4. Legumes in Nepal

S P Pandey[1], C R Yadav[1], K Sah[1], S Pande[2], and P K Joshi[2]

Abstract

Nepal is divided into four major agroclimatic zones, the Terai (part of the Indo-Gangetic Plain to the south), the inner Terai, mid-hills and valleys, and high mountains (in the north). Soil texture varies from rich alluvial deposits in the Terai to course-textured gravel in the high mountains. Annual rainfall varies from 5500 *mm to 3500 mm and temperatures from - 10°C to 35°C. Legumes are important components of Nepalese farming systems and diets. Most of the legumes are grown in different cropping patterns in the Terai. Their yields have remained low, at usually <0.7 t ha^{-1}, because of a range of hiotic and abiotic constraints.* Botrytis cinerea *and pod borers are the most damaging pests of chickpea and lentil while fusarium wilt and sterility mosaic largely affect the pigeonpea crop. Baseline agronomic research on soil fertility management for cropping systems with grain legumes as component crops is required for different agroclimatic zones, especially in the Terai and inner Terai.*

Introduction

Grain legumes constitute a key component of various cropping systems in Nepal. They occupy more than 311,661 ha (13% of food crops land area) and produce a total of 214,820 t grains (Table 4.1). Grain legumes rank fourth in area and production after rice (*Oryza sativa* L.), maize *(Zea mays* L.), and wheat (*Triticum aestivum* L.). Thus, they significantly contribute to the dietary needs of the people, have considerable potential for export, and can restore soil fertility. Grain legumes are essential components of the Nepalese diet but their consumption is only 9 kg per capita per annum which is four times less than that recommended by the Food and Agriculture Organization of the United Nations (FAO), Italy (36 kg per capita per annum) (FAO 1981).

Legumes are grown in both summer and winter in Nepal. The main summer grain legumes are soybean (*CAycine max* (L.) Merr.), black gram (*Vigna mungo* (L.) Hepper), horse gram (*Macrotyloma uniflorum* (Lam.) Verde.), cowpea (*Vigna unguiculata* (L.) Walp.), mung bean (*Vigna radiata* (L.) Wilczek), and groundnut (*Arachis hypogaea* L.). Major winter grain legumes include lentil (*Lens culinaris* Medic), khesari *(Lathyrus sativus* L.; lathyrus; grass pea), chickpea (*Cicer arietinum* L.), and faba bean *(Vicia faba* L.). Pigeonpea (*Cajanus cajan* (L.) Millsp.) is sown early in the rainy season and harvested in the following spring/summer. Legumes are the second most important crops grown in rotation in rice-wheat cropping systems (RWCS). The main winter grain legumes, lentil, khesari (lathyrus), and chickpea are sown after harvest of rice and cover about 15% (0.23 million ha) of total rice area. Besides the grain legumes,

Table 4.1. Area, production, and yield of major grain legumes in Nepal during 1995/96.

Grain legumes	Area (ha)	Production (0	Yield (kg ha-')
Lentil	157080	117720	749
Chickpea	19080	13640	715
Pigeonpea	25530	19300	756
Black gram	25500	15300	600
Khesari (lathyrus)	34240	18170	531
Horse gram	11640	5610	482
Soybean	20770	13710	660
Others[1]	17810	11400	640
Total	311661	214820	641

1. Others = mung bean, cowpea, groundnut, and faba bean.
Source. Munstry of Agriculture, His Majesty's Government, Nepal.

1. Nepal Agricultural Research Council, Khumaltar, P.O. Box 5459, Lalitpur, Kathmandu, Nepal.
2. ICRISAT, Patancheru 502 324, Andhra Pradesh, India.

some green manure legumes such as dhaincha (*Sesbania cannabina* (Retz.) Pers.) are also grown in limited areas in rice-wheat rotations, between wheat and rice crops.

Although the rice-winter grain legumes cropping system is a long-standing traditional cropping system in Nepal, the introduction of wheat after rice since the early 1960s has relegated the legumes to more marginal rice fields. Since then, the more fertile and irrigated lands have been occupied by rice-wheat rotations which use high input technology including improved seeds and fertilizers. However, the rise in the cost of fertilizers, their unavailability at the right time and low purchasing power of the farmers coupled with the slow growth of irrigation facilities have limited the potential productivity of rice-wheat cropping in Nepal. The national average yields in 1995/96 were 2.4 t ha^{-1} for rice and 1.5 t ha^{-1} for wheat. Besides, there are increasing concerns that the continuous rice-wheat (cereal-based) rotation has caused mining of soil nutrients, and increased incidence of diseases, insect pests, and weeds, resulting in environmental degradation and yield declines.

Therefore, the necessity of inclusion of legumes in RWCS is recognized more than ever due to their ability to enrich the soil fertility through biological nitrogen fixation (BNF), tolerate drought hazards, perform relatively better than other crops on marginal lands, and provide cheaper sources of protein for human nutrition. However, their yield levels are very low, at <0.7 t ha^{-1}, and they cannot compete with other winter crops such as wheat unless market prices are favorable and their indirect benefits to soil fertility and the environment are taken into account. Keeping these points in view, the present initiative was undertaken to:

- Bring out the status of legumes in rice-based cropping systems in Nepal in terms of their distribution, production, and yield trends;
- Understand and illustrate the spatial changes that have occurred in major grain legumes in RWCS during recent years;
- Elucidate the actual and potential role of legumes in RWCS;
- Assess biotic and abiotic stresses limiting legume cultivation and productivity; and
- Identify the constraints and indicate potential areas for expansion of legume cultivation.

Geographic information systems (GIS) software was used to process and analyze the time series statistics on legumes and integrate them with relevant bio-physical and socioeconomic information. It is expected that the information thus produced and presented in this chapter will enable planners, decision makers, and other concerned scientists to better understand the role of legumes in sustaining RWCS in Nepal.

Edaphic and Climatic Features

Nepal is located between latitudes 26°22 N to 30°27'N and longitudes 80°4'E to 88°12'E in the Hindu Kush Himalaya Range of South Asia. Administratively Nepal is divided into 75 districts (Fig. 4.1). Physiographically, the country is divided into 5 regions: Terai, Siwalik, Middle Mountain, High Mountain, and High Himalaya (Fig. 4.2). These regions have distinct geological, climatic, and hydrological characteristics that reflect in soils, vegetation, and land use pattern.

The Terai region is part of the Indo-Gangetic Plain (1GP) to the south and represents only 14% of the total land area of Nepal, but contains about 46% of the gross cultivated area. The rice-wheat/ legumes cropping systems are mostly concentrated in Terai, with very little in the Siwalik and Middle Mountain physiographic regions.

The Terai plain comprises nearly level alluvial tracts, predominantly of medium- to fine-textured sediments. The major soils are imperfectly to poorly drained Haplaquepts in the southern parts; and well drained Hapludolls at the foot of the Churia range (Fig. 4.3). The

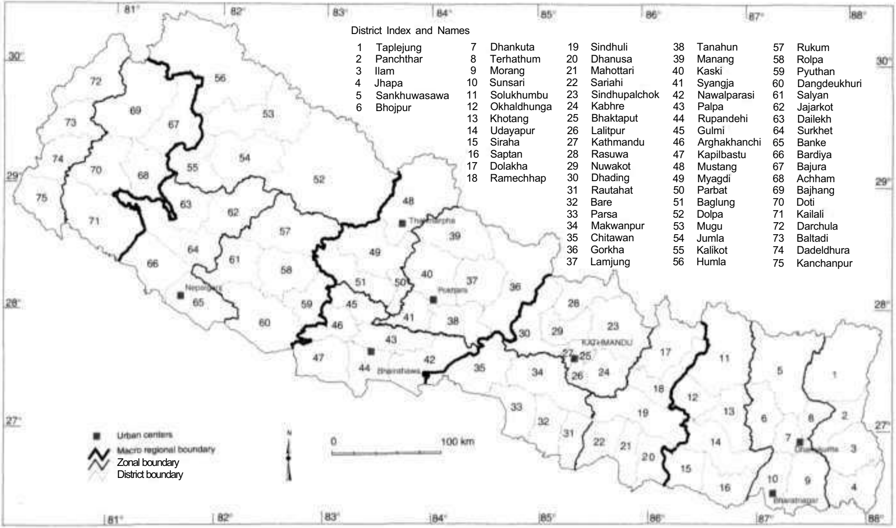

Figure 4.1. Administrative divisions (districts) and major urban centers in legume-growing areas of Nepal.

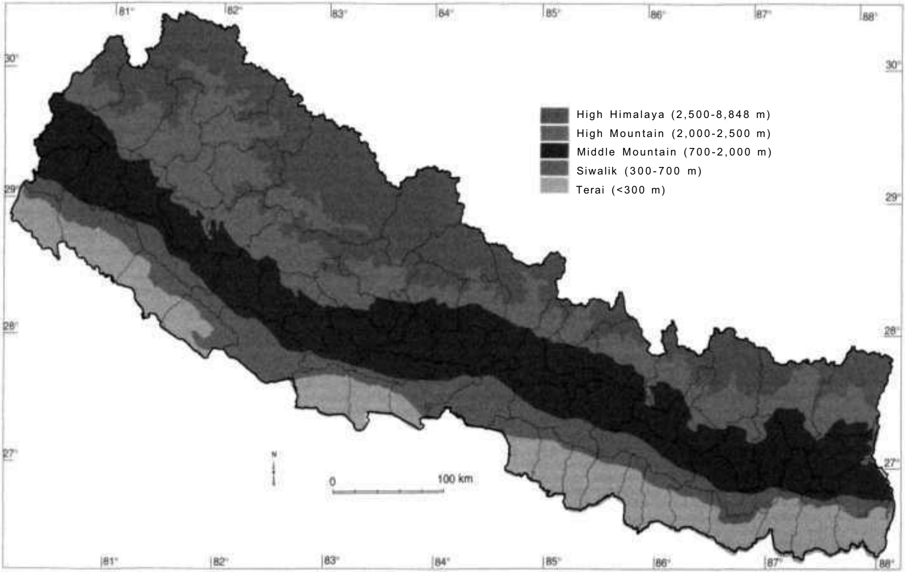

Figure 4.2. Physiographic regions of Nepal (Source: Topographic Survey Branch, Department of Survey, His Majesty's Government, Nepal, 1983).

Haplaquepts are suited for rice in the rainy season and for upland crops including wheat and legumes in the dry season. Most of the Hapludolls are under forest vegetation.

The inner Terai valleys (Chitwan, Dang-Deukhuri, and Surkhet valleys) are covered mainly by moderately coarse to medium-textured alluvial sediments. These valleys consist of series of terraces and flood plains. Most of the lands in these valleys are under intensive cultivation. The dominant soils are well to somewhat excessively drained Dystrochrepts, suited for upland crops (Fig. 4.3). Drought in the dry season limits their agricultural use. However, the low-lying areas with imperfectly to poorly drained Udorthents and Haplaquents are best suited for rice cultivation.

The level of organic matter in most cultivated soils in Terai and inner Terai where RWCS are concentrated (below 2,000 m) is low (<1%). This could represent a major constraint of soil fertility to a sustainable increase in rice-wheat productivity. At elevations above 2,000 m, the soils contain 2-3% organic matter. Cooler climatic conditions and more vegetation coverage are contributing factors to higher organic matter accumulation in this region.

Generally, the soils of Nepal are deficient in nitrogen (N), with phosphorus (P) being the second most important plant nutrient limiting crop yield. Soil tests for potassium (K) generally indicate high levels, but K deficiency has also been reported in recent years (Regmi et al. 1996; Sherchan and Gurung 1997). There is very little evidence of calcium (Ca) and magnesium (Mg) deficiency limiting rice-wheat production. However, soil content of sulfur (S) has been reported low in most of the soils of Nepal indicating that S is a potential limiting nutrient to the growth of legumes, as legumes are susceptible to S deficiency. Micronutrient deficiencies such as zinc (Zn) in rice; boron (B) in wheat, legumes, and vegetables; and molybdenum (Mo) in vegetables and legumes are increasingly observed.

An annual rainfall of 1200-2000 mm occurs in the main rice-wheat/legumes growing areas of the Terai (Fig. 4.4). About 80% of total annual rainfall occurs in the monsoon season between Jun and Sep which is the main rice-growing period (Fig. 4.4). Nepal also receives some winter rains through the westerly weather system. It occurs more in the western part of the Terai and contributes to some extent to winter crops, including wheat and legumes. Some pre-monsoon rains occur during the drier period of Apr-Jun.

In general, the trend in seasonal variations of temperature is similar throughout the country, although the topographic effects influence significantly at the micro-level (Fig. 4.5). Temperatures rise steadily from minimum values in winter during Jan-Feb to maximum values during Apr-May and then fall slightly during the monsoon period due to presence of heavy clouds and rain. Temperatures then drop sharply to winter minimum values. The maximum temperature rises very sharply in spring (Mar-May) while the rise of minimum temperature is gradual. The mean maximum temperature in subtropical agroecological zones where rice-wheat and legumes are cropped is in the range 25-35°C (Fig. 4.5).

Area, Production, and Yield

Spatial Distribution of Area and Yields

Grain legumes are mainly grown in the Terai region. It is interesting to note that the winter legumes, particularly pigeonpea and chickpea, are clustered mainly in three distinct pockets of the Terai region: six districts in central Terai (Siraha, Dhanusha, Mahottari, Rautahat, Bara, and Parsa), three districts in western Terai (Nawalparasi, Rupandehi, and Kapilbastu) and four districts in far western Terai (Banke, Bardiya, Kailali, and Kanchanpur). This is very well related to agroclimatic factors, as these districts fall under sub-humid to moderately dry

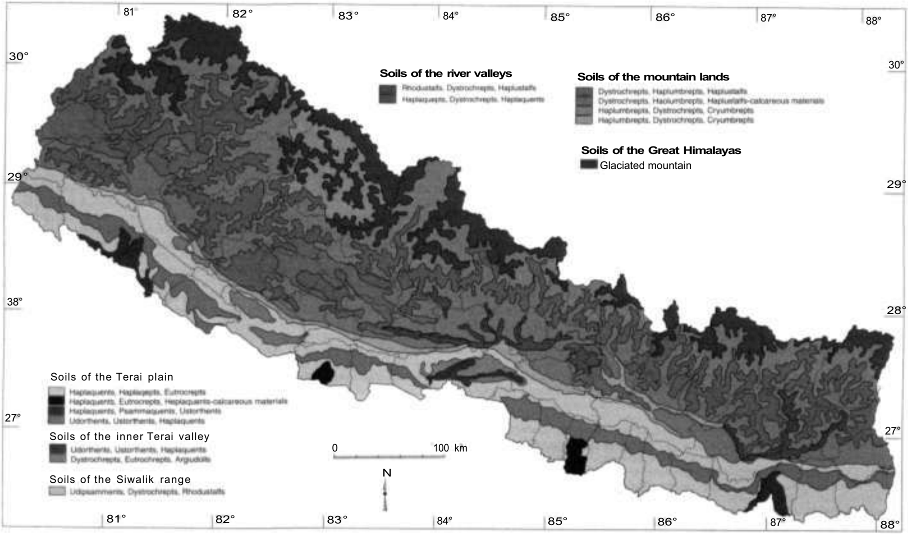

Figure 4.3. Generalized soils map of Nepal (Source: Soil Science Division, Nepal Agricultural Research Council).

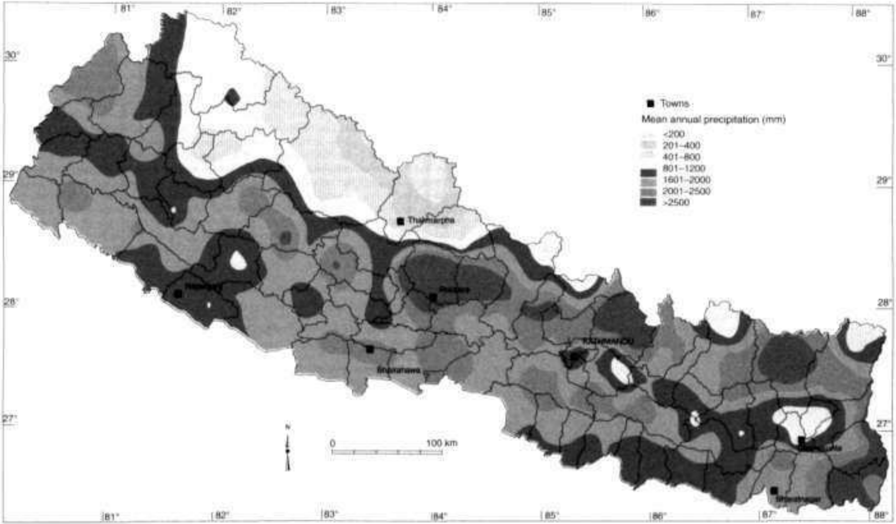

Figure 4.4. Mean annual precipitation in Nepal (Source: Department of Hydrology and Meteorology, Department of Survey, His Majesty's Government, Nepal, 1988).

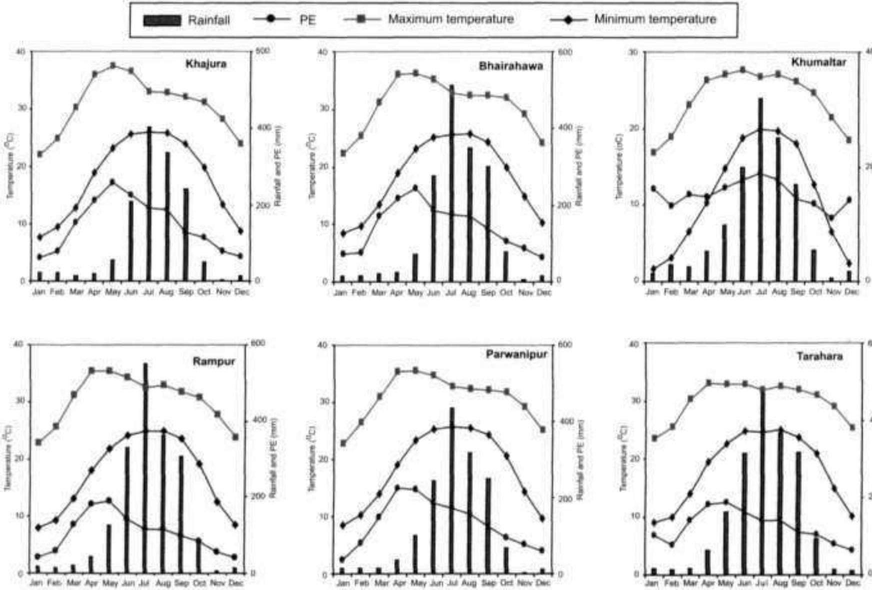

Figure 4.5. Monthly mean rainfall, maximum and minimum temperature (T), and potential evaporation (PE) at some locations representative of legume-growing areas in Nepal (Source: Manandhar and Shakya, 1996).

agroecological regions (Fig. 4.2) where the length of growing period is comparatively shorter (< 160-180 days). The annual rainfall ranges from 1200 mm to 1600 mm (Fig. 4.4), but over 85% of the rain occurs between Jul and Sep (Fig. 4.5).

Lentil

Cultivation of lentil has increased all over the Terai districts during 1984/85 to 1994/95 (Fig. 4.6). In particular, the four districts of central Terai (Sarlahi, Rautahat, Rara, and Parsa) and two districts of the far western Terai (Kailali and Kanchanpur) have shown considerable intensification of lentil cultivation. However, yields remain static at 0.5 to <1 t ha^{-1}.

Khesari (lathyrus)

Khesari (lathyrus) cultivation is more intensively concentrated in the districts of eastern Terai, followed by those in central Terai (Fig. 4.7). The crop area has drastically decreased in most of the districts except Jhapa, Sunsari, and Saptari districts in eastern Terai where the agroclimatic condition is moderately humid (Figs. 4.2 and 4.4) and other winter legume species are sparsely grown. In other districts, khesari (lathyrus) has been replaced by other crops probably due to the increased cultivation of lentil, wheat, sugarcane (*Saccharum officinarum* L.) or other more marketable crops.

Pigeonpea

The cultivation of pigeonpea, however, has intensified further in its traditional niche areas (Fig. 4.8). But it has shown a decreasing trend in the far eastern and western Terai districts. Since pigeonpea is not extensively grown in these districts, it does not significantly affect the national scenario.

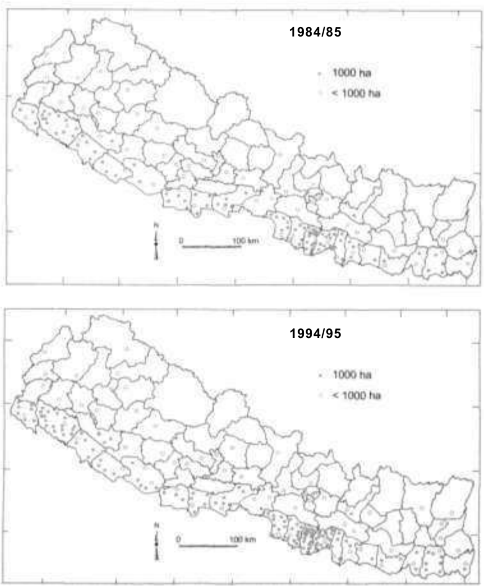

Figure 4.6. Lentil distribution in Nepal in 1984/85 and 1994/95 (Source: Agriculture Statistics Division, Ministry of Agriculture, His Majesty's Government, Nepal).

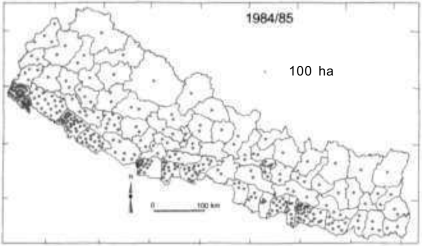

Figure 4.7. Khesari (lathyrus) distribution in Nepal in 1984/85. Data for 1994/95 not available (Source: Agriculture Statistics Division, Ministry of Agriculture, His Majesty's Government, Nepal).

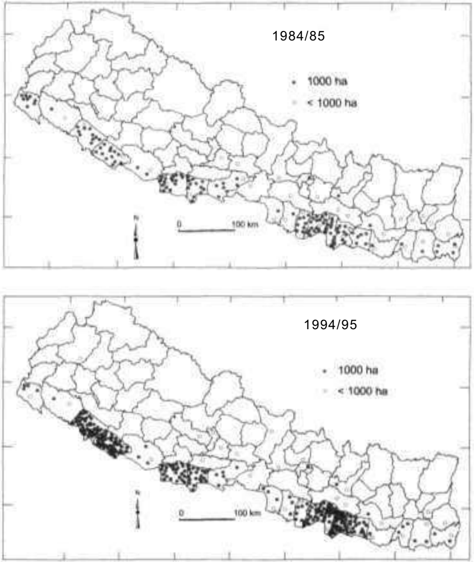

Figure 4.8. Pigeonpea distribution in Nepal in 1984/85 and 1994/95 (Source: Agriculture Statistics Division, Ministry of Agriculture, His Majesty's Government, Nepal).

Chickpea

Contrary to lentil and pigeonpea, chickpea cultivation has decreased in almost all the mid-hill districts as well as in a number of central Terai districts over the 10-year period from 1984/85 to 1994/95 (Fig. 4.9). It is interesting to note, however, that chickpea cultivation has also concentrated in the same three Terai districts (Bardia, Kailali, and Kanchanpur) of far western Nepal where lentil and pigeonpea intensification has also taken place. This shift in chickpea cultivation from eastern to western parts of the country relates to the severe incidence of botrytis gray mold (BGM) *(Botrytis cinerea)* in the eastern part compared to the western part.

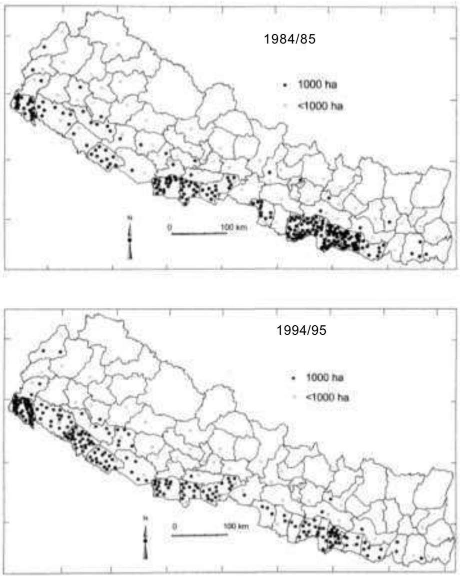

Figure 4.9. Chickpea distribution in Nepal in 1984/85 and 1994/95 (Source: Agriculture Statistics Division, Ministry of Agriculture, His Majesty's Government, Nepal).

Black gram

Black gram is cultivated in hilly areas, mainly in the eastern part of Nepal (Fig. 4.10).

Soybean

Like Black gram, soybean is cultivated mainly in hilly areas, towards the east of the country (Fig. 4.11).

Groundnut

Groundnut is restricted to the central-eastern part oftheTerai (Fig. 4.12).

The expansion of lentil and pigeonpea cultivation could Be due to their increased demand for export and a special support of the Department of Agriculture to lentil cultivation under a World Bank project. The increase of lentil area Has distinctly influenced the trend of total legume area. The decline in khesari (lathvrus) area could Be due to

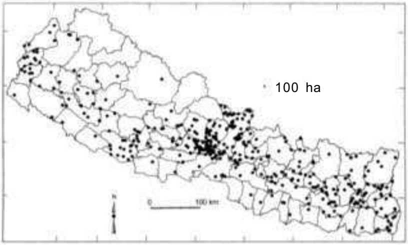

Figure 4.10. Black gram distribution in Nepal in 1994/95 (Source: Agriculture Statistics Division, Ministry of Agriculture, His Majesty's Government, Nepal).

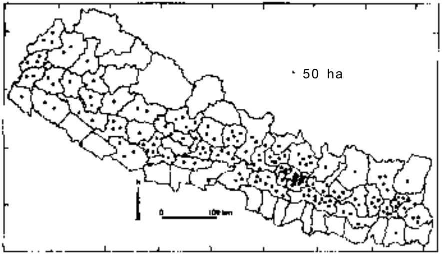

Figure 4.11. Soybean distribution in Nepal in 1994/95 (Source: Agriculture Statistics Division, Ministry of Agriculture, His Majesty's Government, Nepal).

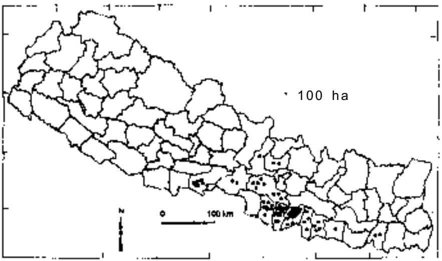

Figure 4.12. Groundnut distribution in Nepal in 1994/95 (Source: Agriculture Statistics Division, Ministry of Agriculture, His Majesty's Government, Nepal).

the Government's prohibition of its cultivation and increased public awareness of its potential role in causing lathyrism if regularly consumed. The decline of chickpea area has been attributed to increased infestation of BGM and fusarium wilt as well as pod borer (*Helicoverpa armigera* Hiibner).

However, there is still further scope for expanding the lentil cultivation, particularly in rainfed rice fields because of less suitability for wheat cultivation due to moisture stress. If the present trend of lentil cultivation continues, the area under khesari (lathyrus) may further decrease in future. Production of lentil has doubled from 58,000 t in 1984/85 to 118,000 t in 1995/96 (Fig. 4.13). Also, the production of pigeonpea has increased by 84% in the same period. But the production of khesari (lathyrus) and chickpea by contrast has declined by 32% and 15%, respectively. The increase and decrease of the total production figures, however, have followed the trends of area of these crops. This indicates that no significant improvement in legume productivity has taken place, as indicated in the yield trends shown in Figure 4.13. In general, the yields have remained low and static. No district has reported yields of >1 t ha^{-1}, although prospects for improvements are shown by the yield potential of improved varieties (Table 4.2). This indicates that attempts made for dissemination of improved varieties and cultivation practices were inadequate as a broad

Table 4.2. Grain legume varieties released in Nepal.

Crop/ Variety	Year of release	Origin	Days to maturity	Yield potential (t ha^{-1})	Released tor region
Lentil					
Sindur	1979	Nepal	148	1.5	Terai and mid-hill
Simirik	1979	India (T 36)	143	1.5	Terai and mid-hill
Sishir	1979	India (P 43)	150	2.0	Terai, inner Terai, and mid-hill

continued

Table 4.2 *continued*

Crop/ Variety	Year of release	Origin	Days to maturity	Yield potential (t ha^{-1})	Released for region
Simal	1989	India (LG7)	143	2.1	Terai, inner Terai, and mid-hill
Sikhar	1989	Pakistan (ILL 4404)	143	2.5	Terai, inner Terai, and mid-hill
Chickpea					
Dhanush	1980	Nepal	144	1.8	Terai/inner Terai
Trishul	1980	Nepal	144	1.7	Terai/inner Terai
Radha	1987	India (LG 74)	142	1.6	Terai/inner Terai
Sita	1987	India (1CCC 4)	140	1.5	Terai/inner Terai
Kosheli	1990	India (ICCC 31)	154	1.6	Western Terai
Kalika	1990	India (ICCL 82198)	152	1.4	Western to Central Terai
Pigeonpea					
Bageshwari	1991	Nepal (PR 5147)	261	2.0	Terai
Rampur Rahar1	1991	Nepal	197	1.5	Central Terai
Soybean					
Hardee	1976	USA	124	2.4	Terai and inner Terai
Hill	1976	USA	166	1.7	Hills
Rensotn	1987	USA	145	1.0	Mid-hill and valley for intercropping
Seti	1989	Taiwan (AVRDC)[1]	150	1.2	Mid-hill and valley for intercropping
Cob	1989	USA	123	2.5	Terai and inner Terai
Lumle-1	1995	Nepal	142	1.7	Inner Terai and hill
Cowpea					
Askash	1989	Nigeria	65	1.0	Terai and inner Terai
Prakash	1989	Nigeria	60	0.8	Terai and inner Terai
Mung bean					
Pusa baisakhi	1979	India	60	1.5	Terai/inner Terai
Black grain					
Kalu	1979	India	85	1.0	Warm Valley

1. Asian Vegetable Research and Development Center.

yield gap exists. There is considerable scope for increasing yields if the production constraints (biotic, abiotic, and socioeconomic) are precisely identified and addressed.

Constraints to Grain Legume Cultivation

Biotic Constraints

Diseases and insect pests are the two most important biotic constraints to the production of legumes in Nepal, but sometimes infestation of weeds can also cause considerable yield loss.

Diseases

There are a large number of diseases recorded in grain legume crops (Table 4.3). Among these, wilt, BGM, and rust are the most serious in most of the legume crops.

Lentil. Vascular wilt, collar rot, rust, and BGM are noted as the most serious diseases in lentil (Table 4.3). They occur widely in the Terai as well as in the hill areas. They may cause considerable loss in grain yield. Botrytis gray mold mainly occurs in the eastern and central region but can be found sporadically throughout the Terai. However, vascular wilt and collar rot are distributed throughout the major growing areas.

Pigeonpea. Fusarium wilt, sterility mosaic, and macrophomina stem canker are the major diseases of pigeonpea (Table 4.3). These diseases occur right across the Terai region, where pigeonpea is grown. Individually, they may cause more than 50% yield loss in pigeonpea.

Chickpea. Botrytis gray mold is the most important disease of chickpea, particularly in the eastern part of the country (Table 4.3),

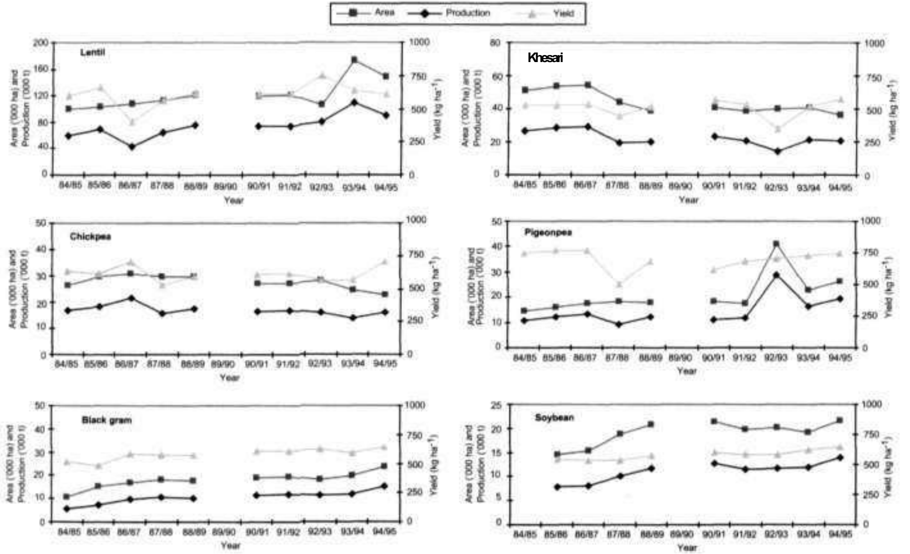

Figure 4.13. Trends in area, production, and yields of the major grain legumes in Nepal (Source: Manandhar and Shakya 1996). Data for 1989/90 not available.

Table 4.3. Diseases of major grain legumes, their distribution, and status in Nepal.

Disease	Causal organism	Distribution	Status
Lentil			
Vascular wilt	*Fusarium oxysporum* f. sp *lentis*	All lentil-growing areas, hill, inner Terai, and Terai	Major
Collar rot	*Sclerotium rolfsii*	Rice-based cropping system	Major
Black root rot	*Fusarium solani*	Hill and Terai	Minor
Rust	*Uromyces viciae-fabae*	Hill and Terai	Major (sometimes)
Gray mold	*Botrytis cinerea*	Hill and Terai	Major (sometimes)
Alternaria blight	*Alternaria alternata*	Hill and Terai	Minor
Pea seedborne mosaic	Pea seedborne mosaic virus	Hill	Minor
Wet root rot	*Rhizoctonia solani*	Hill and Terai	Minor
Pigeonpea			
Wilt	*Fusarium udum*	All pigeonpea-growing areas	Major
Sterility mosaic	Virus (?)	All pigeonpea-growing areas	Major (sometimes)
Alternaria blight	*Alternaria* sp	Eastern Terai and inner Terai	Major in late-sown or rabi pigeonpea
Collar rot	*Sclerotium rolfsii*	Sporadic across whole of lerai	Minor
Macrophomina stem canker	*Macrophomina phaseolina*	All pigeonpea-growing areas (more in western Terai)	Major (sometimes)
Yellow mosaic	Mung bean yellow mosaic virus	Sporadic across whole of Terai	Minor
Phyllosticta leaf spot	*Phyllosticta cajani*	Sporadic across whole of Terai	Minor
Cercospora leaf spot	*Cercospora* sp	Sporadic across whole of Terai	Minor
Botrytis gray mold	*Botrytis cinerea*	Sporadic across whole of Terai	Minor
Chickpea			
Botrytis gray mold	*Botrytis cinerea*	Major in all chickpea growing areas but less in western Terai	Major
Fusarium wilt	*Fusarium oxysporum* f sp. *ciceris*	Major in all chickpea growing areas but less in western Terai	Major
Alternaria blight	*Alternaria* sp	Sporadic across whole of Terai	Minor
Sclerotinia stem rot	*Sclerotinia sclerotiorum*	Sporadic across whole of Terai	Minor
Black root rot	*Fusarium solani*	Major in moist soil conditions	Major (sometimes)
Collar rot	*Sclerotium rolfsii*	Major in moist soil conditions	Major (sometimes)
Dry root rot	*Macrophomina phaseolina* (sclerotial state *Rhizoctonia balaticola)*	Sporadic across whole of Terai	Minor
Chickpea stunt	Bean (pea) leaf roll virus	Sporadic across whole of Terai	Minor
Soybean			
Frogeye leaf spot	*Cercospora sojina*	Hill and high hill	Major
Rust	*Phakopsora pachyrhizi*	Hill and valleys	Major

continued

Table 4.3 *continued*

Disease	Causal organism	Distribution	Status
Bacterial pustule	*Xanthomonas campestris* pv. *glycines*	Hill, valleys, and Terai	Major (sometimes)
Bacterial blight	*Pseudomonas syringae* pv. *glycinea*	Hill and valleys	Minor
Septoria brown spot	*Septoria glycines*	Hill and Terai"	Minor
Anthracnose	*Collectotrichum truncatum*	Hill and Terai	Major (sometimes)
Cercospora blight and leaf spot (purple seed stain)	*Cercospora kikuchii*	Hill and Terai	Minor
Pod and stem blight	*Phomopsis phaseoli*	Hill and Terai	Major (sometimes)
Red crown rot	*Calonectria crotalariae*	Hill and Terai (major in waterlogged conditions)	Major (sometimes)
Soybean mosaic	Soybean mosaic virus	Hill and Terai	Minor
Yellow mosaic	Mung bean yellow mosaic virus	Terai	Major
Black gram and mung bean			
Cercospora leaf spot	*Cercospora* sp	Hill and Terai	Major
Yellow mosaic-	Mung bean yellow mosaic virus	Hill and more in Terai	Major
Powdery mildew	*Erysiphe polygoni*	Hill and Terai	Major (sometimes)
Groundnut			
Early leaf spot	*Cercospora arachidicola*	Hill and Terai	Major
Late leaf spot	*Phaeoisariopsis personata*	Hill and Terai	Major
Rust	*Puccinia arachidis*	Hill and Terai	Minor
Sclerotium stem rot	*Sclerotium rolfsii*	Hill and Terai	Minor
Bud necrosis	Bud necrosis virus	Hill and Terai	Major (sometimes)
Faba bean			
Rust	*Uromyces viciae-fabae*	Hill and Terai	Major
Chocolate spot	*Botrytis fabae*	Hill and Terai	Major
Root rot and wilt	*Fusarium* spp and *Rhizoctonia solani*	Hill and Terai	Minor
Pea seedborne mosaic vims	Pea seedborne mosaic virus	Hill	Minor
Bean yellow mosaic	Bean yellow mosaic virus	Hill	Minor
Pea			
Pea seedborne mosaic	Pea seedborne mosaic virus	Hill and Terai	Major
Powdery mildew	*Erysiphe pisi*	Hill and Terai	Major
Aphanomyces root rot	*Aphanomyces euteiches*	Hill	Minor

Source: Joshi, Sharada, Nepal Agricultural Research Council, personal communication, 1997.

causing as high as 100% loss in yield (NARSC 1989). Regular epidemics of BGM discouraged farmers in the eastern part of the country from cultivating chickpea. As a result the area under chickpea in this region has shown a declining trend and the chickpea area has shifted from the eastern to western Terai districts. Other important and widespread diseases of chickpea are fusarium wilt, collar rot, and black root rot.

Soybean. Cereospera blight and leaf spot, pod and stem blight, and rust are the major diseases (Table 4.3). Rust causes a serious loss in productivity and is distributed in the hilly regions of the country.

Black gram and mung bean. Cereospera leaf spot and yellow mosaic are the major diseases (Table 4.3). Powdery mildew is also observed in some areas of the country.

Groundnut. Leaf spot (early and late) and rust arc considered as the major diseases for groundnut (Table 4.3).

Khesari (lathyrus). Only powdery mildew has been observed in some parts of the country, and its effect on yield reduction is yet to be quantified.

Insect pests

There are a large number of insect pests that infest the legumes (Table 4.4) but only some of them are a threat to the crop. For example, the pod borer (*H. armigera*) is a very serious pest that can cause more than 60% yield damage in chickpea on farmers' fields of Banke and Bardia districts located in the western part of the country (Thakur 1997). It is also a serious pest of pigeonpea. Similarly, *Spilosoma* (*Diacrisia*) *obliqua* Walker (hairy catterpillar) is a major pest of soybean, black gram, mung bean, and groundnut. Aphids are commonly found on khesari (lathyrus), mung bean, black gram, cowpea, and lentil, particularly during dry spells. Insect pests are also major problems in storage where they can damage the seed and cause loss of seed viability. Seeds of pulses are severely damaged by the bruchids, *Callasubruchus chinensis* (L.) and C. *maculatus* Fab.

Weeds

Farmers consider legumes as minor crops and generally do not weed their crops. They allow the weeds to grow and cut them as green forage for cattle as needed in some of the legume crops, particularly pigeonpea. Hence weeds compete with legumes for light, water, nutrients, and space and can cause substantial yield losses. Little research work has been done in this area. Aziz (1993) reported that grain yield loss due to unrestricted weed growth in lentil was around 25% and the critical period of weed competition ranged from 20 days to 30 days after emergence. Depending upon the duration of the crop, the critical period for weed competition in pulses varies from 20 days to 45 days after sowing. Most farmers perform only two operations (sowing and harvesting) in the cultivation of winter grain legumes. As a result, crops are often heavily infested with weeds. Several species of weeds have been recorded in legume crops of which *Cyperus rotundus* L. (nut grass), *Chenopodiwn album* L. (lamb's quarters), and *Vicia sativa* L. (common vetch) are noted as major ones (Table 4.5).

Abiotic Constraints

Various climatic and soil factors limit the productivity of both winter and summer food legumes grown in different agroecological zones in Nepal. Among these, early and terminal drought, excess moisture, adverse temperatures, high humidity, and poor soil fertility are major constraints.

Table 4.4. Insect pests of major grain legumes in Nepal, 1997.

Crop	Insect pests	Status
Lentil	*Agrotis ipsilon* Hufnagel	Major pest in Terai
	Agrotis segetum Schiff.	Major pest in Hill
	Acrythosiphon pisum Harris	Major pest in some geographic regions
	Helicoverpa armigera Hubner	Major pest universally
	Callosabruchus chinensis L.	Major
	Callosobruchus maculatus Fab.	Major
	Phyllotreta sinuata Redt.	Minor
	Athalia sp	Minor
	Adonia variegata Goeze	Minor
Chickpea	*Agrotis ipsilon* Hufnagel	Major pest in Terai
	Agrotis segetum Schiff.	Major pest in Hill
	Plusia orichalcea F.	Major pests in some geographic regions
	Helicoverpa armigera Hiibner	Major
	Callosobruchus chinensis L.	Major
	Callosobruchus maculatus Fab.	Major
Faba bean	*Aphis fabae* Scopoli	Major-
	Aphis craccivora Koch.	Minor
	Nezara antennata Scott.	Minor
	Helicoverpa armigera Hubner	Minor
Pea	*Acrythosiphon pisum* Harris	Major
	Helicoverpa armigera Hiibner	Major
	Bruchus pisorum L.	Major
	Macrosiphum pisum Harris	Minor
	Taeniothrips flavidulus	Minor
	Empoasca sp	Minor
	Phytomyza atricornis Meig	Minor
	Lampides boeticus L.	Minor
Pigeonpea	*Melanagromyza obtusa* Malloch	Major
	Ophiomyia phaseoli Tryo.	Major
	Ophiomyia centrosematis Meijere	Major

continued

Table 4.4 *continued*

Crop	Insect pests	Status
	Bemisia tabaci Genn.	Major
	Callosobruchus maculatus Fab.	Major
	Callosobruchus chinensis L.	Major
	Helicoverpa armigera Hiibner	Major
	Spodoptera litura Fab.	Major
	Exelastis atomosa Walsingham	Major
	Maruca testulalis Geyer	Major
	Alcidodes sp.	Sporadic and minor
	Empoasca fabae Harris	Sporadic and minor
	Nezara viridula L.	Minor
	Liriomyza cicerina Rondani	Minor
	Aphis craccivora Koch.	Minor
	Etiella zinckenella Treitschke	Minor
	Lampides boeticus L.	Minor
Khesari (lathyrus)	*Aphis craccivora* Koch.	Minor
Mung bear	*Spilosoma* (*Diacrisia*) *obliqua* Walker	Major
	Maruca testulalis Geyer	Major
	Helicoverpa armigera Hiibner	Major
	Callosobruchus chinensis L.	Major
	Callosobruchus maculatus F.	Major
	Agrotis ipsilon Hufnagel	Minor
	Aphis craccivora Koch.	Minor
Cowpea	*Maruca testulalis* Geyer	Major
	Bemisia tabaci Genn.	Major
	Aphis craccivora Koch.	Major
	Melanagromyza sp	Major
	Callosobruchus maculatus Fab.	Major
	Callosobruchus chinensis L.	Major
	Empoasca fabae Harris	Minor
	Nezara viridula L.	Minor

Source: B.K. Gyawali, Nepal Agricultural Research Council, Khumaltar, Lalitpur, Nepal, personal communication,1997.

Table 4.5. Common weeds of lentil in Nepal.

Botanical name	Common name	Family
Cvperus rotundus L.	*Motha;* nut grass	Gramineae
Cynodon dactvlon (*L.*) Pers.	*Duvo;* Bermuda grass	Gramineae
Anagalis arvensis L.	Pimpernal	Primulaceae
Capsella bursa-pastoris (L.) Moench)	Shepherd's purse	Cruciferae
Chenopodium album L.	Lamb's quarters	Chenopodiaceae
Spergula arvensis L.	Corn-spurry	Caryophyllaceae
Sciene-biera pinnatifida	Swinecress	Crucifereae
Vicia hirsuta S.F. Grav	Tiny vetch	Leguminosae
Vicia sativa L.	Spring vetch; common vetch	Leguminosae
Alopecurus pratensis L.	Meadow foxtail	Gramineae
Phalaris minor Retz.	Small canary grass	Gramineae

Source. J.D.Ranjeet, Nepal Agricultmal Researchl, Khumaltar,

Early and terminal drought

Early and terminal drought stress is the major problem of legume production. The major legumes [lentil, khesari (lathyrus), and chickpea] are grown on conserved soil moisture in the postrainy season and invariably suffer from terminal drought if there is little or no winter rainfall. If the monsoon rains finish early or the winter legume crops are sown late, there may be insufficient soil moisture for proper germination and emergence, especially in lighter soils.

Excess soil moisture and humidity

Excessive rainfall can occur during the late monsoon season. This can cause substantial yield loss to winter legumes as it delays their sowing. If rainfall occurs at the reproductive stage, it damages flowers and encourages foliar diseases such as BGM in chickpea and lentil, rust in lentil, and leaf spots (early and late) in groundnut. Some of the diseases (e.g., BGM) can, in turn, cause complete yield losses.

High temperature

A sudden rise in temperature in late February and early March severely reduces vegetative growth and pod formation especially in late-sown crops of lentil and chickpea.

Mineral nutrition

Soil acidity poses a serious constraint to legumes in Nepal, where surface soil pH falls below 5.0. Acidity problems are greater in the eastern part of the country due to leaching of bases because of higher rainfall. Consequently, legumes face P deficiency and nodulation problems. Boron has been shown to be a major yield reducer of chickpea and lentil, at least in the inner Terai (Srivastava et al. 1997, 1999). These researchers also report Mo responses in chickpea and Zn responses in lentil. As legumes are generally relegated to more marginal soils, the likelihood of them being limited by nutrient deficiencies increases.

Socioeconomic Constraints

Despite the importance of pulses in Nepalese farming systems, they have only subsidiary status in the total farming systems due to the greater importance given to cereals as staple food crops. Pulses have lower stability in production and higher losses in storage than cereals. Their market prices also fluctuate widely. The Government's as well as farmers' priority is the production of cereal crops such as rice, maize, and wheat. Farmers consider legumes as very sensitive to diseases, pests, and weather conditions; thus high and stable yields cannot be assured.

Crop establishment

As a consequence of the lower status given to pulse crops, farmers take inadequate care of them at sowing, despite availability of knowledge of optimum sowing techniques. Recommended seed rates to obtain optimum plant stands are not followed and usually seed of poor quality (having low germination rate) is used. Pulses are usually broadcast sown on an inadequately prepared seedbed. The net result is poor and uneven plant stands, which mitigate against achieving high yields at an early stage.

Input use

Farmers give least preference to applying agricultural inputs, such as fertilizers or plant protection measures, to pulses. In Nepal, such inputs are relatively high priced and often scarce, and thus reserved for cereals or high value crops. Further, application of fertilizers and irrigation to legume crops can result in excessive vegetative growth, with resultant lodging, disease infestation, and low yield.

Profitability

Lack of storage knowhow and capability for legume grains results in a low farm gate price, with high seasonal fluctuations. Thus, despite low input costs, profitability is low for farmers. There are no organized marketing channels or Government support prices for grain legumes, as for cereals. Low-income farmers bear most of the risk associated with legume production.

Role of Legumes in Cropping Systems

Legumes are mostly grown under rainfed rice-based systems. Therefore, legumes have a special role in the rainfed agricultural system. Because of their deep root systems, ability to produce at least some grain under drought conditions, and general hardy nature, legumes are being used by farmers as risk reduction crops and are intermixed or relay cropped with major cereals (Fig. 4.14). The highly diverse environment in Nepal allows cultivation of different species of legumes. At least twelve grain legume species occur in various agroclimatic conditions of the country. In the monsoon climate that prevails in Nepal, 80% of rainfall occurs during Jul and Sep. Moisture is the limiting factor to successful crop production during winter, from about Nov to Apr, where irrigation is not available. Legumes present various opportunities under these conditions.

Grain legumes are important crops because of their high protein content and in-built capacity to utilize atmospheric N. They help in increasing soil fertility by fixing atmospheric N and improving the soil structure through their deep root system and additions of organic matter to the soil. Since N is the most deficient plant nutrient in Nepalese soils, input of N into the soil is, therefore, essential to increase crop productivity. Thus, the role of legumes in this regard is very important. The amount of N fixed by legumes under various on-farm conditions in Nepal is 33-56 kg ha^{-1} (Pandey et al. 1998). Grain legumes have also proved ideal for growing as mixed crops and intercropping under dryland farming situations of the country.

Farmers' response in] 1 districts on residual effects of legumes in their subsequent crops also revealed that legumes, in comparison to wheat or fallow land, contribute to enhanced yields of rice to the extent of 10-35% (Pande and Joshi 1995).

Pulses are predominantly grown as associated and relay crops with cereals and oilseeds. The summer species are mixed with maize and finger millet (*Eleusine coracana* (L.) Gaertn.) in the hills and some species such as black gram, soybean, pigeonpea, and mung bean are also grown on paddy bunds in low-lying areas. Winter legumes,

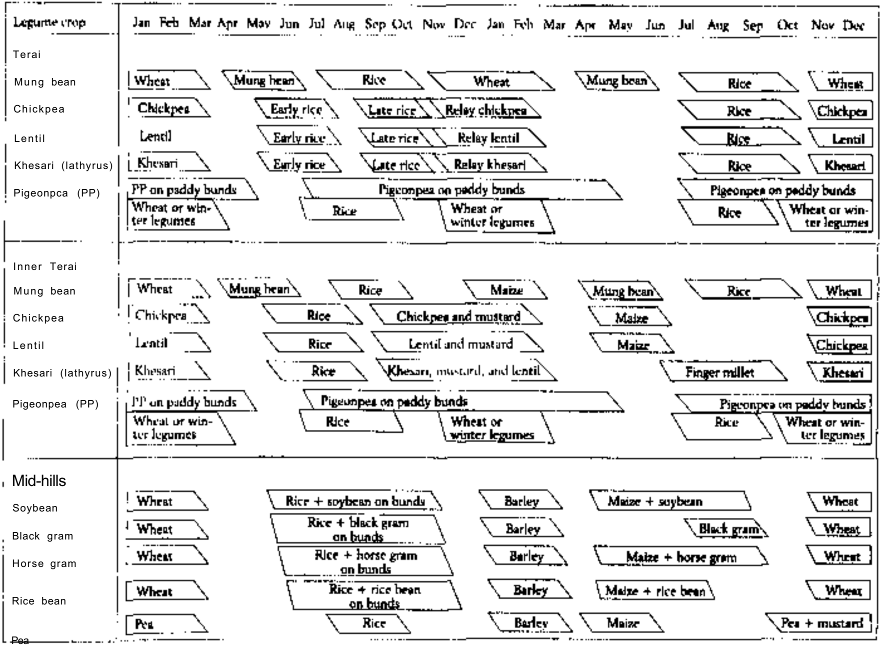

Figure 4.14. Representative cropping systems in major grain legumes producing regions of Nepal (Source: Rachie and Bharati 1985).

especially lentil, chickpea, and khesari (lathyrus), are often intermixed with winter crops such as barley (*Hordeum vulgare* L.), mustard (*Brassica* sp), and linseed (*Linum usitatissimum* L.). Sometimes they are sown as relay crops with late rice when winter moisture is limiting. In other cropping patterns, short-duration mung bean and cowpea are increasingly being planted as catch crops between wheat and rice in irrigated areas of the Terai. The major cropping systems incorporating grain legumes are discussed as follows (Fig. 4.14).

Lentil

Lentil is cultivated as a sole and relay crop with summer season rice and maize in the Terai and inner Terai regions of the country. It is broadcast on saturated soils by the end of Oct to mid-Nov, about 10-20 days before the rice harvest, as a relay crop. Lentil is also grown after upland maize. Lentil is usually sown in Oct-Nov as a mixed crop with mustard; this system is expanding.

Chickpea

Chickpea is grown on relatively heavier soils under the rice-chickpea cropping system. Also, chickpea is cultivated as a mixed crop with linseed, barley, and mustard.

Khesari (Lathyrus)

Khesari (lathyrus) is still the second most important pulse crop in Nepal. It is cultivated as a relay crop with rainy season rice in medium lowland areas of the country. It is broadcast on the saturated soils by the end of Oct to early Nov, about 10-12 days before the paddy harvest. It is the hardiest crop among pulses and can thrive in soils with excess or deficit moisture. Khesari (lathyrus) requires no major input costs and the yield is stable. It faces no major insect or disease problems in the country. But the area of khesari (lathyrus) is decreasing as the Government has banned this crop. Local landraccs have stable yields but are high in neurotoxin content.

Pigeonpea

Pigeonpea is the third most important legume in Nepal. It is mostly grown under upland conditions as a sole crop or mixed crop with maize and on paddy bunds. Pigeonpea on paddy bunds is very popular in the eastern part of the country whereas it is grown mainly as a sole crop in the western part and as a mixed crop in the mid-hills and inner Terai. Long-duration varieties are grown in the western part of the country whereas medium-duration varieties and rabi (postrainy season) pigeonpea are popular in the eastern part. Generally, normal season planting is done during Jun-Jul, with the onset of monsoon rains, whereas rabi planting is done in Aug-Sep.

Soybean

Soybean is a major legume in the mid-hill region of the country. It is mainly grown as a mixed crop with maize. As the maize crop normally receives some intercultural operations and inputs, these factors also contribute to soybean production. Soybean is also grown as a sole crop in some parts of inner Terai where there is market accessibility. It is also grown on paddy bunds in the mid-hills and inner Terai.

Black Gram

Black gram is a comparatively hardy pulse crop and is mostly grown in well-drained upland mid-hill regions of the country after maize harvest or is intercropped with maize. It is a photoperiod-sensitive crop and is location specific. Much genetic variation has been observed in this crop in Nepal. In some areas, scented genotypes have been recorded. It is a most profitable crop for the farmer because it commands a good market price. Yellow mosaic is the major constraint of production in this crop.

Mung Bean

Mung bean area is very much concentrated in the eastern part of the country. It is mostly grown in the RWCS where irrigation facilities are available. It is sown in Mar-Apr and harvested before the onset of the monsoon rains. One or two pickings of pods are done and then the crop residue is incorporated into the soil as a green manure.

Groundnut

Groundnut is mostly grown in a groundnut-mustard cropping pattern in the upland sandy soils and river basin areas of the country. It is planted in May-Jun and harvested in Oct-Nov. Groundnut and pigeonpea intercropping is very popular in some areas of the country where a winter crop is not feasible due to soil moisture deficit.

National Policies and Emphasis Towards Legumes Production

In Nepal, a major portion of cultivated area in the country is under rainfed conditions and pulses have adjusted well in different mixed and intercropping situations and crop rotations. There has been a 30% increase in availability of grain legumes during 1984/85 to 1995/96, as compared to the 2.5% per annum population growth rate. Future research strategies should emphasize the development of short-duration, high-yielding, disease-resistant varieties for multiple cropping systems. Despite the importance of legume crops in Nepal, the 20 years Agriculture Perspective Plan has not considered them as priority crops. However, recently their importance has been realized in national policy considerations.

Prioritization of the Crops

- Relative importance of grain legume species in the national economy in the Terai - lentil, chickpea, pigeonpea, and khesari (lathyrus).
- Location-specific needs, based on environment, food requirement, and cropping systems in the mid-hills - soybean, pea (*Pisum sativum* L.), common bean (*Phaseolus vulgaris* L.; French bean), and black grain.
- Import substitution/export promotion - pigeonpea, chickpea, and lentil.
- Focus on mixed cropping, intercropping and relay cropping - lentil and khesari (lathyrus).

Future Research Priorities for Grain Legumes in Nepal

- Breeding varieties resistant to major biotic constraints such as diseases, insect pests, and nematodes.
- Improving yield levels by developing input-responsive improved plant types.
- Evolving early-maturing varieties suitable for different cropping patterns (intercropping, relay cropping, and sole cropping).

- Germplasm collection and evaluation.
- Identification of efficient strains of *Rhizobium.*
- Development of integrated pest management systems.
- Development of better agronomic practices for major pulses and production systems and postharvest technology.
- Initiate systematic research on horse gram, pea, common bean, and black gram.

Prospects for Increased Production and Use of Legumes

The wide gap between the potential and the national average yields shows that there is a great scope for increasing the grain legume production in Nepal. Moreover, about 30% of the total rice area (420,000 ha) still remains fallow during winter due to various reasons such as lack of soil moisture and late rice planting and harvesting. If this area can be tapped for extending legume cultivation by focused efforts on research and development, legumes area can be doubled. The production can be increased by both increasing productivity and bringing additional area under legumes.

Increasing Crop Productivity

Crop productivity can be increased by popularization of improved varieties of legumes, phosphatic fertilizers, and providing one or two need-based light irrigations. The current technology allows an immediate possibility of raising legumes production. The components of the crop production strategy are discussed below.

Summer mung bean/cowpea/black gram cultivation

There has been an increase in the area under irrigation in Nepal. This has resulted in greater opportunities for increasing the cropping intensity of the farm units. One of the most promising technologies of legumes production in the country has been the cultivation of summer mung bean or cowpea in the irrigated areas. Not only are more synchronous varieties of summer mung bean and cowpea available but new early-maturing, disease-resistant cultivars are making their appearance. Agronomic requirements of this wheat-legume-rice system have also been established.

Extension of early-maturing pigeonpea genotypes in the wheat/maize-mustard belt

A number of early-maturing pigeonpea genotypes which can vacate fields well in time for timely planting of wheat are now available and pigeonpea-wheat or maize-rabi pigeonpea rotations can be followed. The yield potential of these genotypes is 1.5-2.0 t ha^{-1}. There is apparently a great scope for introduction of these genotypes in irrigated areas where long-duration pigeonpea is otherwise an important crop.

Intensified seed production program

There is a great and continuing shortage of seed of improved varieties of pulses. There is thus an urgent need for a large-scale seed production program in the country, that will facilitate the availability of quality seeds of improved varieties to farmers.

Extensive plant protection measures

As pod borer (H. *armigera*) causes serious damage to pulse crops, on-farm implementation of integrated pest management strategies is required. This would involve greater use of cultivars showing some resistance to insect attack or ability to escape from it, combined with need-based use of pesticides, both chemical and biological [nucleopolyhedro virus (NPV)|.

Increasing Area

An extension of area under grain legumes is possible with improved technology available as discussed below.

Irrigated command areas

Double cropping with early- or extra-early-maturing pigeonpea cultivars which mature in 120-155 days can expand the area under pigeonpea. These varieties, if planted as a summer crop in Apr-Jun, with the onset of monsoon rains, can be harvested by late Oct and thus enable normal planting of a wheat crop by mid-Nov. Cultivation of rabi pigeonpea varieties is another possibility and this has resulted in more stable yields than sowing in summer, mixed with maize or millets, as traditionally done. Early-maturing summer mung bean and cowpea varieties released for irrigated areas should be popularized. Intercropping of black gram and mung bean in sugarcane and cotton (*Gossypium* sp) can be extended.

Rainfed areas

Short-duration varieties of lentil and neurotoxin-free khesari (lathyrus) should be popularized for rice fallow areas. The relay cropping of lentil and khesari (lathyrus) has great potential in rice-based systems and large areas can be covered. The seeds, however need to be treated with efficient strains of *Rhizobium.* In the eastern Terai, in conditions of extreme waterlogging and where soils become very hard after drying, neurotoxin-free varieties of khesari (lathyrus) are likely to be more successful than lentil. Intercropping of black gram with maize can be expanded in the mid-hills. Pigeonpea as an intercrop with maize, groundnut, or cotton is another cropping system with potential for expansion.

An integrated approach by government and non-governmental organizations to develop enthusiasm among the farmers for the cultivation of legumes should be attempted. Growing of cereal-cereal sequences may not be sustainable in the longer term because of declining soil health. Therefore, attempts are needed to ensure that legumes at least occasionally break such sequences, as their positive effects on soil health in the IGP region have been well documented (Kumar Rao et ai. 1998).

Conclusion

The grain legumes are predominantly grown as associated and relay crops with cereals and oilseeds. The summer legumes are grown mixed with maize and finger millet in the hills. Some of the legumes such as black gram, soybean, and pigeonpea are also grown along with rice on the bunds of paddy fields. The winter grain legumes [lentil, khesari (lathyrus), chickpea] follow the rice crop and are often intermixed with wheat, barley, mustard, and linseed. They are also occasionally relay planted with late rice when moisture would be limiting. Mung bean and cowpea are at times planted as catch crops for grain and/or green manuring between wheat and rice in irrigated areas.

During the past 10 years (1984/85-1995/96), the area, production, and yields of legume crops have increased on an average by 27%, 60%, and 15% respectively. As a result, the per capita availability of legume grain has increased by 30% from 7 kg person^{-1} annum^{-1} in 1984/85 to ~ 10 kg person^{-1} annum^{-1} in 1995/96 despite a population growth rate of 2.5% per annum. Yet, the per capita legume availability is only one-third of the requirement of 36 kg person^{-1} annum^{-1} (FAO 1981). The slight improvements are probably driven partly by the promotion of export markets and favorable price in the local market and partly by the research and development efforts, particularly in the lentil crop. The winter grain legumes that are predominantly grown in rice-wheat systems occupy a more important place than the summer legumes, by sharing more than 75% of total legume area. Nevertheless, the summer legumes have equal importance in maize-based cropping systems particularly in the hill region.

Among the winter grain legumes, lentil alone occupies 67% of the area and contributes nearly 70% of the total production. The other winter legumes, khesari (lathyrus), pigeonpea, and chickpea, rank second, third, and fourth respectively in coverage and production in the country. Therefore, lentil is the most dominant grain legume grown in RWCS in Nepal.

Insect pests (mainly pod borers] and diseases (mainly foliar) are the most important biotic constraints to legumes production in Nepal. Among abiotic stresses drought ranks as the most widespread and severe yield reducer of chickpea and lentil. There is a need to assemble and validate the available genetic and agronomic components of alleviating biotic and abiotic stresses, so as to develop practical production packages that would result in higher and more stable yields of grain legumes. More detailed constraints analyses than this generalized one would facilitate focused research and development priority setting, so as to better attract funding support to this important aspect of agricultural production and sustainability in Nepal.

References

Aziz, M.A. 1993. Critical period of weed competition in lentil. LENS Newsletter 20(1):43-45.

FAO (Food and Agriculture Organization of the United Nations). 1981. FAO production yearbook 1980. Rome, Italy: FAO.

Kumar Rao, J.V.D.K., Johansen, C., and Rego, T.J. (eds.). 1998. Residual effects of legumes in rice and wheat cropping systems of the Indo-Gangetic Plain. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics; and New Delhi, India: Oxford & IBH Publishing Co. Pvt. Ltd. 250 pp.

Manandhar, D.N., and Shakya, D.M. 1996. Climate and crops of Nepal. Khumaltar, Nepal: Nepal Agricultural Research Council and Swiss Agency for Development Cooperation. 111 pp.

NARSC (Nepal Agricultural Research and Service Center). 1989. Annual Report 1987/88. Khumaltar, Nepal: NARSC. 73 pp.

Pande, S., and Joshi, P.K. 1995. Constraints and prospects of legumes in the rice-wheat based cropping system in Terai region of Nepal, Trip Report, 7 Dec-31 Dec 1995. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 5 pp. (Limited circulation.)

Pandey, S.P., Bhattarai, S., Rajbhandari, N.K., Sah, R.P., and Sapkota, R.P. 1998. Overview and prospects for enhancing residual benefits of legumes in rice and wheat cropping systems in Nepal. Pages 176-189 *in* Residual effects of legumes in rice and wheat cropping systems of the Indo-Gangetic Plain (Kumar Rao, J.D.V.K., Johansen, C., and Rego, T.J., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics; and New Delhi, India: Oxford & IBH Publishing Co. Pvt. Ltd.

Rachic, K.O., and Bharati, M.P. 1985. A consultancy report on pulses improvement in Nepal. Singha Darbar, Kathmandu, Nepal: Ministry of Agriculture, Government of Nepal.

Regmi, A.P., Pandey, S.P., and Joshy, D. 1996. A long-term soil fertility experiment in rice-rice-wheat system in Nepal. Presented at the Regional Workshop on Long-term Rice-Wheat Soil Fertility Experiment, 15-18 Oct 1996, Surajkund, India.

Sherchan, D.P., and Gurung, G.B. 1997. Effect of long-term application of chemical fertilizer and manure on crop yields and soil chemical proportion under rice-wheat cropping pattern. Presented at the Winter Crops Workshop, 8-10 Sep 1997, Khumaltar, Lalitpur, Nepal.

Srivastava, S.P., Johansen, C., Joshi, M., and Rego, T.J. 1999. Boron deficiency of lentil in Nepal. LENS Newsletter 26(I&2):22-24.

Srivastava, S.P., Yadav, C.R., Rego, T.J., Johansen, C., and Saxena, N.P. 1997. Diagnosis and alleviation of boron deficiency causing flower and pod abortion in chickpea (*Cicer arietinum* L.) in Nepal. Pages 95-99 *in* Boron in soils and plants (Bell, R.W., and Rerkasem, B., eds.). Developments in Plant and Soil Sciences. Vol. 76. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Thakur, P. 1997. Helicoverpa management through IPM approach on chickpea. Presented at the Winter Crops Workshop, 8-10 Sep 1997, Khumaltar, Lalitpur, Nepal.