for its green pods, twigs, and underground rhizome. It is a multipurpose crop being grown from terai to the hills. Winged bean has a diploid genome (2n=2×=18) and an estimated genome size of 1.22 Gbp/C (Vatanparast *et al.,* 2016).

Trigonella

Fenugreek (*Trigonella foenicum graecum* L.) has 2n=14, 16, 30, and 46 in somatic cells, and the

B chromosome was also observed in somatic cells of some taxa (Martin *et al.,* 2011). The genome size of *Trigonella foenum-graecum* is ~ 685 Mbp (c-value approximately 0.7) which is ~1.5 fold larger than the model legumes, *Lotus japonicus* and *Medicago truncatula*, both have compact genomes of ~470 Mbp (Young *et al.,* 2003). It is an important annual legume consumed as a vegetable and the seeds as spices. Four wild species recorded in Nepal are: *Trigonella emodii* Benth., *Trigonella gracilis* Benth., *Trigonella curniculata* L. and *Trigonella pubescens* Edge ex Baker. The fodder species of fenugreek introduced from Australia was poorly adapted in the Terai of mid-western Nepal.

***Vigna* Savi.**

The genus consists of 15 species recorded in Nepal (www.Ffloras.org.). The major ones are *Vigna aconitifolius* (Jacq.) Marechal, *Vigna angularis* (Willd.) Ohwi. & H. Ohashi, *Vigna mungo* (L.) Hepper Wild, *Vigna radiata* (L.) Wilczek, *Vigna umbellata* (Thumb.) Ohwi and Ohashi, *Vigna unguiculata* (L.) Walp. and *Vigna unguiculata* (L.) Walp *var. sesquipedalis* (L.) H. Ohashi. Other species are growing as wild in various parts of the country.

Blackgram (*Vigna mungo* L. *Hepper*) is an important summer grain legume in mid-hills. Its diploid chromosome is 2n=2x=22 with a genome size of 574 Mbp. Blackgram dhal produced in the hills is considered to have better cooking quality. Landraces were collected in 1998 in the country and materials introduced from Bangladesh (before 1988) were evaluated for identifying/developing the best genotypes. Very recently, materials from India have been tested at various agroecological zones for yield performance.

Mungbean (*Vigna radiata* L. Wilczek), is a diploid 2n=2x=22 with a genome size of 509 Mbp. It is a short-duration (60-70 days) crop, which is grown as rainfed bari-land (after maize) and lowland irrigated areas of terai and inner terai (after wheat). More than 75% mungbean area is mainly concentrated in the eastern and central Terai, where irrigated facilities are available, while the remaining 25% area is in the western Terai and foothills. The estimated area under mungbean is about 12000 ha with a production of 6500 mt and productivity of 0.5 t/ha (Joshi *et. al.,* 1997)**.** Green foliage is used as fodder and green manure. Mungbean is considered the most digestible among other pulses and its soup is widely used as a healthy diet. Fried mung bean is popular as a snack. Large quantity of mungbean is imported from India as domestic production cannot meet the growing demand.

Ricebean (*Vigna umbellata* (Thumb.) Ohwi and Ohashi) locally known as *Mashyang, Siltung, Jhilinge, Guras* is one of the neglected and under-utilized summer grain legumes cultivated mainly in the hilly areas under mixed cropping with maize with no additional inputs and care. Ricebean is known for its diverse distribution and is adapted to a range of altitudes from the lowlands to the high, and across the country from the east to the far west. The crop has excellent food and fodder values and is grown as fodder, green manure, and cover crop. The dry seeds are eaten boiled as *dhal* (soup) and young immature pods are consumed as vegetables (Gupta *et al.,* 2009). A great variation in seed color has been observed in landraces and research on the development of high-yielding short-duration varieties was initiated through the FOSRIN project in 2006. It is an important food legume, particularly in the mid-hills of Nepal, and has a pivotal role as a pulse in supporting the food security of the rural poor people in this area. Ricebean is a diploid species with 2n=2x=22 chromosomes.

Cowpea (*Vigna unguiculata* L. Walp) and *Vigna unguiculata* (L.)Walp var. *sesquipedalis* (L.) H. Ohashi is a diploid with 2n=2x=22 chromosomes and has a genome size of 613 Mb (Arumuganathan and Earle, 1991). It is one of the important grain legumes consumed as green vegetables or dried pulse as dhal. In mid hills, local cowpea (*Kartike bodi*, *Makai* bodi trailing type long duration local landraces) is grown as an intercrop with maize. Short-duration varieties are grown as a mono-crop in the spring season or after the rainy season in September with supplemental irrigation. Area and production are increasing every year because of the availability of dual-purpose (green pods as vegetable and dried pulse) short-duration varieties.

Vicia

Faba bean *(Vicia faba* L.) or broad bean (local name *Bakula*) is a minor grain legume. Faba bean is a diploid with 2n=2x=12 chromosomes and has a genome size of 12797 Mbp (Schubert and Oud, 1997; Fuchs *et al.,* 1998). Large seeded type *Vicia faba L. var. eu faba major* is commonly grown in Kathmandu valley and adjoining districts as a kitchen garden, whereas small seeded *Vicia faba L. Var. eu faba minor* with green or black color testa are grown as a field crop or in a home garden in the terai. Large pods are consumed mostly as green vegetables and dry seeds

as roasted bean and small seeds are usually split and consumed as soup. Seven wild species *Vicia august folia* L., *Vicia himalensis* (Camb.) (Benth.), *Vicia hirsuta* (L.) Gray, *Vicia bakeri* Ali, *Vicia tetrasperma* Moench. *Vicia rigidula* Royle and *Vicia tenufolia* Roth. grow as weeds in crop and pasture lands from Terai to the high hills.

COLLECTION, CHARACTERIZATION, AND EVALUATION OF LEGUME GERMPLASM

Landraces of grain legumes have been grown by people from time immemorial. However, due to the introduction of high-yielding varieties of cereals and also legumes, expansion in irrigated areas, and introduction of input-responsive cereals and, grain legumes have been pushed to more marginal areas and some of the landraces are being eroded due its replacement by high-yielding exotic lines or varieties. Shifts in cropping patterns and crop area among others have resulted in the loss of landraces. Grasspea areas have decreased from 51170 hectares in 1984-85 to less than 8000 hectares in 2013-14, suggesting the loss of valuable landraces.

Grain Legume Research Program (GLRP) initiated systemic collection of germplasm in 1979 jointly with the International Crop Research Institute for the Semi-arid Tropics (ICRISAT), and collected 100 pigeonpea and 45 chickpea landraces from 16 districts of Nepal. In 1987, Nepal Agricultural Association (NAA) with funding support from the International Development and Research Centre (IDRC), Canada collected 76 landraces of grass pea from 18 Terai and inner Terai districts (Adhikary *et al.,* 1987). Following this, Winrock International and the US Peace Corps sponsored the collection of 43 landraces of lentil from 11 Terai districts (Furman *et al.* 1988). In 1995, legume germplasm collection was organized jointly by the Center for Legumes in Mediterranean Agriculture (CLIMA) and NARC and 716 accessions of different legumes (Table 2) were further added to the existing germplasm (Larry *et al.,* 1995). Landraces collected from the above collection missions were shared with PGRU/ NARC-GLRP. Legume Research Program (NGLRP) collected 90 landraces of *Phaseolus* bean from Jumla and adjacent districts through a Hill Agriculture Research Programme (HARP) supported project in 1999. In addition, sporadic collection of grain legume germplasm by GLRP, Agronomy Division, other NARC centers, and joint collection missions organized by Agriculture Botany Division from

Table 2. The grain legume germplasm held as landraces at NAGRC, Khumaltar and other global centers

Species	NAGRC, Khumaltar	Other centers			
		ICARDA	ICRISAT	Agriculture Canada	AVRDC
Soybean	539	6			
Lentil	490	140			
Blackgram	166	44			
Pigeonpea	279	29	129		
Lathyrus	164	100		76	
Pea	188	99			
Pea arvense	-	17			
Chickpea	-	70	191		
Fababean	62	93			
Mungbean	82	9			
Ricebean	150				8
Cowpea	221	3			
Common bean	498				
Horsegram	56				
Adzuki bean	7				
Hyacinth bean	9				
Sword bean	7				
Fenugreek		13			
Kidney bean	2				
Vicia species		51			
Common spring vetch	16				
Others		19			
Total	2936	714	174	76	8

time to time have contributed to the existing germplasm in the country. A total of 2936 landraces of different legume crops have been conserved at the Gene bank of NAPGRC (Table 3). GLRP Khajura and Agronomy Division Khumaltar have active collections of 218 landraces and 627 exotic germplasm of various legume crops (Table 4). Duplicate samples of landraces collected during joint collection missions have been maintained at gene banks of ICRISAT, ICARDA, AVRDC, and the University of Manitoba Canada. AVRDC has 8 genotypes of rice bean from 2000 m altitude in the Bajura district (World Vegetable Center 2007).

Characterization of grain legume germplasm

The first systemic characterization of legume germplasm using IBPGR descriptors was carried out in 2087-88 at NARC research centers (Furman and Bharati 1989). A total 270 chickpea, 70 cow pea, 87 grass pea, 137 lentil, 53 mung bean, 227 pigeonpea, 30 and soybean germplasm were characterized by GLRP. Similarly, 230 soybeans, 250 beans, 140 pea, 136 rice bean, 90 lentils and 171 grass pea accessions have been characterized as per the IBPGR descriptors at NPGRC, Khumaltar (Joshi *et al*., 2013). Neupane *et al*. (2005) conducted a characterization of 100 common bean germplasm at ARS Jumla, and Pandey *et al*. (2011) at RARS Lumle. Wide variation in morphology, and yield components among landraces have been observed. Suitable varieties identified through the study have been used in crop improvement program and some of the cultivars are promoted in a farmer's field. Bajracharya *et al.* (2010) conducted a molecular diversity analysis of 91 rice bean landraces from Nepal and 21 from India. Similarly, DNAs of 75 accessions of beans and 50 accessions of rice bean have been preserved at NAGRC, Khumaltar (Joshi, 2017; Bajracharya *et al.*, 2010). Darai *et al.* (2017) conducted the molecular characterization of high Iron (Fe) and Zinc (Zn) grain concentrations of twenty-five lentil accessions for genetic diversity and molecular assessment.

Table 3. Germplasm of legume crops available at GLRP, Khajura, Nepal

Crops	Total active germplasm	Exotic lines	Local landraces
Lentil	146	145	1
Chickpea	116	115	1
Grasspea	30	25	5
Kidneybean/ Rajma	21	15	6
Mungbean	171	56	115
Cowpea	86	82	4
Soybean	150	113	37
Blackgram	40	1	39
Pigeonpea	85	75	10
Grand Total	845	627	218

Table 4. Summary of grain legume germplasm characterized as per IBPGR descriptors

SN	Crops	Total	Landraces	Exotic
01	Chickpea	237	121	116
02	Cowpea	72	0	72
03	Lathyrus	87	82	5
04	Lentil	137	124	13
05	Mungbean	53	2	51
06	Pigeonpea	227	128	99
07	Soybean	230	73	157
08	Phaseolus bean	100	90	10
		1043	530	513

VARIETAL DIVERSITY ANALYSIS

Grass pea

A wide range of variability was recorded in plant height, number of pods per plant, seeds per pod, 100-seed weight, and grain yield in the evaluation of 76 local and 17 exotic germplasm (Furman and Bharati, 1989). Local germplasm lines were found to be more adopted higher yielding and early but had smaller seed sizes than the exotic germplasm (Bharati and Neupane, 1988). Landraces showed a high level of ODAP content in the seeds. In an attempt to promote grasspea lines with low levels of Oxalyl Diammonium Propionic Acid (ODAP) in seeds, 19-A, 20-A, CLIMA Pink, CLIMA-2 and BARI-2 were introduced as low ODAP lines from CLIMA Australia. Due to the better adaptability of CLIMA Pink, 19A, and 20A, these were introduced in grass pea growing pockets in some districts to replace the landraces with high levels of ODAP (Neupane and Tiwari, 2005). CLIMA pink has been adopted by farmers in Padharia village in Sirha district of Nepal.

Kidney bean

Ninety landraces of kidney were characterized as per the IBPGR descriptor at ARS Jumla (Neupane *et al*., 2007). A wide range of variability was recorded in seed size, seed color, and plant morphology and as

many as 18 local names were given to beans. *Kharani Khairo, Mriggaula, Phokserang, Bhotesimi Bokasimi, Gheusimi, Ratodolpaya, Piyalasimi, Kalosimi, Setosimi, Rajma, Rajmash, Simi, Motosimi, Malesimi, Akashesimi, Hariyosimi, Lekalisimi* are some of the names by which beans are known to different ethnic groups in the area. Most of the local landraces were a mixture of different types, varying in seed size, shape, and color. Examination of seed samples revealed that the color of the seed ranged from pink, purple, ash, cream, yellow, maroon, black, and violet, to shining purple, red, and different shades of the main color. The seed shape was predominantly elliptical. Others were ovoid, round, kidney-shaped, flat or square, and cuboids. Kidneybean eight genotypes PB0002 and PB0048 selected from landraces were high-yielding and promising both for green pods and dry seeds for growing as a rainy season crop in the mid to high hills of mid/far western region (FORWARD Nepal). Other landraces found promising at Jumla are KBL 2, KBL 3, KBL 3, KBL4, KBL5, and KBL6.

Soybean

In soybean, the development of new genotypes from the existing ones with improvement is the main objective. High levels of variations have been observed for nine different morphological traits including seed yield and its contributing traits among the soybean accessions. A total of forty diverse accessions of local landraces and exotic lines were evaluated in the subtropical rainfed climate of Rampur Chitwan in the summer season and observed variation for agro-morphological traits. Some of the high-yielding accessions of soybean were 272W, Cobb, G-758, and Puja. Likewise, a total of hundred-one accessions were evaluated for grain yield and yield parameters and identified G-18428, TGX 1990-67F, G-757, V9 (B/pur-9, TGX1990-5F, Co 157, Chatewan-9, TGX1990-93F, V7 (B/ pur-7), C2020 and G-8514 accessions for high yield. However mean yield performances of soybean accessions over the years affirmed soybean cultivars G-757, G-758, G-8586, V8 (B/pur-8), 272 W were the better performer than the check Cobb. The cluster analysis grouped the 40 accessions into five major groups at the genetic distance of 202.63 based on seven morphological traits. It was also found that, among the five clusters, cluster I was the largest and consisted of 32 accessions, and the second largest group was clusters II and IV, and each consisted of three accessions. The smallest group was clusters III and V, and each cluster contained only one accession. Similarly, the 101 accessions collected from the National Agricultural Genetic Resources Centre (Gene Bank) and exotic lines from IITA, Nigeria clustered into five major groups at the genetic distance of 267.82 based on seven morphological traits. Among the five clusters, cluster I was the largest and consisted of eighty-four accessions, and the second largest group was cluster II consisted of fourteen accessions. The smallest groups were clustered III, IV, and V, which contained 1, 2, and 1 accession each, respectively. To obtain greater heterosis, accessions having distant clusters could be used as parents for hybridization programs. The accessions from cluster I and cluster II could be used for a hybridization program with the soybean accessions of clusters III, IV, and V to develop high-yielding soybean varieties for further improvement. The first seven principal components were extracted which accounted for about 100% variability among the 104 soybean accessions for all morphological characters. There was high diversity found in the seed coat color of the soybean local landraces. Out of thirty-three accessions, thirteen of them had black seed coat color; two had buff, one grey, three imperfect black, two reddish-brown, eight yellow, and the remaining four had yellowish white seed coat color. The flower color and pattern of the flower were also found diverse among the collected accessions. Out of the thirty-three local landraces, twenty-one had white flower color, four had purple throats, and three had purple flowers. Some of the five landraces had a trailing type, typical little leaves like wild type along with purple flower colors. This study indicated the presence of high levels of genetic variability among the soybean accessions in terms of evaluated characters

UTILIZATION OF LANDRACES IN VARIETAL IMPROVEMENT

Following the principles of conservation through utilization, efforts have been made to utilize landraces in variety improvement programs through the official release of the variety directly or as a parent in the crossing program to transfer desirable traits of landraces to high-yielding genotypes or lines. Nepal Agricultural Research Council (NARC) has released pigeon pea varieties Bageshwori and Rampur Rahar-1, chickpea varieties Trishul and Dhanush and lentil variety Sindur, asparagus bean varieties Khumal Tane and Sarlahi Tane from landraces (Upadhyay, 1999). Apart from high yields, pigeon pea variety Bageshwori, a selection from landrace from the Dhanusha district is resistant to sterility mosaic virus disease (SMD) and it has been

used as a source of resistance in crop improvement program at ICRISAT (ICRISAT 2007). However due to the multiplicity of grain legume species and the inadequacy of manpower at NARC, efforts towards utilization of landraces in the variety improvement program have been inadequate and import of elite lines, segregating population from CG centers has got priority in the Grain Legume Research Program of NARC. To address the issue, a collaborative crop breeding program with CG centers has been initiated wherein suitable crosses for the Nepali environment are made in CG centers and the advanced lines and segregating materials are sent to Nepal for local selection and advancing as a variety. The efforts made by the Nepal Agricultural Research Council (NARC) resulted in the development of several varieties of food legumes and released, registered, or denotified for cultivation (Table 5).

Table 5. Released varieties of Food Legumes in Nepal

SN	Variety	Accession No	Source	Release year
	Lentil			
1	Sindur	LO-111-25	**Nepal**	1979
2	Sisir	P43	India	1979
3	Simrik	T36	India	1979
4	Shikhar	LL 4404	Pakistan	1989
5	Simal	LG 7	India	1989
6	Khajura Masuro 1	LG 198	India	1999
7	Khajura Masuro 2	PL 639	India	1999
8	Shital	ILL 2580	ICARDA	2004
9	Sagun	ILL 6829	ICARDA	2009
10	Maheshwori Bharati	ILL 7982	ICARDA	2009
11	Khajura Masuro 3	ILL 6037 x ILL 8007	Nepal	**2017**
12	Khajura Masuro 4	ILL7723	ICARDA	**2018**
13	Kalo Masuro	Black Masuro	Nepal	**2018**
	Chickpea			
1	Dhanush		Nepal	1980
2	Trishuli*		Nepal	1980
3	Radha	JG 74	India	1987
4	Sita	ICC4	ICRISAT	1987
5	Koseli	ICCC32	ICRISAT	1991
6	Kalika	ICCL82108	ICRISAT	1991
7	Tara	ICCX840508-36	Nepal	2009
8	Avrodhi	Avrodhi	India	2009
	Soybean			
1	Hill*	(Downfield x Haberlandt) x Sib of Lee	USA	1976
2	Hardee	D 49-772 x Improved Pelican	USA	1976
3	Cobb	F 57-737 x D 58-3358	USA	1989
4	Ransom	(N 55-5931 x N55-3818) x D56-1185	USA	1989
5	Seti	KS 419 x KS 525	Taiwan	1989
6	Lumle-1	Local	Nepal	1997
7	Tarkari Bhatmas-1	Huichin#2	China	2004
8	Puja	PK 416	India	2006
	Pigeonpea			
1	Bageshwori	PR 5147	Nepal	1991
2	Rampur Rahar-1	Local	Nepal	1991
	Blackgram			
1	Kalu	T 9	India	1971
2	Rampur Kalo mas	BLG0067-1	Nepal	2018
3	Khajura Kalo Mas-1	BLG0003-2-1	Nepal	2018
	Mungbean			
1	Pusa Baisakhi		India	1975
2	Pratikshya	VC 6372(45-8-1)	AVRDC	2006

3	Kalyan	NM 94	AVRDC	2006
4	Khajura Mung-1	HUM-16	India	2018
	Cowpea			
1	Aakash	IT82D-752	IITA	1990
2	Prakash	IT82D-889	IITA	1990
3	Surya	IT86D-792	IITA	2004
4	*Malepatan-1	IITA Nigeria	IITA	2011
5	Gajale Bodi	IT98K205-8	IITA	2009
	Kidney bean			
1	Trishuli Geu Simi		Nepal	1994
2	Jhange Simi-1		Nepal	1994
	Field Pea			
1	Sarlahi Arkel		India	1994
2	New Line		India	1994
3	Sikkime		India	1994
	Registered food legume varieties			
	Cowpea			
1	Double harvest		China	2010
2	Karma stickless		Thailand	2013
3	NO-324		Japan	2013
4	Sila-464		Thailand	2013
5	Chandra o41 OP		Thailand	2010
	Pole bean			
1	Mandir OP		Thailand	2010

* Denotified

Table 6. Religious cultural importance of grain legumes

Species	Religious uses
Blackgram	Bara made from blackgram is offered to ancestors during pitripooja by Hindus, For Rahu and Ketu graha Shanti, In Newar community, Blackgram is offered to Saturn during graha pooja conducted in the birthday. During Hanuman Pooja in Shrawan, Bara from Blackgram is offered to the deity. Blackgram leaves are eaten during narak Chaturdashi in the first lunar of Kartik, Samayabaji with Bara is offered to Bhagawati
Chickpea	Roasted chickpea offered to Shantoshi Mata Pooja on Friday, for offering sweets to Goddess Saraswati during Saraswoti Pooja
Common bean	In Karnali zone, broken cotyledons of beans are used for Tika in the foreheads.
Horsegram	Grahadaan of Saturn, wedding auspicious day obstacles, it is used
Lentil	Lentil is offered to pacify Mangal (Mars)
Mungbean	Mungbean seeds are used in Mercury planet (Bhudhagraha shanti). In Rama Ekadashi, Mung laddo is offered to Lord Keshav, Krishna-Satyabhama
Pea	Offered to Shukra graha during birthday in Newar community, in Swasthani pooja pea and roasted wheat is offered, water-soaked small pea is thrown during chariot ceremony of Chandeshory fair in Banepa
Mungbean	Mungbean seeds are used in Mercury planet (Bhudhagraha shanti). In Rama Ekadashi, Mung laddo is offered to Lord Keshav, Krishna-Satyabhama
Soybean	Black seeded soybean is a constituent of Samayabaji (a mixture of salted beaten rice Syavabji, (choyela) black soybean, cowpea and dried fish) offered to Goddesh Bhagawati. It is also used to pacify Saturn, and bad- spirits
Yam bean	Extensively used in Saraswoti puja, or by women fasting in Ekadashi in the Central Terai
Rice bean	During *Gaura Parba*, a festival celebrated widely in far-western region of Nepal, ricebean is one of the five grains used in preparing *Biruda*, an offering that is made to the festival deity.

SOCIO CULTURAL USE OF GRAIN LEGUMES

Several legume crops have special socio-cultural and religious significance in the Nepali community (Table 6). In this context, black gram, black seeded soybean, horse gram, mungbean and pea (Regmi PP), and ricebean (Khadka and Acharya, 2009) have special significance. Ricebean has cultural and religious values in Nepalese society. *Batuk and Bara* are used during wedding ceremonies and other social functions in Magar and Newar communities respectively. The Nepalese have a tradition of preparing soup (*Kwanti*) from a mixture of nine-grain legumes during the festival of Janai-Purnima. *Khichadi* is a traditional dish prepared from a mixture of rice and black gram or ricebean on the occasion of Maghe-Sankranti, a festival celebrated by Nepalese during mid-January.

CONCLUSION

Nepal has a rich diversity of food legume species. These legume crops are an indispensable part of the prevailing farming systems in various agroecological zones of the country. Due to the role played by legumes in human food, livestock feed, maintenance of soil fertility, and increased market demand for legumes, the area and production of these crops has increased in recent years. However, due to the introduction of input-intensive high-yielding varieties of cereal crops, population pressure on land area, and other developmental interventions, there has been a shift in the area of pulses, resulting in losses in agro-biodiversity at the species and variety level. Past efforts on the collection and conservation of landraces have to be supported by their utilization in crop improvement programs. Collection of landraces from new areas and of neglected species e.g. rice bean, horse gram should get top priority. We suggest the following intervention areas for the conservation of plant genetic resources in the context of grain legumes:

- Prioritize for collection of horse gram, pea, common bean, and rice bean germplasm
- Collection of lentil germplasm from high hills/ mountains, cowpea germplasm from mid-hills
- Characterization and maintenance of a database of legume landraces and their wild relatives for easy access to breeders
- Prioritizing using of landraces in crop improvement programs to confer local adaptation traits into new varieties
- Establishment of satellite breeding programs at different agro-ecological zones as per the importance of grain legume crops
- Characterization and evaluation of germplasm at agronomic, biochemical, and molecular levels to support crop improvement program
- Identification of trait-specific germplasm and gene pools of food legumes for use in crop improvement program
- Ensuring maintenance of germplasm in a safe and secure way
- Use improved methodologies and tools for genetic improvement (pre-breeding, advanced biometry, crop information system, etc.).
- Use of molecular tools to access variation for high-yielding cultivar development
- Initiate research on underutilized or minor grain legumes such as rice bran, horse gram, field pea, and faba bean.

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