Status and Future Prospects of Pulses in Nepal[1]

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1. Introduction

Agriculture is the main source of income and livelihood of 66% of rural population in Nepal (MOAC 2009), with about 80% of population depend on subsistence farming, and have major concerns on household food security and poor nutrition (FAO 2009). FAO food deprivation data 2005-07 for Nepal showed that 4.5 million people live under the condition of undernourishment (FAOSTAT 2011). Cereal crops are the staple food and contribute major share in area and production. Growing cereal crops year after year or intensive cereal production (short duration paddy, spring maize) systems have led to the degradation soil fertility, soil health, pest disease dynamics and soil erosion. Pulses (grain legumes) are important in terms of nutrition and subsistence farming. It plays role in enhancing the soil fertility by symbiotic nitrogen fixation. Pulses supply the major part of the dietary protein (20-25% protein by weight, which is 2-3 times that of wheat and rice) for majority of poor who cannot afford expensive animal protein and vegetarians. Crop residues and by-products are valuable as fodder, feed and firewood. In 2009, pulses (excluding soybean) export and import were of US$ 75,459,000 and US$ 29,184,000, respectively (FAO 2011).

Area, Production and Productivity

In world, pulses or grain legumes (solely harvested for dry grains) are grown in 69.29 million ha with production of 64.0 million ton and productivity of 924 kg/ha (FAO 2010) during 2009. India is the largest grower (30% share in area), producer (23% share in production) and consumer. Nepal contributes about 0.4% of world pulse area and production. Diverse climate and environmental conditions of Nepal offer opportunities for growing many species of food legumes. Grain legumes research received relatively little attention in Nepal as the primary need is on assuring food supply for the increasing population. In Nepal, pulses (includes soybean) occupies 10% of total cultivated land, ranking fourth in area after rice, wheat and maize. Grain legumes are grown in 319,472 ha with production and productivity of 262,357 and 821 kg/ha, respectively (MoAC 2010). Majority of pulses area and production are confined to terai and inner terai, and winter legumes contribute the major share in area and production (Figure 1). Winter grain legumes crops such as lentil, chickpea, grasspea, fieldpea and fababean are grown entirely dependent on residual soil moisture after the harvest of rice (post rice) or seed broadcasted on standing rice about 7-15 days prior to rice harvest (relay cropping). While warm season grain legumes are grown during summer month (monsoon rain) in mono, mixed with maize/ fingermillet or on paddy bund

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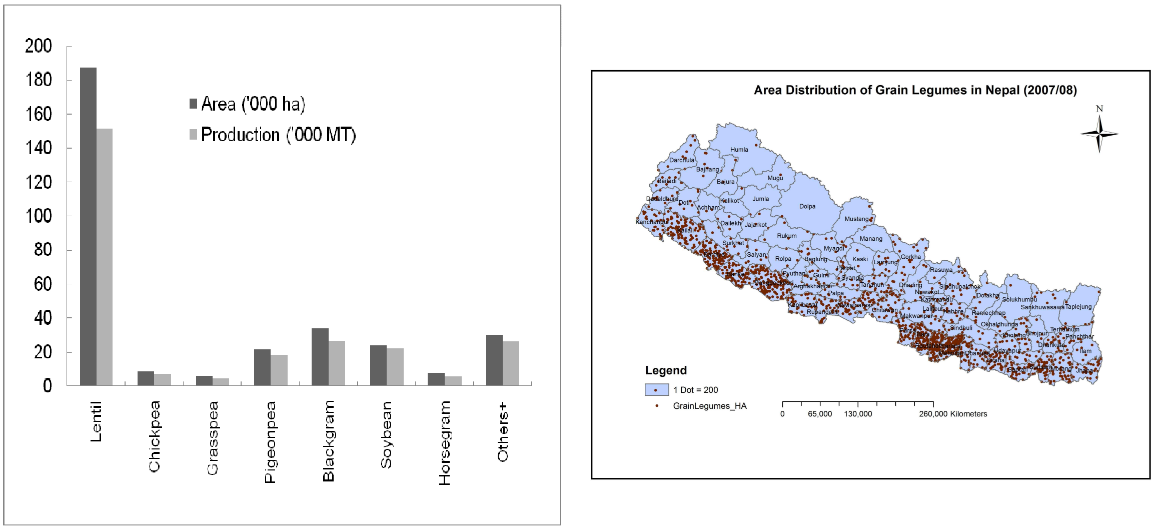

Figure 1: Pulses area and production (2009/10) and map showing area distribution in Nepal.

Importance of Pulses

Grain legumes or pulses are grown mainly as rainfed crops in lowland rice based system in terai/ inner terai or upland maize based system in hills. Winter legumes accounts for about 63% total area and production under grain legumes (Appendix 1). The cultivation of lentil, chickpea, and grasspea are mainly confined to terai regions while warm season grain legumes such as soybean, blackgram, pigeonpea and horsegram share about 28% in area and production under grain legumes, and have special significance in the hill farming systems. *Phaseolus* bean, mungbean, cowpea, ricebean, fababean and fieldpeas occupy small area (10%), but they are important in specific pockets as cash generating crops. The brief accounts of the important pulses grown at varied agro-ecological zones of Nepal are:

Lentil (*Lens culinaris* subsp. *culinaris* Medikus) locally known as *Masuro*, is a major grain legume accounting for about 59% of area and production under grain legume. 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 price 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 reduction in grasspea area due to ban on its marketing 1991/92 (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 season and less diseases. Lentil dhal consumption is in 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 in children worldwide. Fe requirement 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).

Chickpea (*Cicer arietinum* L.) locally called *Chana* covers about 3% of the total area and production (MoAC 2010). It has a scope in warm valleys and river basin in hills. There has been a sharp reduction in area and production of chickpea due to *Botrytis* gray mold disease (BGM) and *Helicoverpa* podborer (Pokhrel *et. al*., 1999). 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 of tender leaves and twigs and using as green vegetable is a traditional practice among some communities in the terai. Seed is a good source of protein (18-22%), carbohydrate (52-70%), fat (4-10%), minerals (calcium, phosphorus, iron) and vitamins. Its straw has also good forage value.

Grasspea (*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). The area and production is reduced drastically primarily due to discouragement in its consumption as Nepal government imposed a ban on marketing of grasspea since 1991/92 (NGLRP 1998). Dietary intake of large quantities over a longer period is believed to cause neurological disorder (lathyrism) due to the presence of neurotoxin, ODAP [β-(*N*-Oxalyl)-L-α,β-diamino propionic acid]. ODAP content in local varieties is high and ranges from 0.6-0.8 %. Young leaves are consumed as green vegetable. They are also rolled and dried for off-season use as a vegetable (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).

Fababean *(Vicia faba* L.) or broad bean (local name *Bakula*) is the minor grain legume. Large seeded type is commonly grown in Kathmandu Valley and adjoining districts as a kitchen garden whereas small seeded (green or black color testa) types are grown as a field crop or in a home garden. Large pods consumed mostly as green vegetable and dry seed as roasted bean and small seed usually splited and consumed as soup.

Fieldpea (*Pisum sativum* L.) is an important crop and can be grown successfully in terai (<100 m) during winter to high mountain (3000 m) during summer months (Khadka--). A great variation in seed size and seed color is observed in local fieldpea. Green peas are important as green vegetable.

Soybean (*Glycine max* L. Merril) is an important legume of midhill that occupies about 80% to total soybean area and production. However, soybean is becoming popular as sole crop in terai and inner terai due to high yield potential and high demand of soyameal in poultry industry. Seed contains 45-50% protein, 20% oil and rich in vitamin B, C, E and minerals. It can be used as a good supplemental food with cereal especially in the underdeveloped country where majority population suffers from malnutrition. Soybean has a very diverse utilization as seed is used to prepare baby food and food for diabetic patients, green pods used as green vegetables and dry seeds roasted or fried eaten as snacks. Soybean oil is cholesterol free, 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.

Blackgram (*Vigna mungo* L. *Hepper*) is an important summer grain legume in mid hills. Blackgram dhal produced in the hills is considered to have better cooking quality. Landraces collected in 1998, 2001 in the country and materials introduced from Bangladesh (before 1988) were evaluated and single plant selections were carried to identify/develop the best genotypes. Very recently, materials from India have been tested at various agro-ecological zones for yield performance.

Pigeonpea (*Cajanus cajan* L. Millsp.) is an important grain legume in drier areas of central and mid western terai, and in the mid hill, a new introduction. This crop can be grown in wasteland, terraces, bund and in agro-forestry systems. It has got multiple uses as food, fuel, fodder, soil fertility improvement and reducing soil degradation in sloppy land. In general, monocrop of pigeonpea is taken in dry area of western terai, while bund planting is popular in central and eastern terai. Mixed cropping pigeonpea with maize, sorghum and sesame is popular among farmers in the terai.

Mungbean (*Vigna radiata* L. Wilczek), a short duration (60-70 days) crop is grown as rainfed bariland (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 facility is available, while the remaining 25% area is in the western terai and foothills. The estimated area under mungbean is about 12000 ha with 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 as the most digestible among other pulses and its soup is widely used as healthy diet. Fried mungbean is popular as snack. Large quantity of mungbean is imported from India as domestic production cannot meet the growing demand.

Cowpea (*Vigna unguiculata* L. Walp) is one of the important grain legumes consumed as green vegetable 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 rainy season in September with supplemental irrigation. The estimated area, production and productivity are 6000 ha, 3660 mt and 610 kg/ha, respectively. Area and production are increasing every year because of availability of dual purpose (green pods as vegetable and dried pulse) short duration varieties.

Kidneybean (*Phaseolus vulgaris* L.) also known as *Simi*, *Rajma, Frenchbean*, *Phaseolus* bean, the indeterminate long duration type is 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 size 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 system with partial irrigation. The area under rajma is in increasing trends due to ease in marketing and good return.

Ricebean (*Vigna umbellata* L. 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 of Nepal as mixed cropped with maize with no additional inputs and care. A great variation in seed color has been observed in landraces were observed and research has initiated since 2006 to develop high yielding short duration cultivars.

Grain Legumes in the Cropping System

Grain legumes play a vital role in crop diversification, restoration of soil fertility and breaking down disease cycles. There is a future scope of expanding grain legumes area by utilizing the rice or maize fallow/ maize or increasing crop intensity by inclusion of short duration grain legumes, lentil, mungbean and cowpea in between two cereal crops. Intercropping lentil with autumn planted sugarcane and mungbean with spring planted sugarcane are emerging new cropping patterns in the terai.

Lowland

Rice - lentil or chickpea – fallow
Rice – lentil – spring maize
Rice – lentil – rice
Rice/lentil or grasspea – fallow

Rice – lentil + fieldpea + linseed + grasspea
Rice – lentil + rapeseed or mustard - maize (or fallow)
Rice – fieldpea - maize
Rice (blackgram or soybean or pigeonpea in bund) – wheat + fieldpea or chickpea
Rice (blackgram or soybean or pigeonpea in bund) – wheat + tori + fieldpea
Rice – maize/mungbean or cowpea
Rice – wheat – mungbean or blackgram
Rice – rajma – spring maize
Rice + pigeonpea (on bunds)

Upland

Summer maize – fallow
Summer maize + cowpea + kidneybean – fallow
Summer maize + soybean or ricebean or horsegram – fallow
Summer maize + pigeonpea
Upland rice (early) – blackgram
Summer maize / blackgram river basins
Summer maize – blackgram + niger
Summer maize – lentil + rapeseed mustard
Sugarcane (autumn planted) + lentil
Sugarcane (spring planted) + mungbean

Kidneybean – barley (in high hills)
Kidneybean – wheat (in high hills)
Kidneybean – vegetables
Simmer maize + kidney bean – wheat or barley
Summer maize /fieldpea (high hills and hills)

Wheat + fieldpea (terai to midhills)
Rice / fieldpea

2. Constraints in Production

The wide gap between the attainable yield potentials and farmers field are due to various biotic, abiotic and socio-economic factors. The major diseases and pests of grain legume crops are presented in Table 1. The major diseases are wilt root rot, Stemphylium blight in lentil, mungbean yellow mosaic virus in blackgram, soybean and mungbean, white mold in rajma and *Botrytis* gray mold in chickpea. *Helicoverva* pod borer is the major production constraint in chickpea production. In storage, bruchids can cause severe losses. The major abiotic factors affecting winter crop production are soil moisture deficits (drought and high temperature during pod filling stage), micronutrient disorders (nutrient deficiency boron). Low adoption of improved package of practices, inadequate extension services and promotional activities, lack of systematic seed production mechanism, non-availability of inputs on time (seeds, fertilizers etc.), unavailability of suitable varieties for varied agro-ecological domains and technologies for all grain legumes crops, yield instability over years, high losses in storage, and other socio-economic constraints.

Table 1: Major biotic constraints in different grain legumes as identified from different production zones of Nepal.

Crop	Production Zone		
	Terai (southern flat plain)	Mid hills	High hills
Lentil	-Wilt (*Fusarium oxysporum* f. sp. lentis)/root rot complex (*Rhizoctonia solani, R bataticola, Sclerotinia sclerotiorum*), *Stemphylium blight* (*Stemphylium botryosum*) -Aphids, pod borer -Weeds	-Wilt/root rot, rust -Cut worms, aphids	-
Chickpea	-*Botrytis* gray mold, BGM *(Botrytis cineria*), wilt (*Fusarium oxysporum*)/root rot (*Sclerotinia sclerotiorum, S rolfsii*), stunt -*Helicoverva* pod borer (*Helicoverpa armigera*) -Flower drop, pod abortion	-	-
Grasspea	-Powdery mildew, collar rot -Trips, aphids -High ODAP content	-	-
Fababean	-Rust (*Uromyces viciae-fabae*), chocolate spot (*Botrytis fabae*) -Aphid (*Aphis fabae)*	-Rust, chocolate spot	
Fieldpea	-Powdery mildew (*Erysiphe pisi*), pea seed borne mosaic virus	-Powdery mildew	
Soybean	-Mungbean yellow mosaic virus (MYMV), anthracnose, pod blight, bacterial pustule -Hairy caterpillar, stink bugs	-Frog eye leaf spot, pod blight, bacterial pustule, anthracnose -Hairy caterpillar -Flower drop	- Frog eye leaf spot - Hairy caterpillar
Mungbean	-MYMV, powdery mildew, *Rhizoctonia* web blight, *Cercospora* leaf spot (CLS) -Thrips, aphids, sucking insect (stink bug)		
Blackgram	-MYMV, web blight -Hairy caterpillar, thrips, aphid	-Powdery mildew	
Cowpea	-YMV -Thrips, aphids, pod borer, red beetle	-YMV, anthracnose, pod and stem blight	
Phaseolus bean	- White mold, YMV, collar rot, root rot, pod blight (Anthracnose) - Stink bugs	-YMV, rust	
Pigeonpea	- Wilt, root rots, sterility mosaic disease (SMD), powdery mildew, *Phytophthora* blight - Pod borer (*Maruca* sp), pod fly, blister beetle		

3. Trends in Production, Supply and Demand

Trends in area, production and productivity

There has been a sharp increase in area and production under grain legumes (Figure 1). Grain legumes showed increased of 40%, 99% and 42% in area, production and productivity, respectively, over the last 25 years (Figure 2, Appendix 1). Acreage under lentil, pigeonpea, blackgram, had jumped up while there was sharp decline in area under chickpea, grasspea and horsegram. Also, introduction of lentil in rice fallow, and increase in cropping intensity by introduction of short duration pulses viz: mungbean, cowpea and rajma after rice or before wheat had contributed to increase total area under grain legumes. Though grain yield has been increased by about 40%, the national average production is still less than 1 mt/ha.

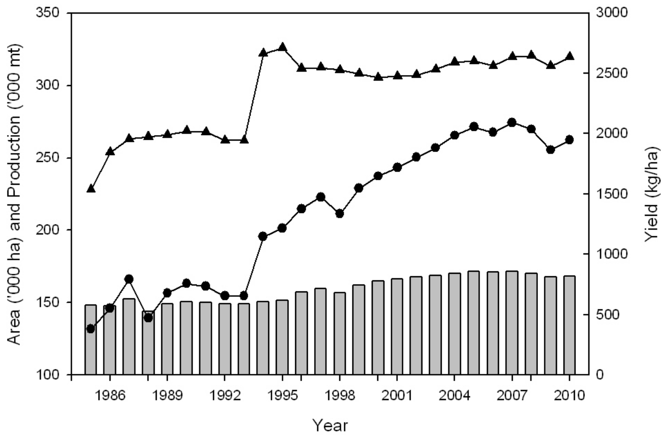

Figure 2: Trends in grain legumes area, production and yield in Nepal (1984/85 to 2009/10)

Trend in import/export

Pulses are important agricultural export commodities in the country. Among the pulses the share of lentils is dominant. Lentil was Nepal's third largest exportable commodity during the year 2009-10 (TEPC 2011). Despite its recognition as a lentil exporting country, there is a wide variation in the volume of exports across years, primarily due to changes in volume of production as a result of unfavorable weather, or as a result of changes in production scenario in the Indian market which plays significant influence in world trade of lentils (Figure 3). In the fiscal year 2008/2009, Nepal exported 56768 mt, whereas in 2009/2010 only 37560 mt lentils were exported (Appendix 2.1). Although, Nepal used to export lentil to Korea, USA, UK and Bangladesh in the past years, Bangladesh has emerged as a major importer of Nepali lentils (Figure 2.2). Bangladesh was the major buyer importing 83% of lentils from Nepal. Nepali lentils have received premium prices in the international market. Export price of lentils was US$ 1299/mt in 2008/09 and US$ 1364 per mt in 2009/2010. In 2010, India imposed restriction on the export of lentils, and as a consequence the imports from India were reduced from 32360 mt in 2009 to mere 7645 mt in 2010. Its implication was the reduced volume of export from Nepal in 2009/2010.

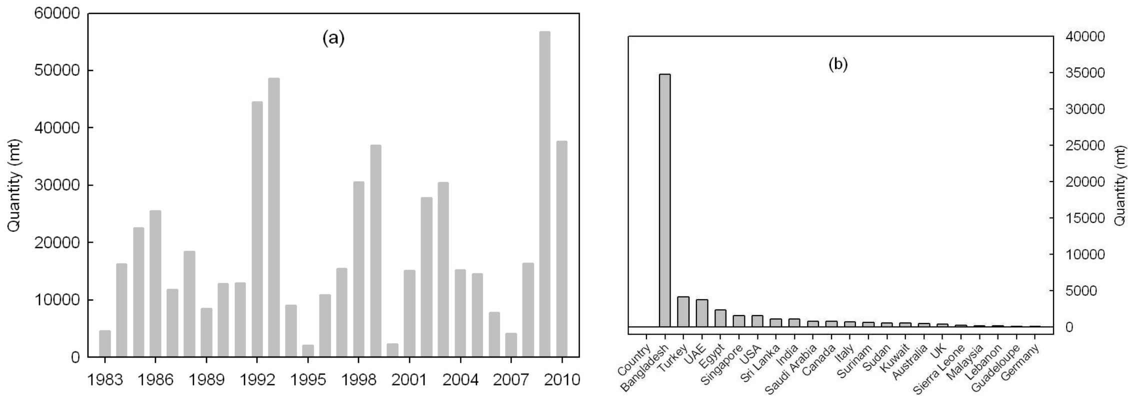

Figure 3: (a) Export trend (1983-2010) and (b) quantity exported from Nepal during 2010.

The local consumption of lentils imported from India provides export opportunities for Nepali lentils. In 2009/10, 44032.2 mt of pulses valued NRs 1376.67 million was imported, mainly from India (Appendix 3). Dried peas, chickpea, Bean (*Phaseolus*, Broad bean) and lentil were the major import grain legumes. Nepal imports lentils primarily from India. In the import side, the import price of lentils was US$ 402/mt in 2009 and US$ 412/mt in 2010. The volume of imports fluctuates across years due to changes in production and import policy of India. The domestic and export prices of lentils in the country fluctuates across years due primarily to production levels and price structures in India. Having vast area (290,000 ha) of fallow land after rice harvest in the terai and inner terai regions, there is an ample scope for the horizontal expansion of area and increase in the productivity and production of lentils and thus stabilize the volume available for exports.

Trends in Consumption

The domestic consumption of pulses is in increasing trends. The FAO data showed the increased in consumption of pulses from 19 g in 1990-92 to 24 g/person/day in 2003-05 which is still below the WHO recommendation of per capita daily consumption of 80 g/day (e-news 2008). Compared to the per capita consumption of 2.61 kg in the eighties (Khadka ---), a three folds increase in consumption has occurred. However, the level of consumption varies across various agro ecological zones of the country. Household (HH) survey conducted in four terai districts in the mid western region showed average pulse intake of 17 kg/person/year in 2006 (Appendix 3). However, at the national level, taking per capita availability as the proxy for per capita consumption, the per capita consumption of pulses for year 2011 is about 9.7 kg/person/year (Table 4). With the expected improvement in living standards and consequential changes food habits, the per capita consumption is expected to rise, which necessitates production increases of pulses in the future.

Table 2: Estimated Per capita Consumption of pulses for 2011

Description	Total quantity	References
Total pulse production (Mt)	262357	CBS/MOAC 2009/10
Total pulse import (Mt)	44032.2	This report Table 4
Total pulse export (Mt)	37876.8	This Report Table 5
Total pulse seed use per annum (Mt)	11581	
Total pulse availability (Mt)	256932	
Population as of 2011 (No)	26620809	CBS preliminary results Sept 2011 Population of Nepal (2011 census)
Per capita availability kg/person/year*	9.7	
Per capita consumption g/person/day	26.4	

*Estimated per capita consumption = Estimated per capita availability=

$$\frac{\{(\text{Total production+total import})-(\text{Total export+use in seeds+ use in animal feeds if any+storage loss+ handling loss})\}}{\text{Total population}}$$

4. Research Achievements

National Grain Legumes Research Program (NGLRP) was established in 1985 with the main aim of the program is to develop and recommend suitable technologies on different grain legumes and increase production and productivity at national level. Research activities at NGLRP are variety development, crop management (agronomical and integrated pest and disease management), outreach (testing and up scaling of promising genotypes through RARS, ARS, NGOs, DADOs/ NGLRP command areas), source seed production and dissemination of technology (training, field visit and fair). At present, research activities on lentil, pigeonpea, blackgram, soybean, chickpea, cowpea, mungbean, *Phaseolus* bean, ricebean and grasspea are being conducted at NGLRP Rampur and at other testing research stations and farmers fields. NGLRP has been working in collaboration with national

(Department of Agriculture, NGO, INGO, farmers groups, seed company etc) and international organizations such as ICRISAT, India (pigeonpea/ deshi chickpea, groundnut); ICARDA, Syria (lentil, Kabuli chickpea, fababean, and grasspea), AVRDC, Taiwan (vegetable soybean, mungbean), CLIMA Australia, IITA, Nigeria (grain type soybean, cowpea), IIPR Kanpur India for germplasm exchange, funding, technical support, human resource development. Grain legumes improved technologies have been developed with the collaboration with various research and extension partners including valuable support of farmers.

Germplasm collection and evaluation

Collection mission had been undertaken at different occasions. In 1987, the first local collection was organized as a multi-crop expedition with supports from IDRC, Canada. Local landraces were collected from central to the western Nepal. A year later collections were made from central to the eastern terai through supports from USAID. In 1995, grain legumes were collected throughout the terai and inner terai regions as organized jointly by NGLRP, CLIMA and ICARDA (Robertson *et. al.*, 1995). Similarly, a number of collections had been made by Agric. Botany Division, Khumatar. At present a total of 2936 accessions of different grain legume crops are maintained at National Agriculture Genetic Resources Center (NAGRC), Khumaltar (Table 3). Local materials have been collected from 66 districts representing terai, mid hill and high hills of Nepal (Appendix 4). Uptil now 1118 accessions comprising of lentil, ricebean, blackgram, grasspea, cowpea, broadbean and adzuki bean had been rejuvenation and characterized at various NARC research stations, Nepalgunj, Khumaltar, Parwanipur and Malepatan.

Table 3: Pulse germplasm held at NAGRC, Khumaltar (source: National Pulse Meet 2011

SN	Crops	No. of Accessions
1	Soybean	539
2	Common field beans (Simi)	498
3	Lentil	490
4	Pigeonpea	279
5	Cowpea	221
6	Peas	188
7	Blackgram	166
8	Grasspea	164
9	Ricebean	150
10	Green gram	82
11	Broad bean (fababean)	62
12	Horsegram	56
13	Common spring vetch	16
14	Hyacinth bean	9
15	Adzuki bean	7
16	Sword bean	7
17	Kidney bean	2
	Total	**2936**

Varietal improvement program

A total of 35 varieties of grain legumes have been released for general cultivation (Appendix 5). In winter food legumes, ten lentil and eight chickpea varieties have been recommended for cultivation. Lentil varieties released selections of local landraces (Sindur), local selection of South Asian origin introduced either from India (Simrik. Sisir, Simal, Shital, Khajura Masuro-1) or from ICARDA (Sikhar, Khajura Masuro-2), however, the recently released varieties Sagun and Maheswor Bharati are from crosses made using lentils from South Asia and West Asia, specifically for Nepal. These varieties have 40-60% higher yield and 20-30% larger seed size as compared to released variety Shital/Simal, and resistant to moderately resistant to *Stemphylium* blight and wilt disease. In chickpea, seven varieties released so far are of desi type and one Kabuli (Koseli). Tara is desi type chickpea, a selection of a cross between K850 and Dhanush made at NGLRP Rampur in 1984.

Research work on soybean improvement was initiated in 1972/73. In the past, much effort had been put on the introduction and evaluation of exotic genotypes. Up till now eight varieties of soybean, two varieties of pigeonpea, three varieties each of mungbean and cowpea, and one variety of blackgram had been released for general cultivation (Appendix 5). Soybean varieties except Tarkari Bhatmas-1 (green testa color) are of seed type (cream/buff testa color). Lumle-1 is a pure line selection from local collection and the suspected country of origin is China and is indeterminate cultivar, medium tall with round bold seed. This variety contains about 53.3% protein (Sthapit *et. al.*, 1988) with relatively soft seeds (Joshi *et. al.*, 1994). This variety can be grown with the altitude ranging from low to high hills (400-1600 m). In rice bund planting, this variety produced 22% higher yield than local and Seti in Lumle research command area. Similarly, the latest released soybean variety Tarkari Bhatman-1 is a selection from Huichin#2 developed in China, and suitable for vegetable purpose as green fresh pod or seed soaked overnight cooked as curry, or boiled and fried.

For the purpose of green pulse vegetable three varieties of pole/*Phaseolus* bean, two varieties of peas and a variety of cowpea have been released for general cultivation (Appendix 5.3).

Promising genotypes

Lentil

- Early maturing genotype ILL 8006 (Bari Masoor 4) suitable for rice-lentil-spring maize cropping pattern.
- Widely adapted promising genotypes LN0136, RL 27, RL 88, ILL 7164, RL 93, ILL 6467, LG 12, ILL 7163, ILL 7162, ILL 7537 (1.3-1.7 t/ha).
- Promising lines selected from ICARDA nurseries: ILL 10135, ILL 10641, ILL 9886, ILL 5782, ILL 5480, ILL 9932, ILL 9842, ILL 10213, ILL 10249, ILL 7979 and ILL 6994.
- Khajura Masuro 2 (released), RL 6, RL 12, ILL 8006 and Sisir rich in both Fe (82-101 mg/100 g seed) and Zn (62-75 mg/100 g seed). Shikhar, Simal, Simrik, ILL 7716, and RL 11 high in Fe (59-84 mg/100 g seed) whereas ILL 7543, ILL 3111, ILL 7164 and ILL 6260 are high in Zn (60-75 mg/100 g seed).

Chickpea

- Promising lines: ICCV 87312, ICCV 87372, ICCX 840508-33, ICCX 840508-38, BG 1206 and KWR 108 (mean grain yield 1.0-1.6 t/ha), KPG59 (high yield and tolerant to BGM and podborer)
- BG 1206, ICCX 840508-44 and KWR 108 were bold seeded (>20g/ 100 seed vs. about 8.5 g/100 seed in Dhanush).

Grasspea

- Low ODAP (<0.04%) containing lines CLIMA Pink, 19B, 20A and Bari 2 promising in terms of grain yield.
- Sel-1959, Sel-290, Sel-2119, Sel-2177, Sel-387, Sel-299, Sel-449 and Sel-1942 showed good forage value under Nepalgunj condition.

Fababean

- Promising lines, Sel.98 Lat.11135, F6/1437/03-2, F6/1443/03, F6/1438/03–1, F6/1441/03–1, Rebaya 40.

Soybean

- Promising genotypes LS-77-16-16, Kavre local, F-778817, TGX-311-23D and IARS-87-1, Iang Beaking, G 4504 and G 1871 (grain yield of 1.5 to 2.0 t/ha). CM 9125, G 8754, LS-77-16-1, SB0065 and SB0095 resistant to mungbean yellow mosaic virus (MYMV).

Cowpea

- Dual purpose types: IT83S 899, IT86F-2062-5-PKR, IT86F-2062-5 White and IT86F-2089-5 (green tender long pod).

Mungbean

- Genotypes VC 6173(B-10), VC 6368 (46-40-4), NIMB101, Bari mung and VC 6153B-20G had about 25% higher grain yield and 10-50% larger seed size as compared to local Saptari (maturity about 65 days). Bari mung and NIMB 101 are resistant to MYMV.

Blackgram

- High yielders BLG0003-2-1 (Nepal), BLG0067-1 (Nepal), BLG0072-1 (Nepal), BLG0076-2 (Nepal), BLG0068-2 (RU 54 Bangladesh) and BLG0069-1 (RU 34 Bangladesh): mean grain yield of 500-1270 kg/ha.
- BLG0055-1-1, BLG0076-2, BLG0072-1, BLG0067-1 Bari Mash -1, Bari Mash-2 and Bari Mash-3: resistant to MYMV.

Pigeonpea

- ICPL86005 good performance in central terai.
- Rampur: Optimum sowing time 1st week of June for medium duration (Rampur Rahar-1 and ICPL 86005). About 45-50% yield reduction in delay sowing (up to June end).
- Extra-short duration variety ICPL88039 promising for growing in pigeonpea-wheat rotation and also on the edges of terraces in the hills of mid western Nepal.
- Long duration variety ICP7035 is resistant to both *Fusarium* wilt and SMD and is suitable for inclusion in agroforestry system in the terai and low hills.

Kidneybean

- Promising winterbean (rajma) varieties PDR 14, Black Queen and Amber (700-1100 kg/ha) at Rampur, and Utkarsha, Parwanipur-1, Parwanipur-2, Amber and PDR 14 (about 3 t/ha) at Parwanipur.
- PDR 14 moderately tolerant to white mold.
- Kidneybean varieties PB0002 and PB0048 are 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/farwestern region.

Ricebean

- Promising landraces NPGR00008, NPGR00015, NPGR00076, NPGR00194, NPGR05364, NPGR05420, LRGR 91, LRGR 111 and LRGR99.

Production technology

- Preemergence application of Stomp 30EC (Pendimethalin) @ 2.5-3 ml/L water is effective in controlling weeds during early stage of crop growth.
- In lentil, the optimum sowing times are 2^{nd} to 4^{th} week of Nov and 2^{nd} to 4^{th} week of Oct in terai and midhill, respectively. In rice relay system, seed is broadcasting at 1-2 weeks prior to paddy harvest while the recommended seed rates in mixed cropping is 30 kg lentil and 2 kg mustard per hectare.
- In soybean, optimum times of sowing are 2^{nd}-3^{rd} week of June in terai, 4th week of May in mid hill and relay 40 and 55 days after maize sowing.
- In blackgram the optimum times of sowing are July last week and June 2nd week and for terai and midhills, respectively.
- In mungbean, optimum time of sowing is Mar / Apr (after harvest of rice and prior to paddy under partial irrigation), and last week of July to first week of August for monoculture.
- In short duration determinate cowpea, 17-32% reduction in grain yield occurred when planting was delayed after first week of August in inner/terai, but large seed with mean grain yield of 1.0 t/ha can be achieved with late sown crops.
- Seed priming (soaking of seed in plain water for 12 hours followed by shade drying prior to broadcasting) increased seed yield by about 26% in lentil and 40% in chickpea over non primed seed. Mungbean seed priming with sodium molybdate alone for 4-6 hr produced 12-16% higher grain yield as compared to non primed seed. Priming mungbean seeds with rhizobium plus sodium molybdate resulted in mean yield increases of 25 percent over non-priming (Neupane *et. al*., 2011).
- Intercropping of chickpea with linseed (2:1), wheat (2:2) or mustard (4:2) were found profitable
- In pigeonpea, optimum time of sowing for normal and rabi crops are June/July and 1^{st} week of Sept, respectively.
- Soybean is found suitable and profitable legume as intercrop with maize (maize soybean in 1:2 ratio).
- Maize and pigeonepea intercropping in the ratio of 1:1 or 2:1 have also shown promising results under upland condition.

Nutrient management

Soil Science Division (SSD) of NARC has a lead role in conduction of nutrient and soil management research in coloration with NGLRP, NARC regional/agricultural research stations, department of agriculture, NGOs and other collaborating partners. Soybean fixed substantially more N than was harvested in grain in the monocrop and intercrop systems at Khumaltar and Rampur. On-station research on *Rhizobium* inoculation had shown grain yield increase of 15-62% in soybean, 12-45% in lentil, 49% in blackgram, 16-33% in groundnut and 67% in Fababean as compared to non inoculated crops (National Pulse Meet 2011). Indigenous and exotic strains of *Rhizobium* for different legumes such as lentil, chickpea, soybean, cowpea and groundnut are maintained at SSD. *Rhizobium* culture collection, production and distribution are being carried out in soybean, lentil, chickpea, fieldpea, fababean, mungbean, blackgram and cowpea.

Some of the recommended nutrient management are:

- The general recommendation of chemical fertilizers @20:40:20 kg $N:P_2O_5:K_2O$ /ha applied in all grain legumes, except for rajma which requires high dose of N (up to 120 kg/ha). In case where soybean and cowpea are intercropped with maize no fertilizers are applied for legumes.
- Seed inoculation with Rhizobium @ 5 g/kg seed is recommended in new areas where legumes are grown for the first time.
- Seed yields from application of half dose of chemical fertilizer (10:20:20 kg $N:P_2O_5:K_2O$/ha) plus FYM (5 t/ha) was comparable to 10 t/ha FYM alone in short duration cowpea varieties.

Water management

Grain legumes are highly sensitive to excess water affecting days to flowering, days to maturity, plant height, pods/plant, seed yield and straw biomass. However, grain legume crops can withstand short period of waterlogging. Winter grain legumes in particular lentil is subjected to early and terminal drought thus drastically reducing the grain yield. There is a need to initiate water management research in grain legumes.

Crop protection

- Integrated Crop Management (ICM) technology in chickpea gives 2-3 fold increases in seed yields over control. ICM technology consists of improved variety, seed dressing with Bavistin @ 2 g/kg, basal fertilizer application @ 20:40:20 kg $N:P_2O_5:K_2O$/ha, *Rhizobium* inoculation, need based foliar application of Thiodan @ 2 ml/L water (2-3 times) for the management of pod borer and Bavistin @ 2 g/lit water 2-3 times for the management of BGM.
- In lentil, two sprays of Mancozeb 75WP or Carbendazim 50WP reduce severity of *Stemphylium* blight disease.
- In pigeonpea, two spray of Thiodan @ 2 g/L water and Bavistin @ 2 g/L water to control pod borer and pod blight, respectively.
- In rajma, Benomyl 50 WP spray @ 1 g/L water or Bavistin seed treatment (2 g/kg seed) + Bavistin spray (2 g/L water) to control white mold.
- Village level HNPV production and application (250 **LE @1 ml/L)** and 500 LE per ha for the management of podborer in chickpea and pigeonpea.
- Botanicals such as *Achorus calamus*, rice husk ash and mustard were found effective against bruchid (*Callososbruchus maculatus* F) in lentil (National Pulse Meet 2011).
- Maximum number of bugs was found in Mungbean VC 6173 and therefore probable trap crop in management of bug (*Phaseolus aureus* Roxb.) mid hill and terai (National Pulse Meet 2011).

Seed production

NGLRP has responsibility to coordinate, produce and supply source seed (breeder and foundation seed) to RARSs, ARSs under NARC and seed growers. About 5 mt of source seed of grain legumes are produced at Rampur, also RARSs and ARSs also produce foundation seed and made available to seed growers, DADOs and farmers. Formal grain legumes source seed demand by DADOs and seed producer groups (Balance Sheet) was about 12 mt in 2008/09, which constitute about 0.2% of total seed requirement. Community based seed production is becoming successful where producer groups produce and supply improve seeds to farmers. The seed replacement rate (SRR) of pulses is only about 3 percentage (Bajracharya 2011), suggesting the need of a massive seed increase and distribution program. In this context, seed production through community based seed production system (CBSPs) has significantly improved farmers' access to improved seeds of grain legumes. In the past four years, FORWARD a national NGO based at Chitwan has facilitated the production and marketing of more than 160 mt legume seeds (Figure 3). The government needs to plan for achieving a seed replacement rate (SRR) of 25% to sustain increased productivity of pulses through wider use of high yielding varieties.

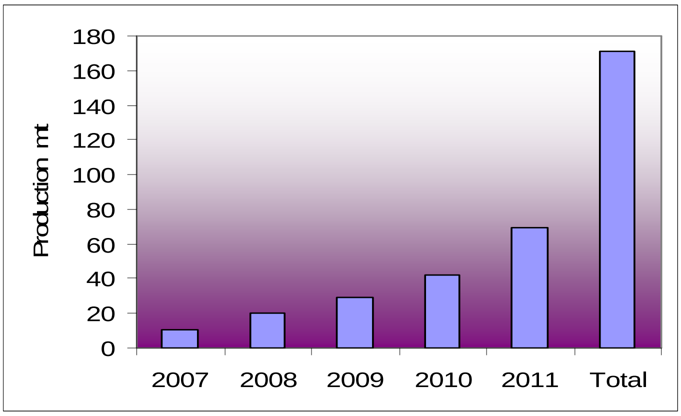

Figure 4: Grain legume seed production through CBSPs facilitated by FORWARD

5. Initiatives for Promotion of Pulse Production

Lessons Learnt from Past Initiatives

The technology transfer activities of grain legumes have been carried out for the past decade in major pulse growing areas. Department of Agriculture (DoA) has the main responsible for the transfer of technology of all the crops. After established of NARC in 1991, research stations covering varied agro-ecological conditions of the country are also responsible for on-farm evaluation and validation of on-station generated technologies through outreach sites. Farmer preferred varieties and technologies are recommended based on the participatory evaluation by concerned stakeholders. The improved technologies are disseminated and scaled up through distribution of minikits, large plot demonstration, training, field visits and community seed increase coordinated by the district agriculture development offices in collaboration with local NGOs and CBOs. Though limited work on formal surveys for assessment of project impacts have been done in grain legumes, information collected through formal/informal channels, official records, farm visits, district reports, farmers interaction, NARDIF project/ IFAD project completion reports indicate improved pulse technologies have made considerable impact on crop diversification, cash income generation and increase dietary intake pulse thus improving the living standard of farmers.

Technology Adoption and Its Impact

A range of grain legumes were introduced in Sindhuli/ Ramechap river basin areas (500-650 m amsl) in 2007 where double crops of cereals: rice-fallow-maize, rice-maize-fallow, rice-wheat-fallow were the common cropping patterns. Lentil, short duration cowpea and mungbean had been successfully grown in the cropping patterns: rice-lentil-maize, rice-maize/cowpea or mungbean, rice-wheat-cowpea or mungbean (Figure 5, Appendix 6). Farmers were able to get high net return by inclusion of grain legumes. There has been a tremendous increase in area under pulses at sites under studies are presented in Tables 4.1, 4.2. Seed production of promising lines of *Phaselous* bean in farmer's field of Dailekh district has contributed in improving seed availability and increase in household income (Appendix 7).

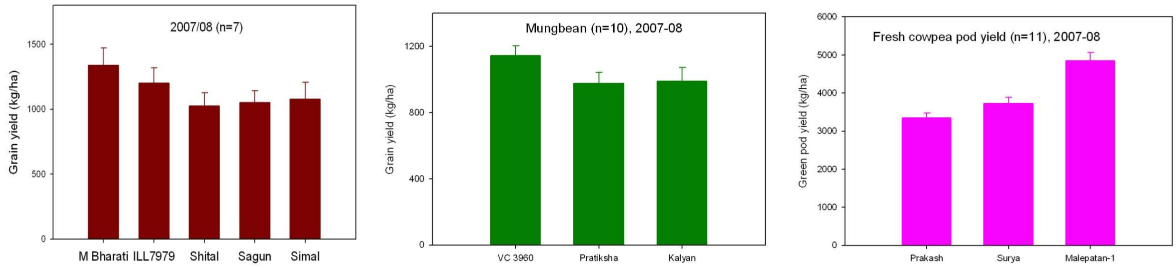

Figure 5: Performance of improved varieties of lentil, cowpea and mungbean in Ramechap and Sindhuli districts.

Table 4.1: Adoption of grain legumes in Ramechap/Sindhuli (2007-10)

Crop	Description	2007/08	2008/09	2009/10
Lentil	No. farmers	40	127	350
	Area (ha)	0.5	4.4	13.3
	Production (t)	0.57	7.17	19.95
Cowpea	No. farmers	25	70	200
	Area (ha)	0.25	1.5	4.75
	Production (t)	0.250	0.327	10.355
Mungbean	No. farmers	20	58	170
	Area (ha)	0.2	1.1	4.75
	Production (t)	0.196	1.98	8.36

Source: Khadka *et. al.*, 2010

Table 4.2: Adoption of lentil varieties in Maintada of Surkhet (IFAD 954-ICRISAT project)

Variety	Sample size	Starting year (Y) of the project (2008)	Year 2 2009	Year 3 2010
Sagun	No. of farmers	15	35	65
	Area (ha)	0.6	1.6	3.2
Maheswor Bharati	No. of farmers	18	40	60
	Area (ha)	0.4	2	3.2
ILL 7723	No. of farmers	20	90	120
	Area (ha)	0.8	4.8	8
Khajura Masuro-1	No. of farmers	16	90	120
	Area (ha)	1.5	15	20
Local Lentil	No. of farmers	200	240	270
	Area (ha)	12	16	24

Ongoing Programs and Activities

At present, nine projects NARC projects on grain legumes are ongoing at NGLRP, Rampur. This includes two projects on varietal development and plant pathology, one each on agronomy, entomology, outreach, seed production and farm management (training, field day etc).

Variety Development (in collaboration with RARSs, ARSs Disciplinary Divisions, DADO, NGO)

1. Varietal research for improvement of winter grain legume crops: lentil, chickpea, grasspea hybridization in lentil, agro-morphological characterization of germplasm, multilocation yield trials, PRVT/FAT in farmers fields)-NGLRP
2. Varietal improvement on summer grain legumes: soybean, mungbean, blackgram, cowpea, pigeonpea, rajmabean and ricebean (mode of reproduction on ricebean, agro-morphological characterization of germplasm, multilocation yield trials, PRVT/FAT in farmers fields)-NGLRP.

Agronomy/Soil

1. Enhancing grain legume productivity through improved agronomic management (studies on waterlogging tolerance on lentil, maize and kharif pigeonpea intercropping, relay of short duration grain legumes under spring maize, response of soybean varieties to sowing dates, and response of soybean to the application of boron and molybdenum at Rampur)-NGLRP Ramppurpur.
2. Study on the effect of biofertilizers and chemical fertilizers on nodulation in lentil and their residual effect in rice productivity at NGLRP Rampur-Soil Science Division.

Disease Management

1. Enhancing productivity of lentil through integrated management of Stemphulium blight of lentil (efficacies of plant extracts and fungicides against Stemphylium blight of lentil in-vitro test (lab condition), in-vivo test (field condition), effect of biological control agents against Stemphylium blight of lentil in-vitro test and in-vivo test-NGLRP
2. Enhancing productivity of legumes (rajma, blackgram, lentil through integrated disease management (evaluation of bio-control agents to manage white mold of rajma, effect of variety cum date of planting on white mold of rajma, validation of farmers' indigenous knowledge on management of mungbean yellow mosaic virus in blackgram, identifying sources of genetic resistance to major diseases in lentil and rajma)-NGLRP
3. Integrated Management of Stemphylium blight, wilt and root rot of lentil– Plant Pathology Division
4. Investigation on bacterial pathogens of soybean, fungal pathogens of lentil, soybean, chickpea, investigation on plant viruses of soybean, mungbean, blackgram, lentil and exploration of biological control agents and eco-friendly substances against soil borne pathogens (*Rhizoctonia, Fusarium* and *Sclerotinia*) – Plant Pathology Division

Integrated Pest Management

1. Integrated management of grain legumes insect-pests: Preparation and use of HNPV, integrated insect management of grain legumes, monitoring of aphid species in cowpea, field experimentation to manage aphid and management of cow pea pest in storage condition – NGLRP, RARS Nepalgunj
2. Determining status of priority insect pests and review on entomological research in Nepal – Entomology Division

Outreach: Participatory technology development and promotion of grain legumes (verification and transfer of technologies to stakeholders, publications, information dissemination through different print and electronic media) in inner terai and mid hills-NGLRP, Disciplinary Divisions, RARSs, ARSS.

Seed Production: Source seed of different grain legumes (soybean, cowpea, pigeonpea, lentil, chickpea, mungbean, rajma, ricebean) are being produced at NGLRP Rampur at RARSs and ARSs.

Farm Management includes enhancement of coordination and networking of plant pathological researches, and institutional and individual capacity.

Collaborative Projects

Some of the ongoing NARC collaborative projects with international Agriculture Research Centers are:

1. *Shuttle Breeding Project on Pulses (SBPP)-SAARC: development and identification of high yielding varieties of pulses for sustainable agriculture in South Asia-SAARC*

This project was incepted in July 2009 with an objective of increasing the productivity of legumes and nutritional security of resource poor people in SAARC regions through the development of high yielding varieties of different grain legumes. This project had open the opportunity of exchange and sharing of genetic materials of blackgram, mungbean, lentil, Rajmash and *Lathyrus* among the participating countries, Nepal, India and Bhutan. The promising materials are being tested at various agro-ecological sites of Nepal.

2. *Biofortification of lentils under Harvest plus Challenge Program of CGIAR-Promotion of lentil cultivars with high concentration of Iron and Zinc in mid hills*

This project aims at identification of high Fe and Zn content lentils, promotion of these lentils in farmer's field, strengthen seed production system in Nepal. In lentil seed, Fe and Zn content ranged from 64-127 mg/ 100 g and 35-88 mg/100 g seed, respectively (NGLRP 2006, 2008). Khajura Masuro-2, RL 6, RL 12, ILL 8006 and Sisir are rich in both Fe (82-101 g/100 g seed) and Zn (62-75 g/100 g seed). High in Fe containing lentils are Shikhar, Simal, Simrik, ILL 7716, and RL 11 (59-84/100 g seed), and ILL 7543, ILL 3111, ILL 7164 and ILL 6260, are high Zn (60-75 mg/100 g seed).

3. IFAD/ICRISAT 954: Harnessing the true potential of legumes: Economic and knowledge empowerment of poor rainfed farmers in Asia

In Nepal, FPVS, seed production and ICM activities covering seven grain legumes viz., chickpea, pigeonpea, groundnut, soybean, mungbean, *Phaseolus* bean and lentil are conducted at six hilly districts (Bajura, Dang, Surkhet, Dailekh, Jumla and Doti) through five NARC stations, in collaboration with the District Agriculture Development Offices (DADOs) and NGO (FORWARD), WUPAP and other CBOs with technical backstopping from NGLRP, Rampur and National Oilseeds Research Program (NORP), Nawalpur. A total of 92 FPVS trials (42 in pigeonpea, 20 in *Phaseolus* bean, 14 in chickpea and 16 in lentil), 501 sets for up-scaling (301 in chickpea, 90 in lentil, 90 in pigeonpea and 20 in *Phaseolus* bean), 43 ICM trials (12 in chickpea, 16 in lentil and 15 in pigeonpea) and village level seed increase of different legumes in 4.5 ha were organized.

4. SSNP-AF/SS-2 (Social Safety Nets Projects – Additional Financing/ Seed Subcomponent-2)

This project aims at increasing the availability of quality seed and strengthening the seed processing units in NARC research stations. Production of breeder and foundation seed of lentils are also mandated apart from cereal crops rice, wheat, maize and millet. In the first year (2010/11), 2.7 mt of foundation and 1 mt of breeder seed of lentil were targeted to produce at NGLRP, Rampur, National Rice Research Program (NRRP), Hardinath, NORP Sarlahi and Jute Research Program Itahari. The targeted breeder and foundation seed production at NARC stations for year 2011/12 are 3.3 mt and 11.15 mt, respectively.

Future Strategy

- Decentralized research/ breeder seed production, breeder and foundation seed production at NARC stations
- Identify RARS/ARS/Divisions as research sub centers for targeted species under direct supervision of NGLRP
  - Soybean: Agronomy Division Khumaltar or NHCRP Kabre
  - Pigeonpea: RARS Nepalgunj
  - Chickpea: RARS Parwanipur, RARS Nepalgunj
  - Mungbean: Parwanipur or Rampur
- Breeding for terminal drought and heat stress
- Facilitation of general seed (certified, improved, TL) production by CBSPs, DISSPRO and private companies through regular supply of source seeds.
- Joint exploration of genetic materials by commodity and other research program, cooperation in rejuvenation, characterization (quality, biotic/abiotic stress), climate change adoption studies on grain legumes germplasm comparing with modern varieties
- Molecular research
- Research on value addition and product diversification of grain legumes
- Research on selection of varieties and technologies to address the issues of climate change
- Research on IPM and IDM for the management of major pest and diseases of grain legumes
- Strengthening on-farm research through NARC outreach sites
- Grain legume technology transfer in system based perspective through wider involvement of DOA, NGOs and other stakeholders
- Mechanization/ cost reducing technologies
- Infrastructure development (laboratory, glasshouse, office space, storage)
- Capacity building
- Location and crop specific nutrient recommendation for specific soil and crop specific

Future policy of the govt. for enhancing pulse production

- Government should recognize the contribution of pulses in household/ national food security program. Uptill now, rice, wheat, maize and millet only have been considered for providing food security to the people.
- Grain legumes should be included in DISSPRO program. In the district seed sufficiency program (DISSPRO), seed production of pulses is not supported; as a result farmers' access to seeds of improved varieties of pulses is very poor, resulting in poor yield of pulses.
- Seed village concept for seed self sufficiency.
- NSC should prioritize seed production and distribution of major pulses.
- Government should provide support to processing industries and exporters.
- Develop crop specific strategy for future direction.
- MoAC/NARC to strengthen grain legumes mission in collaboration with extension department and I/NGOs to cope with the nutritional security.
- Soybean mill for edible oil and raw materials for feed industries.
- Establish national pulse forum to provide priority to capacity building.

6. Future challenges and requirement of pulses

- Growing demand for food and nutrition
- Inadequate research priority: many species, and some still to be explored and utilized
- Declining productivity of landraces (eg soybean and blackgram)
- Imbalanced use of fertilizers
- Monoculture: hybrid, dense planting and high N fertilizer affecting legume yields in maize based system
- Climate change: shortening growing period (winter legumes), severe drought, high risk in crop production
- Yield potential not realized
- Pests, diseases, weeds, soil nutrients (micronutrients)
- Multiple pickings (mungbean/ cowpea)
- Genotype x Environment interaction (varieties for specific production zones)
- High cost of cultivation
- Unavailability of quality seed/ lack of systematized seed supply system

Research Need

- Systematic breeding program.
- Varietal development
    - Collection, characterization, evaluation and utilization of underutilized grain legumes: horsegram, fieldpeas and fababean
    - High yielding fieldpeas varieties with standing ability
    - High yielding varieties of different legumes suitable for different agro-ecological zones and cropping patterns
    - High yielding varieties having multiple resistant to biotic and abiotic stresses
- Crop management practices to mitigate adverse effect of drought and heat – relating climatic variables to crop growth stages.
- Screening and development of climate resilient varieties using physiological tools.
- Characterization of climatically vulnerable area using GIS tools.

- Carbon sequestration – incorporation of biomass.
- Technological options for water use-efficiency and availability (life saving irrigation).
- Effective transfer of technology to reduce yield gaps between research farms and farmers fields.
- Commercialization by optimum utilization of resources: supplemental irrigation, nutrients and weed management and mechanization, improved access to marketing information and business skills to commercial pulse growers.
- Quality seed production: strengthen community based seed production.
- Post harvest technologies to reduce losses due to storage pests.
- Nutritional quality/ diversification of value added products such as protein rich baby food, snacks items, and by-product poultry industries could generate employment opportunity.
- Promotion of Grain legumes in degraded land and Agro-forestry system for nutritional security in rural areas.
- Value chain study on major pulses including soybean.
- Impact of wheat and gain legumes mixed cropping (wheat + pea, wheat + chickpea, wheat + lentil) on the yield and attributes.
- Develop appropriate resource conservation technology/ conservation based agriculture.
- Verify and validate the bio-fertilizer management trial on grain legumes in different agro-eco zone.
- Mobile service for effective controls the biotic problems.

7. Opportunities for increasing pulses production

There is a vast opportunity for increase pulse production due to eth following reasons:

A. Diverse agroclimate and cropping systems: Allows a number of commercially important pulses to be grown, eg lentil from terai to high hills, pea terai to high hills, kidney bean terai (winter) to high hills (summer), soybean midhills and terai (commercial scale) etc.

B. High export potential and good will: Nepal has already entered into international market of pulses. Nepali lentils are accepted by the term "Small pink (red) and tasty". There are opportunities for export by assigning geographysical indicator (GI) such as *Terai lentil, Nepal lentils, organic lentils etc*. In addition there are opportunities for promotion of kidney bean from High hills, peas (canned) and pods from the midhills and mungbean from the terai.

C. Domestic demands increasing: Because of the rise of income and consequence changes in food habits, the domestic consumption of pulses is in increasing trends and there should not be marketing problem.

D. Abundance of local land races: The existing local land races of legumes in the country have not been properly explored and evaluated. Limited study shows wide variability in many useful traits (maturity ranges, diseases, insect resistances, drought hardiness, cooking quality and social acceptance of local landraces such as black soybean for religious purpose etc.) that could be useful in crop improvement programs in the country or elsewhere.

E. Vegetarian population in the southern side: Because of the large vegetarian population of India, and growing demand of pulses, there is always an opportunity to export pulses.

F. Vast are still under fallow in the terai: About 290000 ha land remains fallow after rice harvest. There is an opportunity to expand winter legumes through s development of varieties and suitable technologies.

8. Future outlook for enhancing pulse production in South Asia - From Country Perspective

Grain legumes play an important role in nutritional security of poor rural population. Also, there is a good scope as an export commodity (lentil as whole/split seed as dhal) or improving utilisation of plant protein by diversifying products. This also generates employment thereby increase income. However, grain legumes research have not received adequate institutional support for yield improvement as they are always considered secondary importance and grown in marginal lands with minimum or no inputs. Commercialization of high valued legumes such as lentil, mungbean, rajma (kidney bean) and pea by improving access of farmers to improved seeds, fertilizers, supplemental irrigation, better post harvest management and marketing are the present needs in increasing production and productivity. Research to address the problems faced by value chain actors (farmers, traders, processors, exporters, consumers, input suppliers etc.) of pulse subsector is equally important to promote commercial farming of grain legumes.

Considering the diverse agro-climatic conditions and cropping systems prevalent in the country, we see tremendous scope to contribute to enhance pulse production in south Asia. Nepal is among the top 5 the lentil exporting countries in the world. About 290000 ha of rice fallows could be brought into winter legumes through development of suitable technologies and its dissemination, expansion of irrigation facilities, and policy reforms for the promotion of legumes. For this to happen two pronged approaches eg increasing production through utilizing the comparative advantages of diverse agroclimate and commercialization of exportable species through increasing competitiveness in production (lowering the cost of production and maintaining quality standards) should be followed.

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Appendix 1: Trends in area (ha), production (mt) and yield (kg/ha) of grain legumes (1987/88 to 2009/10)

SN	Crop	1984/85			2009/10			Percent change	
		Area	Production	Yield	Area	Production	Yield	Area	Production
1	Lentil	98560	58400	593	187438	151758	810	90	160
2	Chickpea	25890	16000	618	8647	7065	817	-67	-56
3	Grasspea	51170	26610	520	5986	4453	744	-88	-83
4	Pigeonpea	14260	10500	736	21296	18648	876	49	78
5	Blackgram	9060	4660	514	33779	26673	790	273	472
6	Soybean	11320	6180	546	23943	22042	921	112	257
7	Horsegram	10600	5600	528	8000	5532	692	-25	-1
8	Others*	7160	3730	521	30383	26186	862	324	602
	Total	**228020**	**131680**	**577**	**319472**	**262357**	**821**	**40**	**99**

*Others includes fababean, field peas, mungbean, cowpea, ricebean, *Phaseolus* etc

Appendix 2.1: Pulse exported (value in million Nepali Rupees and quantity in mt) from Nepal 2009/10

SN	Pulses/Grain Legumes	1974/75	2007/08		2009/10		Country
		Value	Quantity	Value	Quantity	Value	
1	Chickpea	-	-	-	21.9	1.4	UK
2	Lentils	-	18356	1310	37569.9	3744.9	**Bangladesh**, Bhutan, Baharain, Jordan, Kuwait, Malaysia, Saudi Arabia, Singapore, Srilanka, UAE, India, Sierra Leone, Canada, USA, Surinam, Italy, UK
3	Broad bean and horsegram				2.0	0.5	UK
4	Dried leguminous vegetables		105	9	283.0	9.0	USA, Australia
5	Pulses			315			India
	Pulse Total	**8**	**18461**	**1634**	**37876.8**	**3756**	

Appendix 2.2: Pulse imported (value in million rupees and quantity in mt) into Nepal

SN	Crops	2007/08	2009/10		Country
		Value	Quantity	Value	
1	Dried peas	614.5	12203.6	376.51	China PR, Singapore, India, Tanzania, Canada, USA, Australia
2	Chickpea	117.0	6394.3	244.61	Singapore, India, Canada, Tanzania, USA, Australia
3	*Vigna mungo*/ *V radiata*	3.3	0.3	0.01	India
4	Small red (Adzuki) beans (*Phaseolus* or *V angularis*)	-	0.3	0.01	India
5	Kidney bean, *P vulgaris*	0.2	70.6	1.94	India
6	Beans (*V* spp, *Phaseolus* spp), shelled or split	302.0	4076.0	113.31	China PR, India
7	Lentils	-	7645.0	230.21	India, USA, Russia, Turkey
8	Broad beans and horsegram (**pulses-gram**)	**14.6**	186.1	11.99	India, USA
9	Dried leguminous vegetables	10.3	13456.1	398.07	India, USA, Italy, Australia
	Pulses from India	315.4	-	-	-
	Pulse Total	**1377.3**	**44032.2**	**1376.67**	-
	Soybean (whole/broken)	**0.2**	**23875.5**	**921.62**	India
	Crude soybean oil	**4133.6**	**84506.6**	**5963.42**	Indonesia, Singapore, India, **Argentina**, Brazil, Antiqua and Barbuda, Belize, Netherlands, Ukraine
	Soybean oil	**476.9**	**359.1**	**32.82**	Korea R, **Malaysia**, Singapore, Thailand, India

Appendix 3: Consumption of lentil (kg/HH/year) Source: Neupane RK (2006)

Districts	**2003 survey**	**Impact study 2006**	**Family size**
Dang	6.08	30.1	9.0±4.4
Banke	4.21	77.7	8.3±3.2
Bardia	25	28.6	8.1±4.0
Kanchanpur	8.47	37.7	9.7±3.1

Appendix 4: Districts with the number of pulse germplasm collection, Nepal

SN	District	No. Accession	SN	Districts	No. Accession	SN	District	No. Accession
1	Mustang	115	24	Rautahat	35	47	Pyuthan	16
2	Dhanusha	106	25	Sallyan	34	48	Sunsari	16
3	Dhankuta	97	26	Baglung	32	49	Khotang	15
4	Humla	96	27	Kanchanpur	32	50	Arghakhanchi	14
5	Siraha	84	28	Saptari	30	51	Kalikot	14
6	Bajura	81	29	Surkhet	30	52	Nuwakot	14
7	Myagdi	74	30	Tanahun	30	53	Syangja	14
8	Ilam	72	31	Bardia	28	54	Taplejung	14
9	Jumla	69	32	Gorkha	28	55	Rolpa	13
10	Morang	69	33	Kailali	28	56	Okhaldhunga	12
11	Dang	64	34	Chitwan	26	57	Rukum	11
12	Kabhre	63	35	Lalitpur	26	58	Sindhupalchok	9
13	Bara	60	36	Panchthar	23	59	Dandeldhura	8
14	Nawalparasi	57	37	Bhojpur	22	60	Tehrathum	6
15	Banke	56	38	Kaski	22	61	Dhading	5
16	Jhapa	52	39	Solukhumbu	22	62	Sankhuwasabha	5
17	Rupandehi	51	40	Kathmandu	21	63	Makwanpur	3
18	Mahottari	50	41	Manang	21	64	Palpa	2
19	Kapilvastu	45	42	Achham	19	65	Bhaktapur	1
20	Mugu	44	43	Bajhang	19	66	Dolkha	1
21	Lamjung	39	44	Doti	18	67	Others	645
22	Baitadi	36	45	Parsa	18			
23	Sarlahi	36	46	Gulmi	17			

Appendix 5.1: Released varieties of lentil and chickpea in Nepal

SN	Crop/Variety	Accession No.	Source	Release Year	Traits/Reaction to diseases/pests	Domain
	Lentil					
1	Sindur	LO-111-25	Nepal	1979	Susceptible to wilt disease	Terai, midhills
2	Sisir	P43	India	1979	Highly susceptible to wilt disease	”
3	Simrik	T36	India	1979	Susceptible to wilt	”
4	Shikhar	ILL 4404	Pakistan	1989	Field tolerance to wilt, moderately resistant to rust	”
5	Simal	LG 7	India	1989	Field tolerance to wilt, moderately resistant to rust	”
6	Khajura Masuro 1	LG 198	India	1999		Mid western terai
7	Khajura Masuro 2	PL 639	India	1999		Mid western terai
8	Shital	ILL 2580	ICARDA	2004	Moderately resistant to wilt root rot complex, less affected by Stemphylium blight	Terai, midhills
9	Sagun	ILL 6829	ICARDA	2009	Highest mean grain yield recorded 2430 kg/ha (mean of 1355 kg/ha), 1.9 g/100 seed) Resistance to moderately resistant reaction to wilt root rot complex (*Fusarium oxysporum* f. sp. *lentis*, *Sclerotium*sp, *Pythium* sp and *Rhizoctonia* sp) and *Stemphylium* blight	Midhills, river basin
10	Maheswor Bharati	ILL 7982	ICARDA	2009	Easily distinguishable with its bluish dark green foliage, narrow leaflets (1.9 cm^2), very sparse stem and leaf pubescence and bluish purple flowers, strong stem with compact branching and short plant height (average of about 30 cm), resistant to lodging 2.1 g/100 seed), highest mean grain yield of 2900 kg/ha (mean of 1445 kg/ha) Resistance to moderately resistant reaction to wilt root rot complex (*Fusarium oxysporum* f. sp. *lentis*, *Sclerotium*sp, *Pythium* sp and *Rhizoctonia* sp) and *Stemphylium* blight	”
	Chickpea					
1	Dhanush		Nepal	1980		Western to central terai
2	Trisul*		Nepal	1980		Western to central terai
3	Radha	JG 74	India	1987		Terai, inner terai
4	Sita	ICC4	ICRISAT	1987		”
5	Koseli	ICCC32	ICRISAT	1991		Western to central terai
6	Kalika	ICCL82108	ICRISAT	1991		Western to central terai”
7	Tara	ICCX840508-36	Nepal	2009		Terai
8	Avrodhi	Avrodhi	India	2009		Western terai

*Denotify

Appendix 5.2: Released varieties of soybean, blackgram, pigeonpea, mungbean and cowpeas in Nepal

SN	Crop/Variety	Accession No.	Source	Release Year	Reaction to diseases/pests	Domain
	Soybean					
1	Hill*	(Dunfield x Haberlandt) x Sib of Lee	USA	1976		Midhill
2	Hardee	D 49-772 x Improved Pelican	USA	1976	fairly tolerant to bacterial pustules, susceptible to yellow mosaic	Terai
3	Cobb	F 57-737 x D 58-3358	USA	1989		Terai
4	Ransom	(N 55-5931 x N55-3818) x D56-1185	USA	1989	tolerant to frog eye leaf spot and bacterial pustules	Midhill (intercropping)
5	Seti	KS 419 x KS 525	Taiwan	1989	less susceptibility to rust and frog eye leaf spot, tolerant to partial shade	Midhill (intercropping)
6	Lumle-1	Local	Nepal	1997		Midhill (rice bund)
7	Tarkari Bhatmas-1	Huichin#2	China	2004	53.3% protein with relatively soft seeds	Kathmandu valley/similar environments
8	Puja	PK 416	India	2006	Resistant to YMV & bacterial pustules, tolerant to Rhizoctonia	Terai/inner mid hills
	Pigeonpea					
1	Bageshwori	PR 5147	Nepal	1991		Terai
2	Rampur Rahar-1	Local	Nepal	1991		Terai/ inner terai
	Blackgram					
1	Kalu	T 9	India	1971		Warm Valleys
	Mungbean					
1	Pusa Baisakhi		India	1975		Terai/inner terai
2	Pratikshya	VC 6372(45-8-1)	AVRDC	2006		”
3	Kalyan	NM 94	AVRDC	2006		”
	Cowpea					
1	Aakash	IT82D-752	IITA	1990		Terai
2	Prakash	IT82D-889	IITA	1990		”
3	Surya	IT86D-792	IITA	2004		”

5.3: Released varieties of cowpea, pole/*Phaselous* bean and peas (vegetable purpose) in Nepal.

SN	Crop/Variety	Origin	Release Year	Yield Potential (mt/ha)	Maturit y days	Recommended domain
	Cowpea					
1	*Malepatan-1	IITA Nigeria	2011	5.8-10.6	80-85	Midhill, riverbasin, terai
	Pole/*Phaseolus* bean					
1	Trisuli Geu Simi	Nepal	1994	14.0	50-60	Midhill and terai
2	Jhange Simi-1	Nepal	1994	9.0	60-70	Midhill and terai
	Peas					
1	Sarlahi Arkel	India	1994	5.0-7.0	60-65	High and midhill, terai
2	New Line	India	1994	6.0-8.0	85-90	Midhill and terai
3	Sikkime	USA	1994	6.0-8.0	60-80	High and midhill, terai

*Source: ARS, Surkhet

Appendix 6: Lentil grain yield in Sindhuli and Ramechap districts, 2008-09

Sites	Grain yield (kg/ha)	
	Range	Mean
Pakarbas	1050 – 2600	1948
Bhatauli	1710 – 2400	1894
Jhagajholi	950 – 2540	1740
Mean	**950- 2600**	**1861**

Source: Khadka *et al* 2010

Appendix 7: Adoption of *Phaseolus* bean varieties PB0002 & PB0048 for income generation at Ghodabas of Dailekh district (Source: FORWARD)

Year	# of HHs	Seed production (kg)	Seed sold (kg)	Price NRs/kg	Total value NRs	Income per HH per year NRs
2009	25	443	345	200	69000	2760
2010	40	1148	848*	205	173840	4246

Seed sold to DADOs, agrovets, CEAPRED, NEAT and others