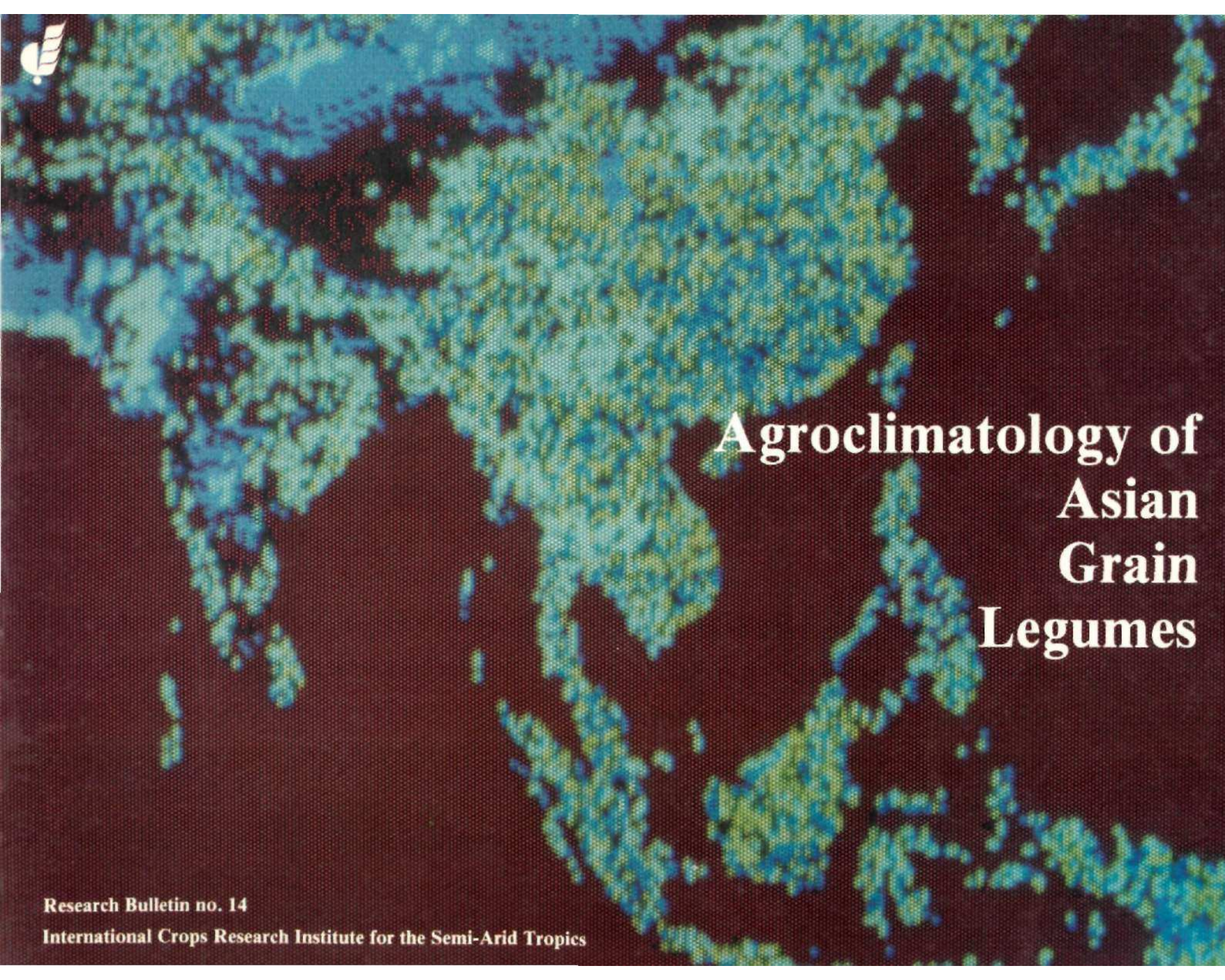

Agroclimatology of Asian Grain Legumes

Research Bulletin no. 14
International Crops Research Institute for the Semi-Arid Tropics

Abstract

Virmani, S.M., Faris, D.G., and Johansen, C. (eds.). 1991. Agroclimatology of Asian grain legumes (chickpea, pigeon pea, and groundnut). Research Bulletin no. 14. Patancheru, A.P. 502 324. India: International Crops Research Institute for the Semi-Arid Tropics.

Grain legumes are an important component of rural diets in Asia. Because of their importance agriculturally and nutritionally, there is a need to identify the agroclimatic factors that influence their production in Asia. This publication consolidates data on the agroclimatology of groundnut-, chickpea-, and pigeonpea-growing areas in 11 Asian countries.

Records are presented in the form of tables, maps, and a short text commentary for each country. Crop distribution and production in the administrative divisions of each country are shown; agroecological zones arc identified on the basis of soil, rainfall, temperature, relief, and current land use records. Major abiotic and biotic stresses are mapped for each country.

The publication makes a valuable preliminary contribution towards identifying location-specific research and agricultural development needs in each country, with special emphasis on the identification of areas with potential to expand production of grain legumes. It is hoped that the Bulletin will serve as a cogent source for researchers, policymakers, and all those who have an interest in the diversification of sustainable agriculture in Asia.

Résumé

Virmani, S.M., Faris, D.G., et Johansen, C. (éds.). 1991. **L'agroclimatologie des légumineuses à grain asiatiques (pois chiche, pois d'Angole et arachide).** Bulletin de recherche n° 14. Patancheru, A.P. 502 324, Inde : International Crops Research Institute for the Semi-Arid Tropics.

Les légumineuses à grain constituent une partie importante de l'alimentation rurale en Asie. Leur importance tant agricole que nutritionnelle souligne le besoin d'identifier les facteurs agroclimatiques qui déterminent leur productivité en Asie. Ce bulletin réunit des données sur l'agroclimatologie des régions de culture de l'arachide, du pois chiche et du pois d'Angole dans 11 pays de l'Asie Sud.

Les données sont présentées pour chaque pays sous forme de tableaux et de cartes, accompagnés de brefs commentaires. La répartition et la production agricole dans les divisions administratives sont indiquées pour chaque pays. Des zones agroécologiques sont déterminées en fonction de données sur les sols, la pluviométrie, la température, le relief, ainsi que l'exploitation actuelle des terres. L'incidence des contraintes biotiques et abiotiques majeures sur les différentes cultures est également représentée.

Ces données peuvent servir de référence préliminaire dans l'identification des besoins en matière de recherche et développement propres à des sites donnés dans différents pays. Un accent particulier est porté sur l'identification des régions où les conditions sont favorables à l'expansion de la production des légumineuses à grain. On espère que ce bulletin servira de source pertinente à l'intention de chercheurs, de décideurs, et de tous ceux qui s'intéressent à la diversification de l'agriculture durable ('sustainable') en Asie.

Cover: Vegetation index over South and Southeast Asia. Source: Climate Applications Branch of NOAA, Columbia, Missouri, USA. (Data for the picture provided by Dr Gary E. Johnson, GRID/UNEP, Bangkok.)

Agroclimatology of Asian Grain Legumes Chickpea, Pigeonpea, and Groundnut

Edited by
S.M. Virmani, D.G. Faris, and C. Johansen

Research Bulletin no. 14

ICRISAT

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1991

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Contents

Introduction

Asian agriculture is faced with challenges centered around feeding a large, rapidly increasing population, continuing subdivision of the natural resource base, need for agricultural diversification away from monocultures, constraints to adoption of intensive technologies by resource-poor farmers, and maintenance of an ecological balance. If we are to address these challenges adequately, we must re-examine our overall agricultural production mission and the research approaches recommended for achieving these objectives.

At ICR1SAT, one of our responses to meet these challenges has been the creation in 1986 of the Asian Grain Legumes Network (AGLN) to facilitate and strengthen the applied legumes research capabilities of the national agricultural research systems (NARS) in Asia so that the farmers' problems can be identified. addressed, and solved expeditiously. The AGLN's structure is based on strong contacts between ICRISAT research scientists and those in NARS to work on well-identified and regionally important research problems. In short, AGLN's role is to facilitate collaborative research in Asian farming, where grain legumes are perceived as important components for the sustainability of agriculture.

The AGLN founding members recommended that the network should endeavor to bring together the agrometeorological data from countries in the region so that agroecological zones could be identified in Asia. This zonation would be used to facilitate the transfer of appropriate plant material and technology to these countries. This recommendation prompted ICRISAT to organize a workshop entitled 'Agroclimatology of Asian Grain Legume Growing Areas' held at ICRISAT Center in December 1988. This workshop was intended to foster special research projects to support AGLN crops. The designation AGLN crops has been used throughout this bulletin to refer to ICRISAT's mandate crops chickpea, pigeonpea. and groundnut. By involving scientists from 11 Asian countries (Bangladesh, People's Republic of China. India, Indonesia. Malaysia. Myanmar. Nepal, Pakistan, the Philippines, Sri Lanka, and Thailand) the workshop also aimed to provide further impetus to agroclimatology research in the NARS involved. This research bulletin is based on the proceedings of the workshop.

At this workshop the participants collated data on area, production, and distribution of AGLN crops and mapped the information generated. On these maps agroecological zones have been delineated, and abiotic and biotic stresses identified for each of the participating countries. The participants also studied guidelines for collection of minimum data sets for cooperative experiments, reviewed data base management systems, and set goals for future research.

Participants to the workshop prepared the sections included in this research bulletin for each of their countries in cooperation with ICRISAT staff. They were assisted in this work by H. van Velthuizen of the Food and Agriculture Organization, Rome, and D.P. Garrity, R.E. Huke, and E.H. Huke of the International Rice Research Institute, Los Banos. the Philippines. Professor Afzal Mohammed of the Centre for Economic and Social Studies in Hyderabad, India, serving as consultant supervised the drawing of the maps. The data for Myanmar was collected following the workshop by ICRISAT staff, and the section subsequently approved by the authors.

S.M. Virmani conceived, formulated, and supervised the workshop and has co-edited this research bulletin with D.G. Faris and C. Johansen.

Y.L. Nene
Deputy Director General

Note to the Reader

This research bulletin is planned as a resource manual for all those interested in diversifying Asian agriculture. The countries represented have primarily agrarian economies, and presenting agriculture's role has required great care and attention. However, the data on which the country presentations have been made were sometimes sparse, particularly on biotic stresses, and the authors and scientific editors have had to sacrifice depth for breadth of coverage. This bulletin is indicative of how information about crops can be drawn together and presented for planners, and should be considered as the first step to more detailed studies within each country. For each country after a brief introduction the following topics are discussed: crop distribution in relation to agroclimatic factors, major stress factors, and future prospects.

A list of sources from which base maps have been reproduced includes:

Bangladesh: Land Resources Appraisal of Bangladesh for Agricultural Development. 1988. Rome: Food and Agriculture Organization of the United Nations.

People's Republic of China: Huke, R.E. 1982. China and Korea: The Dry Season. Los Banos: International Rice Research Institute; People's Republic of China: Chinese Agricultural Year Book. 1980. Beijing: Agricultural Publishing House.

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Malaysia: Government of Malaysia.

Myanmar: World Atlas of Agriculture. 1969. Southeast Asia (Mainland), Plate No. 27. Novara, Italy: Instituto Geografico de Agostini; Myanmar: The Socialist Republic of the Union of Burma. 1984, Yangon: Myanmar Survey Department.

Nepal: Nepal. 1983; and Climates of Nepal, 1985. Kathmandu: Topographical Survey Branch, H.M.G. Survey Department.

Pakistan: World Atlas of Agriculture. 1969. Southwest Asia (Eastern Part), Plate No. 20. Novara, Italy: Instituto Geografico de Agostini; Pakistan: Soils. 1984. Islamabad: Government of Pakistan.

The Philippines: Agroclimatic Map of the Philippines. Los Banos: International Rice Research Institute.

Sri Lanka: World Atlas of Agriculture, 1969. Indian Peninsula (Southern Part) and Ceylon, Plate 22. Novara. Italy: Instituto Geografico de Agostini.

Thailand: National Geographic Atlas of the World. 1975. Washington, DC, USA: National Geographic Society.

Bangladesh[1]

Introduction

The administrative divisions and important urban centers of Bangladesh are shown in Figure 1.

After lathyrus and lentil, chickpea is the most important pulse crop in terms of area and production, constituting 20% of total pulse production. It is grown on residual soil moisture during winter, and is consumed mainly as *dhal* but also as *basson* (flour). Pigeonpea is a minor pulse crop accounting for less than 1% of total pulse production. Long-duration genotypes that mature in 250-300 days are grown. Most pigeonpea is consumed as *dhal,* but some is used as a green vegetable. Stalks arc used as fuelwood. The area and production of chickpea and pigeonpea have declined in recent years (Table 1).

Next to rapeseed, groundnut is the most important oilseed crop in Bangladesh. It is, however, consumed almost entirely as a confectionery product (roasted nuts). It is produced mainly in the postrainy season on residual soil moisture, but is also grown during the rainy season, primarily for seed production. The area cultivated during the postrainy season has declined in recent years, but rainy-season area and production have increased (Table 1).

Table 1. Chickpea, pigeonpea, and groundnut area, production, and productivity in Bangladesh, 1985/86.

	Area ('000 ha)	Production ('000 t)	Average yield (t ha^{-1})
Chickpea	47.35 (82)[1]	35.76 (95)	0.75
Pigeonpea	2.46 (66)	1.70 (66)	0.69
Groundnut			
Rainy season	1.90(179)	2.02(184)	1.06
Postrainy season	16.51 (72)	19.60 (86)	1.19

1. Figures in parentheses are 1985/86 values as percentages of those for 1980/81

Source: Bangladesh Bureau of Statistics, Dhaka, Bangladesh,

Crop Distribution in Relation to Agroclimatic Factors

Chickpea is grown in the postrainy season, mainly in two sequential cropping patterns: rice or jute (Apr-Aug) - fallow (Aug-Oct) - chickpea (Nov-Apr); and rice (Jul-Dec) - chickpea (Dec-Apr) - fallow (Apr-Jun). The Nov-Apr period is considered optimal for chickpea; thus about 60-65% of chickpea is grown in the first pattern. In the second pattern, chickpea sowing is delayed until after the rice harvest.

Pigeonpea is sown in May/Jun, mainly as a border or mixed crop with rice or finger millet. It is harvested in Feb/Mar.

Groundnut is a rainfed crop. It is usually a postrainy-season crop (sown in Oct/Nov and harvested in Mar), and is grown as a sole crop following rice on residual soil moisture. The small rainy-season crop is sown in Apr/May and harvested in Aug/Sep. In both seasons, groundnut may be intercropped with sugarcane, maize, or cotton.

A detailed agroecological zonation of Bangladesh was published by the Food and Agriculture Organization of the United Nations (FAO) in 1988 (Fig. 2).

Chickpea is well adapted to growing at cooler temperatures and on residual soil moisture. Thus it tends to be grown in the central west of the country, on the Ganges Floodplain (agroecological Zone V11l), where temperatures are generally lower and winter rainfall is minimal (Fig. 3). Pigeonpea is also grown mainly in the central west (Fig. 3), but the area under pigeonpea extends northwards, particularly on the Tista Floodplain (agroecological Zone II) where total rainfall and winter temperatures are lower than in the rest of the country. Chickpea and pigeonpea are grown mainly in areas that receive 1200-1400 mm rainfall during the monsoon season and less than 80 mm rainfall during winter.

Most groundnut-growing areas lie in the Old Brahmaputra and Old Meghna Floodplains that comprise mainly agroecological Zones VII and XI and some of Zone VIII (Fig. 4). In northern Bangladesh, most production occurs in the zone with a potential postrainy growing period of 130-140 days, as defined by average soil moisture availability. Further south there is considerable production within the 120- to 130-day zone.

1. **This section was prepared by M.A. Khaleque, M.M. Rahman, and M.** Rahman. Bangladesh Agricultural Research Institute, Joydebpur, Bangladesh, in cooperation with the **following resource persons from ICRISAT: C. Johansen and** Jagdish Kumur.

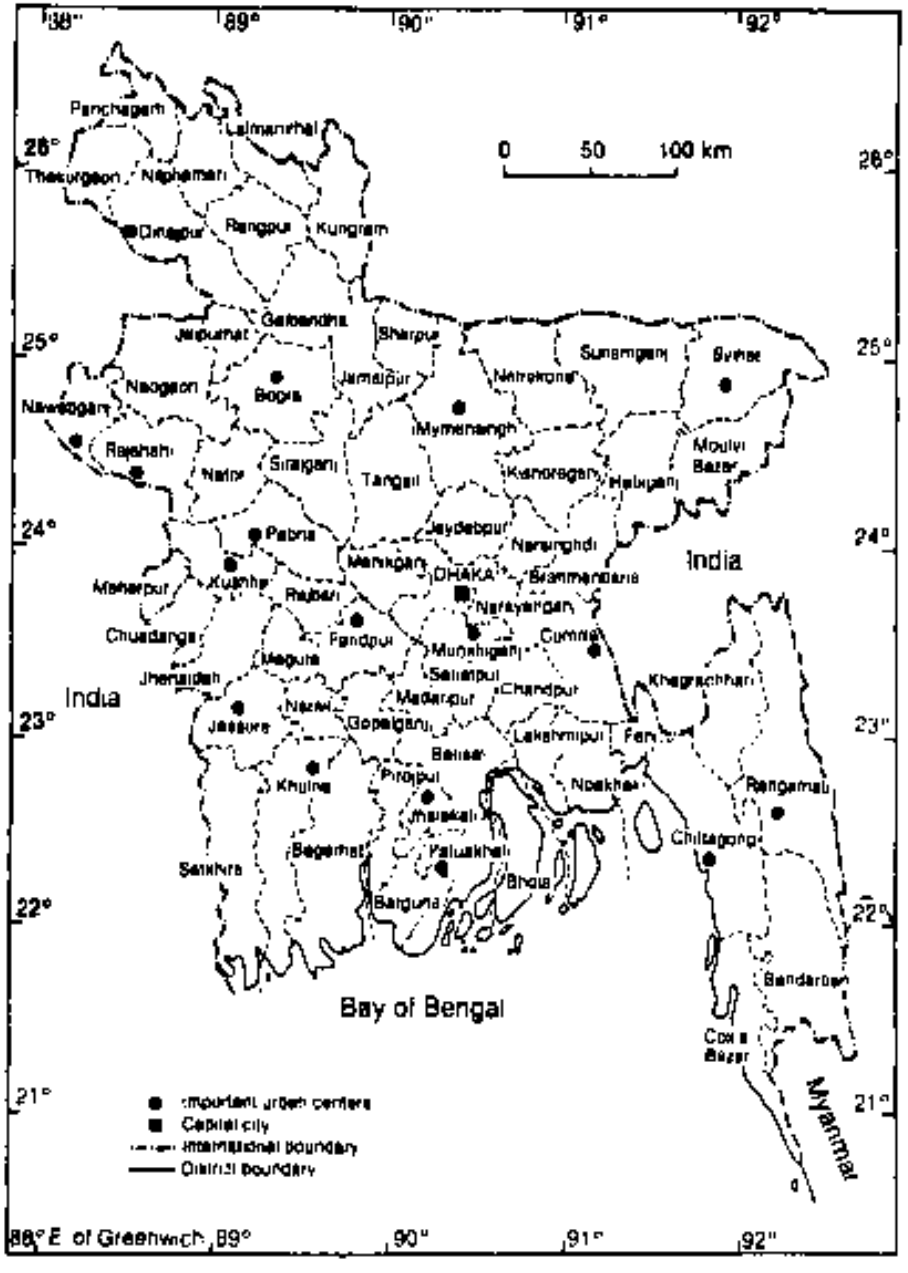


Figure 1. Administrative divisions of Bangladesh.

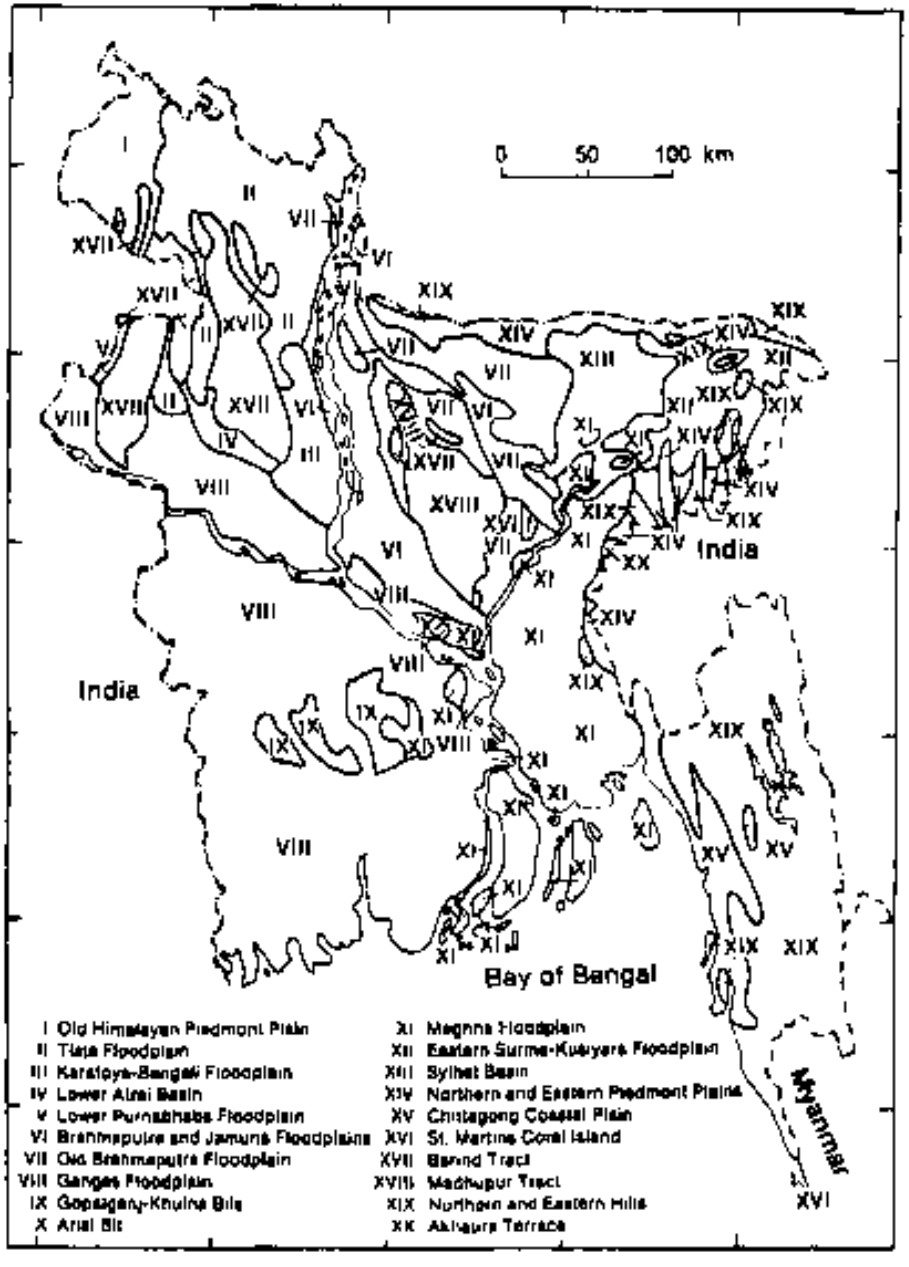


Figure 2. Agroecological zones of Bangladesh.

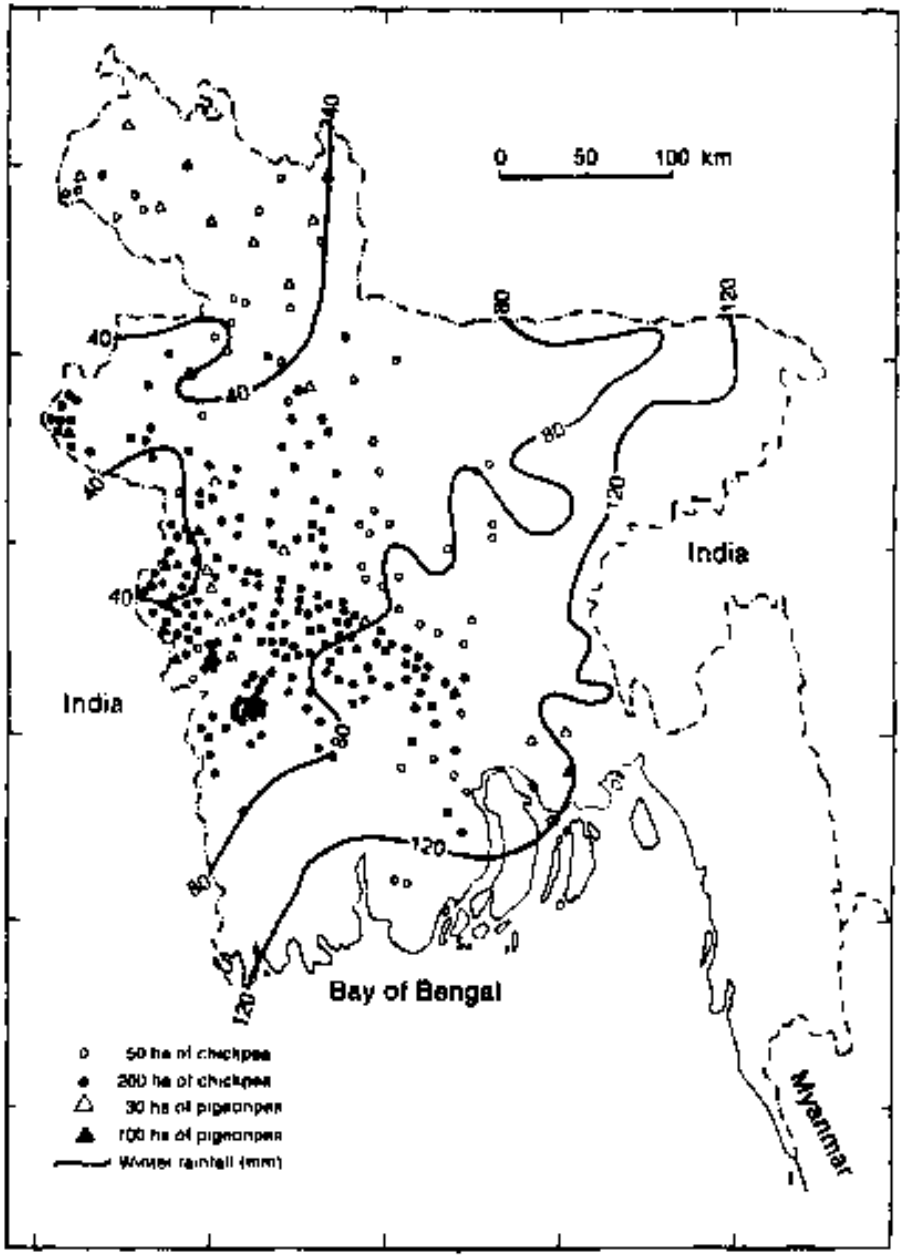


Figure 3. Chickpea and pigeonpea distribution according to winter rainfall in Bangladesh.

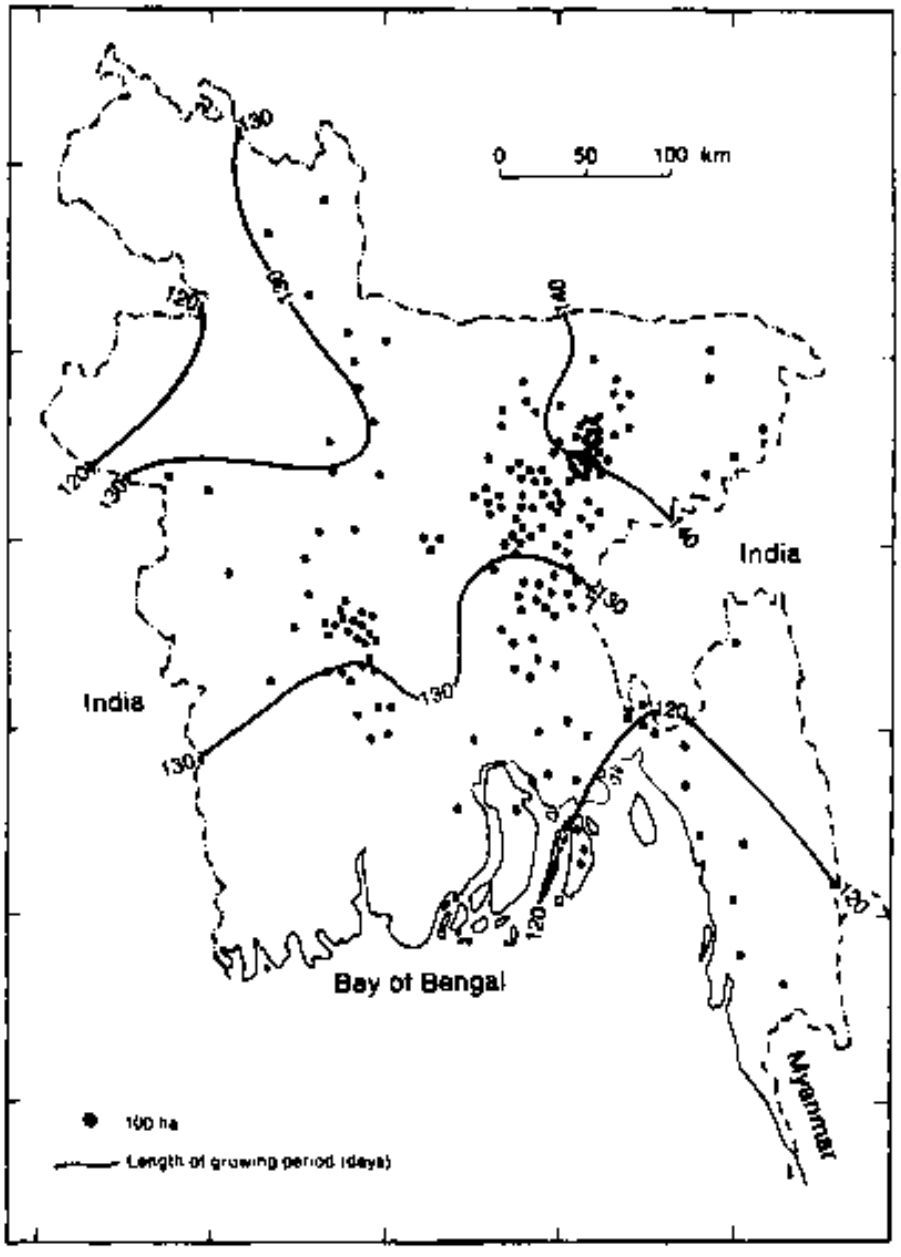


Figure 4. Groundnut distribution and length of growing period in Bangladesh.

Groundnut growth and development is inhibited at temperatures below 20°C, and the crop is distributed mainly in regions with relatively mild winter temperatures. Although soil texture and available moisture (as reflected in the length of postrainy growing period) in the west of the country would be suitable for groundnut, the number of days on which winter temperatures fall below 15°C is relatively high in this zone. A large zone in which winter temperatures fall below 15'C for only 50-70 days (T3) extends northwards across the Old Brahmaputra Floodplain (Fig. 5).

All three crops are produced primarily on gray Floodplain soils, both calcareous and noncalcareous (Fig. 6). The soils of the Ganges Floodplain range from loamy to clay loam with a pH of 6.5-7.5 and available water capacity (AWC) of 160-205 mm within a profile depth of 100 cm. On the Tista Floodplain, soils vary from silty loam to sandy loam with a pH of 5.0-6.5 and an AWC of 160-250 rnm within a profile depth of 100 cm.

Major Stress Factors

The major chickpea diseases are botrytis gray mold *(Botrytis cinerea),* fusarium wilt *(Fusarium oxysporum* f. sp *ciceri),* black root rot *(F. solani),* and collar rot *(Sclerotium rolfsii).* Pod borer *(Helicoverpa armigera)* is the major insect pest of chickpea. For pigeonpea, it is not possible to delineate zones of greater or lesser incidence because biotic constraints have not been examined systematically. The groundnut crop is prone to damage by several diseases including leaf spots (mainly late leaf spot, *Phaeoisariopsis personata),* rust *(Puccinia arachidis),* collar rot *(Aspergillus niger),* and stem rot *(Sclerotium rolfsii).* The major insect pests are thrips *(Frankliniella* spp, *Scirtotlirips dorsalis),* hairy caterpillar *(Amsacta* spp), aphids *(Aphis craccivora),* and jassids *(Empoasca* spp). These diseases and pests occur sporadically wherever chickpea and groundnut are grown.

Future Prospects

A promising area for expanding chickpea cultivation is the Barind Tract (Fig. 6) (agroecological Zone XVII comprising parts of Rajshahi, Bogra, Rangpur, and Dinajpur districts) in the northwest of the country. Here the soils generally remain fallow after the rice harvest in Dec. Late-sown chickpea could be grown if genotypes and agronomic practices are identified to overcome the stresses imposed by low soil moisture availability in the Dec-Feb period, and rapidly rising temperatures in Mar. Similarly, large areas of the Tista Floodplain (in Rangpur

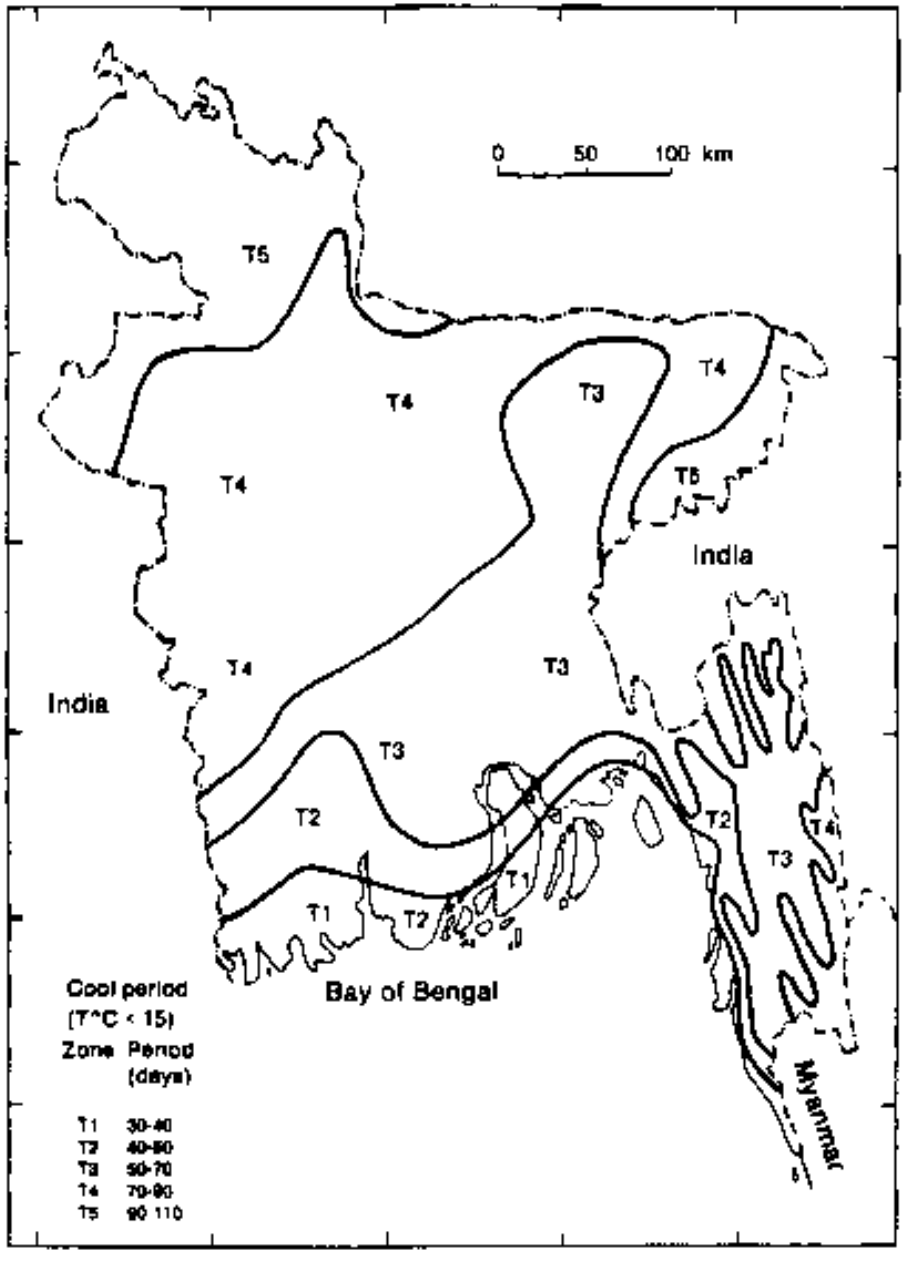


Figure 5. Thermal zones in Bangladesh.

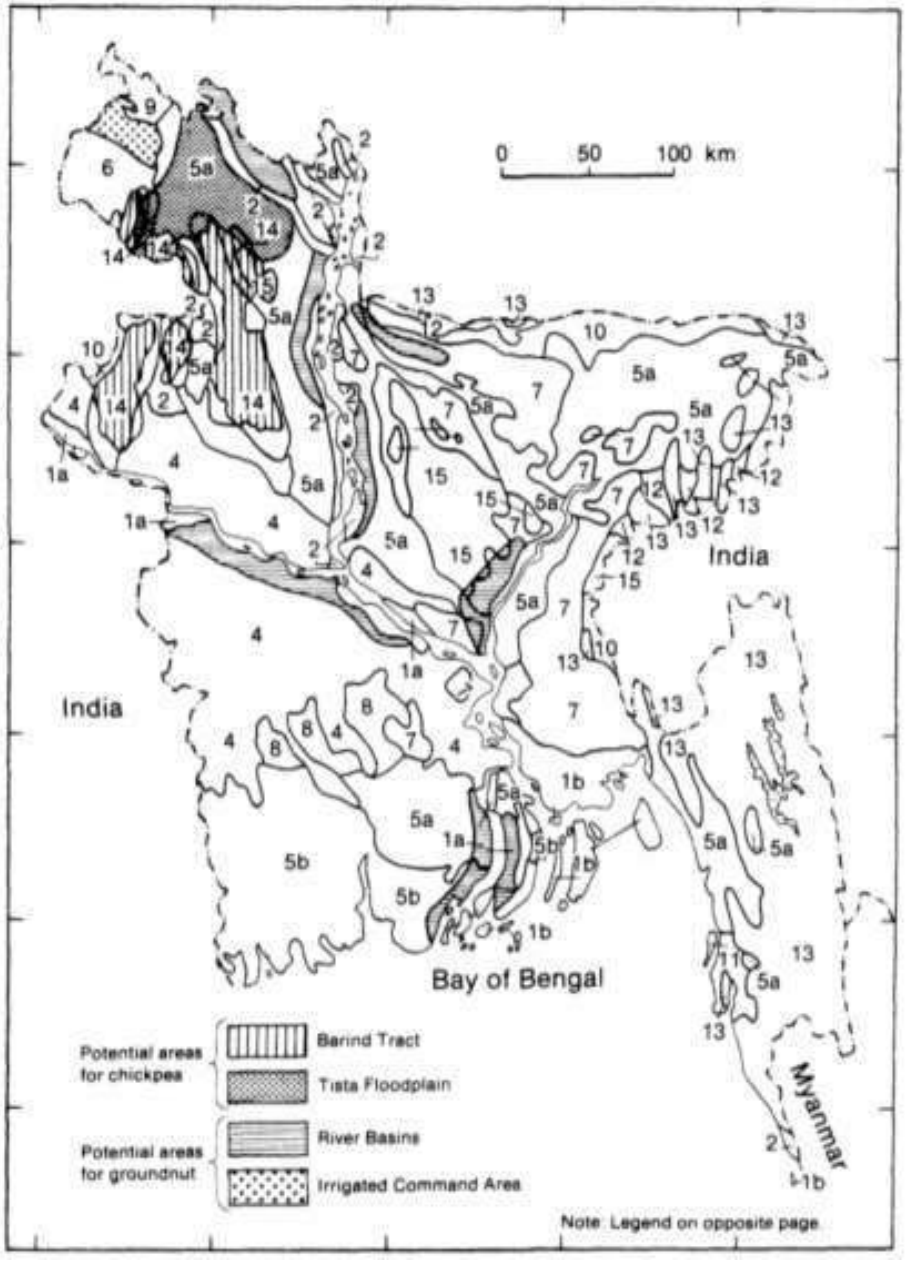


Figure 6. Generalized soil types and potential areas for expanding chickpea and groundnut cultivation in Bangladesh.

and Dinajpur districts) remain fallow after rice. Here, in addition to temperature and drought, low pH and micronutrient deficiencies (e.g.. boron) may limit chickpea production.

The expansion of pigeonpea cultivation will probably depend on the introduction of new genotypes and cropping systems. Medium-duration pigeonpea could be introduced as a rainy-season crop in hilly areas of the southeast, while short/medium-duration pigeonpea could be intercropped with black gram or mung bean in higher, well-drained soils in northern areas (sowing in Sep, after rice or jute); disease-resistant pigeonpea might also prove useful in agroforestry. The scope for postrainy-season pigeonpea in rice fallows is currently limited because of its slow growth rale at low temperatures.

The soils and climate throughout Bangladesh are suitable for groundnut production, except in the northeast and northwest, where low temperatures and limited soil moisture constrain the postrainy-season crop. The flooding of Floodplain areas, and high rainfall in the northeast and southeast, limit the areas suitable for rainy-season production. However, the main factor preventing expansion of the area under groundnut is competition from alternative crops, notably wheat. Intercropping options are being encouraged.

The main areas with potential for expanding postrainy-season groundnut cultivation lie in river basins (Fig. 6) in the districts of Lalmanirhat, Gaibandha, Sirajganj, Jamalpur, Tangail, Kushtia, Faridpur, Dhaka, Narayanganj, Munshiganj, Narsingdi, Patuakhali, and Bhola. The command area in the Thakurgaon and Nilphamari districts, in the extreme northwest of the country is suitable for irrigated groundnut cultivation, but cold-tolerant genotypes would be needed.

Legend

1a Calcareous alluvium (non-saline)
1b Calcareous alluvium (seasonally saline)
2 Noncalcareous alluvium
3 Calcareous gray floodplain soils
4 Calcareous dark gray floodplain soils
5a Noncalcareous gray floodplain soils (non-saline)
5b Noncalcareous gray floodplain soils (seasonally saline)
6 Noncalcareous brown floodplain soils
7 Noncalcareous dark gray floodplain soils
8 Noncalcareous dark gray floodplain soils and peat
9 Black Teral soils
10 Acid basin clays
11 Acid sulphate soils
12 Gray Piedmont soils
13 Brown hill soils
14 Shallow and deep gray terrace soils
15 Deep red-brown terrace soils

People's Republic of China[1]

Introduction

The provinces and important urban centers of the People's Republic of China (hereinafter referred to as China) are shown in Figure I.

China has seven agroecological zones suitable for groundnut production (Fig. 2). Groundnut is the only significant AGLN crop grown in China. Figure 3 shows groundnut growing areas (largest area in Shandong Province), and Figure 4 shows groundnut production. Groundnut area, production and average yields in

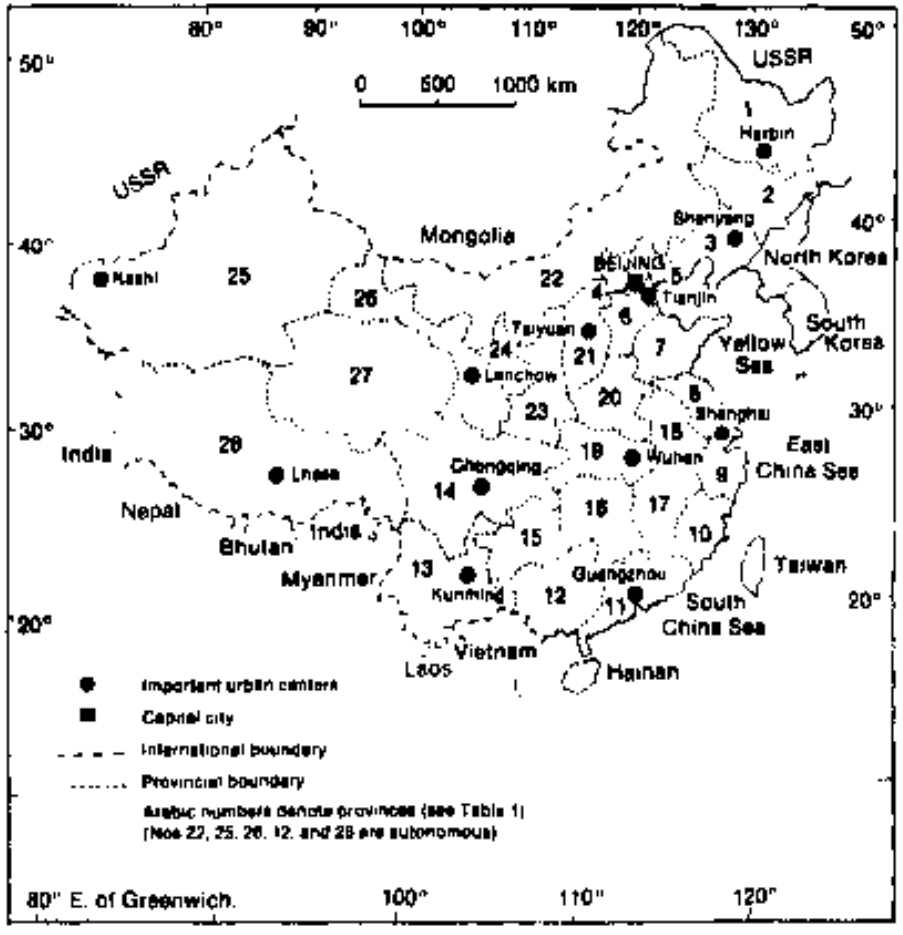


Figure 1. Administrative divisions of China.

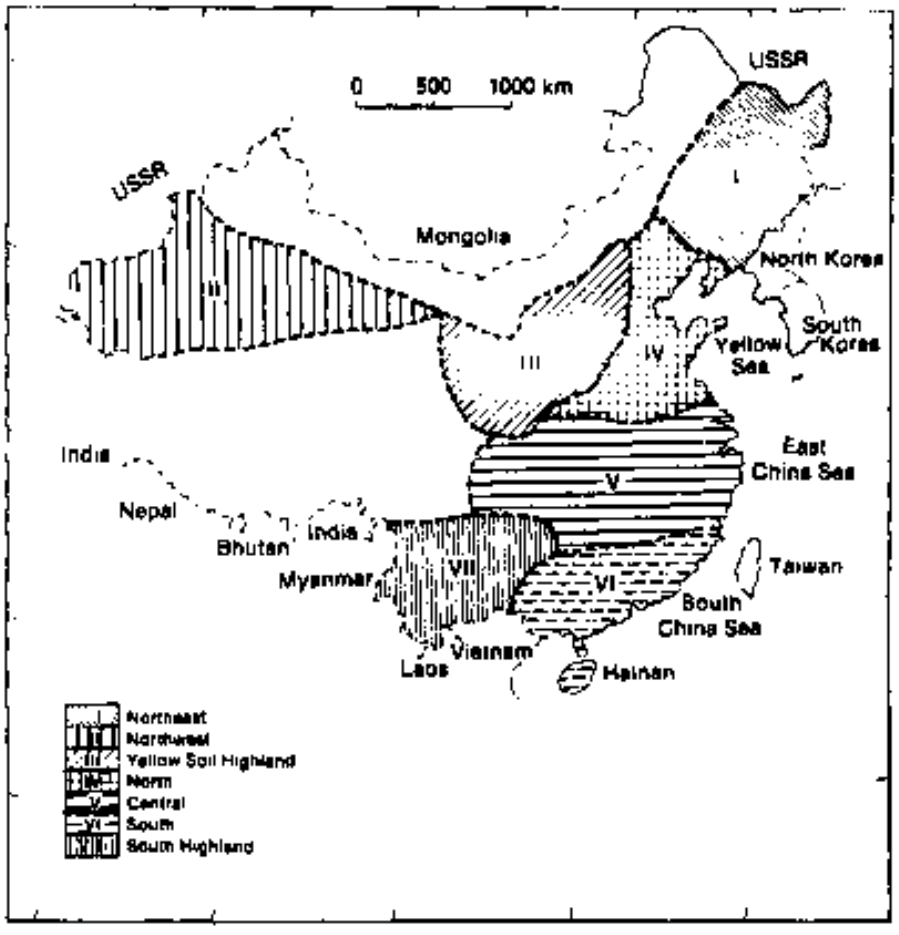


Figure 2. Agroecological zones of China.

1. This section was prepared by Cheng Yannian. Zhou Rung, and Liao Boshou, Chinese Academy of Agricultural Sciences. Beijing, in cooperation with the following resource persons from ICRISAT: D. McDonald. Zhang Xinyou, and V.K. Mehan.

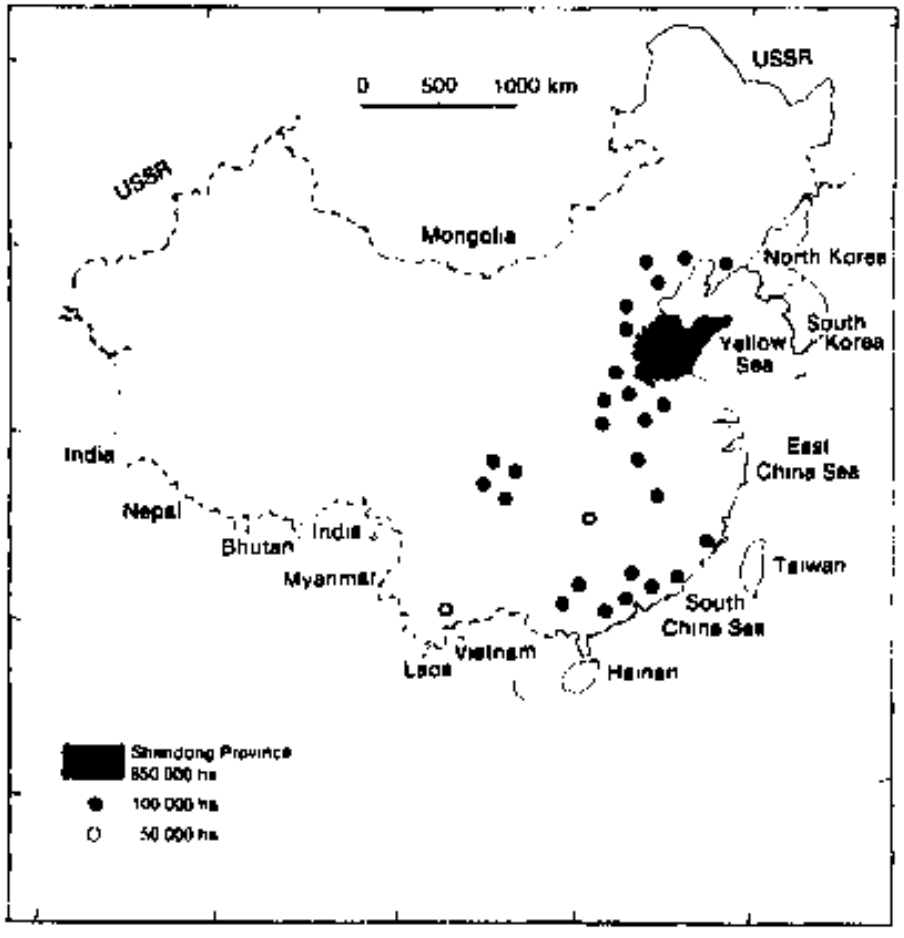


Figure 3. Groundnut distribution in China.

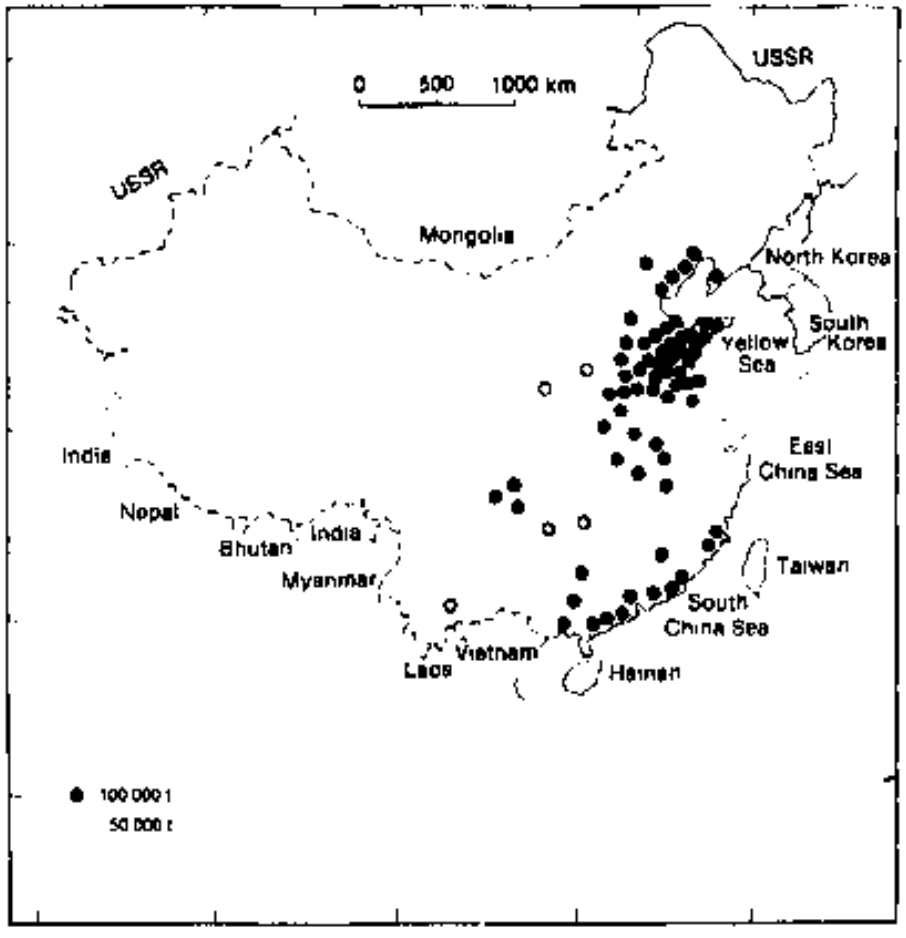


Figure 4. Groundnut production in China.

1986 and 1987 arc given in Table 1. Production and area have both increased markedly over the past decade, from 1.96 million t (dried pods) grown on 1.70 million ha in 1976 to 5.90 million t grown on 3.3 million ha in 1986. showing an average annual growth rate in production of 20%.

Crop Distribution in Relation to Agroclimatic Factors

The factors influencing groundnut production in each zone are shown in Table 2. figure 5, indicating rainfall distribution and temperature, shows how production is restricted by drought and cold in the northwest of the country, while waterlogging and high temperatures are more likely to be problems in the far south.

In the far north, where production is limited at present, the length of the growing period is restricted by temperature, and short-duration cultivars are sown in late spring or early summer (for a description of seasons, see Table 3). In the Central Zone and the southern part of the North Zone, where the bulk of production occurs, groundnut is usually sown in spring or summer depending on the farming system. In the South Zone, which is the second most important groundnut producing zone, two crops are commonly grown, a spring crop (main crop) and an autumn crop (mainly for seed). A summer crop may also be grown in some

Table 1. Groundnut area, production, and productivity in 25 provinces of China, in 1986 and 1987.

Agro-ecological zone[1]	Province	(No.)[2]	Area ('000 ha)		Production ('000 t)		Average yield (1 ha^{-1})	
			1986	1987	1986	1987	1986	1987
IV	Shandong	(7)	850	766	2057	2298	2.42	3.00
IV	Henan	(20)	379	409	537	763	1.41	1.86
VI	Guandong	(11)	414	394	644	577	1.56	1.46
IV	Hebei	(6)	340	310	476	534	1.40	1.72
VI	Guangxi	(12)	184	173	228	176	1.24	1.02
V	Sichuan	(14)	169	158	270	271	1.60	1.71
V	Anhui	(18)	141	129	281	260	1.99	2.01
V	Jiangsu	(8)	136	125	365	337	2.68	2.70
VI	Fujiang	(10)	90	92	162	163	1.80	1.77
V	Jiangxi	(17)	80	90	136	158	1.70	1.76
V	Hubei	(19)	70	65	151	146	2.16	2.25
V	Hunan	(16)	66	67	93	94	1.41	1.40
IV	Liaoning	(3)	162	87	222	130	1.37	1.49
III	Sanxi	(21)	40	36	76	78	1.90	2.17
VII	Yunnan	(13)	33	31	34	29	1.03	0.93
VII	Guizhou	(15)	31	30	45	38	1.45	1.27
111	Shanxi	(23)	25	22	42	42	1.68	1.91
IV	Beijing	(4)	14	12	27	29	1.93	2.42
IV	Tianjing	(5)	12	11	22	22	1.83	2.00
V	Zhejiang	(9)	8	8	12	15	1.50	1.87
I	Jilin	(2)	6	4	9	6	1.32	1.50
I	Helongjiang	(1)	1	<l	2	1	1.74	1.13
III	Inner Mongolia	(22)	<1	<1	<1	<1	1.89	1.29
II	Xinjiang	(25)	<1	<1	1	1	2.70	2.75
111	Gansu	(24)	<1	<1	<1	<1	2.42	2.49
	All China		3251	3019	5881	6169	1.81	2.04

1. See Figures 2 and 5.
2. See Figure 1.

Table 2. Agroecological factors influencing groundnut production in China.

Agro-ecological zone[1]	Average annual temperature (<℃)	Total annual rainfall (mm)	Growing months	Groundnut type grown	Major stress factors
1 Northeast	2-7	450-700	May-Sep	Spanish	Low temperature
II Northwest	3-14	50-280	May-Sep	Virginia Spanish	Low temperature, drought
III Yellow Soil Highland	7-10	300-550	May-Sep	Virginia Spanish	Drought
IV North	11-14	450-900	May-Oct	Virginia Spanish others	Leaf spots, viruses, pests, drought
V Central	15-19	800-1800	Apr-Oct	Spanish Virginia	Leaf spots, rust, bacterial wilt, pests, drought, waterlogging, high temperature
VI South	20-25	1500-2000	Feb-Dec	Spanish	Rust, bacterial wilt, waterlogging, low soil pH
VII South Highland	15-20	900-1400	Mar-Oct	Spanish Virginia	Waterlogging

1. See Figures 2 and 5.

Table 3. Seasons in China.

Spring	3 Feb - 4 May
Summer	5 May - 6 Aug
Autumn	7 Aug - 6 Nov
Winter	7 Nov - 2 Feb

areas of the South Zone (e.g., in Hainan). Both Spanish and Virginia types are grown, except in the South and Northeast Zones, where only Spanish types are produced.

In the groundnut growing areas of China alluvial or hilly sandy soils predominate in northern zones, while in southern zones there are red and yellow sandy loam soils with a pH of less than 7. In central China mixtures of these soil types occur.

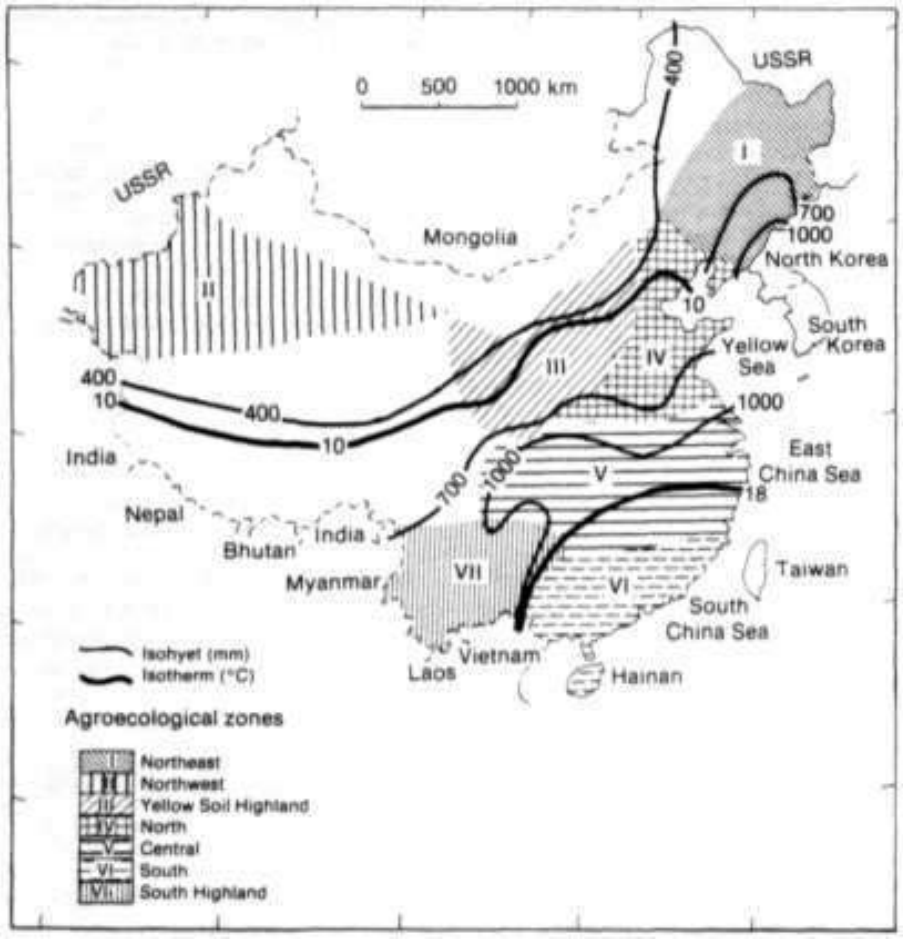


Figure 5. Rainfall and temperature patterns In China.

Groundnut is grown as a sole crop, or in a wide range of rotations with rice, sugarcane, jute, rapeseed, and other crops.

Major Stress Factors

The major abiotic stresses affecting groundnut production are listed by zone in Table 2. Low temperatures are a limiting factor in the Northeast and Northwest Zones. Drought can be a problem in the Northwest, Yellow Soil Highland, North, and Central Zones. Waterlogging may occur in the Central, South, and South Highland Zones. Low pH is a problem in some soils of the South Zone.

The major biotic stresses affecting groundnut are early *(Cercospora arachidicota)* and late *(Phaeoisariopsis personata)* leaf spots that occur sporadically in the main groundnut-growing areas (Fig. 6). Rust *(Puccinia arachidis)* is severe in southern and central areas, while in other groundnut-growing areas its incidence is moderate to low. Bacterial wilt *(Pseudomonas solanacearum)* is severe in parts of southern and central areas, but rarely occurs in northern areas. Peanut stripe virus is a serious problem in the North and Central Zones, but in southern areas its incidence is restricted mainly to research farms (Fig. 7).

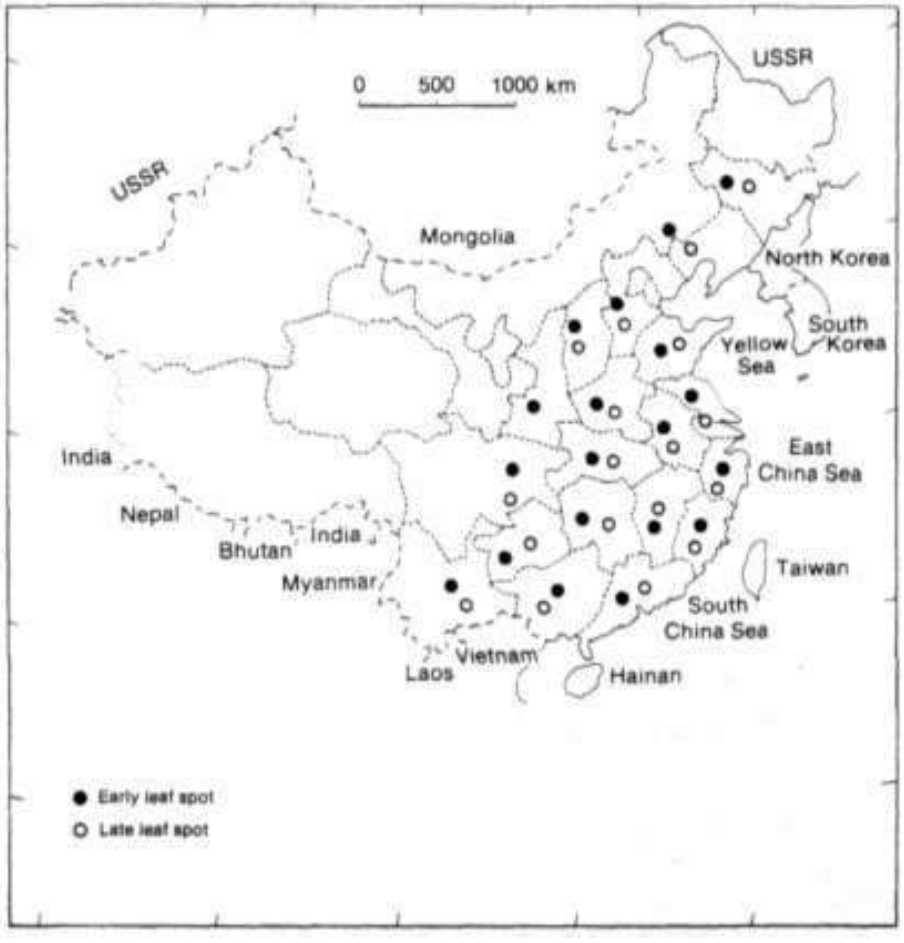


Figure 6. Occurrence of leaf spot diseases on groundnut in China.

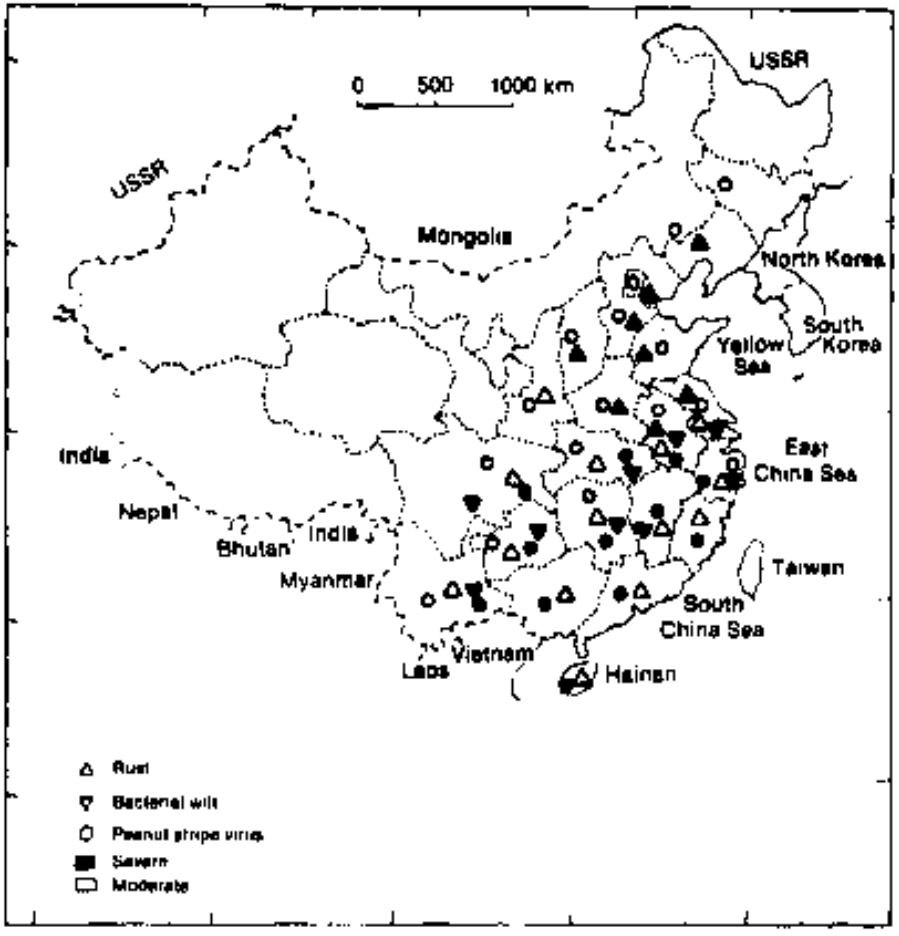


Figure 7. Occurrence of rust, bacterial wilt, and peanut stripe virus diseases on groundnut in China.

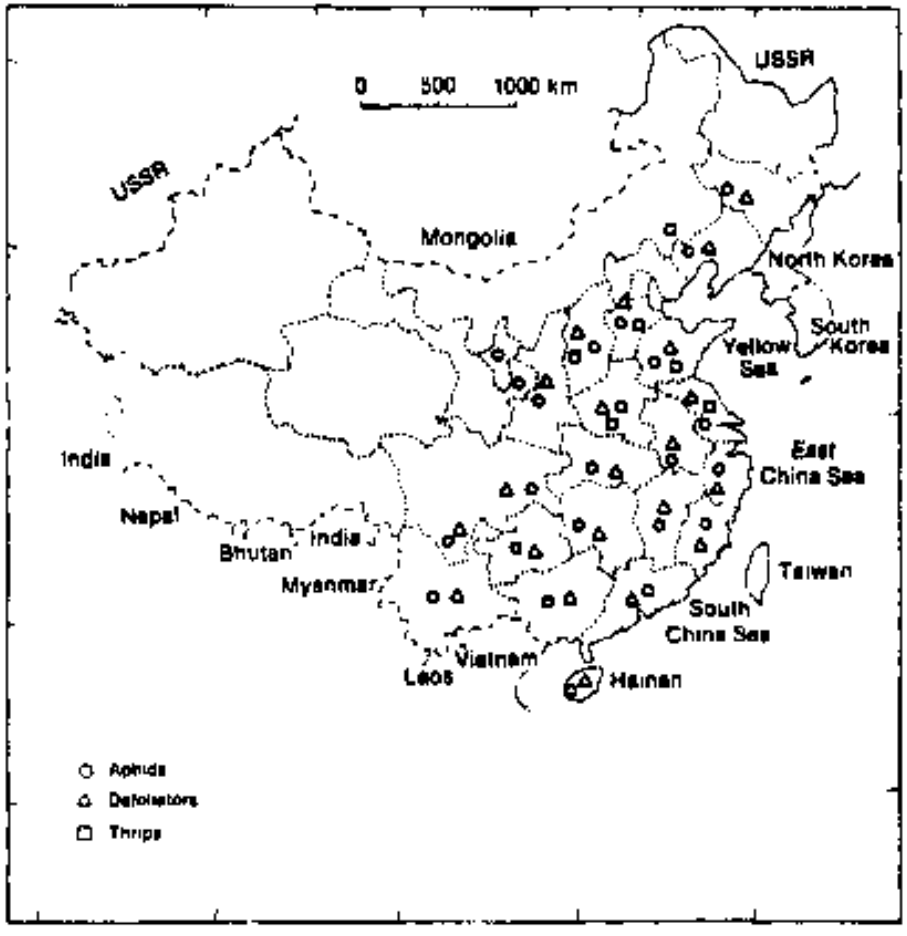


Figure 8. Occurrence of insect pests on groundnut In China.

Very little information is available on the incidence of the various insect pests of groundnut in China. Aphids *(Aphis craccivora)* and defoliators *(Helicoverpa armigera* and *Spodoptera litura)* are widely distributed, while thrips *(Scirtothrips dorsal is* and *Frankliniella* spp) are the most important pests in the North and Central Zones (Fig. 8).

Future Prospects

The increase in groundnut cultivation since 1976 is attributed to the implementation of relevant social and economic policies, the use of improved cultivars and production technologies, associated improvements in processing and trade, and increased consumer demand. Although past progress has been satisfactory, efforts must continue on all fronts if further increases in production and quality are to be achieved. There is limited scope for expanding groundnut area in the main growing zones. However, there may be some opportunities for increasing it in the Yellow Soil Highland Zone.

India[1]

Introduction

The states and important urban centers of India are shown in Figure 1.

Recently, the Government of India divided the country into 16 agroclimatic zones according to rainfall, geomorphological features, vegetation, cropping systems, **and land use,** as depicted in Figure 2.

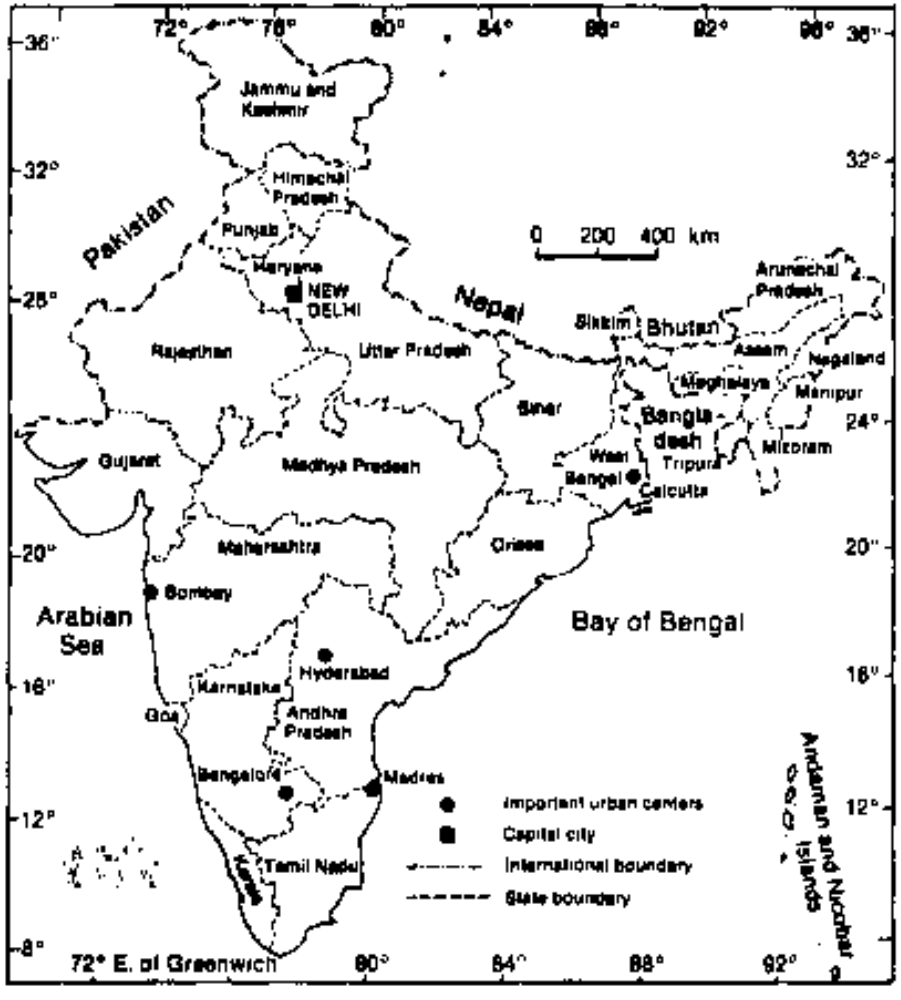


Figure 1. Administrative divisions of India.

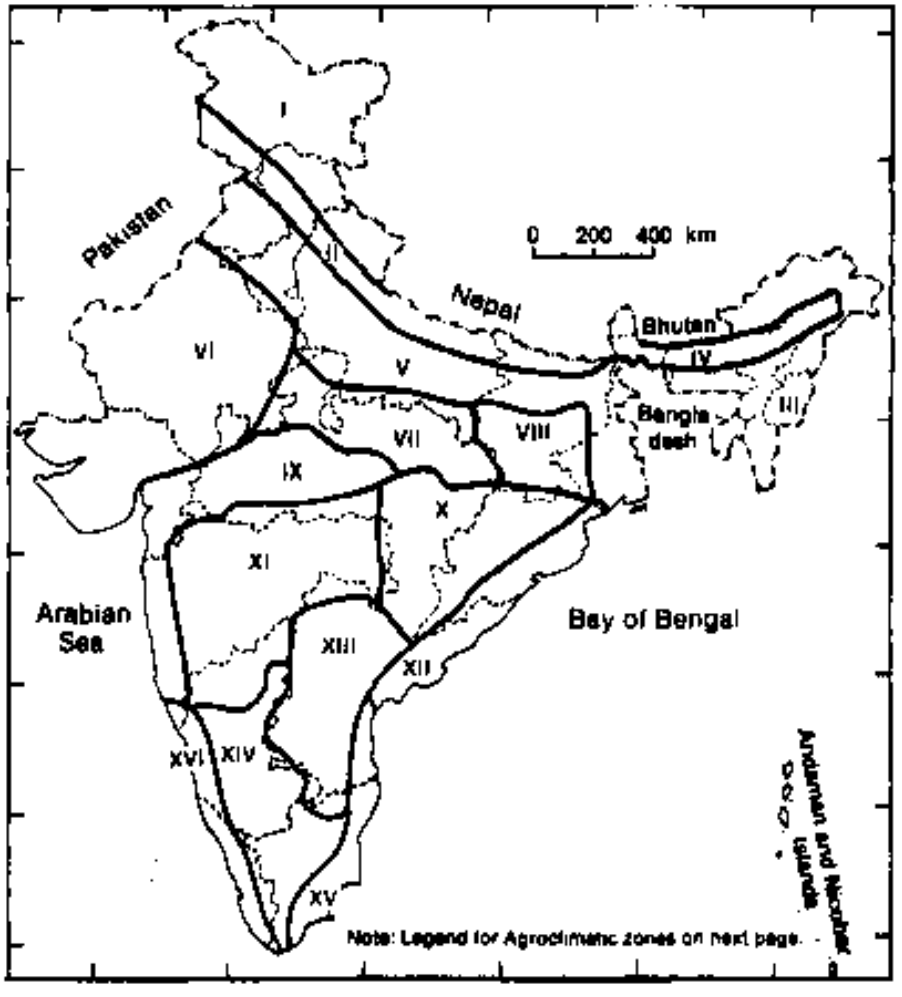


Figure 2. Agroclimatic zones of India.

' 1. This section was prepared by B.V. Ramana Rao, Central Research Institute for Dryland Agriculture, Hyderabad; S. Lal and M. Ali, Directorate of Pulses Research. Kanpur; and A.M. Shekh. Gujarat Agricultural University, Anand, in cooperation with the following resource persons from ICRISAT: S.M. Virmani. Piara Singh, and Laxman Singh.

Legend for Figure 2.

I Humid northwestern Himalayas
II Himalayan foothills
III Humid high rainfall northeastern zone
IV Humid Assam-Bengal plains
V Subhumid and humid Satlej-Ganga alluvial zone
VI Northwestern semi-arid and arid zone
VII Central semi-arid Vindhyan zone
VIII High-rainfall, high-runoff Chhotanagpur plateau
IX Assured-rainfall deep black soil Malwa plateau and Narmada basin
X Chhattisgarh plateau
XI Variable-rainfall south-central Deccan plateau
XII Southeastern brown red soil zone
XIII Southern variable-rainfall, mixed-soil zone
XIV Southern bimodal rainfall zone
XV Eastern Coromandel coastal zone
XVI Western Malabar coastal zone

India is the world's largest producer of chickpea and pigeonpea, and one of the world's top two groundnut producers. Chickpea is confined largely to northern and central India, whereas pigeonpea and groundnut are grown throughout the semi-arid and subhumid zones of the country. The area, production, and yield of the three crops are given in Table 1.

Chickpea yields range from 0.38 to 0.90 t ha^{-1} (Fig. 3), pigeonpea from 0.2 to 1.3 t ha^{-1} (Fig. 4) and groundnut from less than 0.35 to more than 1.75 t ha^{-1}

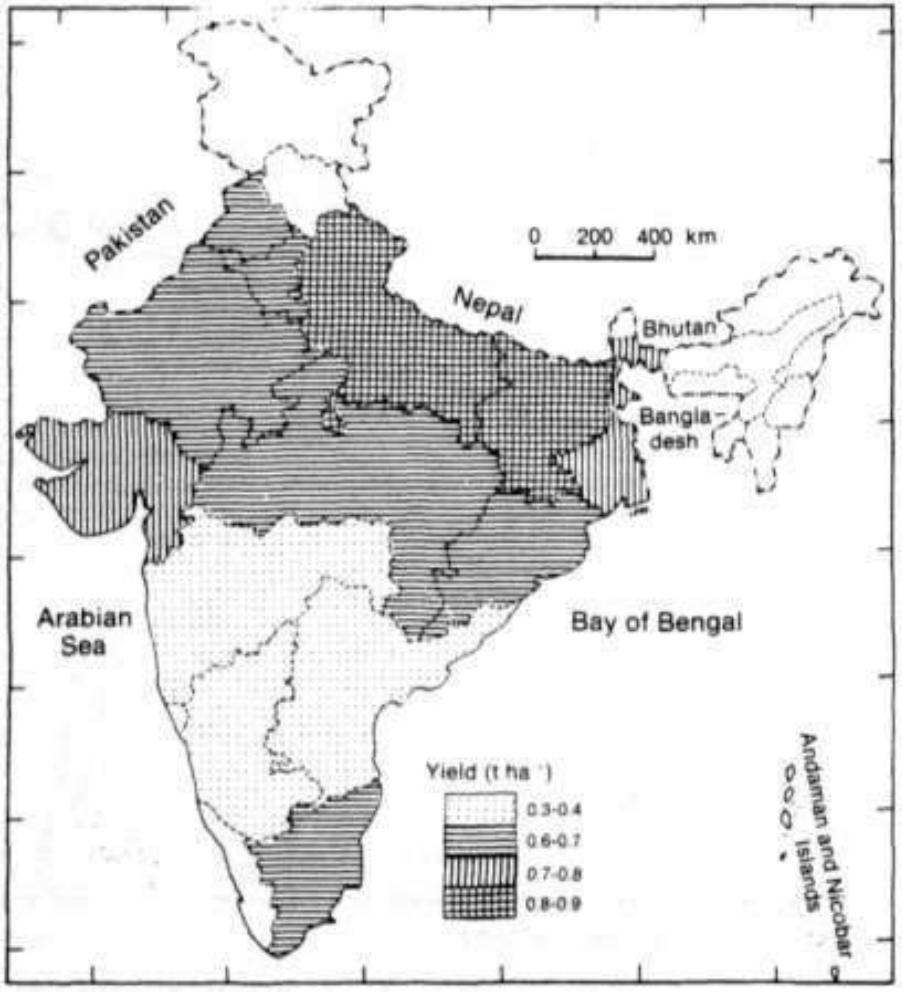


Figure 3 Chickpea yields in India.

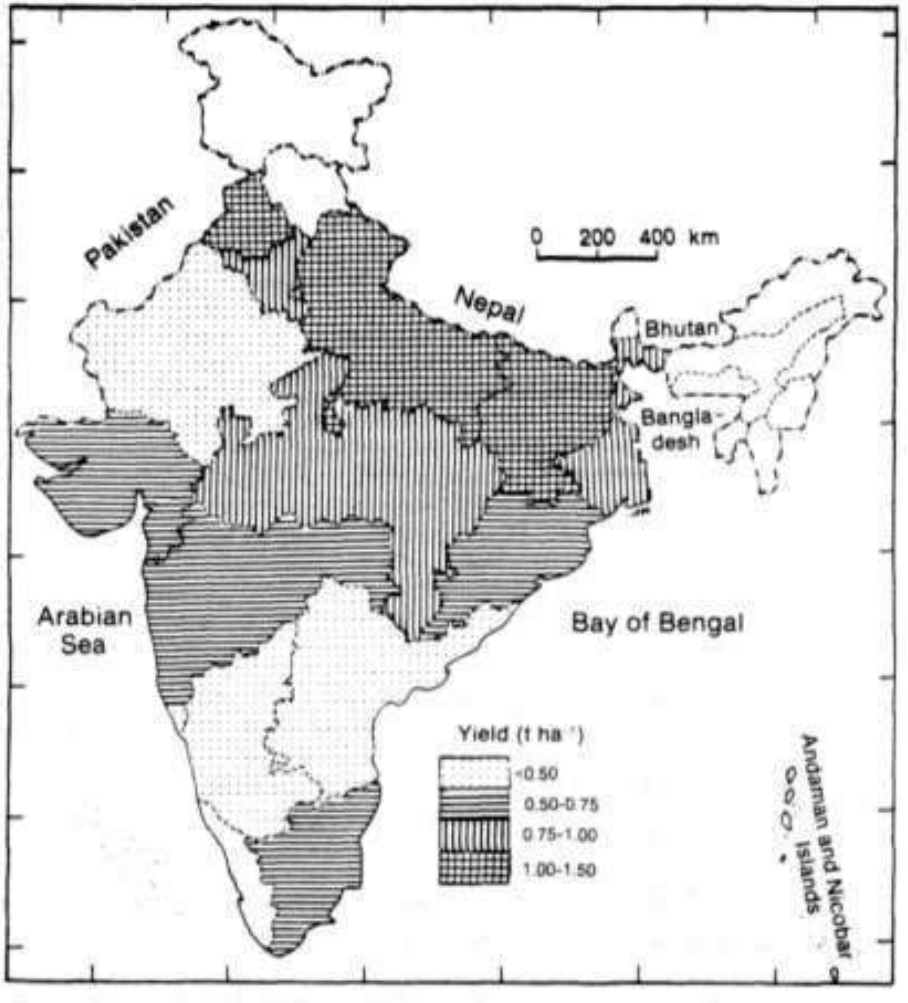


Figure 4. Pigeonpea yields in India.

Table 1. Chickpea, pigeonpea, and groundnut area, production, and productivity in India, 1979-84.

Crop	Area ('000 ha)	Production ('000 t)	Average yield (t ha^{-1})
Chickpea	7 798	5 038	0.65
Pigeonpea	2 973	2 230	0.75
Groundnut	6 376	5 164	0.81

(Fig. 5). The ranges arc attributed to varying cropping systems, agroecological differences, and the influence of biotic and abiotic stresses.

Crop Distribution in Relation to Agroclimatic Factors

Chickpea is a postrainy-season crop (Oct-Apr). It is raised mostly on a receding soil moisture regime in areas where the length of growing period is more than

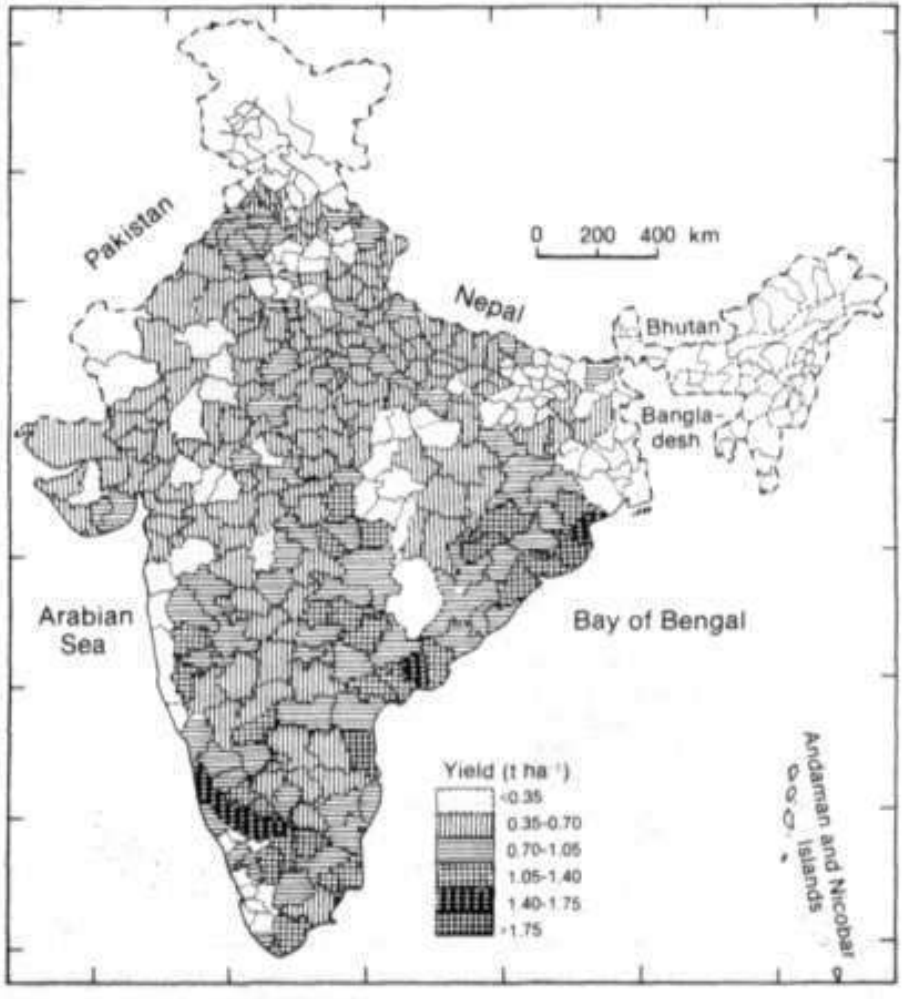


Figure 5. Groundnut yields in India.

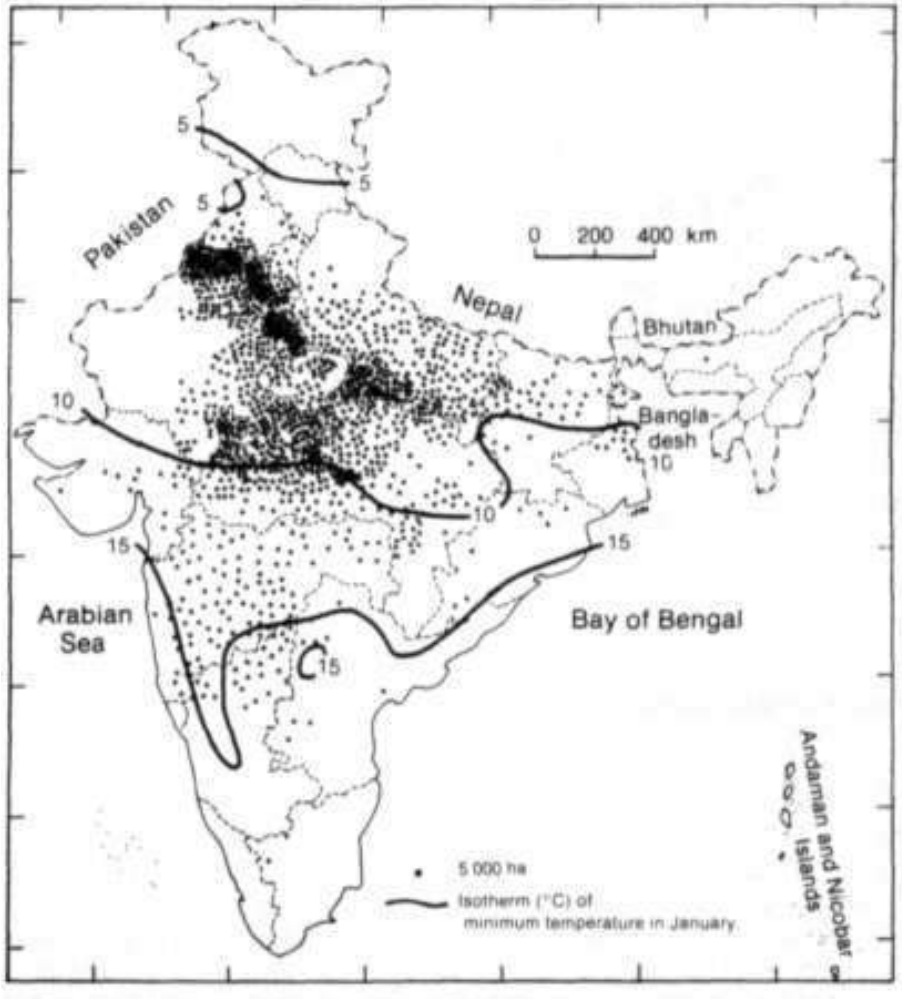


Figure 6. Chickpea distribution and Jan minimum temperature in India.

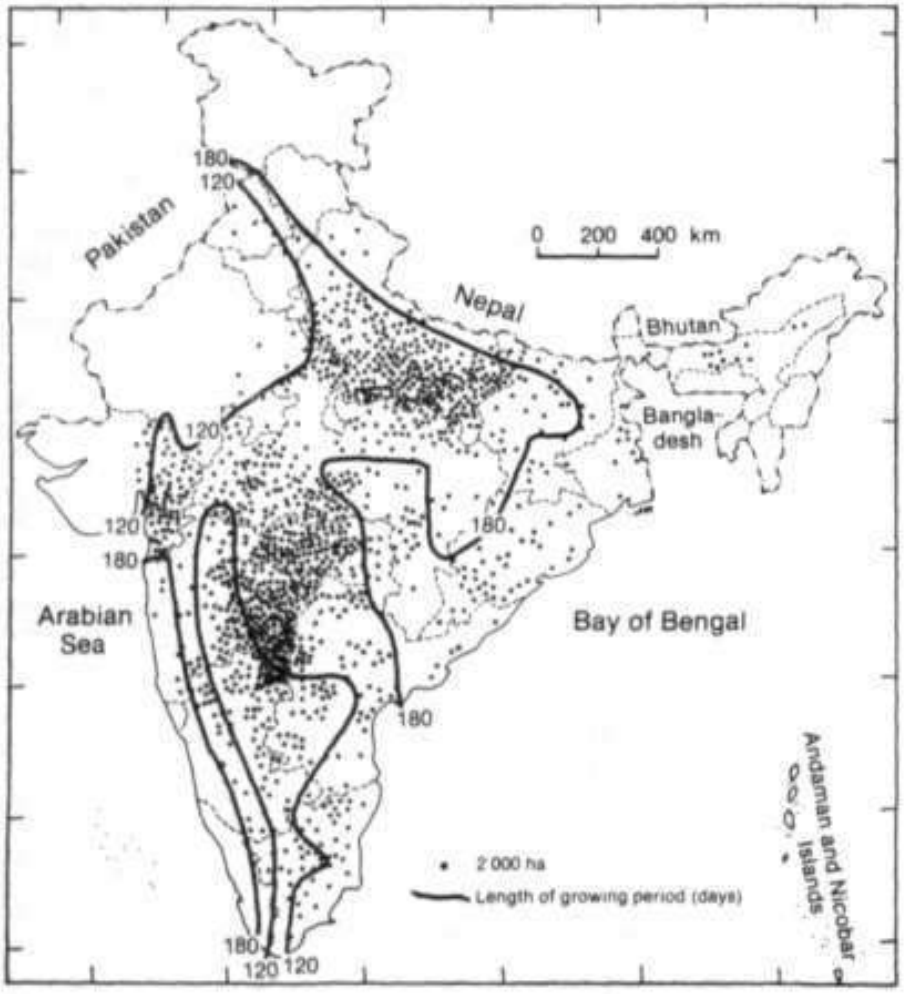


Figure 7. Pigeonpea distribution and length of growing period in India.

ISO days. Suitable soils are sandy to clay loams, where salinity is not a problem. Most chickpea is contined to areas where minimum temperatures in Jan are between 5 and 10°C (Fig. 6). Some chickpea is also grown in the black soil areas of peninsular India, where minimum temperatures arc below 15°C during Jan.

Pigeonpea is grown primarily during the rainy season (Jun-Oct) as an intercrop with other legumes and cereals, wherever the growing period is more than 120 days (Fig. 7). The cropping system and growing period vary considerably. depending on agroclimatic conditions, soil type, and objective of production. Medium to deep, well-drained soils are most suitable for this crop.

Groundnut is grown mostly in the rainy season, on well-drained soils in areas where the average annual rainfall is 500-1000 mm (Fig. 8) and the growing period is not usually less than 100 days (Fig. 9). Some groundnut is also grown in areas receiving 1000-1300 mm annual rainfall. In some areas groundnut is intercropped with maize, cotton, pearl millet, or pigeonpea. The crop is also grown

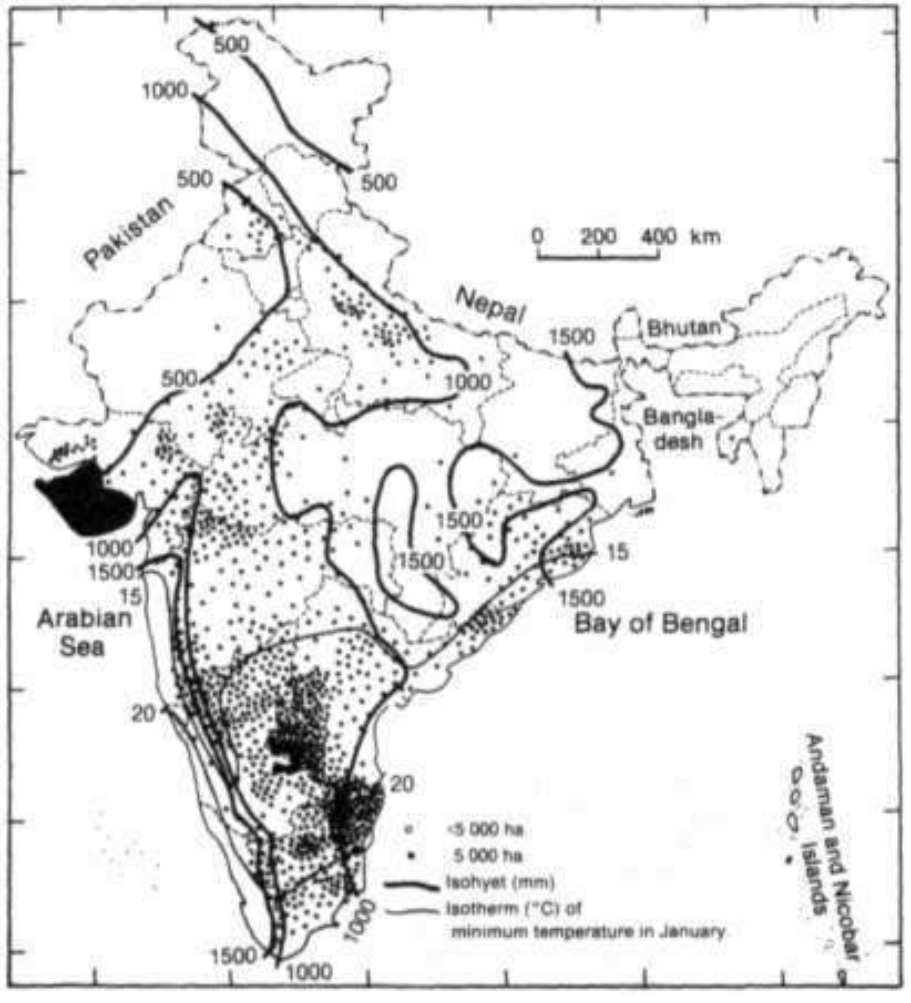


Figure 8. Groundnut distribution, rainfall, and Jan minimum temperature in India.

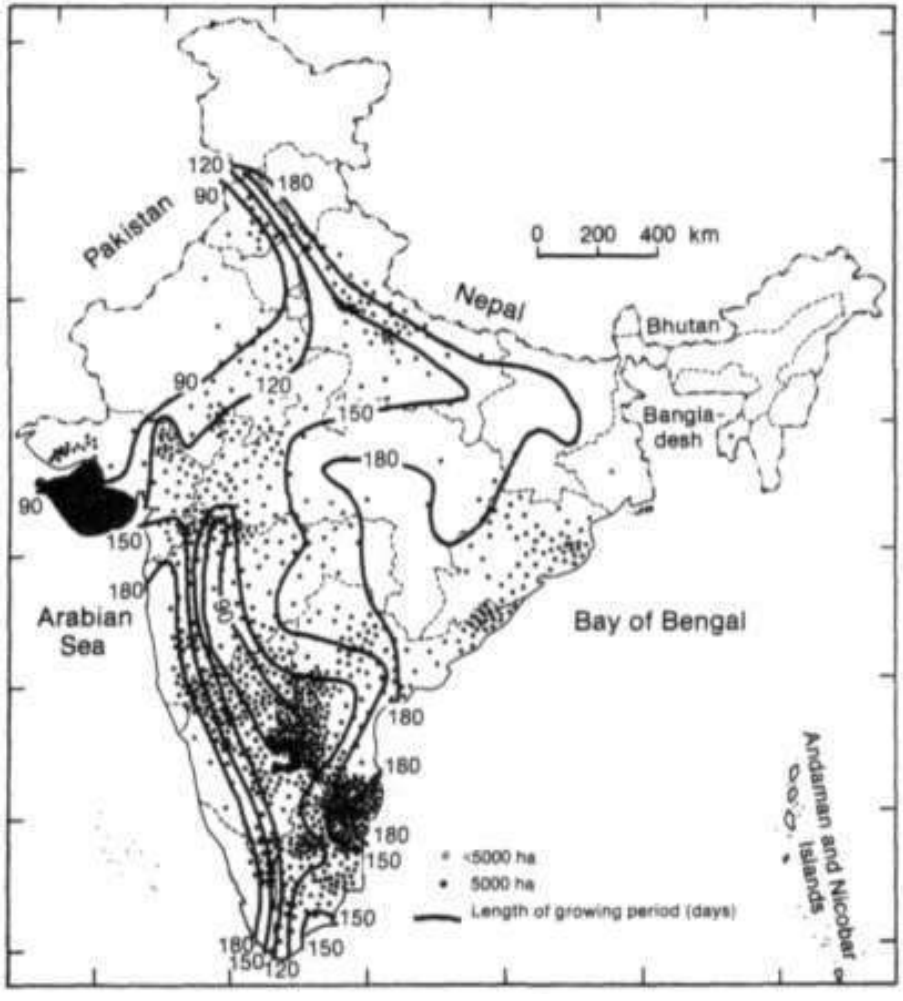


Figure 9. Groundnut distribution and length of growing period In India.

during the postrainy season in peninsular and southern India, where the winters are mild with night temperatures above 15°C.

Major Stress Factors

The abiotic and biotic stresses affecting chickpea, pigeonpea, and groundnut are shown in Table 2. The main abiotic stresses affecting all three crops are drought and adverse soil conditions; chickpea is particularly sensitive to soil salinity. The most serious biotic stresses are pod borer *(Helicoverpa armigera)* whose distribution on chickpea is shown in Figure 10, wilt *(Fusarium oxysporum* f. sp *ciceri),* ascochyta blight *(Ascochyta rabiei),* dry root rot *(Rhizoctonia bataticola)* and other diseases for chickpea (Fig. 11); pod borer *(Helicoverpa armigera)* and podfly *(Melanagromyza obtusa)* (Fig. 12), wilt *(F. udum),* sterility mosaic disease, and stem blight *(Phytophthora drechsleri)* for pigeonpea (Fig. 13); and aflatoxin contamination, late *(Phaeoisariopsis personata)* and early *(Cercospora arachidicota)* leaf spots, rust *(Puccinia arachidis),* collar rot *(Aspergillus niger),* and bud necrosis disease (caused by tomato spotted wilt virus) (Fig. 14); leaf miner *(Aproaerema modicella)* and tobacco caterpillar *(Spodoptera litura)* (Fig. 15) for groundnut.

Table 2. Abiotic and biotic stresses affecting chickpea, pigeonpea, and groundnut in India.

Stresses	Chickpea	Pigeonpea	Groundnut
Abiotic	Drought, high temperature, soil salinity	Drought, frost (in northern India), soil salinity	Drought, calcium deficiency, iron chlorosis, soil crusting/ hardening
Biotic	Wilt, blight, root rot, stunt virus, dry root rot, *Helicoverpa armigera*	Wilt, stem blight, sterility mosaic disease, *Helicoverpa armigera,* pod fly	Leaf spots, rust, viral diseases, termites, aphids, *Helicoverpa armigera*

Future Prospects

India needs high-yielding varieties of chickpea that are resistant to wilt, blight, and pod borer, and arc adapted to northern Indian environments. As soil salinity is increasing in some areas, cultivars tolerant to saline conditions are also needed.

For pigeonpea, the country needs short-duration cultivars to fit into rotations with rice and wheat. Wilt, pod borers, and salinity are the major constraints, so cultivars resistant to these stresses arc required.

Short-duration groundnut cultivars, which match the moisture availability periods and fit into cropping systems as a postrainy-season crop are needed. Major constraints to groundnut cultivation are early and late leaf spot, rust, drought, and iron chlorosis, and therefore varieties are needed that will perform well under these stresses.

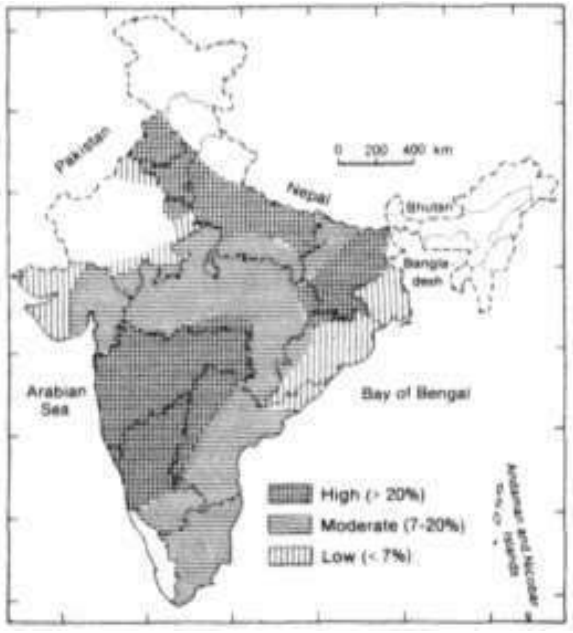
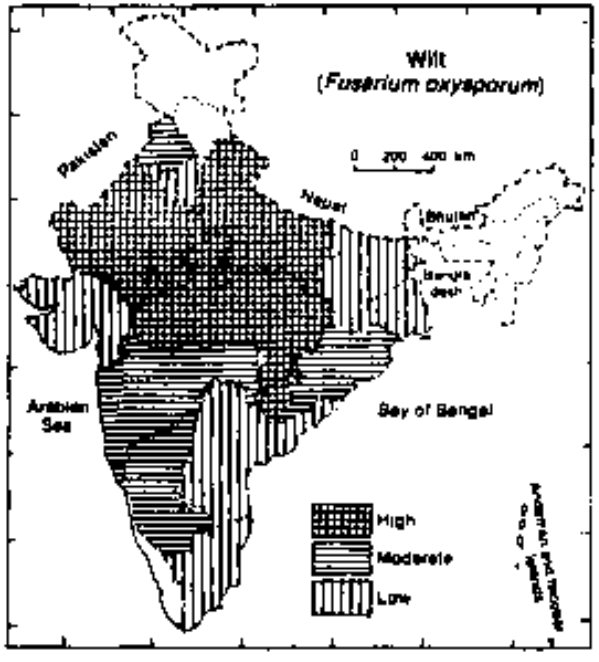
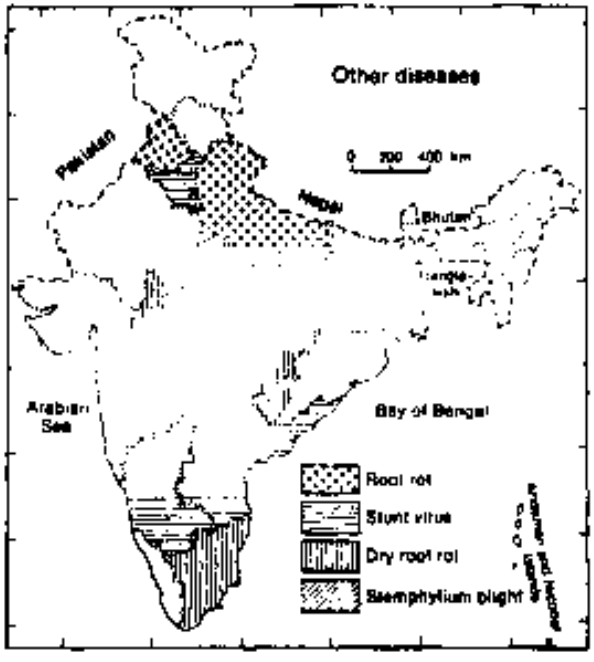


Figure 10. Occurrence of *Helicoverpa armigera* on chickpea in India.





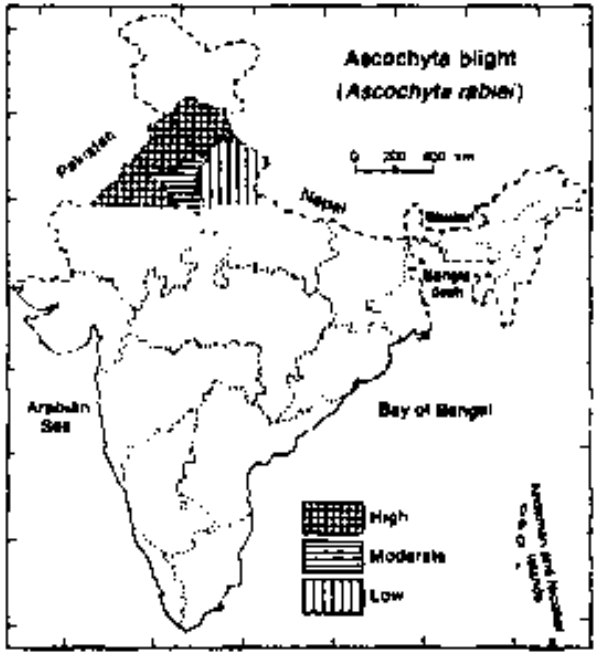


Figure 11. Occurrence of some major chickpea diseases in India.

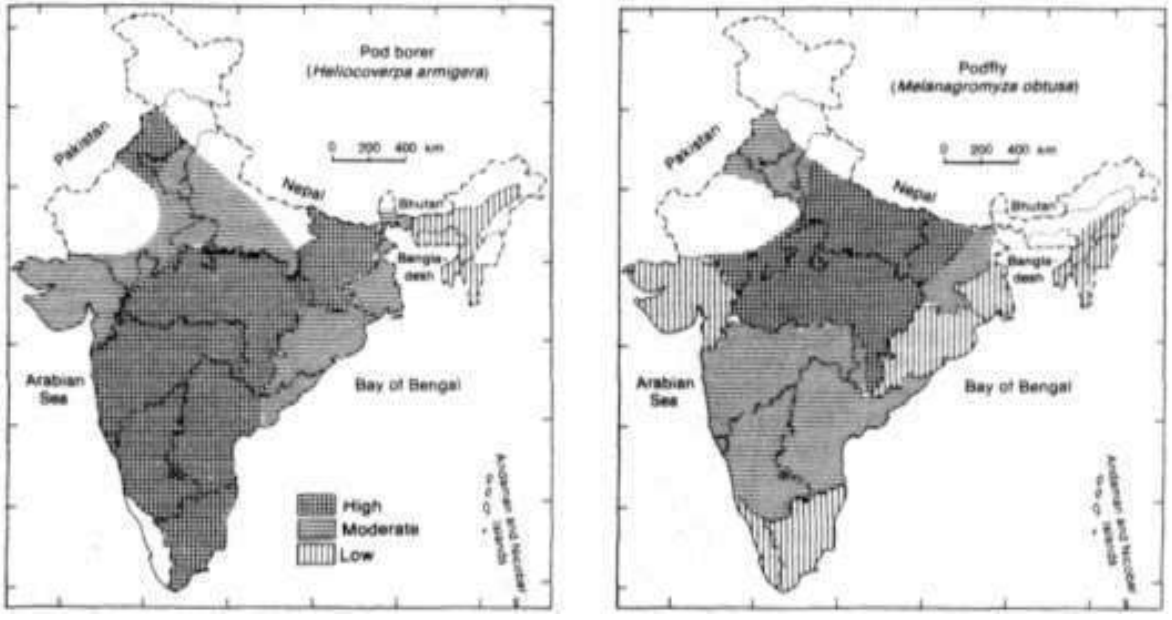


Figure 12. Occurrence of two important insect pests, pod borer and podfly on pigeonpea in India.

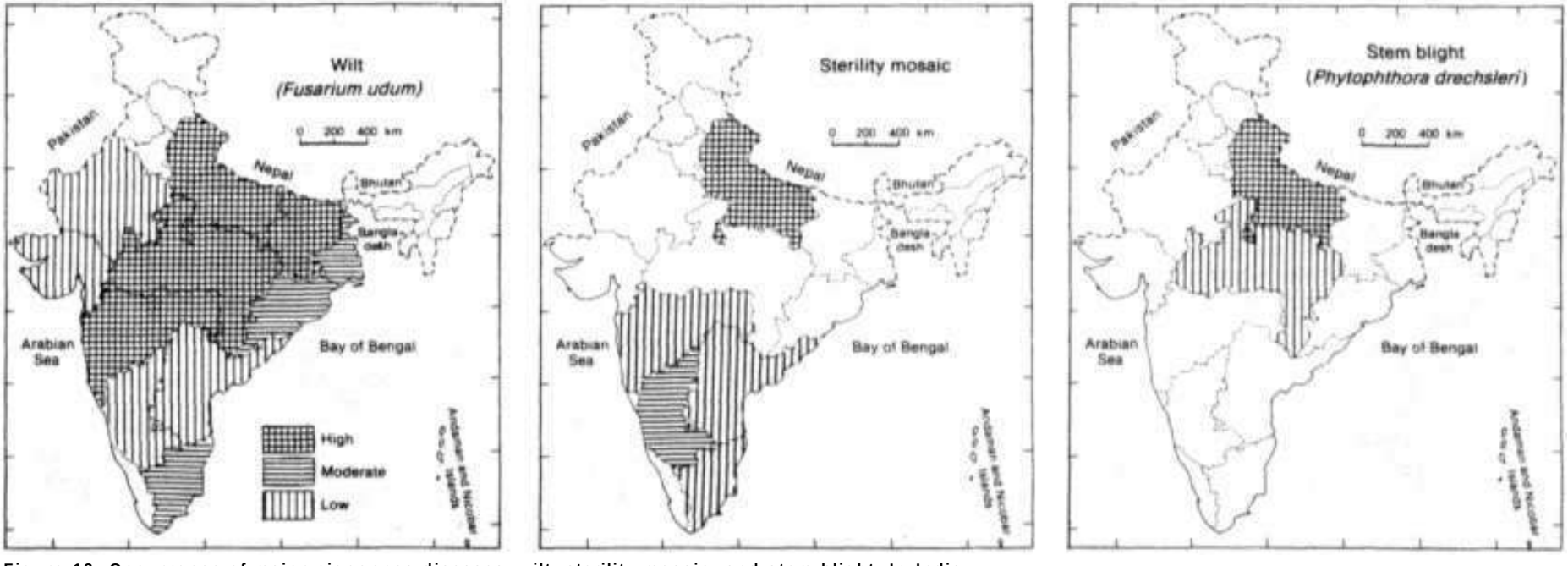


Figure 13. Occurrence of major pigeonpea diseases, wilt, sterility mosaic, and stem blight, In India.

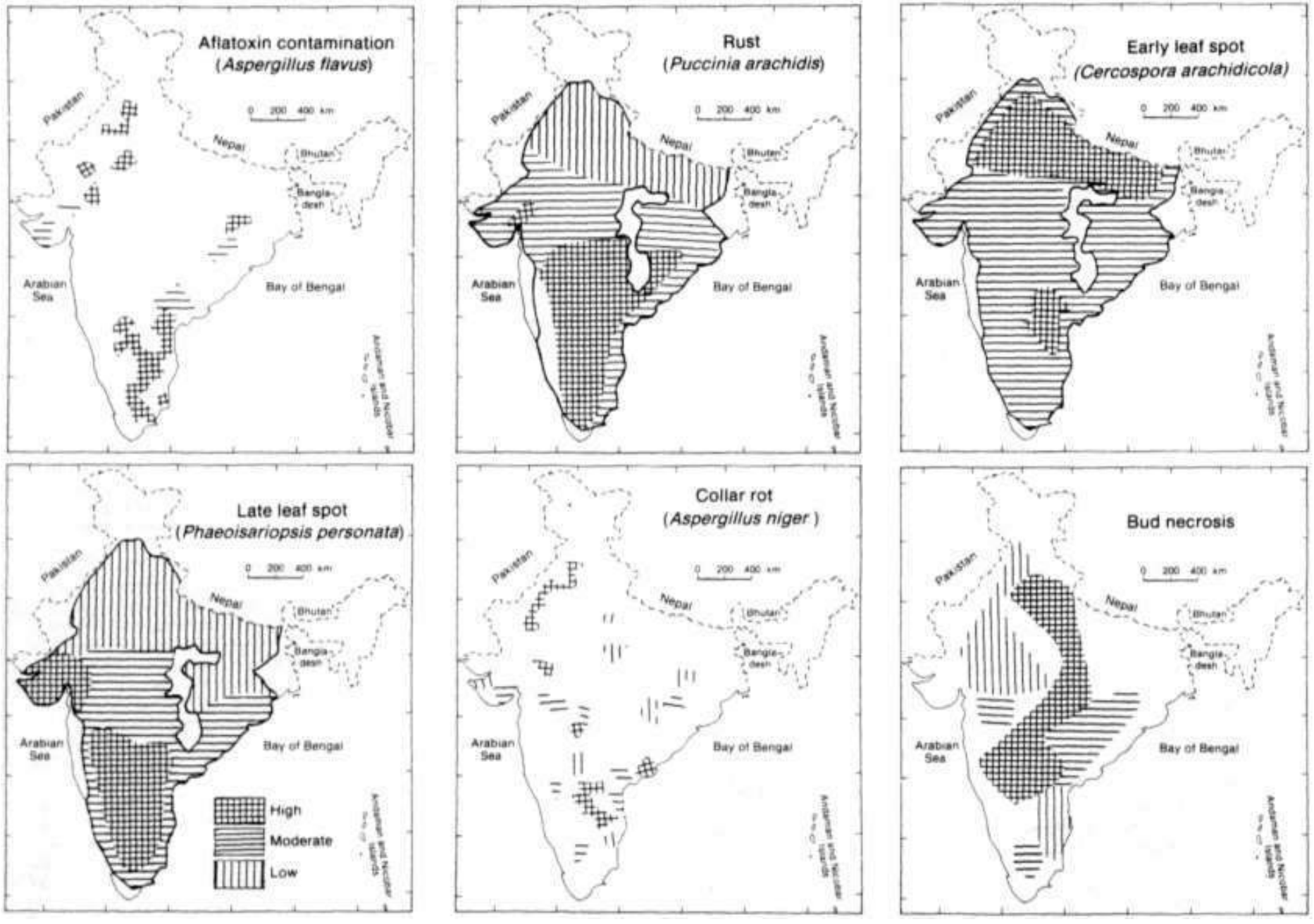
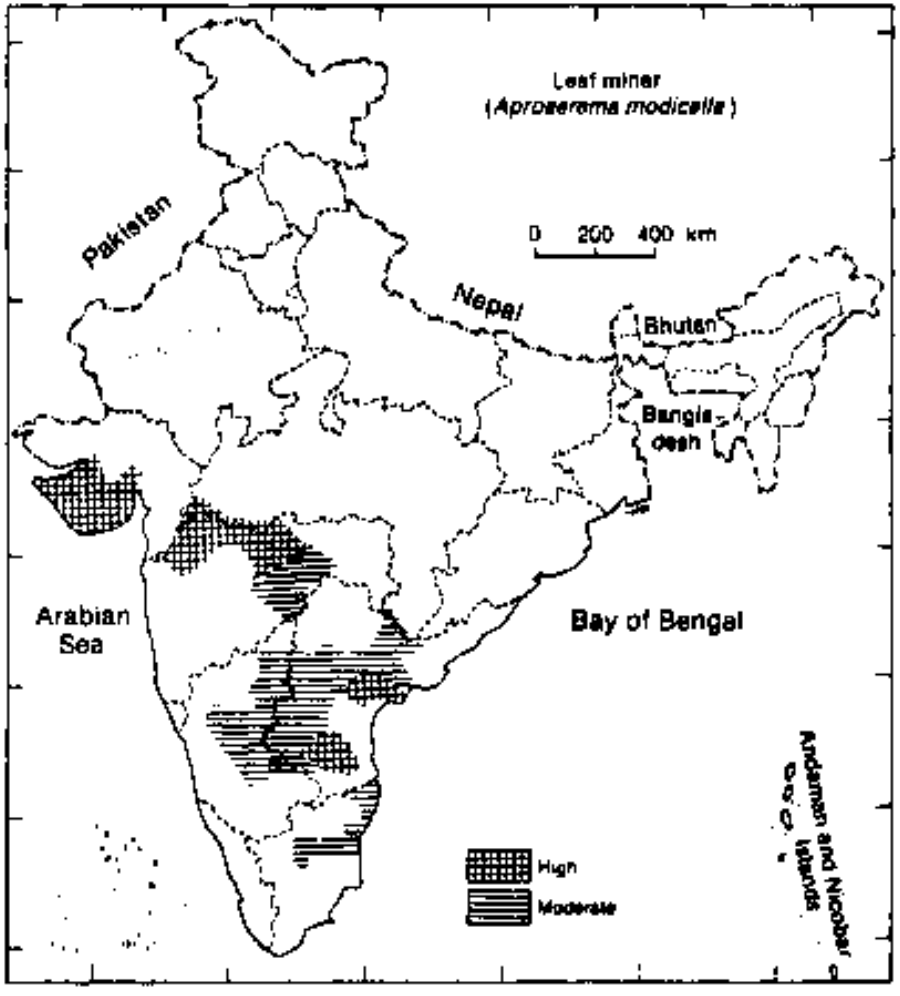


Figure 14. Occurrence of major groundnut diseases, aflatoxin contamination, rust, early leaf spot, late leaf spot, collar rot, and bud necrosis in India.



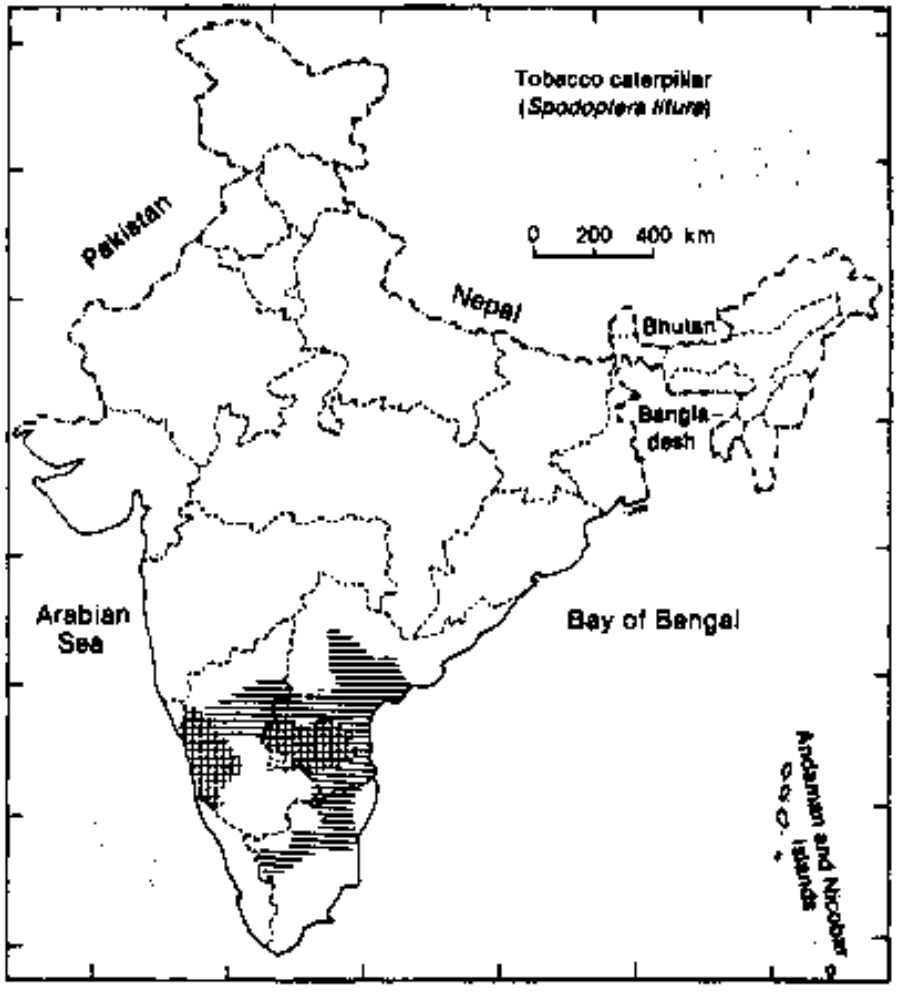


Figure 15. Occurrence of two important insect pests on groundnut in India.

Indonesia[1]

Introduction

The islands, provinces, and important urban centers of Indonesia are shown in Figure I.

Legume cultivation in Indonesia has increased over the past 10 to 15 years. In 1987, the area cultivated to legumes was about 1.6 million ha (about 10% of the total area under food crops). Roughly half this area was accounted for by soybean, a third by groundnut, and a sixth by other legumes. The spatial distribution of legumes is only weakly correlated with agroecological zonation. Other variables, such as physical infrastructure (especially irrigation facilities), the

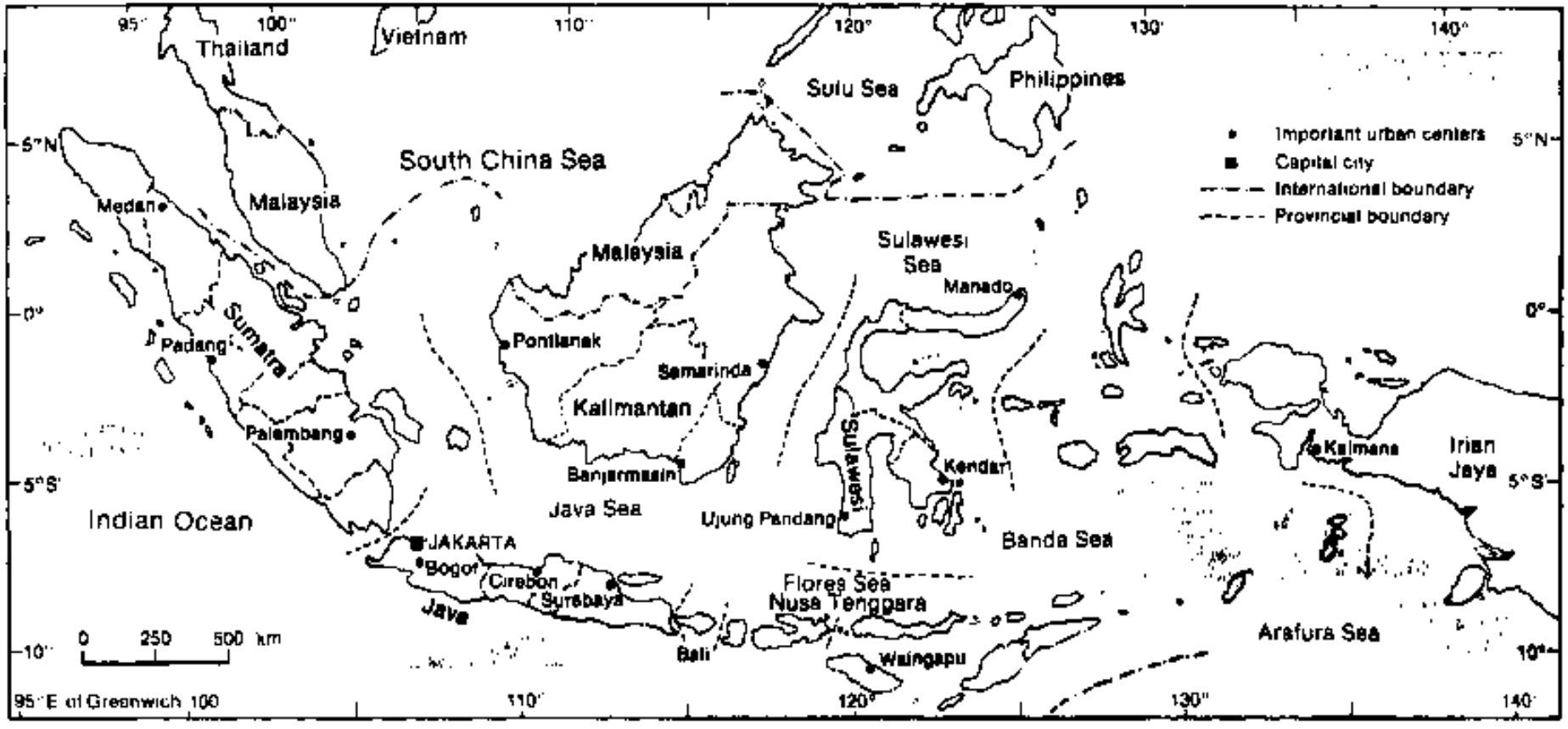


Figure 1. Administrative divisions of Indonesia.

1. This section was prepared by Anwar Wardhani, Djuber Pasaribu, and Irsal Las, Center for Agro Economic Research, Bogor Research Institute for Food Crops, Bogor, Indonesia, and the following resource persons from ICRISAT: J.A. Wightman and A.K.S. Huda.

land:man ratio, proximity of markets, and relative crop profitability, seem to be more important influences on crop distribution.

Demand for legumes is steadily increasing, in line with the growth of population and incomes. During the past 5 years soybean has been imported at an annual rate of 300 000 to 500 000 t, a large proportion of which has been used for animal feed. Pigeonpea is thought to be able to partly substitute for, or complement, soybean as animal feed and as a fermented food *(tempeh)* for human consumption. The prospects for expanding the cultivation of relatively drought-tolerant legumes such as pigeonpea in the drier eastern islands are promising. Groundnut is the only significant AGLN crop grown in Indonesia.

Crop Distribution in Relation to Agroclimatic Factors

Six major agroecological zones, known tentatively as Pragmatic Agroecological Zones, have been delineated for the purposes of allocating national agricultural research mandates and planning agricultural development (Fig. 2). Infrastructure, especially irrigation facilities and bunded fields, is included in the zonation, in addition to climate, soil, and elevation. Work is also under way to identify Cropping Potential Zones and Commodity Priority Zones. The former will be based on a more detailed agroecological zonation incorporating crop-specific requirements; this work is being undertaken first in Java and Sumatra. In identify-

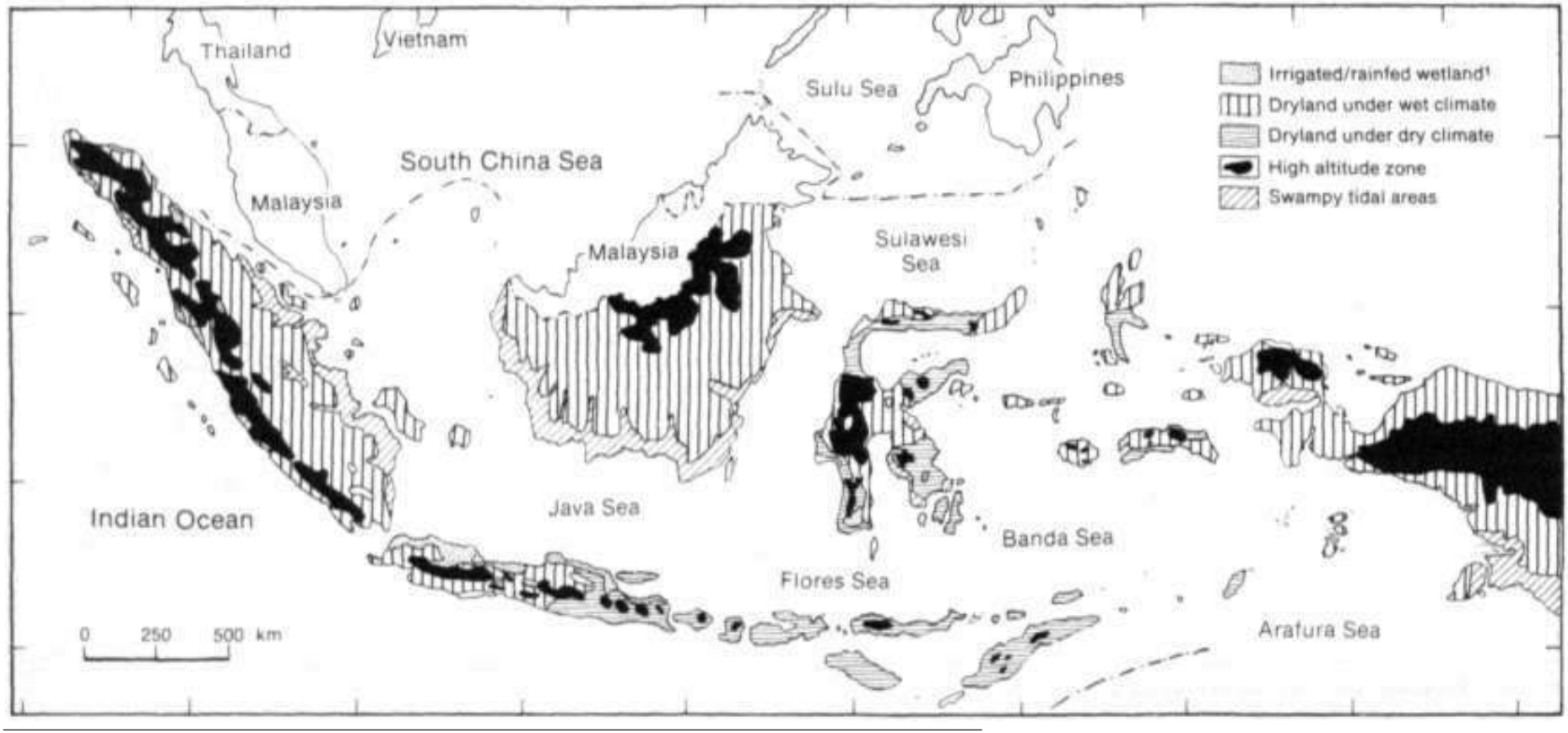


Figure 2. Pragmatic Agroecological Zones of Indonesia.

1 Irrigated and rainfed wetlands are distinct *zones* but are shown together here because the information needed to separate them is lacking

ing Commodity Priority Zones, additional socioeconomic variables will be incorporated.

The six Pragmatic Agroecological Zones and their main characteristics are:

- irrigated rainfed wetland (bunded fields with irrigation available for at least 4 months of the year);
- rainfed wetland (bunded fields with irrigation available for up to 6 months of the year);
- dryland under wet climate (upland with an annual rainfall of at least 2000 mm and growing period of 180 days or more);
- dryland under dry climate (upland with annual rainfall less than 2000 mm and growing period less than 180 days);
- high-altitude zone (areas that arc 700 m or more above sea level);
- swampy tidal areas (lowland areas under the influence of tidal movement, with poor drainage during the growing period).

The increase in groundnut cultivation from 1982 to 1986 is shown in Table 1, The cultivation figures for 1985, by island, arc given in Table 2. As indicated in the crop distribution map (Fig. 3). about two-thirds of Indonesia's groundnut is grown in Java.

In irrigated wetlands, groundnut is grown either in the early dry season (Apr-Jun) or in the late dry season (Jul-Oct). In rainfed wetland and rainfed dryland, the crop is grown during the early rainy season (Nov-Jan) or during the late rainy season (Feb-May). The length of the growing period is shown in Figure 4.

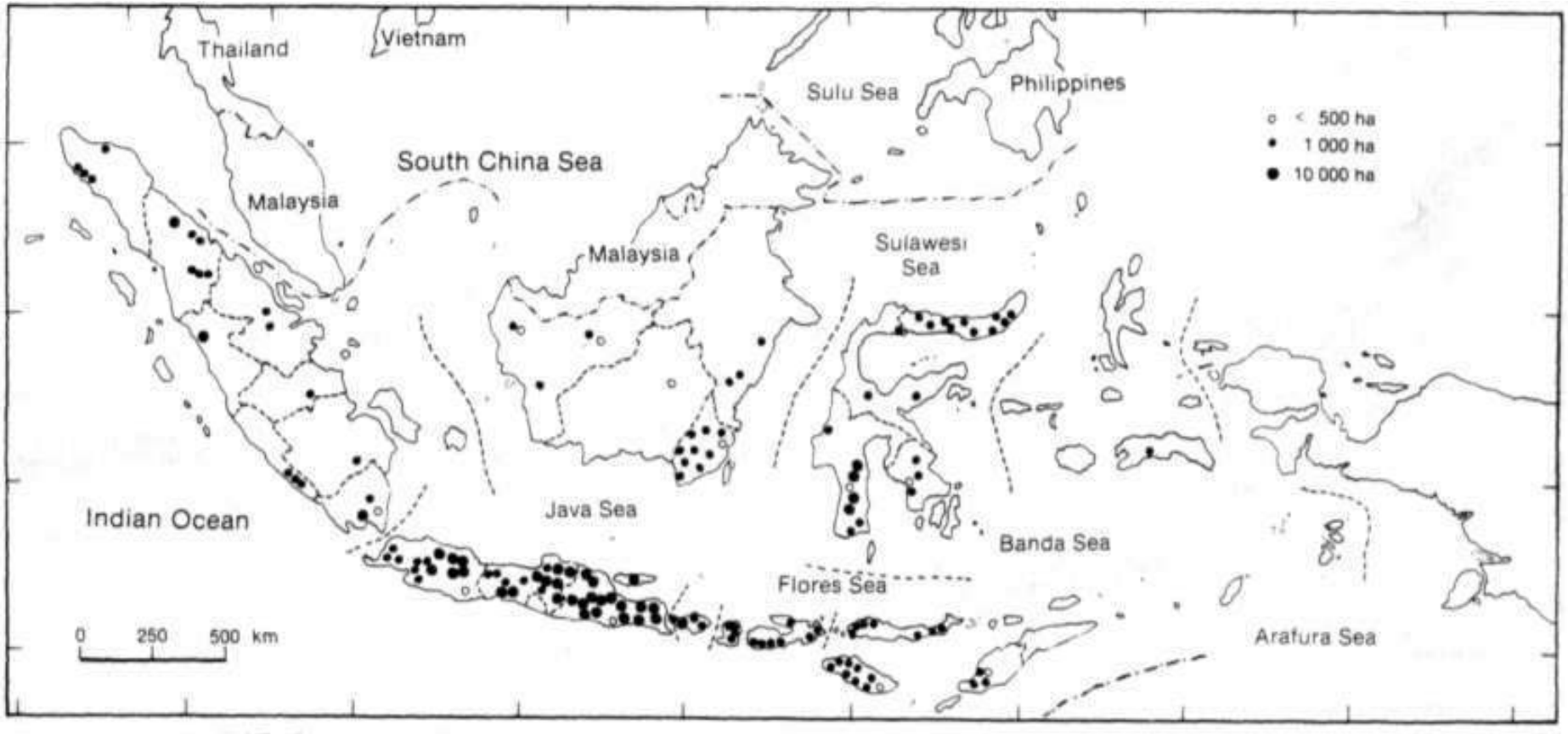


Figure 3. Groundnut distribution In Indonesia.

Table 1. Groundnut area, production, and productivity in Indonesia, 1982-86.

Year	Area ('000 ha)	Production ('000 t)	Average yield (t ha^{-1})
1982	461	437	0.95
1983	481	460	0.96
1984	538	535	0.99
1985	510	528	1.01
1986	601	642	1.07

Source: Central Bureau of Statistics, Indonesia.

Table 2. Groundnut area, production, and productivity by Island in Indonesia, 1985.

Year	Area ('000 ha)	Production ('000 t)	Average yield (t ha^{-1})
Java	337	344	1.02
Sumatra	60	65	1.09
Kalimantan	15	16	1.06
Sulawesi	54	57	1.06
Bali and Nusa Tenggara	39	41	1.05
Other islands	5	4	0.80

Source: Central Bureau of Statistics, Indonesia.

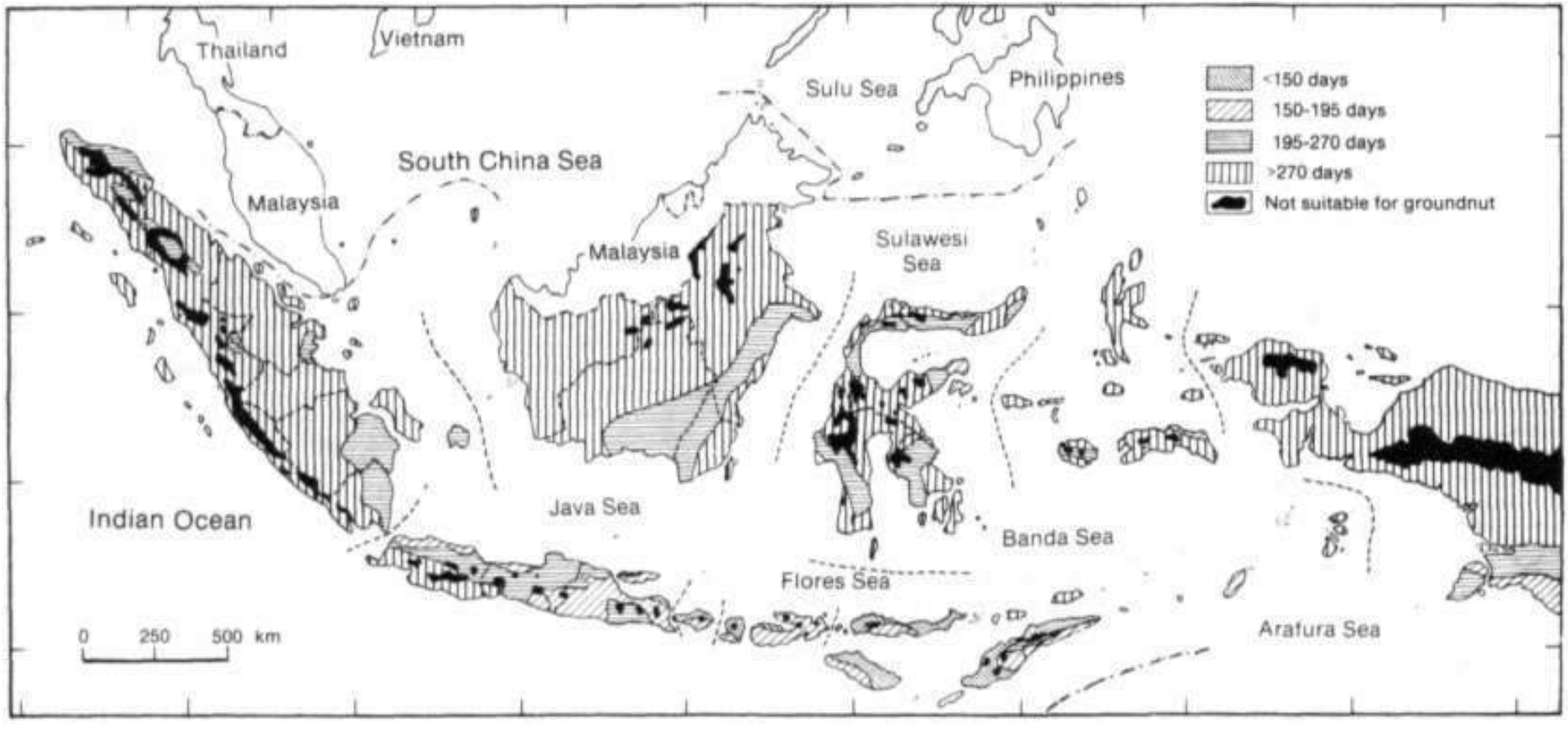


Figure 4. Length of growing period in Indonesia.

The major soils on which groundnut is grown arc alluvial soils and Regosols in wetland areas, and Red Yellow Podzolic soils and Latosols in dryland areas. The soils sown to groundnut are mostly medium to light in texture, with slopes of less than 8%. In the wetlands groundnut benefits from the residual effects of fertilizers applied to the preceding rice crop. In drylands, soils are generally acidic and low in phosphorus (P).

Groundnut is grown as a component of mixed cropping systems. In irrigated or rainfed wetlands the major cropping patterns are: rice-rice-groundnut; rice-groundnut-maize or fallow; and sugarcane-groundnut. The major cropping patterns in the drylands are: groundnut-maize or soybean; upland rice-groundnut; groundnut-groundnut; soybean-groundnut; and groundnut or maize or cassava.

Major Stress Factors

The main abiotic stresses of concern are soil composition and low moisture retention. Soil constraints in dryland areas are far more severe than in the wetlands. Red Yellow Podzolic soils arc generally acidic (pH less than 5.5) and low in P and calcium (Ca), and are susceptible to erosion. Excess soil moisture adversely affects the stand establishment of groundnut grown after wetland rice in poorly drained soils. Owing to unreliable rainfall, lack of soil moisture often occurs in the late growth stages of rainfed crops.

The most important stresses affecting groundnut cultivation in Indonesia are biotic. The main groundnut diseases are: peanut stripe virus (PStV) (Fig. 5), leaf

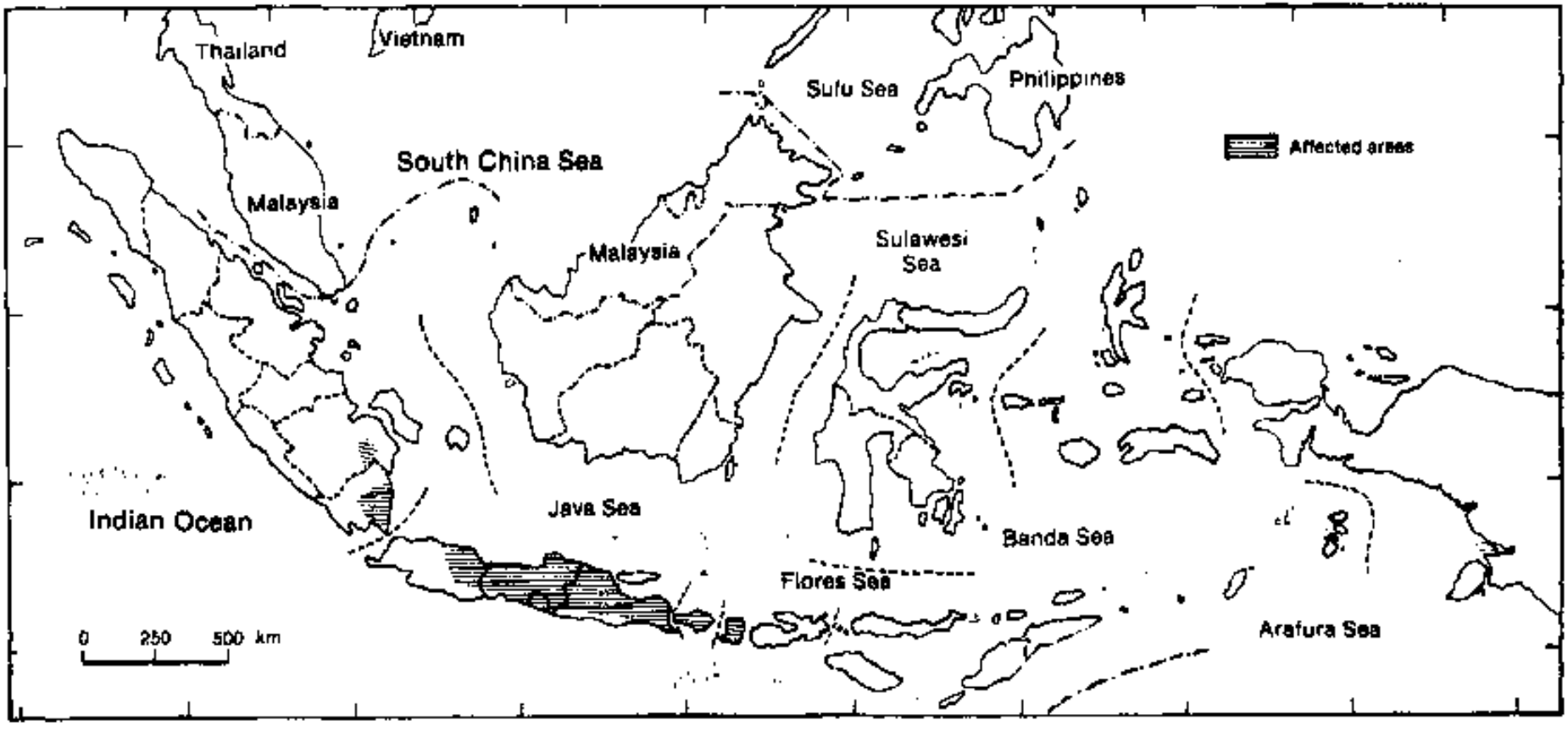


Figure 5. Occurrence of peanut stripe virus on groundnut in Indonesia.

spots *(Cercospora arachidicola* and *Phaeoisariopsis personata)* (Fig. 6), and bacterial wilt *(Pseudomonas solanacearum)* (Fig. 7). Peanut stripe virus is restricted to Java and southern Sumatra, while leaf spots occur throughout the country. Bacterial wilt is more serious in areas with wetter climates (e.g., West-cm Java province). The major insect pests attacking groundnut arc tobacco caterpillar *(Spodoprera litura),* leaf miner *(Aproaerema modicella),* pod borers *(Anisolabis* sp), aphids *(Aphis craccivora),* and thrips *(Scirtothrips dorsalis; Frankliniella* sp).

Future Prospects

The dry climatic zone has probably the most potential for future cultivation of AGLN crops. In this zone, one or possibly two, crops can be grown in a year as sole crops or intercrops. In the wetland zones, cultivation of these legumes could be expanded in areas where irrigation water availability is insufficient for rice cultivation but is adequate for legumes. In drylands under a wet climate, these legumes could be grown during the latter half of the rainy season.

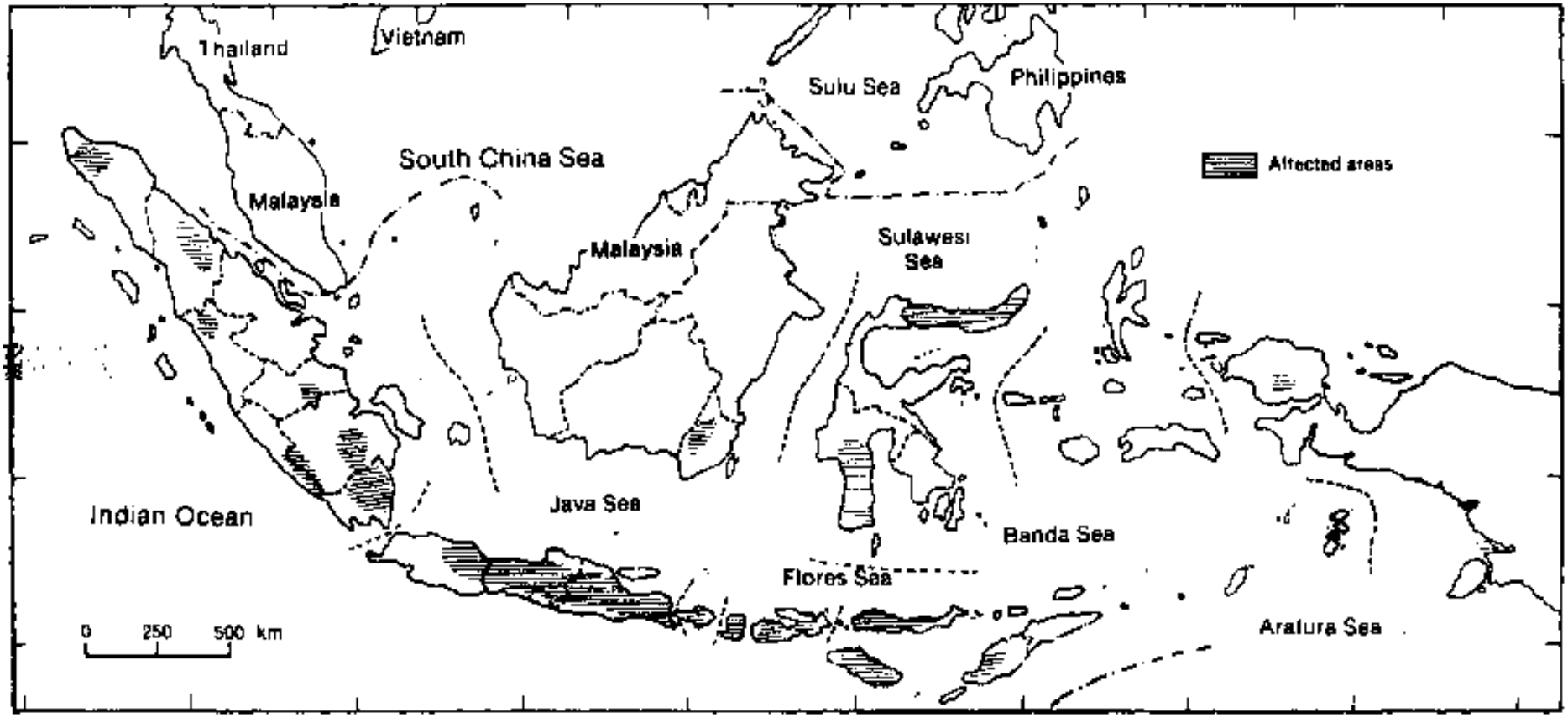


Figure 6. Occurrence of leaf spots on groundnut in Indonesia.

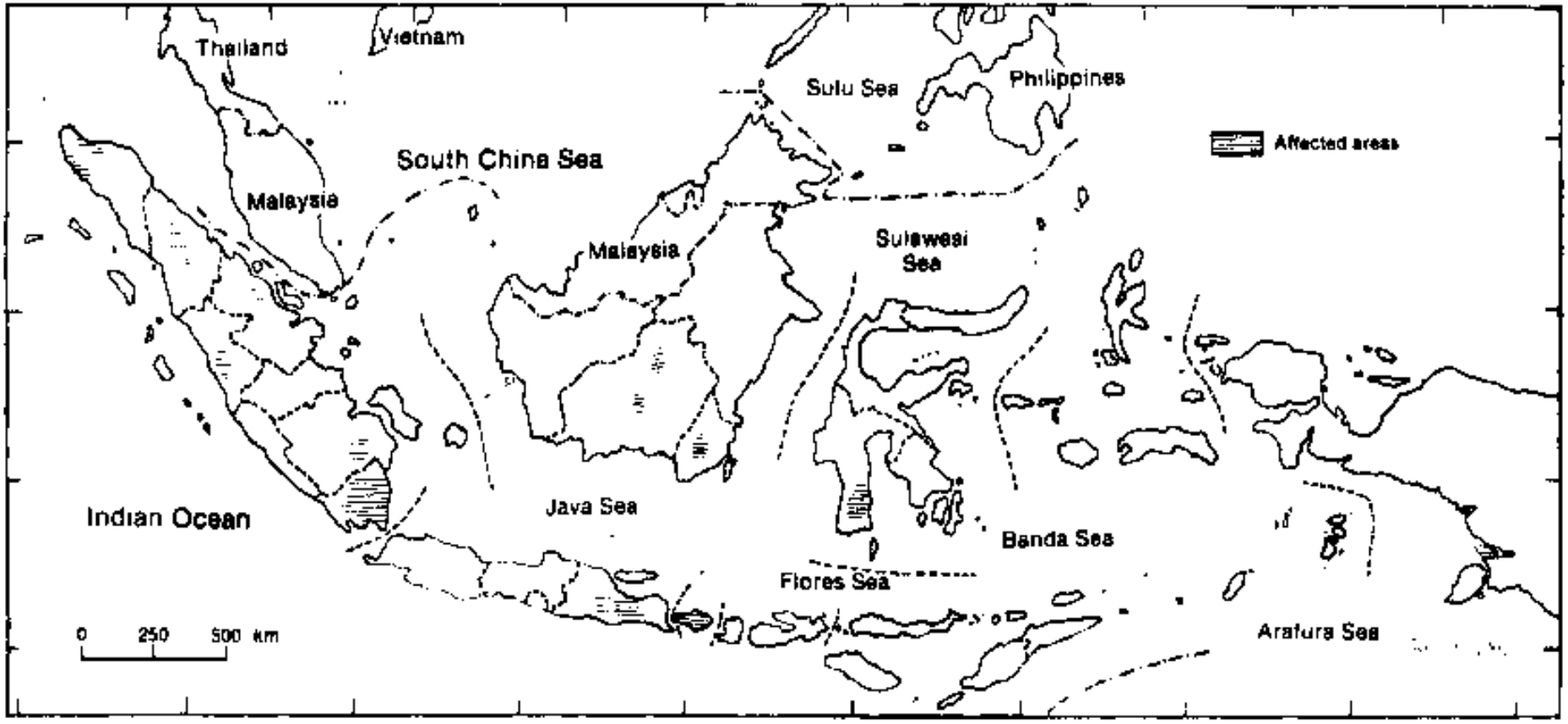


Figure 7. Occurrence of bacterial wilt on groundnut in Indonesia.

Figure 8 shows potential areas for groundnut cultivation. To define these ureas, regions considered unsuitable were excluded (initially, high-altitude areas that were too cool for groundnut cultivation, followed by other areas that were either too wet or too dry). Soils in the remaining areas were evaluated for their suitability, using the FAO/UNESCO Soil Map of the World.

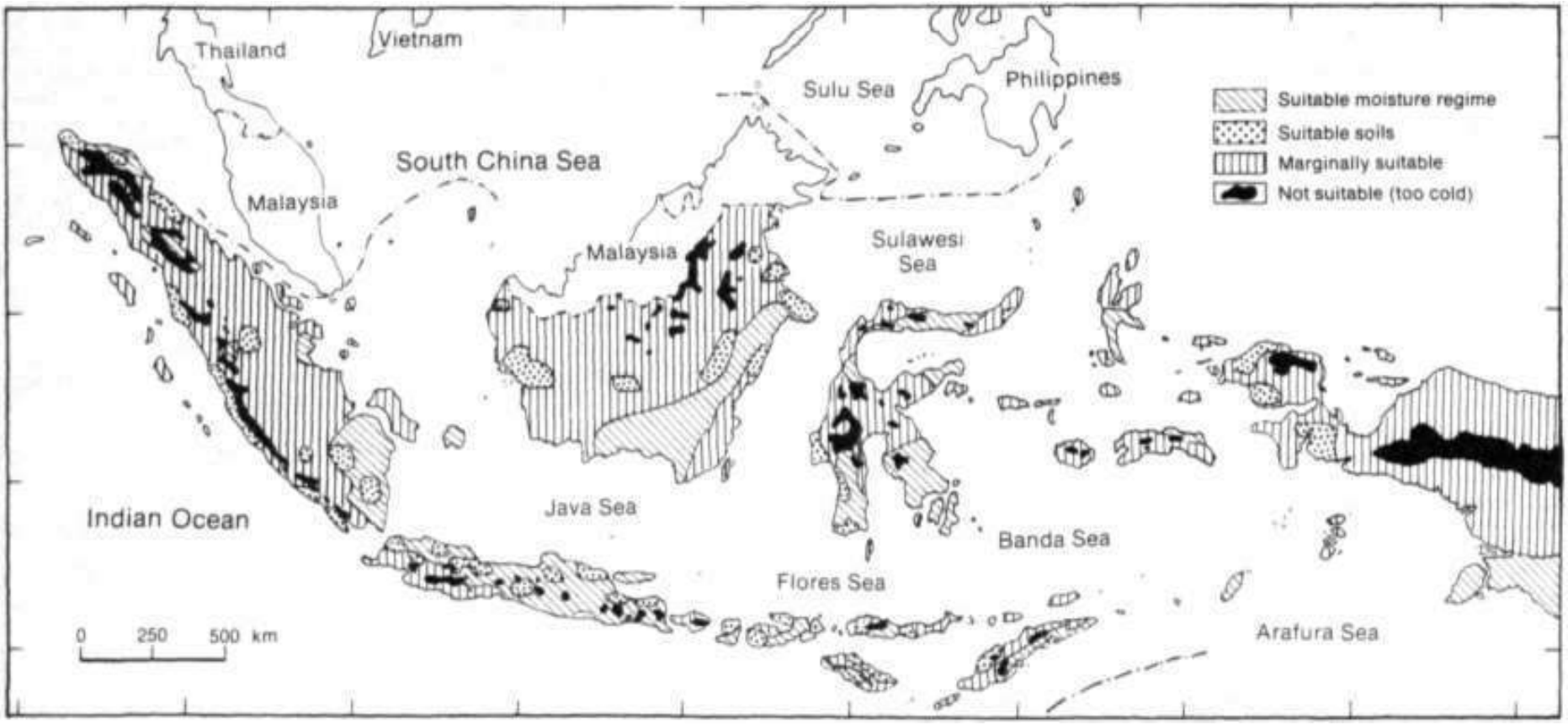


Figure 8. Potential areas for expanding groundnut cultivation in Indonesia.

Malaysia[1]

Introduction

This section deals with peninsular Malaysia only. Non-peninsular East Malaysia (Sabah and Sarawak) has been omitted owing to insufficient data. The states and important urban centers of peninsular Malaysia are shown in Figure I.

In Malaysia, very little chickpea or pigeonpea are grown; and mung bean and soybean are grown in small amounts. Groundnut (spanish type), used mainly for processing into dessert nuts or confectionary, is widely grown.

Malaysia is currently a net importer of groundnut, and imports are expected to increase with growing demand and declining local production. Groundnut area fell from 4589 ha to 1173 ha over the 5-year period 1981-86 (Table 1).

Crop Distribution in Relation to Agroclimatic Factors

Malaysia is divided into 26 agroclimatic zones (Fig. 2). Groundnut is harvested at 90-100 days if the nuts are to be roasted according to the traditional *menglembu* process. For seed, it is harvested at 105-110 days. The recommended variety is Matjam. which conforms to the requirements for *menglemhu* processing.

Table 2 gives some of the main characteristics of lowland peninsular Malaysia's 26 agroecological zones, as defined by FAO land use planning maps. Zones VIII, XX, XXI, XXIV, XXV, and XXVI contain suitable areas for groundnut, while the *bris* soil areas (sandy soils of old raised beaches on the East Coast) and Zones II. IV, XII and XVI contain marginally suitable areas.

There are three main cropping systems in which groundnut is grown: as a sole crop on river Floodplains (as practised in Kelantan and Terengganu); in rotation with rice in paddy areas during the off-season (as practised in Kelantan and Kedah); and as an intercrop with young rubber and oil palm, or on land newly cleared of old rubber and oil palm. A fourth cropping system, which is not yet adopted by farmers but has been found experimentally feasible, is to grow groundnut in rotation with tobacco on *bris* soils.

Groundnut is grown on light- and medium-textured soils with good drainage. The length of the growing period (Fig. 3) is not a constraint to groundnut production in Malaysia. Farmers attempt to time the cropping season such that harvest coincides with a relatively dry period, thereby avoiding problems of aflatoxin contamination.

Figure 4 shows the distribution of groundnut-growing areas in peninsular Malaysia in 1985. The areas currently used for cultivation are not necessarily those most suited to the crop, which has been increasingly displaced by rubber, oil palm, and irrigated double-cropped rice, all of which are more important economically and now occupy 90% of cultivated land.

Areas of potential cultivation have been identified, taking into consideration the climate and soil requirements for groundnut (Fig. 5). These areas have been identified regardless of current land use, in the event that increased groundnut production should become a priority in the future. As temperatures and length of growing period in the country do not pose serious limitations to production, the areas have been chosen mainly on the basis of soil characteristics and topography (non-highland areas).

Table 1. Groundnut area ('000 ha) in peninsular Malaysia by state, 1981 and 1986.

Stale	1981	1986
Johor	0.08	0.02
Kedah	0.06	0.07
Kelantan	2.39	0.42
Melaka	0.01	0.01
Negeri Sembilan	0.08	0.01
Pahang	0.19	0.04
Perak	1.00	0.40
Perlis	0.10	0
Pulau Pinang	0.01	0.01
Selangor	0.01	0.09
Terengganu	0.65	0.11
All peninsular Malaysia	4.59	1.17

1. This section was prepared by S.L. Tan and R. Siti Zainab. Malaysian Agricultural Research and Development Institute, Serdang. Malaysia, in cooperation with the following resource persons from ICRISAT: B.C.G. Gunasekera and C.L.L. Gowda.

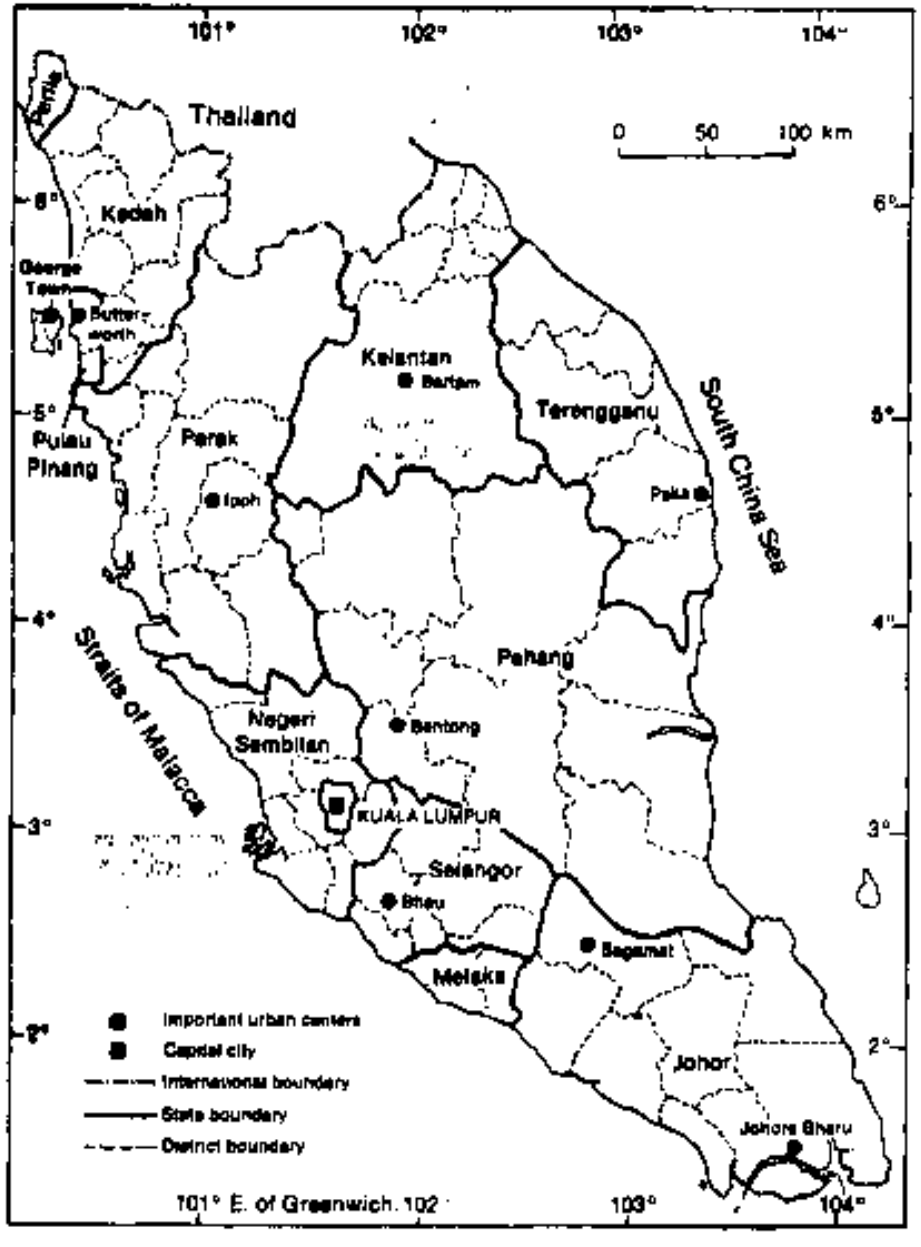


Figure 1. Administrative divisions of peninsular Malaysia.

Table 2. Main characteristics[1] of the agroclimatic lowland zones of peninsular Malaysia, Jan to Dec.

Zone	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
I	D	D	D	d	m	dm	m	m	m	f		D
IP	D	D	D	d		(d)				Fr		D
III	D	D	D		m	m	m	m	Fm	F		D
IV[2]	D	D	d	f					fr	F		
V	D	D			*m*	dm	dm	dm	m	Fr		
VI	D	D	D			d				f		D
VII	f		F	F	m	dm	dm	m	fm	F	F	f
VIII[3]						d	d	d	f	f		
IX		d			m	D	D	dm	m			
X	d	d	f	f		d				f		
XI					m	m	m	m	m			
XII[2]	D	D	d		m	m	m	m	m			
XIII	(d)				m	m	m	m	m			f
XIV	m	dm	m	m	m	m	m	m	m	m	mr	fmr
XV	d	d				d						r
XVI[2]	m	D	D	d							Fr	Fmr
XVII		D	D			d						r
XVIII	D	d	d		d	D	d					
XIX						D					f	r
XX[3]	r	d	d		d						f	r
XXI[3]		D	d	d			d				Fr	Fr
XXII	m(d)	D	D	D	d	d	d			(f)	fr	Fmr
XXIII	dr	D	D	d						fr	fr	r
XXIV[3]	D	D	D	D	d	d	d		d	fr	(f)r	r
XXV[3]		D	D	D	d	d				f	f	F
XXVI[3]	D	D	D	D	D					f	Fm	fm

1. D Dry month (agriculiural rainfall index below 40 during 20% of years on record),
   d Frequent drought stress days (probability over 40%).
   m Morning rainfall maximum.
   F Flash floods highly probable.
   f Flash floods probable.
   r Sunshine less than 40% of possible hours.
   ( ) Only in some parts of the region.
2. Region marginally suitable for groundnut cultivation.
3. Region suitable for groundnut cultivation.

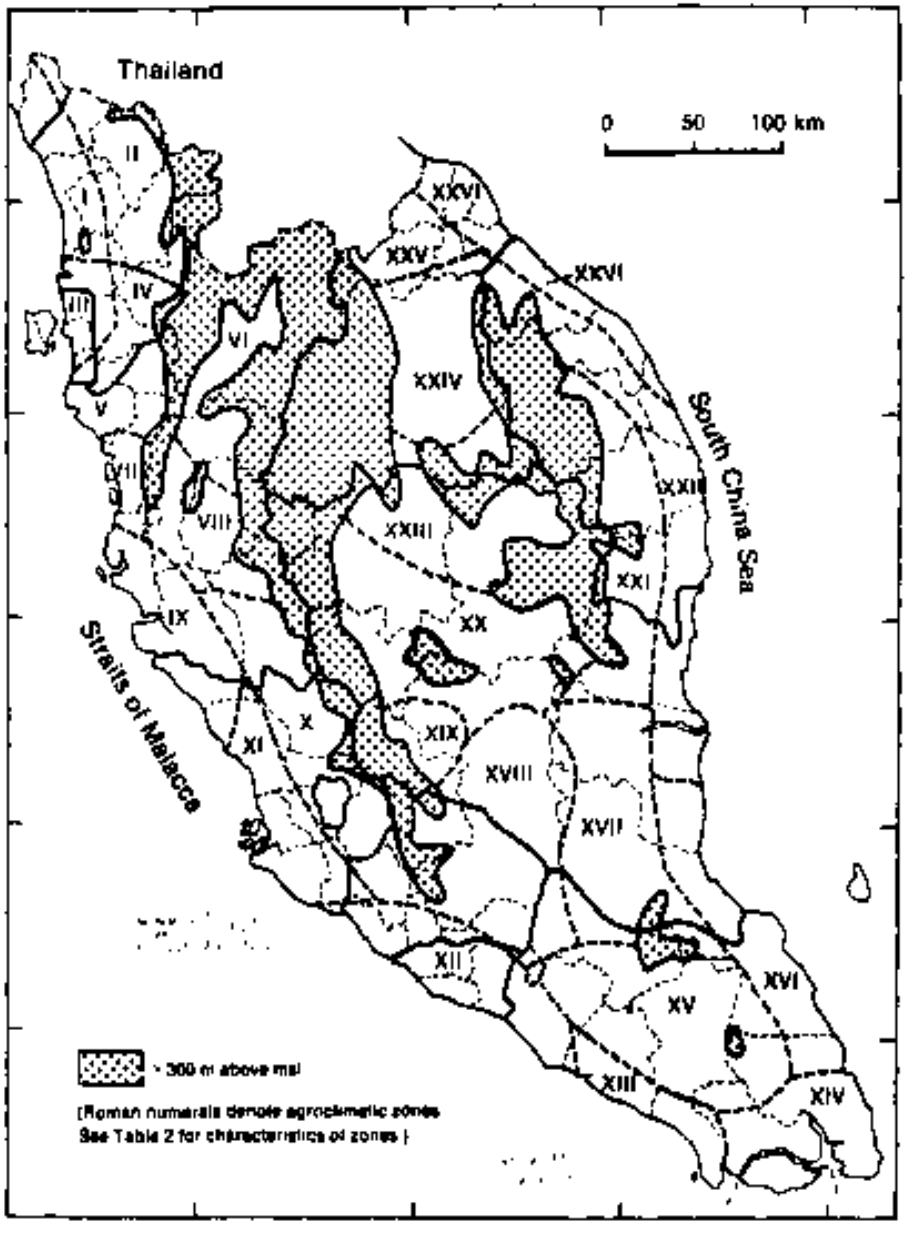


Figure 2. Agroclimatic zones of peninsular Malaysia.

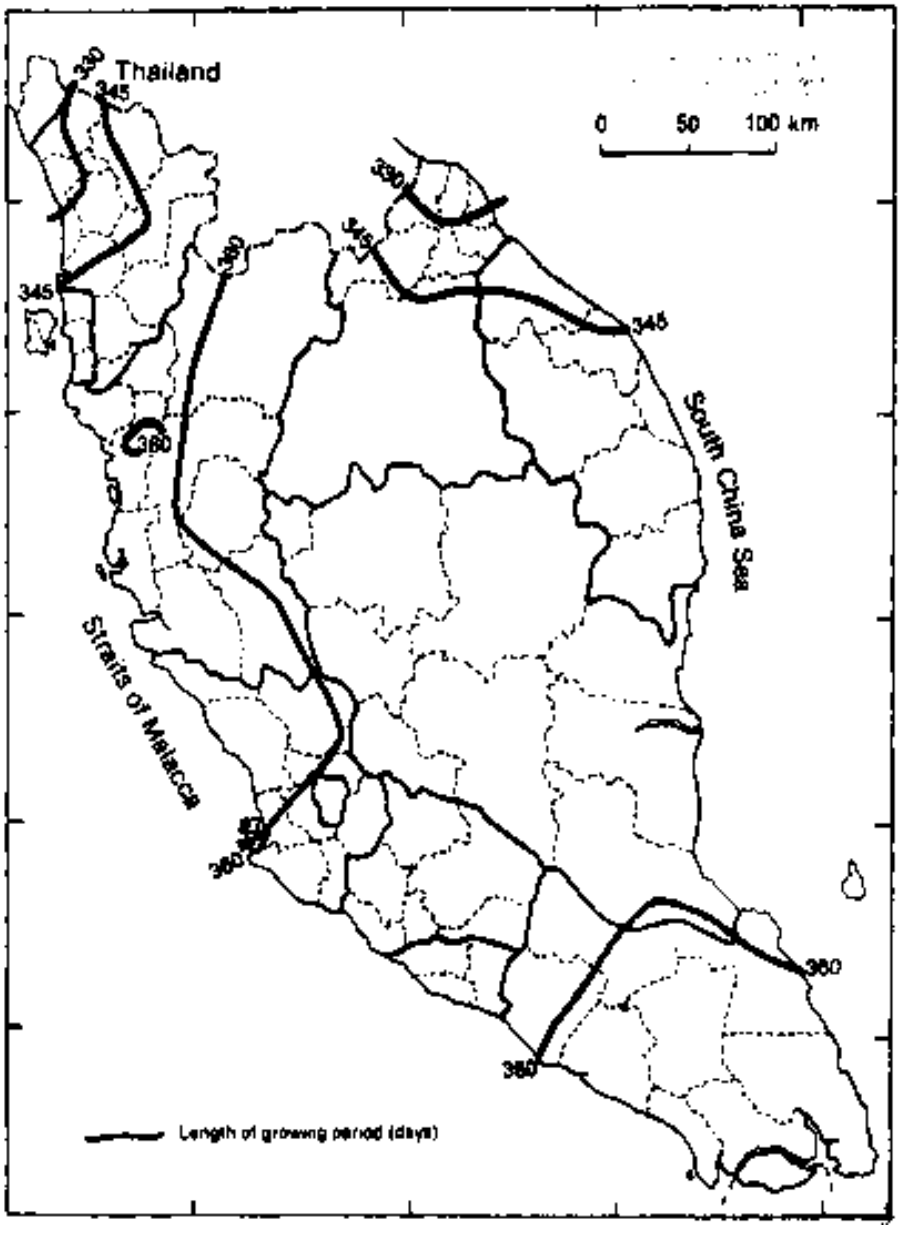


Figure 3. Length of growing period in peninsular Malaysia.

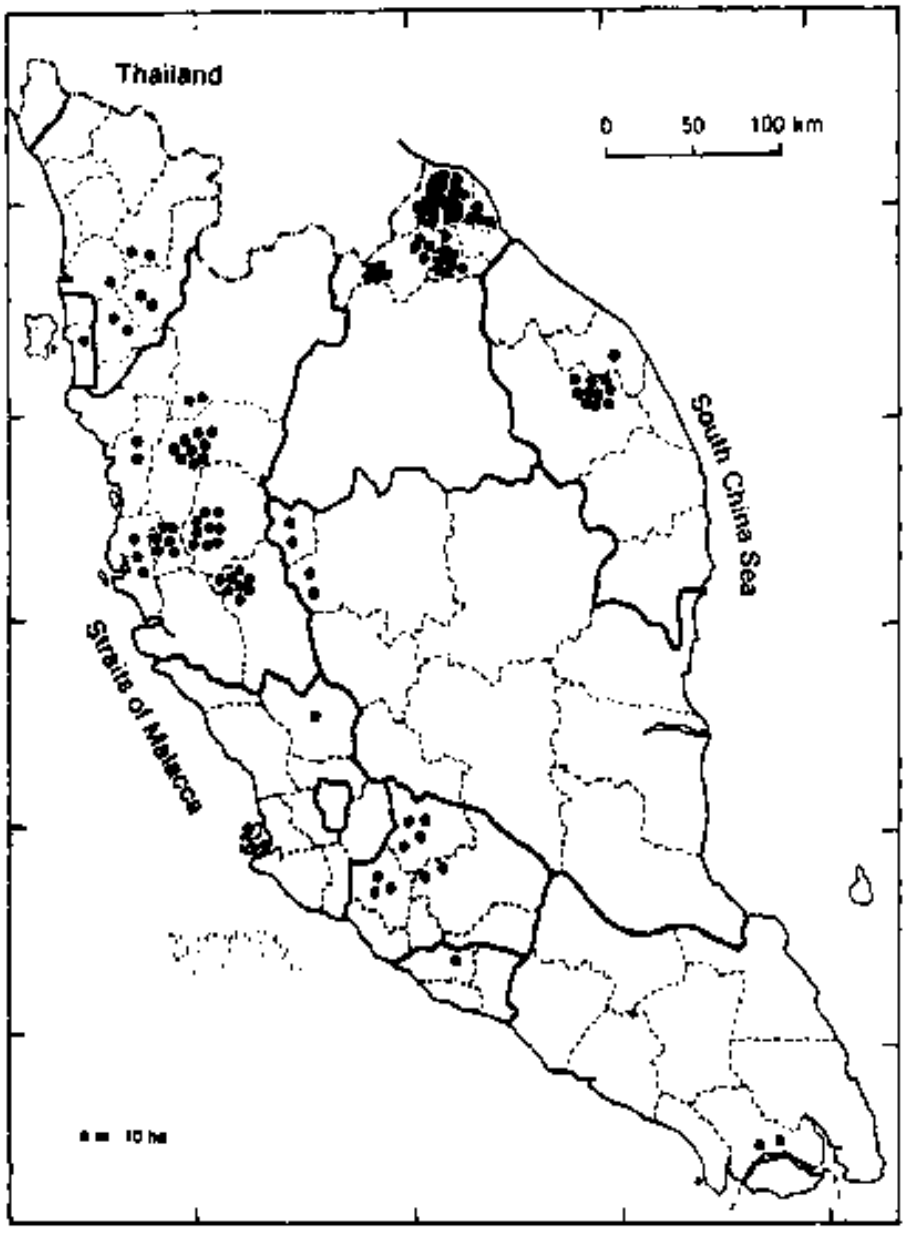


Figure 4. Groundnut distribution in peninsular Malaysia.

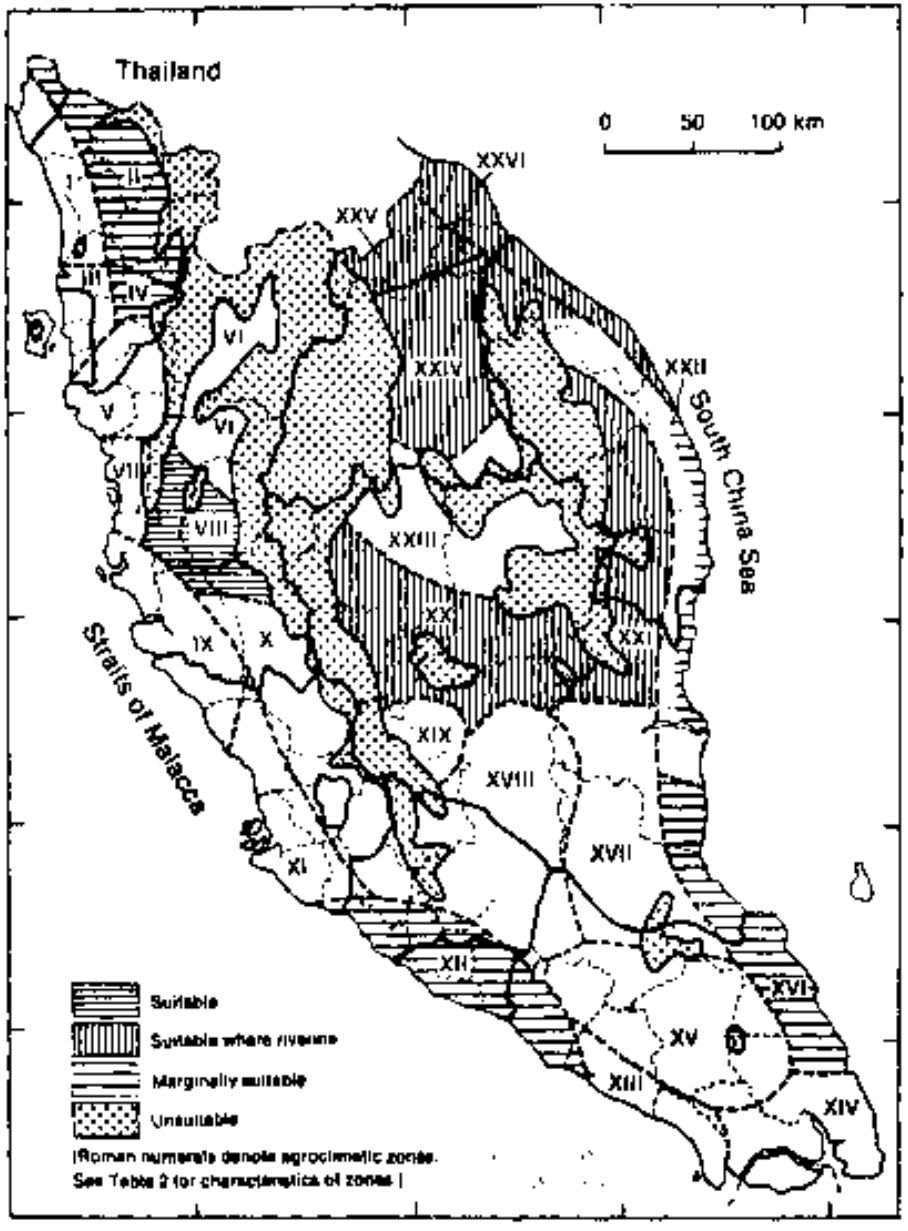


Figure 5. Potential areas tor expanding groundnut cultivation in peninsular Malaysia.

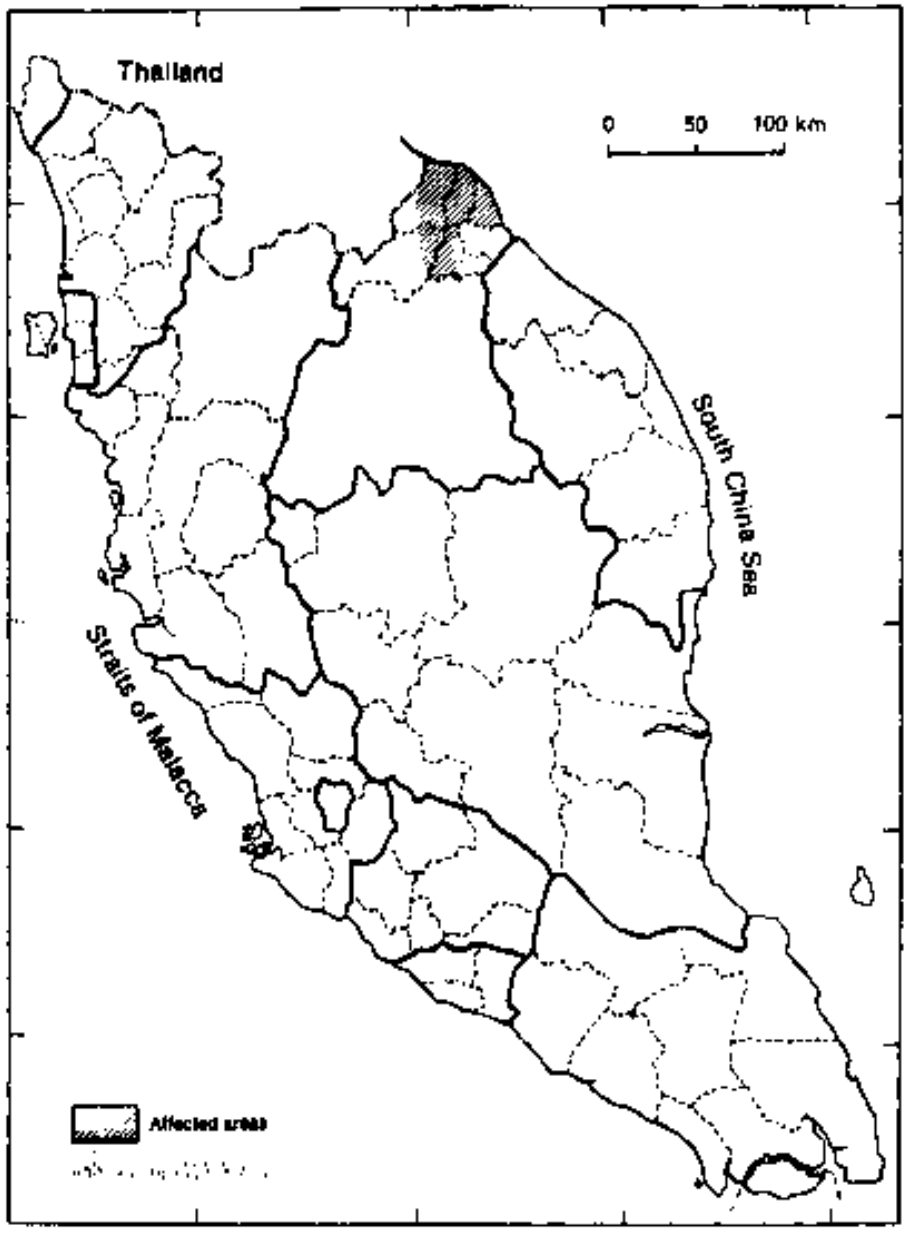


Figure 6. Occurrence of bacterial wilt on groundnut in peninsular Malaysia.

Major Stress Factors

The main abiotic stresses are drought during establishment and early growth, flash floods, and rain or excess moisture at harvest. Other factors limiting cultivation include inadequate seed supply of the recommended varieties, poor postharvest handling practices, labor shortages, and low economic returns compared to other annual crops such as sweet corn and vegetables.

Biotic stresses inhibiting groundnut cultivation include bacterial wilt *(Pseudomonas solanacearum)* (Fig. 6) and collar rot *(Aspergillus niger),* which are becoming increasingly serious on the East Coast; leaf spots *(Cercospora arachidicola* and *Phaeoisariopsis personata)* and rust *(Puccinia arachidis),* which occur late in the growing season; and groundnut mosaic virus, which is less serious. An important insect pest is pod borer *(Helicoverpa armigera).* Other insect pests which occur occasionally are leaf feeder *(Spodoptera litura),* leaf miner *(Aproaerema modicella),* aphid *(Aphis craccivora),* and thrips *(Frankliniella schultzei).*

Future Prospects

Groundnut cultivars combining resistance to bacterial wilt with high yield potential and suitable characteristics for roasted and confectionary nuts are urgently required. Further, varieties resistant to foliar diseases such as leaf spots, rust, and groundnut mosaic virus would also be valuable. In order to broaden the spectrum of groundnut utilization and to offset imports, the introduction of high-yielding Virginia and Valencia types adapted to the humid tropics would be useful.

Myanmar[1]

Introduction

The administrative divisions and important urban centers of Myanmar (formerly Burma) are shown in Figure 1. The country is divided into 14 administrative divisions (seven states and seven divisions). These are further subdivided into 247 townships (districts). Chickpea, pigeonpea, and groundnut are all important in Myanmar.

Crop Distribution in Relation to Agroclimatic Factors

Myanmar's diversity of climate and parent rocks have given the country a wide range of soils, but only Fluvisols, Luvisols, and Aerisols are agriculturally important. Fifteen agroclimatic zones are recognized. These are derived by combining five major soil zones, identified as S1 to S5 (Fig. 2), with three rainfall regimes, low, moderate, and high, identified as zones R3 to R5 (Fig. 3).

Chickpea, grown on 195 145 ha, occupies 31% of the total area under pulses in Myanmar, and is mainly produced in the Sagaing, Bago, Mandalay, Magway, and Ayeyarwady divisions (Fig. 4). It is chiefly grown as a relay or sequential crop after rice in the lowlands. In the uplands, it is grown mostly on soils with a good water-holding capacity, after an early, short-duration crop of maize or pulses, or after fallow, and is sometimes intercropped with wheat. On the banks of the Ayeyarwady in the delta area, chickpea is also grown after flood waters recede. During 1987/88 production was 163 960 t (Table 1), with an average yield of 0.84 t ha^{-1}. Chickpea in Myanmar is cultivated in the winter season and matures in 100-110 days.

Pigeonpea is grown on 66 720 ha and accounts for about 11% of the total area tinder pulses. It is mainly confined to the dry central zone of Sagaing, Mandalay, and Magway divisions (Fig. 5), where it is usually grown in the rainy season. Annual production is about 48 480 t (Table 1), with an average yield of 0.72 t ha^{-1}. Pigeonpea varieties have maturity durations ranging between 150 and 250 days. Medium-duration varieties are commonly sown as an intercrop with groundnut, sesame, or cotton; the longer-duration varieties are mostly grown in the plains in the south.

Groundnut, grown on an area of 536 490 ha, is the country's most important AGLN crop (Table 2). Forty-six percent of total groundnut area is sown during the rainy season (Jun-Oct) and 54% during the dry winter season (Nov-Mar). It is grown as a rainy-season crop mostly in the Mandalay, Magway, and Sagaing divisions, and Shan state which account for more than 70% of production. When grown as a winter-season crop its distribution is somewhat less concentrated. In the rainy season it is grown in the hilly and dry zone of central Myanmar (Fig. 6), and in the winter season in the Ayeyarwady delta, on plains and river banks (Fig. 7). However, groundnut cultivation in winter is almost double that of the rainy season, mostly because of the higher average yield (1.2 t ha^{-1}) in winter compared

Table 1. Chickpea and pigeonpea area, production, and productivity In Myanmar 1987/88.

	Chickpea			Pigeonpea		
State/Division	Area ('000 ha)	Production ('000 t)	Average yield (t ha^{-1})	Area ('000 ha)	Production ('000 t)	Average yield (t ha^{-1})
Sagaing	72.32	55.54	0.76	17.64	12.80	0.72
Bago	44.39	48.77	1.09	0.04	0.02	0.50
Mandalay	36.33	29.21	0.80	34.45	25.38	0.73
Magway	34.98	25.82	0.73	11.40	8.44	0.74
Ayeyarwady	6.31	4.02	0.63			
Shan	0.68	0.52	0.76	0.04	0.02	0.50
Yangon	0.08	0.05	0.62			
Kayah	0.05	0.03	0.6	0.06	[1]	
Chin				3.03	1.82	0.60
Mon				0.06	[1]	
Kachin					-	
Kayin					-	-
Rakhine		-		-	-	-
Tanintharyi						
All Myanmar	195.14	163.96	0.84	66.72	48.48	0.72

1. Not reported.

1. This section was prepared by U Maung Ko, U Kyaw Moe, and U Sein Hlaing, Myanmar Agriculture Service, Yangon, Myanmar, in cooperation with the following resource persons from ICRISAT: S.M. Virmani, Laxman Singh, and C.L.L. Gowda.

Figure 1. Administrative divisions of Myanmar

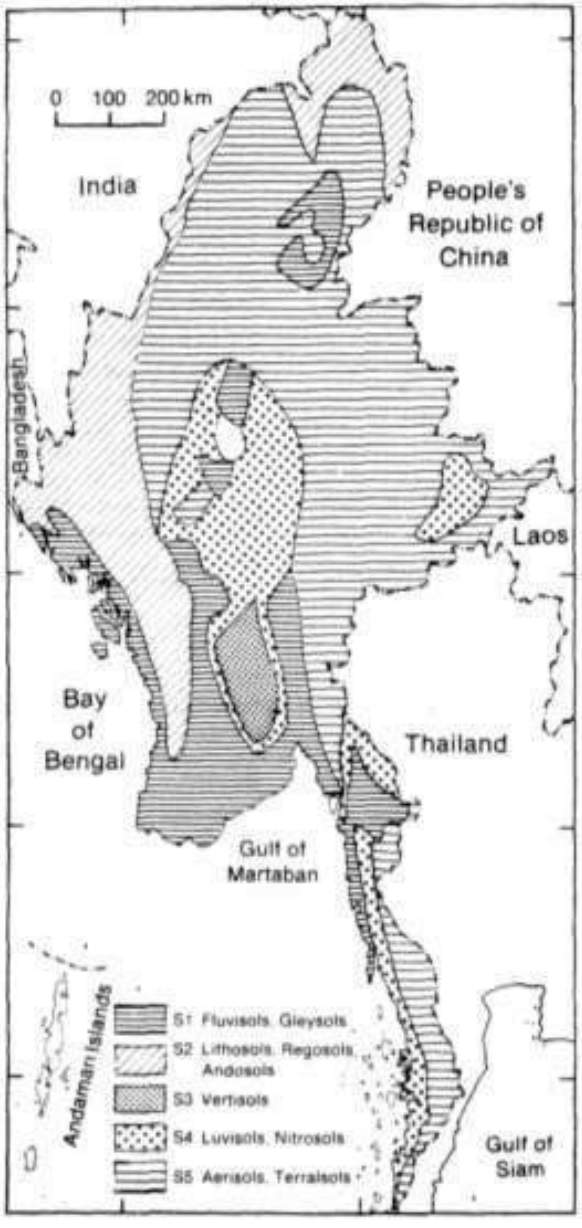


Figure 2. Major soil zones of Myanmar.

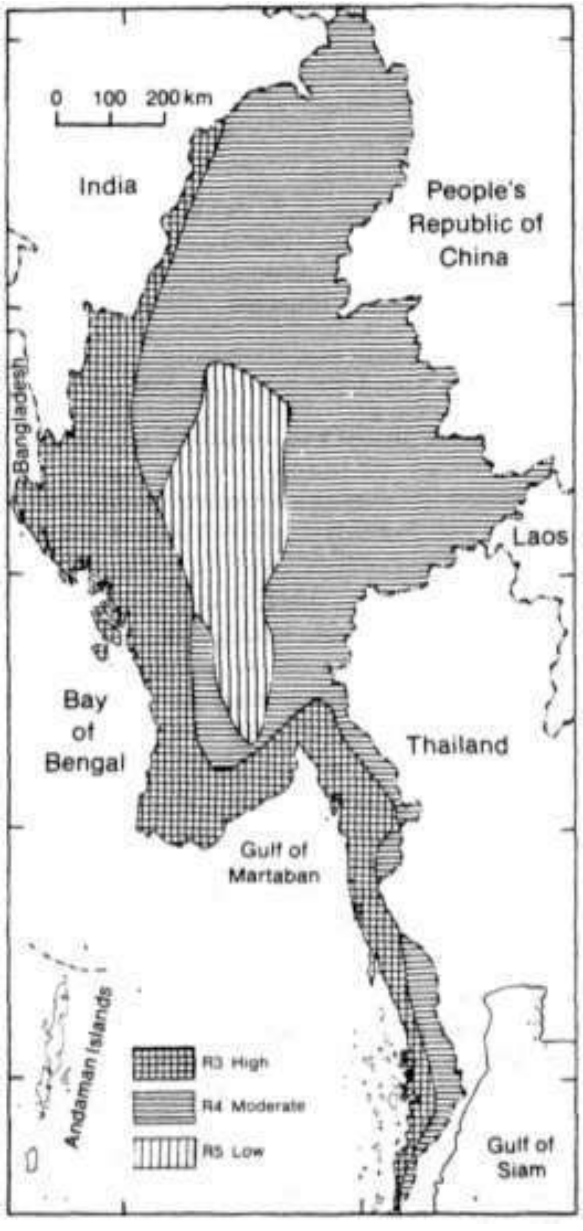


Figure 3. Major rainfall zones in Myanmar.

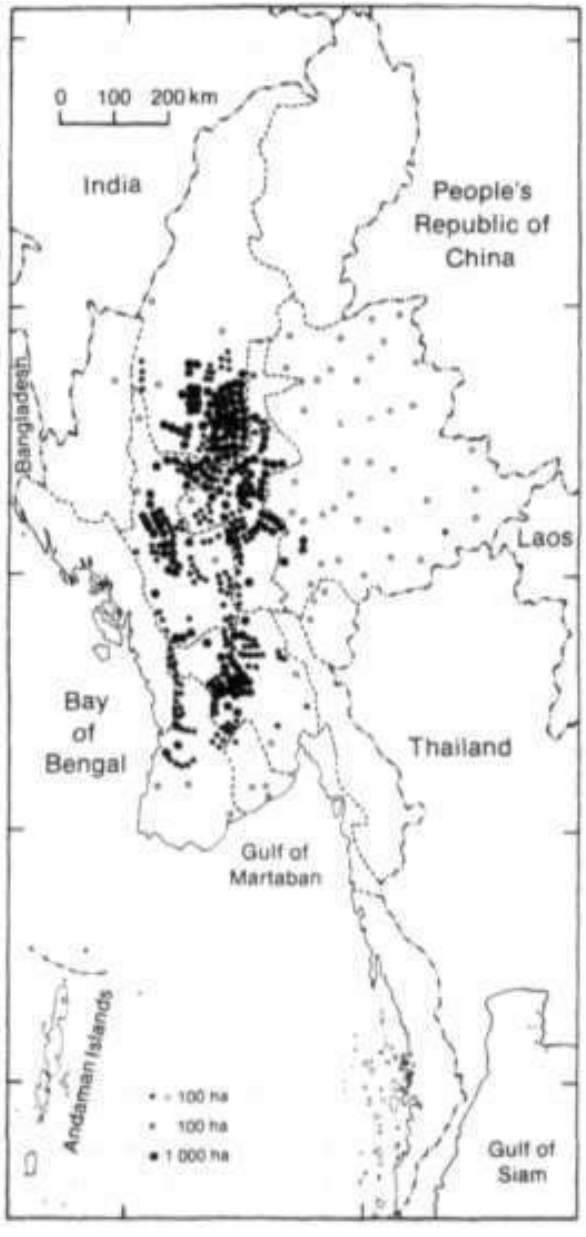


Figure 4. Chickpea distribution in Myanmar.

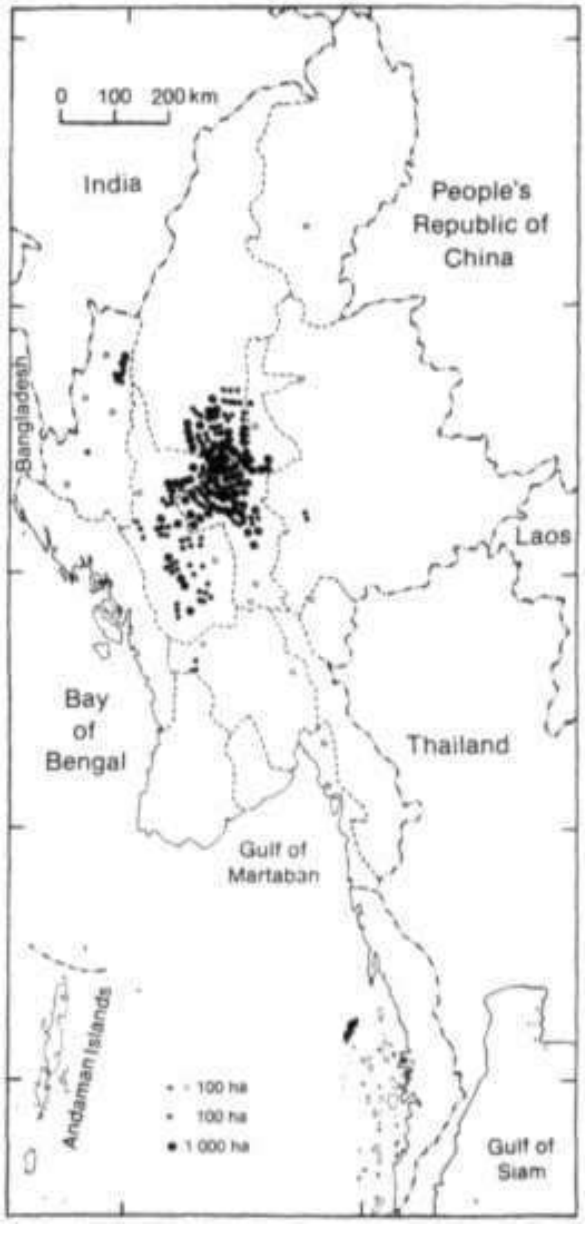


Figure 5. Pigeonpea distribution in Myanmar.

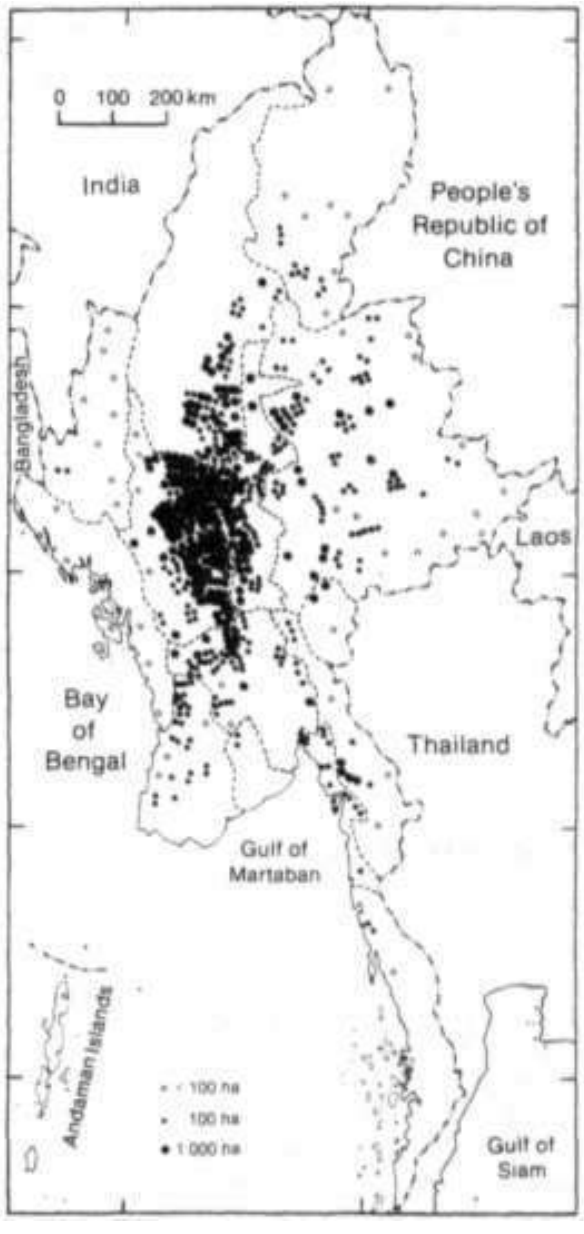


Figure 6. Groundnut (rainy season) distribution in Myanmar.

Table 2. Groundnut area, production, and productivity in Myanmar, 1987/88.

State/Division	Area ('000 ha)			Production ('000 t)	Average yield	Production ('000 t)	Average yield	
	Winter season	Rainy season	Total	Winter season	(t ha^{-1})	Rainy season	(t ha^{-1})	Total
Magway	34.69	92.70	127.39	40.19	1.15	74.69	0.80	114.88
Sagaing	79.70	35.61	115.31	94.63	1.18	21.71	0.60	116.34
Mandalay	39.32	71.38	110.70	46.62	1.18	43.30	0.60	89.92
Bago	63.68	8.18	71.86	84.00	1.31	5.15	0.62	89.15
Ayeyarwady	34.42	5.54	39.96	38.21	1.11	4.10	0.74	42.31
Shan	1.85	25.83	27.68	2.13	1.15	19.23	0.74	21.36
Yangon	12.22	0.13	12.35	13.71	1.12	0.06	0.46	13.77
Kachin	8.94	1.13	10.07	9.76	1.09	0.93	0.82	10.69
Kayin	5.53	1.11	6.64	6.62	1.19	0.72	0.64	7.34
Nen	4.36	1.59	5.95	4.94	1.13	1.22	0.76	6.16
Rakhine	4.44	0.68	5.12	4.24	0.95	0.46	0.67	4.70
Kayah	0.01	2.97	2.98	0.00	0.00	2.13	0.71	2.13
Chin	0.11	0.20	0.31	0.10	0.90	0.14	0.70	0.24
Tanintharyi	0.03	0.14	0.17	0.03	1.00	0.10	0.71	0.13
All Myanmar	289.30	247.19	536.49	345.18	1.19	173.96	0.70	519.14

to only 0.7 t ha^{-1} in the rainy season (Table 2). Short- and medium-duration varieties of groundnut, requiring 90-120 days to mature, are generally grown.

Major Stress Factors

The major abiotic stress for all three legume crops is drought in the agroelimatic zone R5 S4, where rainfall is low and the soils are Luvisols. The length of growing period here varies from less than 120 days to 180 days (Fig. 8). Rainy-season pigeonpea and groundnut encounter both mid-season and late-season droughts. Winter-season crops (chickpea and groundnut) are grown under receding soil moisture.

Pod borer *(Helicoverpa armigera)* is the most important pest of chickpea (Fig. 9). Fusarium wilt *(Fusarium oxysporum* f. sp *ciceri)* (Fig. 9) and root rot *(Rhizoctonia solani)* diseases are moderately important in Mandalay division, and marginally important in Sagaing. Bago, and Magway divisions.

Pod borer (H. *armigera)* and podfly *(Melanagromyza obtusa)* are the major insect pests of pigeonpea. Among diseases, fusarium wilt *(F. udum)* has been observed in some areas.

Among the major biotic stresses affecting groundnut are early *(Cercospora arachidicola)* and late *(Phaeoisariopsis personata)* leaf spots (Fig. 10), and collar rot *(Aspergillus niger).* Late leaf spot is more common than early leaf spot. The leaf spots and collar rot infections reduce yield by 10%. The crop losses due to white grub *(Lachnosterna* sp) are about 5% (Fig. 10) and 2% due to leaf miner/binder *(Aproaerima modicella).*

Future Prospects

There is **considerable** scope for expanding the production of chickpea, pigeonpea, and groundnut in Myanmar. Farmers could profitably diversify by including legumes to a greater extent in several of the country's cereal-based cropping systems. Chickpea cultivation could be expanded in agroclimatic zones R3 S2 and R4 S2, and also in lower Myanmar, provided varieties tolerant to high temperatures and acid soils are available (Fig. 11). The pigeonpea area could be expanded by about 35% by introducing short-duration varieties to fit existing cropping patterns in traditional areas, and as a winter crop in the delta areas and in lower Myanmar. For groundnut, major areas of potential expansion are in agroclimatic zones R4 SI and R5 S3/S4.

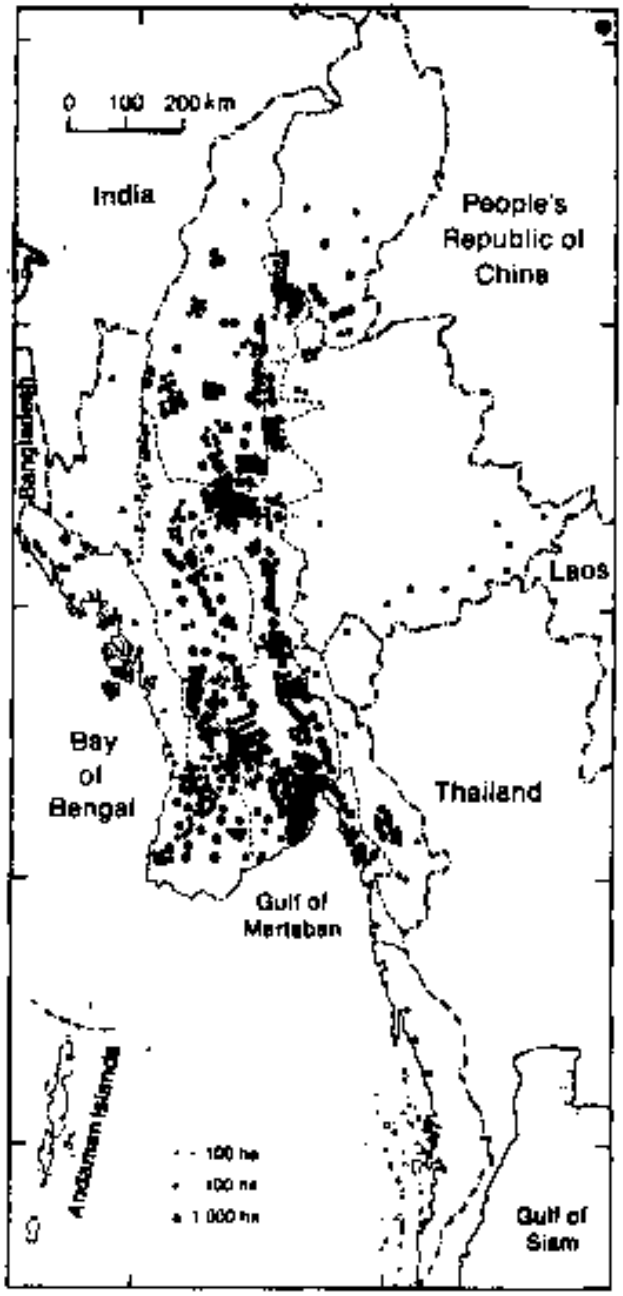


Figure 7. Groundnut (winter season) distribution in Myanmar.

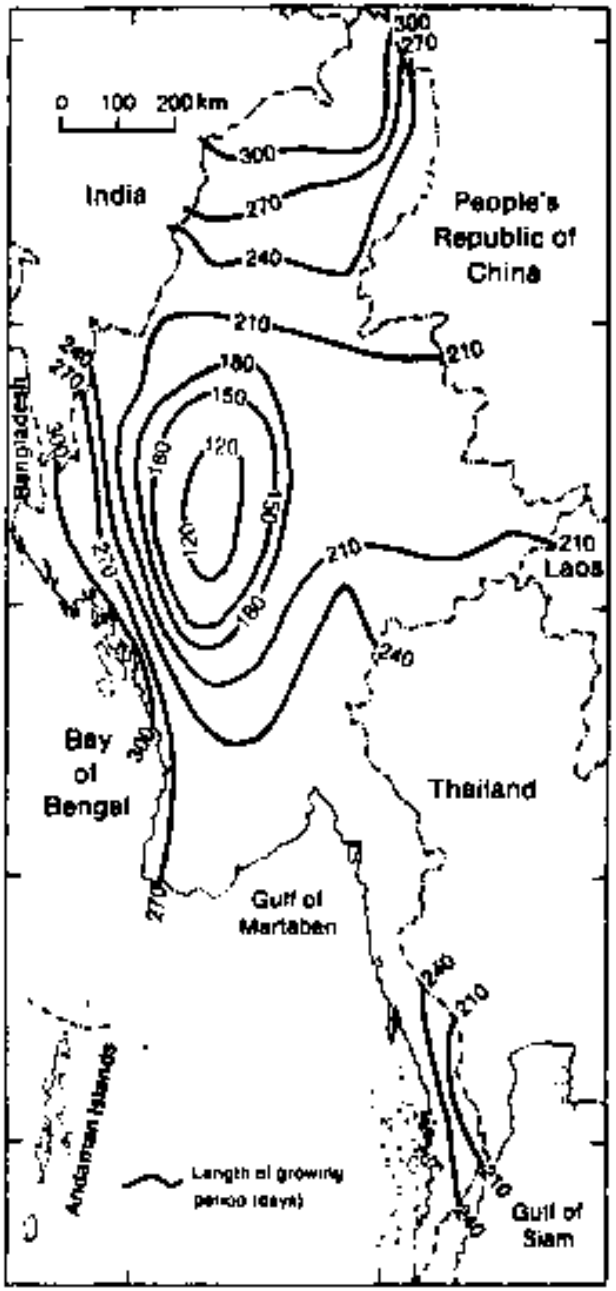


Figure 8. Length of growing period in Myanmar.

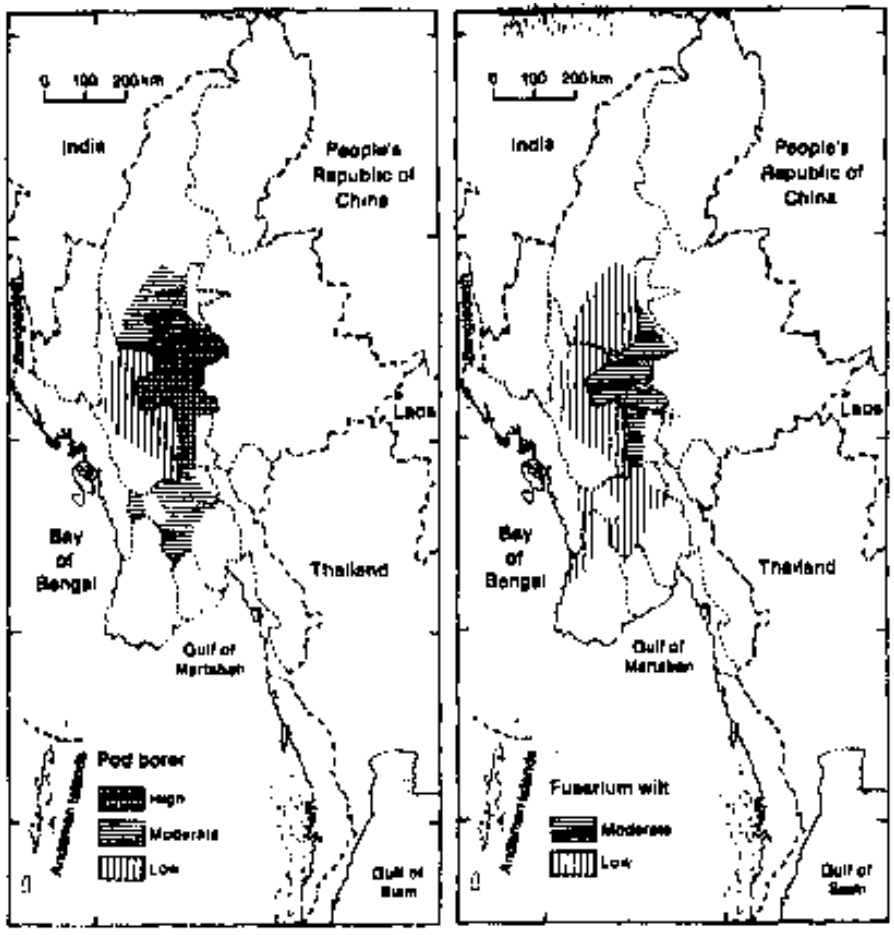


Figure 9. Biotic stresses affecting chickpea production in Myanmar.

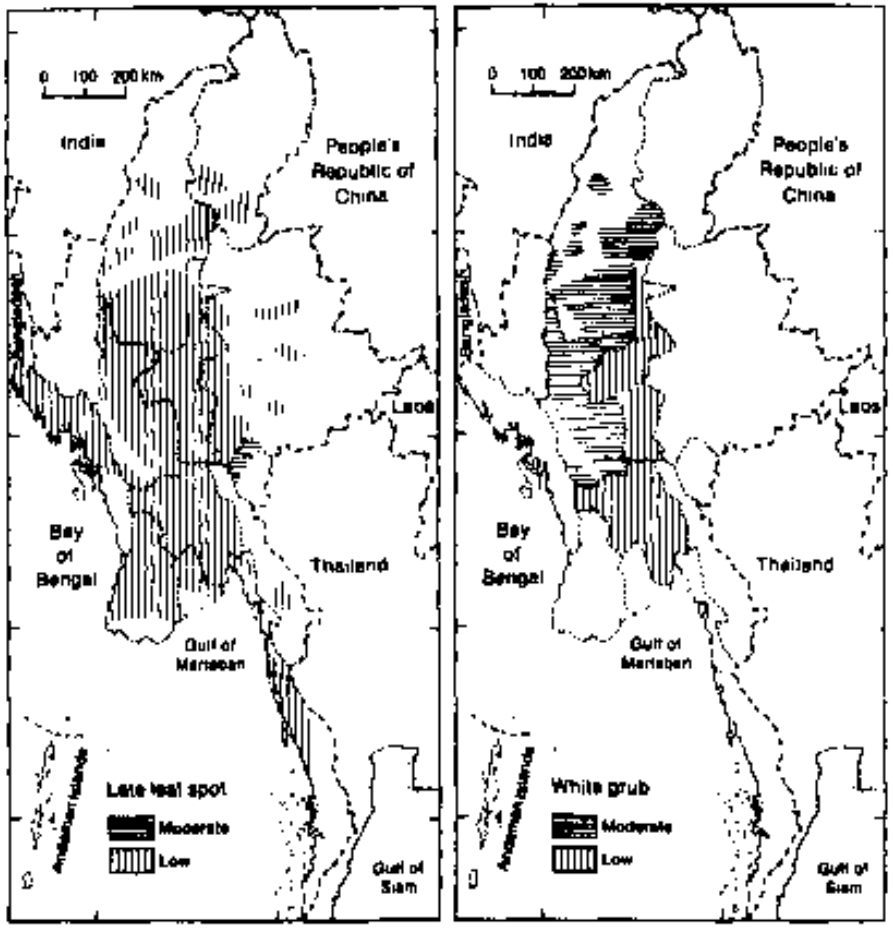


Figure 10. Biotic stresses affecting groundnut production in Myanmar.

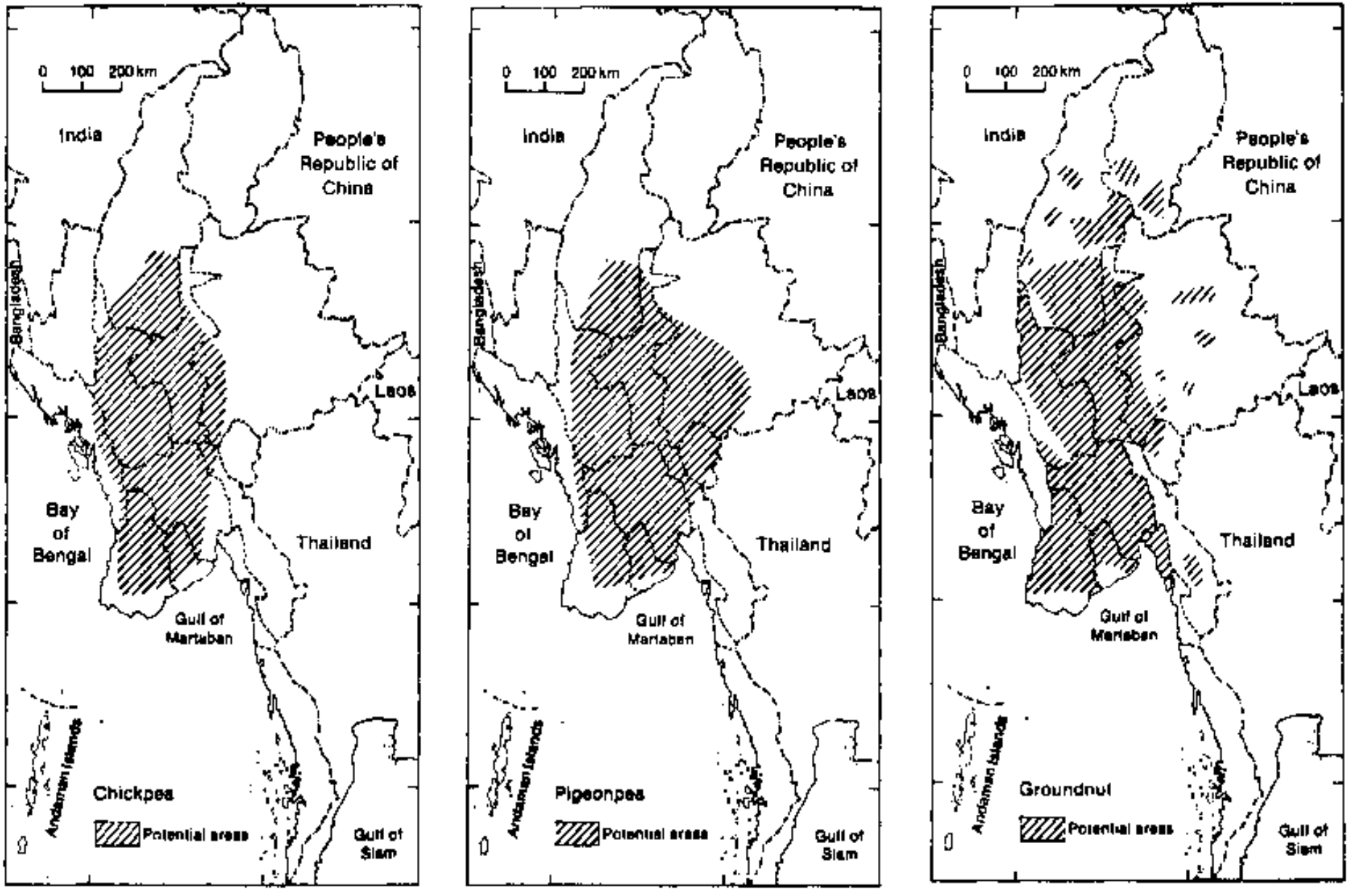


Figure 11. Potential areas for expanding chickpea, pigeonpea, and groundnut cultivation in Myanmar.

Nepal[1]

Introduction

The administrative divisions and important urban centers of Nepal are shown in Figure 1. The country is divided into live regions: Far Western, Mid Western, Western, Central, and Eastern. Each region is divided into administrative zones that arc further subdivided into districts.

About 90% of Nepal's population depends on agriculture for its livelihood. The country's total area is 141 (XX) km^2, of which 3.13 million ha (22%) is cultivated. About 18% of the cultivated land is irrigated, and the remainder is rainfed.

Crop Distribution in Relation to Agroclimatic Factors

As shown in Figure 2, Nepal is divided into four agroclimatic zones, running

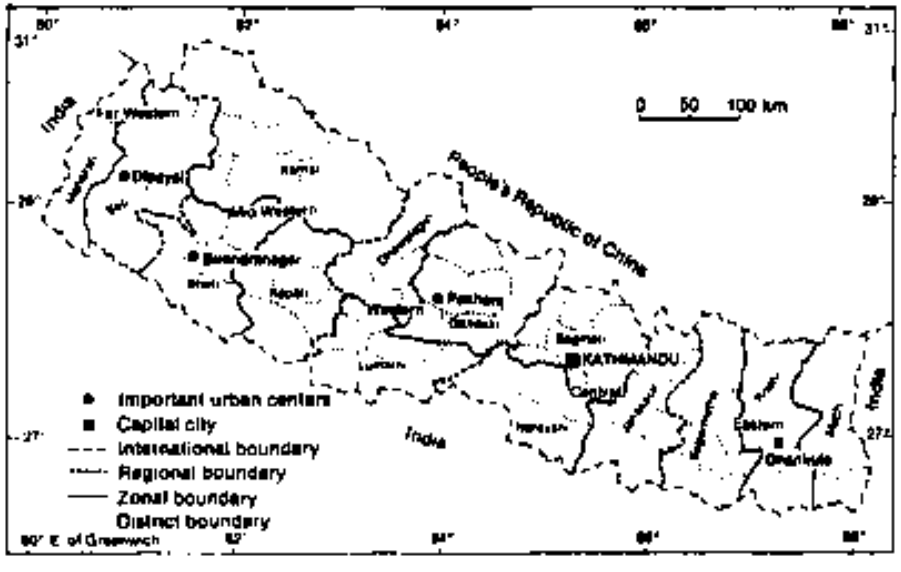


Figure 1. Administrative divisions of Nepal.

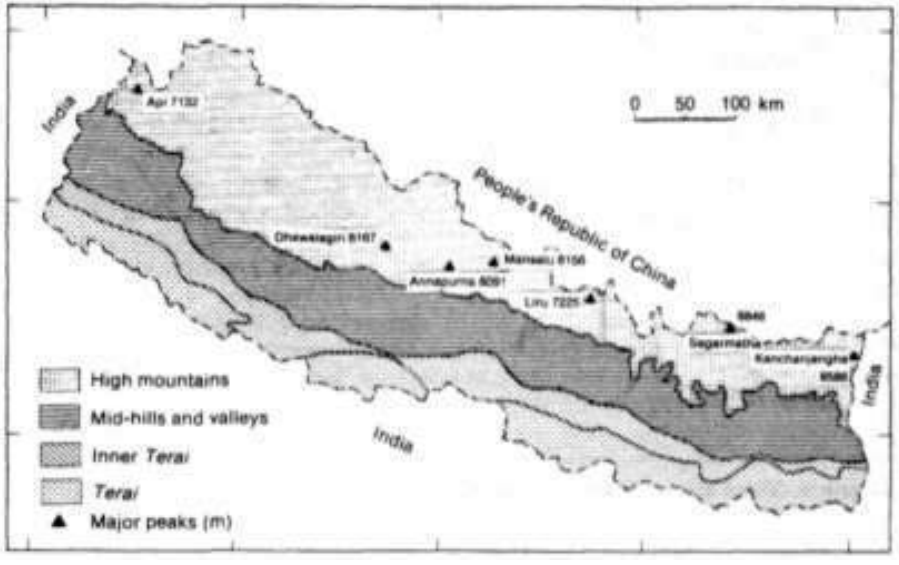


Figure 2. Agroclimatic zones of Nepal.

parallel from east to west: *Terai* (the plains in the south); Inner *Terai;* mid-hills and valleys; and high mountains (in the north).

The climate ranges from warm subtropical in the *Terai* to alpine in the high mountains. Annual precipitation varies considerably with altitude throughout the country, but the center and east of the country are generally wetter than the northwest, with rainfall varying from less than 500 mm in the western high mountains to more than 3500 mm in the western mid-hills and eastern high mountains (Fig. 3). Figure 4 shows mean annual minimum temperatures and Figure 5 mean annual maximum temperatures. Generally, Jan is the coldest month and Jun and Jul are the hottest months. However, each agroclimatic zone contains many microclimates governed primarily by altitude. Soil texture varies from rich alluvial deposits in the *Terai* (neutral to alkaline) to coarse-textured gravels in the high mountains.

The total area under legumes is 268 000 ha, of which approximately 53 000 ha is devoted to AGLN crops. Among AGLN crops, chickpea occupies the largest

1. This section was prepared by D.M. Sakya. Department of Agriculture, Kathmandu; M.P. Bharati. drain Legumes Improvement Program, Kathmandu: and M.L. Jayaswal, Department of Agriculture, Nawalpur. Nepal, in cooperation with the following resource persons from ICRISAT: Onkar Singh and M.J. Vasudeva Rao.

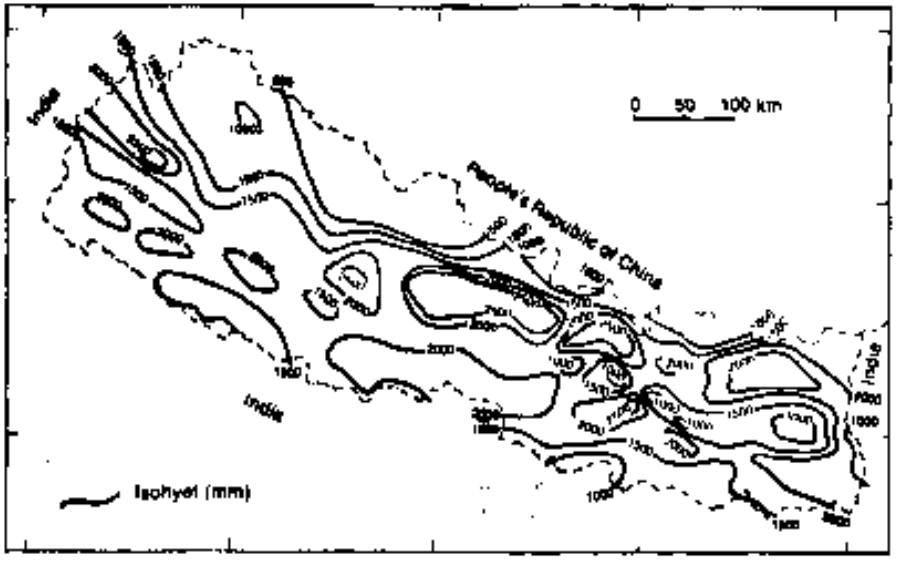


Figure 3. Mean annual precipitation in Nepal.

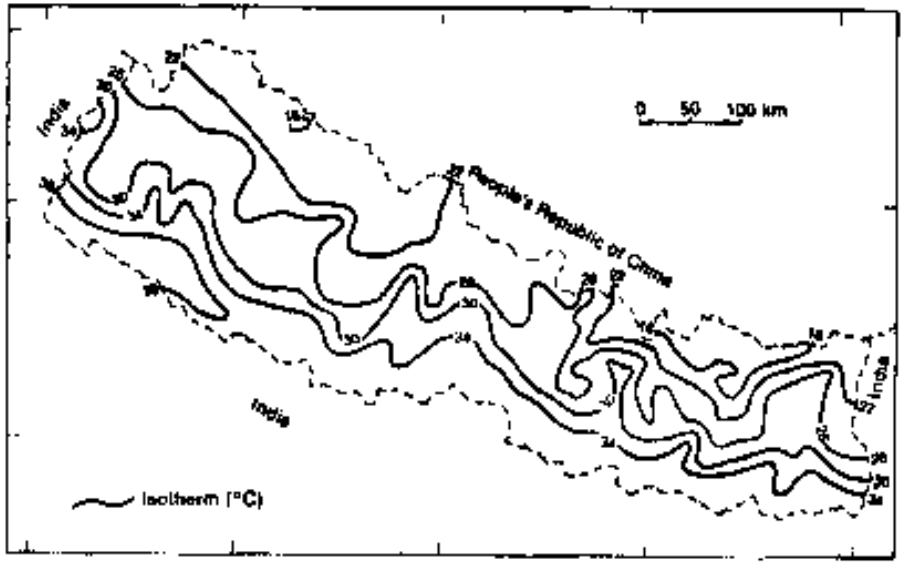


Figure 5. Mean maximum temperatures in Nepal during hottest week.

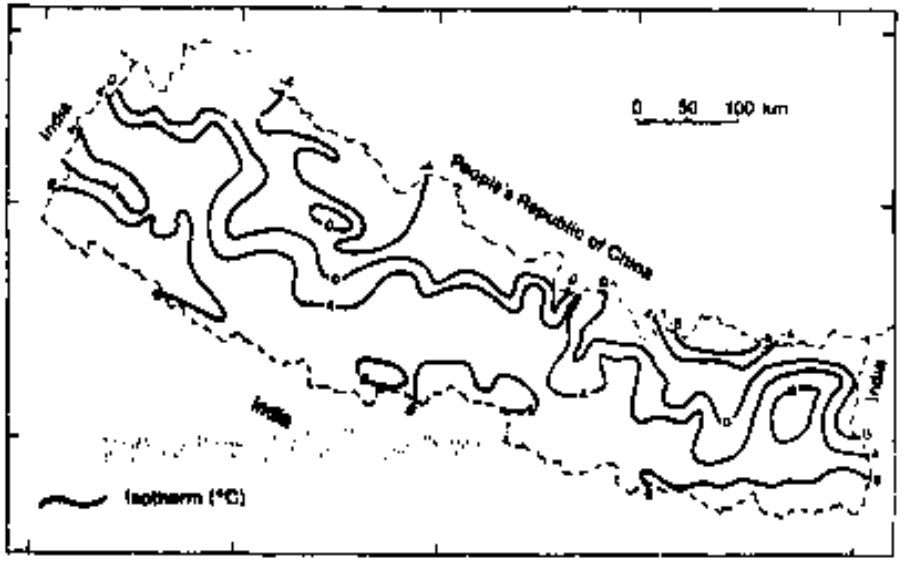


Figure 4. Mean annual minimum temperatures in Nepal.

area (Fig. 6). followed by pigeonpea (Fig. 7) and groundnut (Fig. 8). Legumes are grown mainly in the *Terai* and Inner *Terai;* groundnut is also grown in small pockets in the mid-hills, but detailed records on these areas are not available. Table 1 gives the area, production, and mean yields of the three crops from 1983 to 1988.

Rice and maize arc the principal crops of the country; chickpea, pigeonpea. and groundnut are grown in different cropping patterns (Table 2). As shown in Table 3 chickpea is grown in the winter (Oct-Mar), pigeonpea (usually long-duration genotypes) is sown in Jul and harvested in Mar, and groundnut is grown mainly in summer (Apr-Jun).

Major Stress Factors

Yields of AGLN crops have remained low, owing to many abiotic and biotic constraints. Erosion, caused by high rainfall and rugged topography is a particularly severe problem in Nepal. Soil acidity and deficiencies of calcium (Ca), magnesium (Mg), and molybdenum (Mo) are common.

Botrytis gray mold *(Botrytis cinerea)* is the most damaging disease of chickpea, followed by fusarium wilt *(Fusarium oxysporum* f. sp *ciceri)* and nematodes.

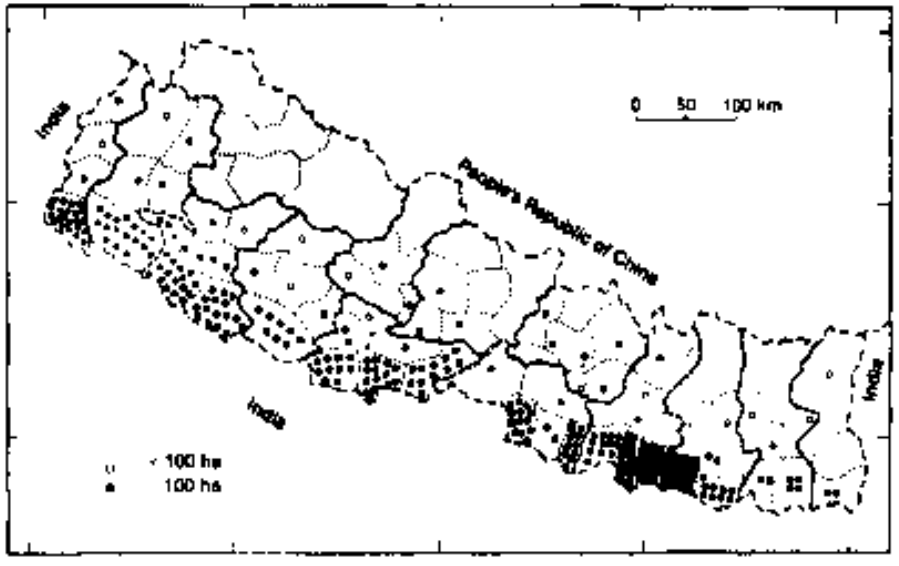


Figure 6. Chickpea distribution in Nepal.

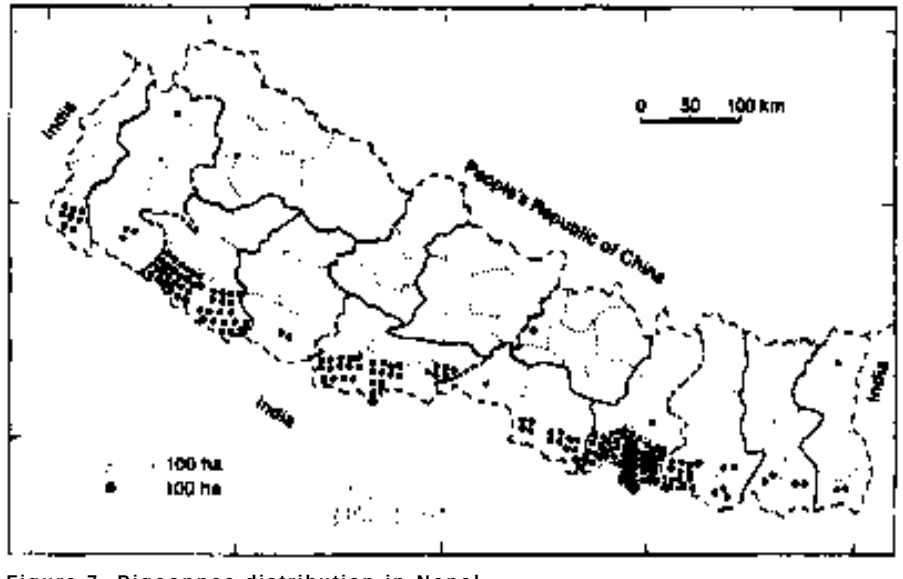


Figure 7. Pigeonpea distribution in Nepal.

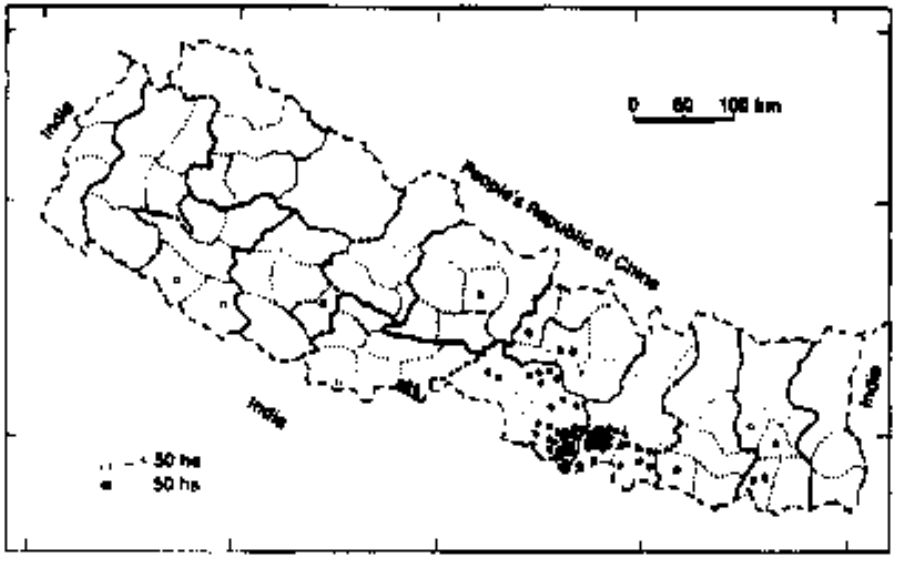


Figure 8. Groundnut distribution in Nepal.

Table 1. Chickpea, pigeonpea, and groundnut area, production, and productivity in Nepal 1983/84-1987/88.

	Area ('000 ha)			Production ('000 t)		
	Chickpea	Pigeonpea	Groundnut	Chickpea	Pigeonpea	Groundnut
1983/84	34	12		13 (0.38)[1]	5 (0.41)	-
1984/85	34	13	1	34 (1.0)	13 (1.0)	-
1985/86	29	16	2	18 (0.62)	12 (0.75)	-
1986/87	31	17	2	21 (0.67)	13 (0.76)	2 (1.0)
1987/88	30	18	5	16 (0.53)	9 (0.50)	5 (1.0)

1. Figures in parentheses denote average yield (t ha^{-1}).

Table 2. Chickpea, pigeonpea, and groundnut cropping patterns in Nepal.

Chickpea	Pigeonpea	Groundnut
Rice relayed with chickpea	Pigeonpea (uplands)-maize-chickpea or fallow	Groundnut-fallow
Early rice-chickpea	Rice mixed with pigeonpea (on rice bunds)	Groundnut-groundnut
Maize-chickpea		Groundnut-rapeseed or mustard, chickpea, wheat

Table 3. Sowing and harvesting times of chickpea, pigeonpea, and groundnut in different agroclimatic zones of Nepal.

	Agroclimatic zones	Moisture regime	Sowing time	Harvesting time
Chickpea	Mid-hills	Rainfed	Oct	Mar
	Terai	Rainfed	Nov	Apr
Pigeonpea	*Terai*	Rainfed	Jul	Mar
Groundnut	*Terai* and Inner *Terai*	Irrigated[1]	Apr	Jun
		Rainfed	Jul	Nov
	Terai	Irrigated	Feb	Jun
	Mid-hills	Rainfed	Apr	Oct/Nov

1. Irrigated in summer season.

Sterility mosaic disease causes serious problems in pigeonpea which is also **affected** by stem canker *(Phoma cajani)* (Fig. 9). Early leaf spot *(Cercospora arachidicola)* is widespread on groundnut and this crop is also affected by late leaf spot *(Phaeoisariopsis personata),* rust *(Puccinia arachidis),* stem rot *(Sclerotium rolfsii),* and bud necrosis disease (Fig. 10).

The pod borer *(Helicoverpa armigera)* is the major insect pest of chickpea and pigeonpea, and podfly *(Melanagromyza obtusa)* affects pigeonpea (Fig. 9). Groundnut is seriously damaged by termites *(Odontotermes* sp and *Microtermes* sp). This crop is also attacked by white grubs *(Lachnosterna consanguinea),* hairy caterpillars *(Amsacta albistriga, A. moorei),* jassids *(Empoasca kerri),* and *Spodoptera* spp (Fig. 10).

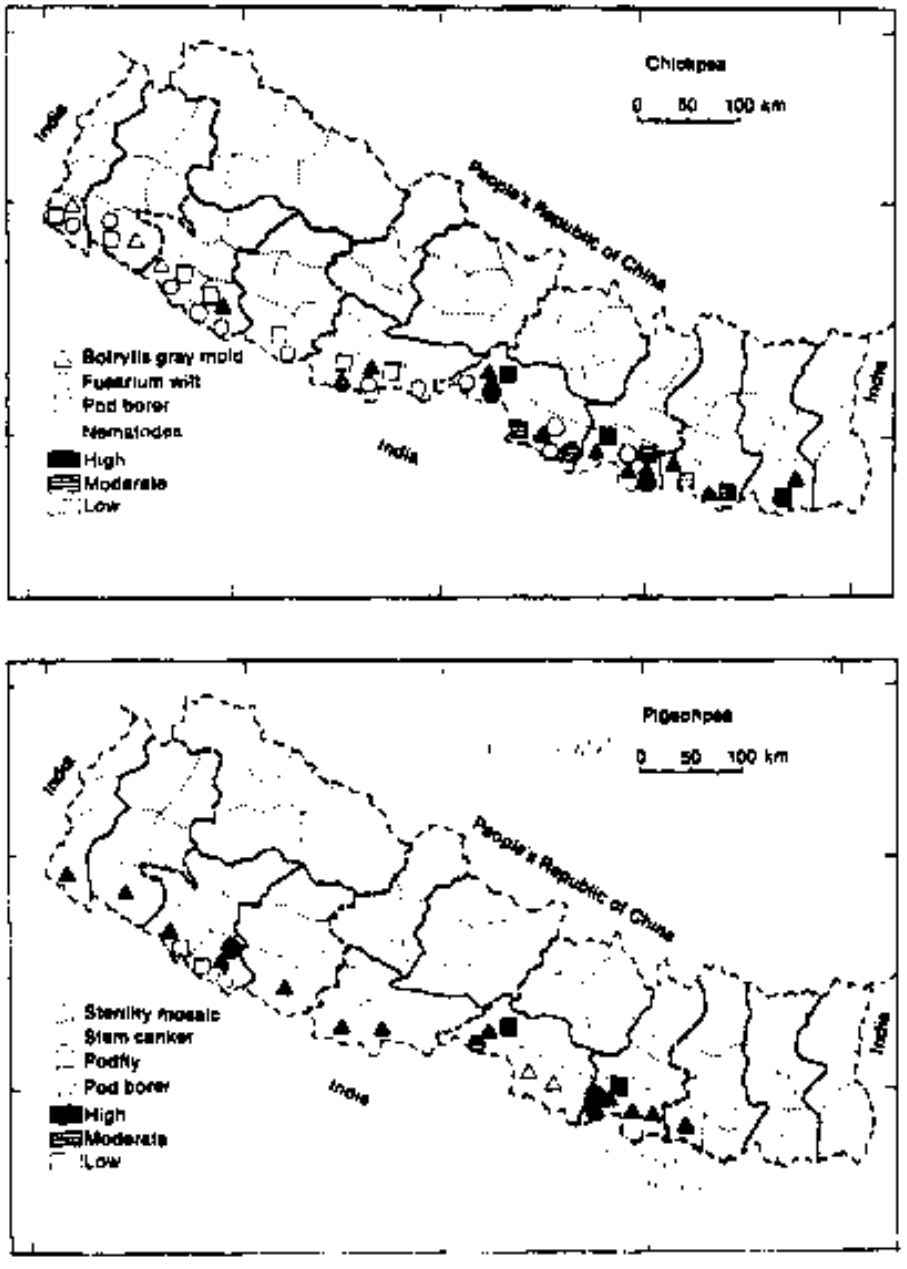
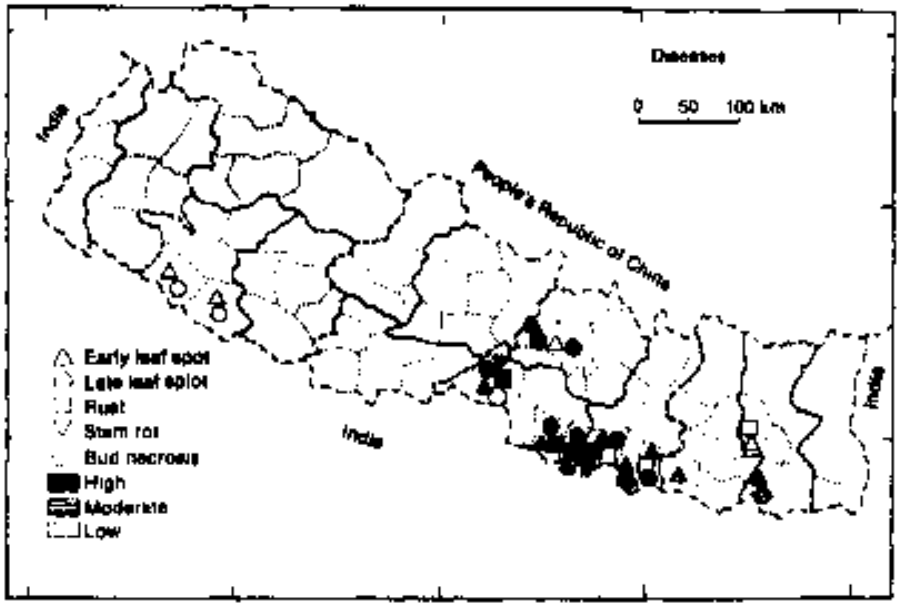


Figure 9. Biotic stresses affecting chickpea and pigeonpea production in Nepal.



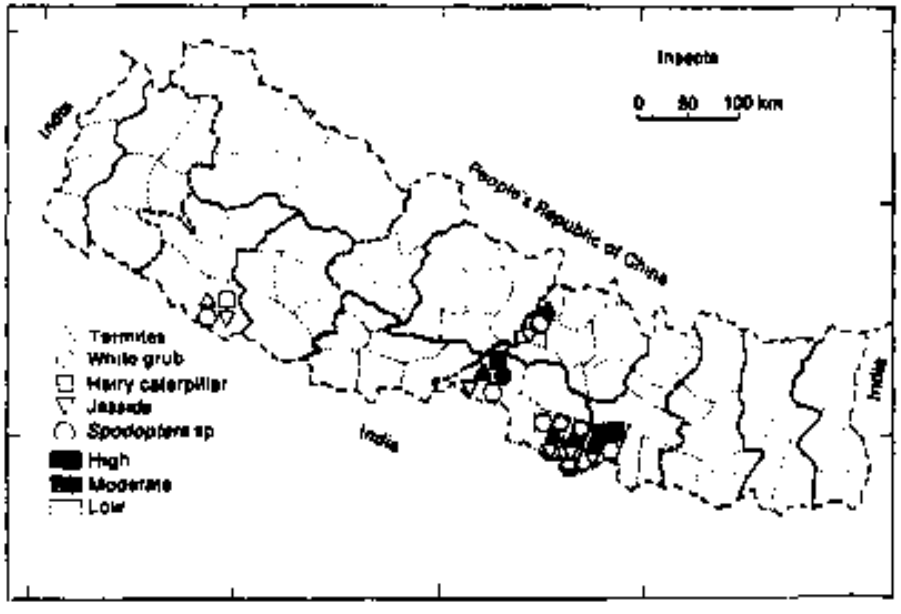


Figure 10. Biotic stresses affecting groundnut production in Nepal.

Future Prospects

The scope for increasing the area under grain legumes in Nepal is rather limited; only some of the area currently under cereals could be diverted to legumes. There is a great need to increase the per hectare yield of AGLN crops by introducing disease resistant, high-yielding varieties. Baseline agronomic research on soil fertility management for cropping systems with grain legume components is required for different agroclimatic zones. Research thrusts on development and promotion of improved cultivars of chickpea with resistance to botrytis gray mold, fusarium wilt, and *Helicoverpa* pod borer are a national priority.

Pakistan[1]

Introduction

The administrative divisions and important urban centers of Pakistan are shown in Figure 1.

The country is divided into 10 agroecological zones based on relief and climate (Fig. 2) and soils (Fig. 3). Chickpea is the most important AGLN crop in terms of area cultivated and production. Records for pigeonpea, generally grown as a border crop, are not available. Groundnut is cultivated on only 63 000 ha, and

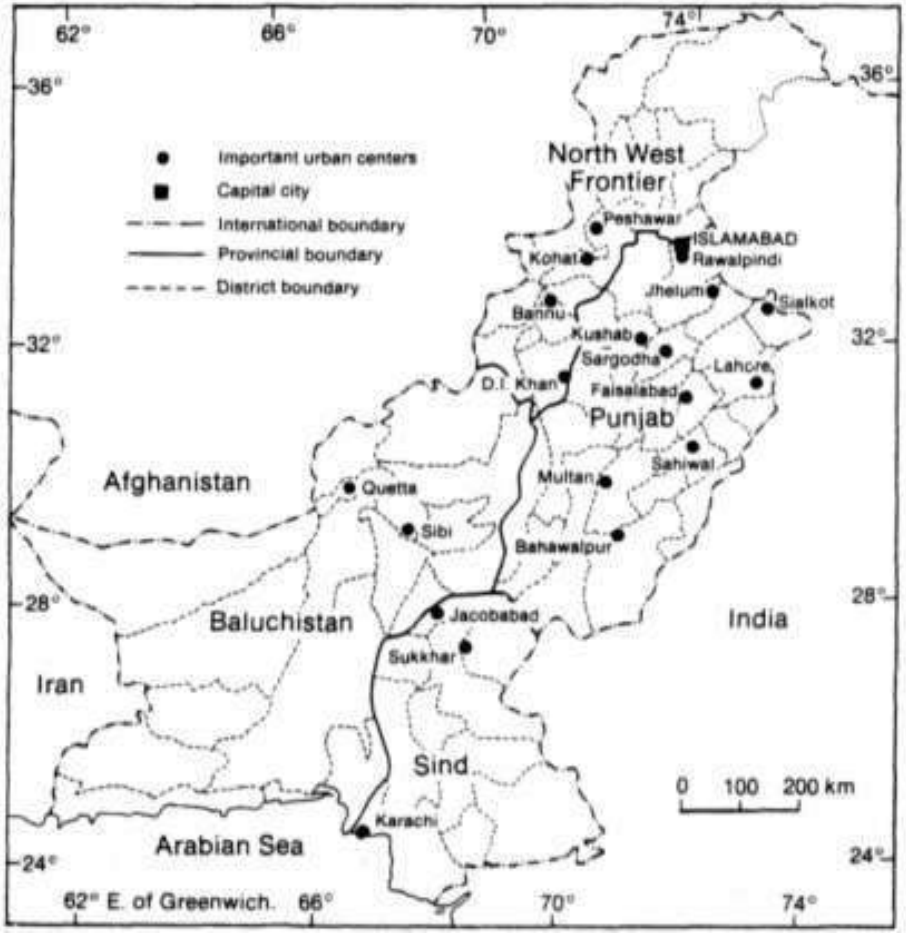


Figure 1. Administrative divisions of Pakistan.

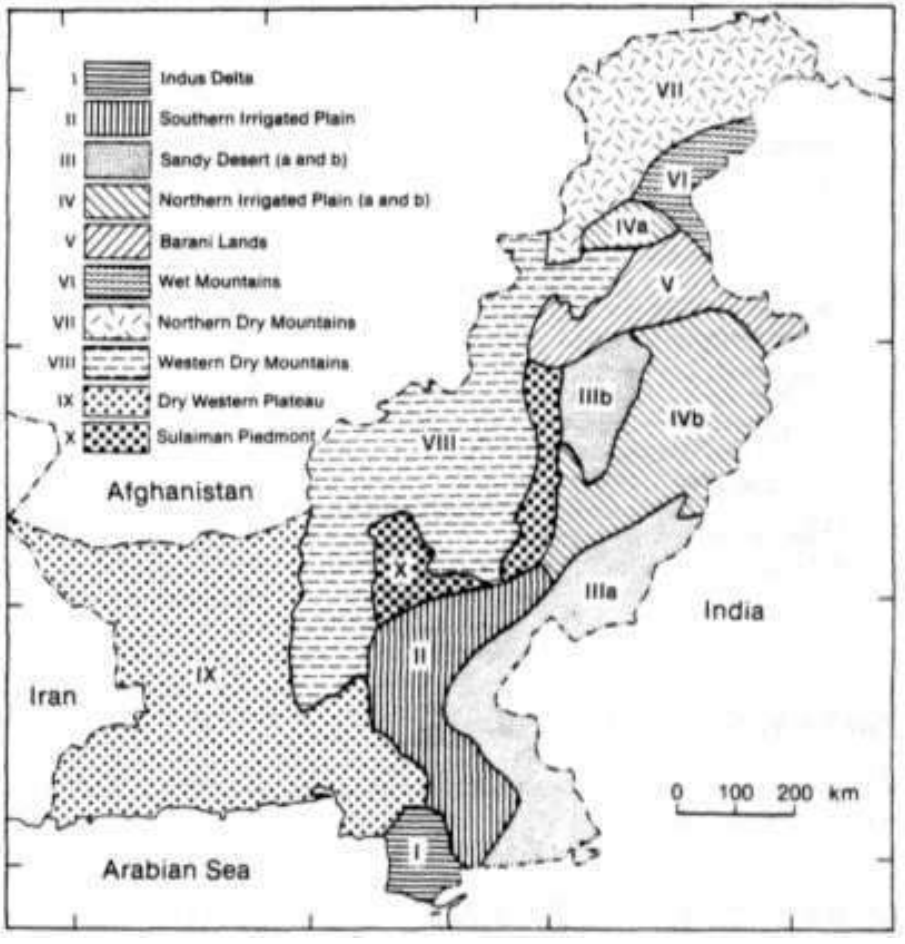


Figure 2. Agroecological zones of Pakistan.

1. This section was prepared by M.A. Khan, A.M. Haqqani. and M. Zubair, National Agricultural Research Centre. Islamabad, Pakistan, in cooperation with the following resource persons from ICRISAT: MP. Pimbert and N.P. Saxena.

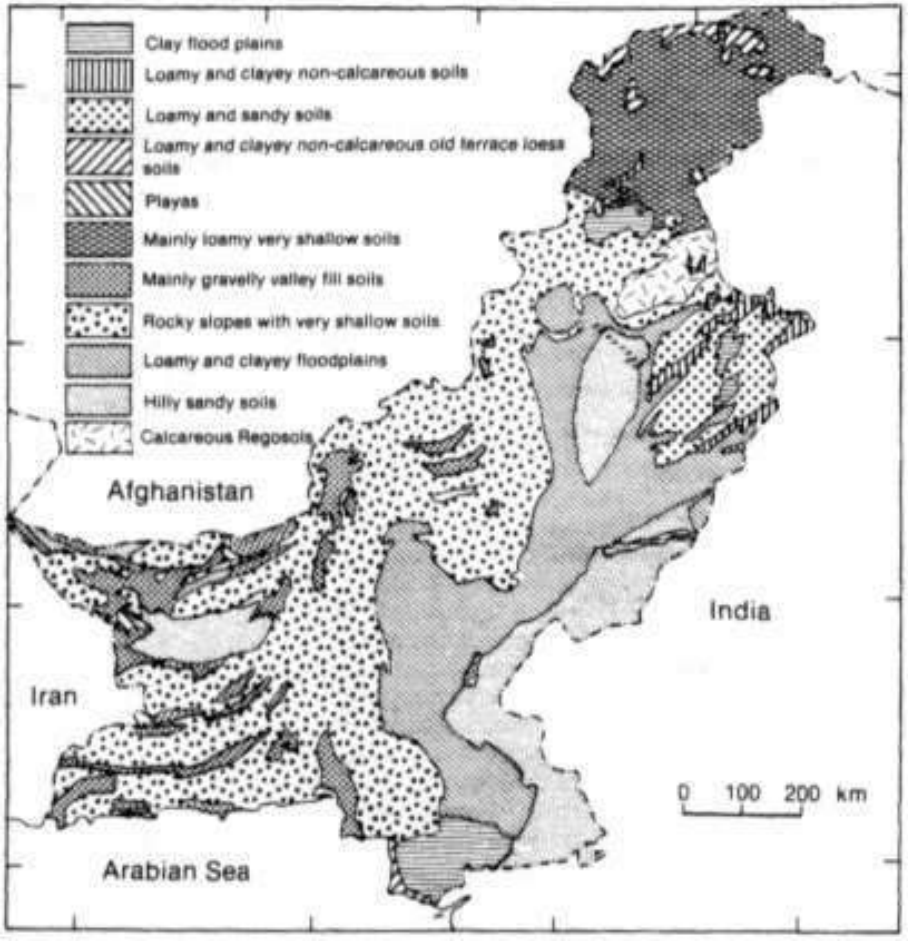


Figure 3. Major toll types of Pakistan.

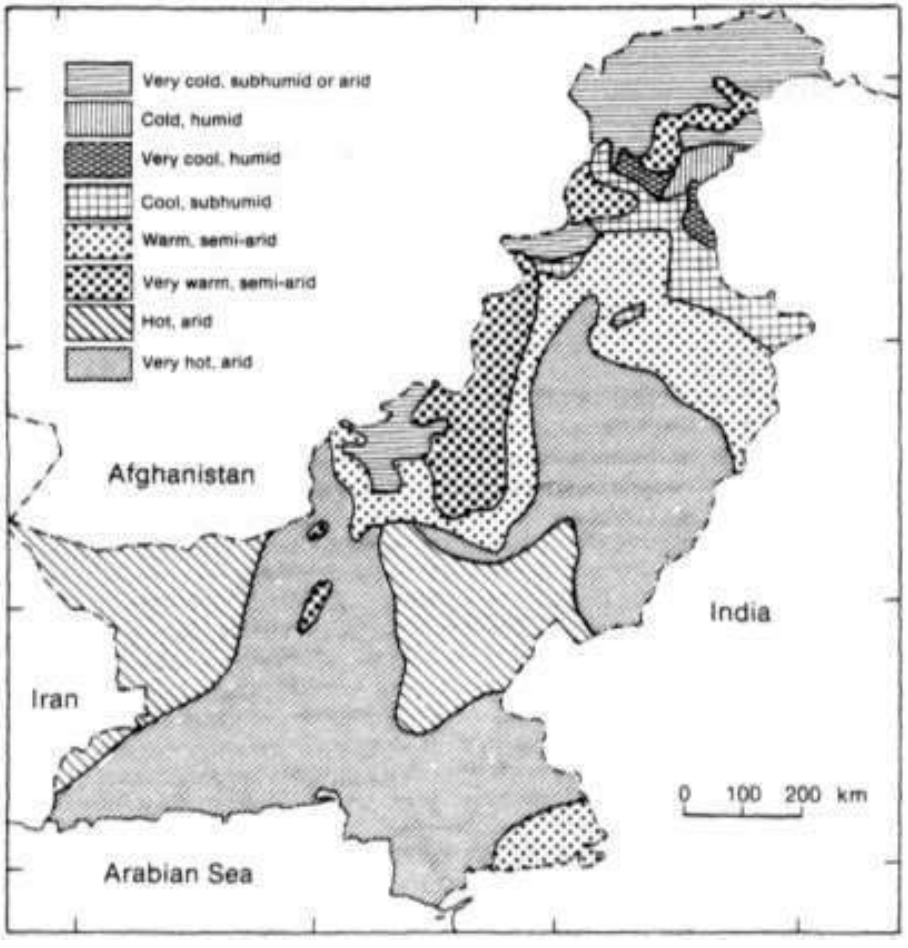


Figure 4. Climatic zones of Pakistan.

therefore most of this section will be devoted to chickpea, with a short final section on groundnut.

Crop Distribution in Relation to Agroclimatic Factors

Generally, Pakistan's climate ranges from very hot and arid in the far south, to very cold and humid in the far north (Fig. 4).

In the north, mean annual precipitation is about 480 mm (Fig. 5), 38% of which is received during the chickpea cropping season (Oct-Apr). Average maximum temperature ranges in Oct are 32-35℃; these fall to 19-20℃ in Dec/Jan. In Apr towards harvest time the maximum temperature is 33-34'C. The minimum temperatures in winter (Nov to mid-Mar) are in the range 2-3℃; during other months these are 15-18℃.

In the southern region (Zone II) average maximum temperatures at sowing time are 29-33℃ falling to 20-24'C in Dec and Jan. and rising again to 36-37℃ at harvest time in early Apr. Minimum temperatures vary from 13-I8"C at sowing to 6*C in Dec/Jan, and are around 27℃ at harvest.

In the north, in Zones IIIb, V, and X, chickpea (mainly brown-seeded *desi* genotypes) is grown as a rainfed sole crop in the postrainy season. The largest

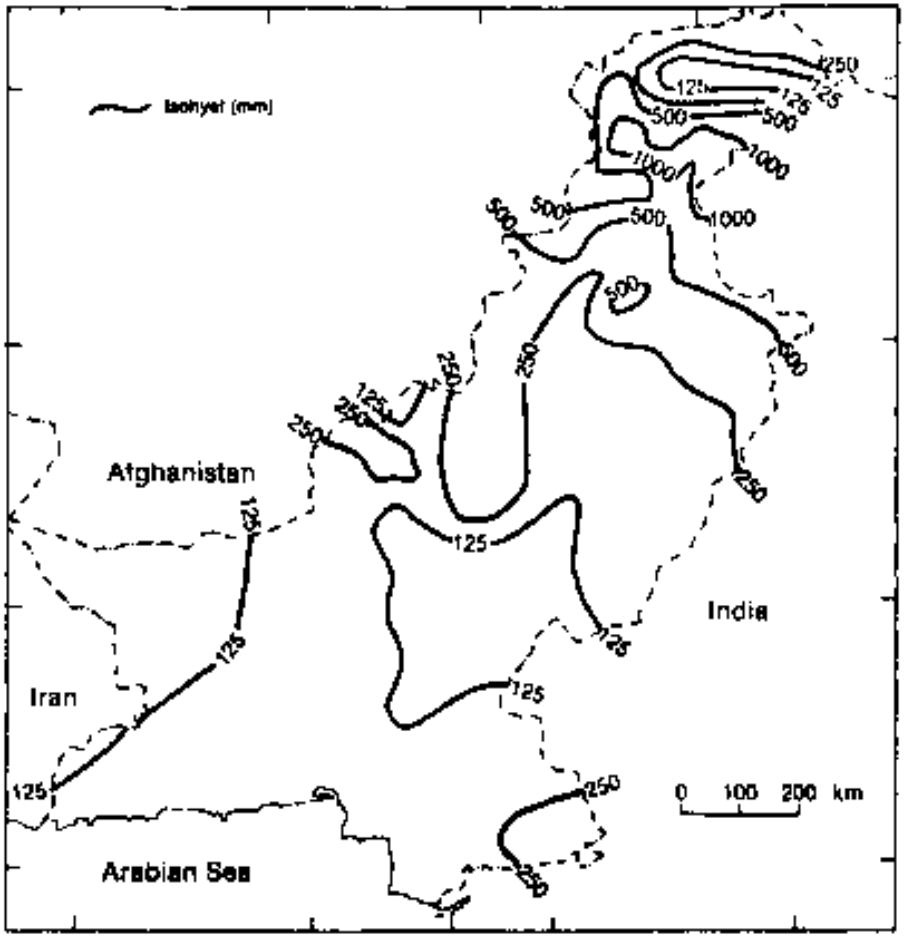


Figure 5. Mean annual rainfall in Pakistan.

areas under chickpea cultivation are in Zones IIIb and V. Fields are fallowed during the rainy season, and the crop is sown in Oct. The length of growing period is around 180 days. The crop is harvested in mid-Apr. Chickpea is also grown in rotation with rice in small areas in the north under irrigation (e.g., Sialkot in Zone IVa).

These chickpea-growing zones, which account for 80% of the total area under chickpea, lie mostly between latitudes 31°N and 33°N (Fig. 6). Soils range from silty loams to clay loams, have a pH of between 7 and 8.3, and organic matter content of 0.3 to 0.6% (Table 1).

Table 1. Soil characteristics of zones suitable for chickpea production in Pakistan.

Zone	Soil type	pH	Organic matter (%)
II	Silly loam, clay loam	7.8-8.3	0.4-0.5
III	Sand, loamy fine sand (moderately calcareous)	>7.0	0.4
IV	Sandy loam, clay loam	8.2	0.4-0.6
V	Silt loam, silty clay loam, clay loams	7.5-8.0	<0.5
X	Loam	>7.0	0.3-0.4

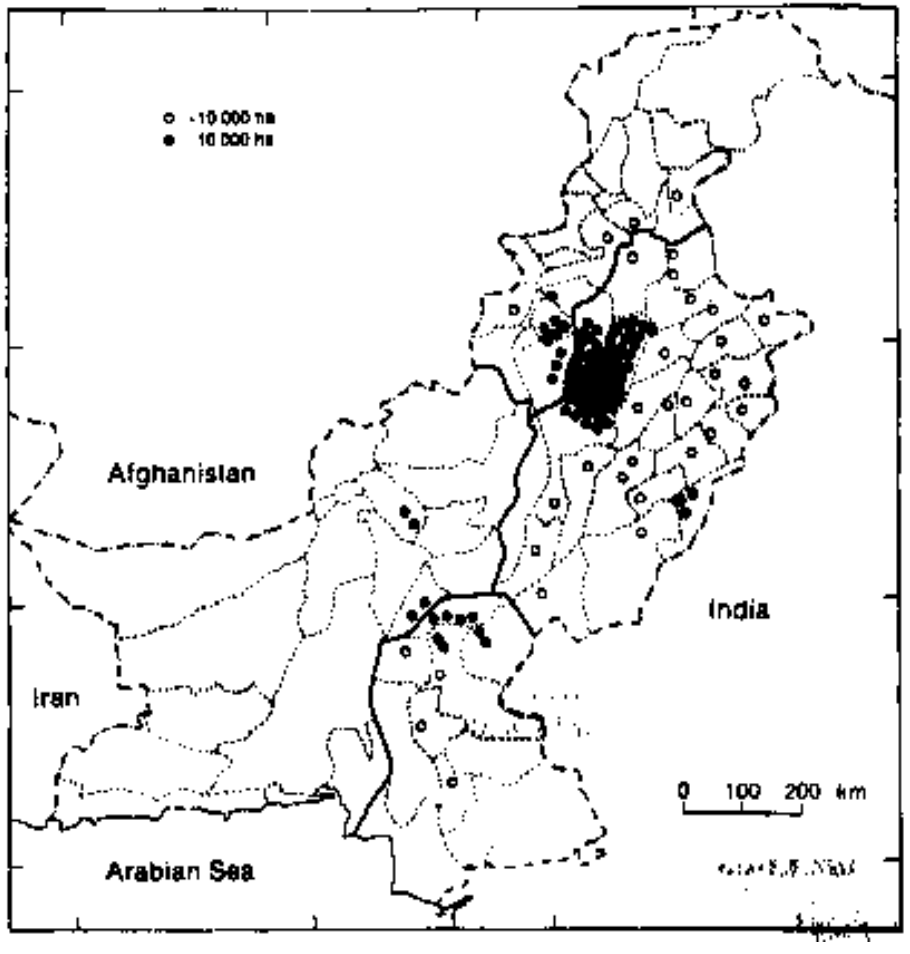


Figure 6. Chickpea distribution in Pakistan.

Chickpea (mainly *kabuli* genotypes) is also grown in a small area (10% of the total area) in the northern part of Zone II, at a latitude of 28*N. Here chickpea is grown mainly after rice on residual soil moisture. The length of the growing period is 180 days. Supplementary irrigation is sometimes given. Soil types, pH. and organic matter content in this area are similar to those of the northern region (Fig. 6).

Groundnut is consumed mainly as roasted nuts in Pakistan. About 85% of the groundnut-growing area is located in the Punjab (Zone V), 11% in the North West Frontier Province (Zones lVa, VII. and V11I), and 5% in the Sind (Zones II and IIIa) (Fig. 7). In 1986/87, average yields were 1.9 t ha^{-1}, and overall production was about 75 000 t. In Rawalpindi, the most important production area, the climate is semi-arid and hot. In summer mean monthly rainfall is about 85 mm, while in winter it is 30 to 45 mm. The length of growing period is from mid-Nov to Jun. Most groundnut is grown as a sole crop, but some is intercropped with sorghum and maize. The usual rotation is groundnut followed by wheat.

Major Stress Factors

The major abiotic stress is drought, particularly in Zone IIIb and in the southern part of Zone V. The effect of drought is clearly illustrated by differences in yield; under rainfed conditions in the main chickpea growing areas (Zones IIIb and V), yields are around 0.4 t ha^{-1}, compared to 0.8 t ha^{-1} under irrigated conditions in Sind (northern part of Zone II). Iron deficiency occurs sporadically in a few less-important chickpea growing areas (e.g.. Rawalpindi in Zone V).

In the north (Zones IIIb, lVa, V, and X), the most serious disease affecting chickpea is ascochyta blight *(Ascochyta rabiei);* wilt *(Fusarium oxysporum* f. sp *ciceri)* is the second most important disease (Fig. 8). In the south (Zone II), wilt and dry root rot *(Rhizoctonia bataticola)* are important, but blight does not occur. Pod borer *(Helicoverpa armigera)* is the predominant pest in Zone II. and also has considerable economic importance in the Potwar area (northern parts of Zones V and IVb). Competition from weeds is a serious problem in all chickpea-growing areas in Pakistan. The major biotic stress reported on groundnut is vertebrate pests, mainly rats (Fig. 7).

Future Prospects

Although the climate is favorable, farmers in areas other than Zones II, IIIb, and V show a relative lack of interest in growing chickpea. There is little potential for increasing the area under cultivation, but yields can be improved substantially, even with existing genotypes.

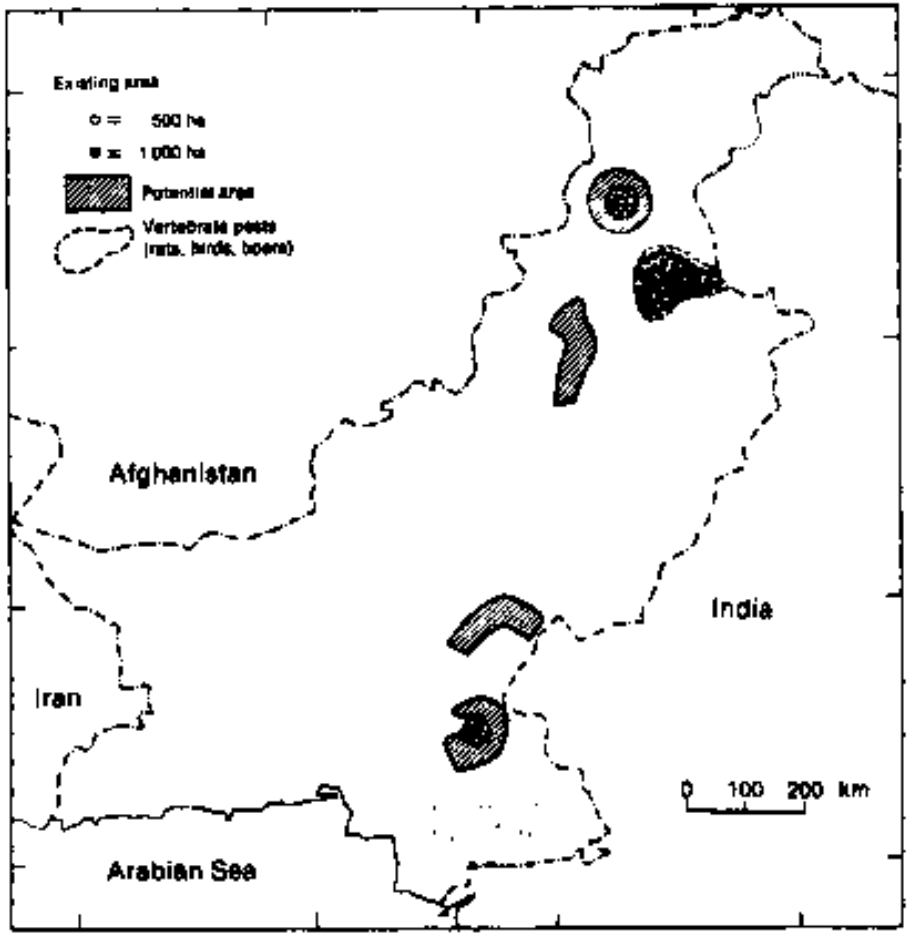


Figure 7. Groundnut distribution, its areas of potential expansion, and biotic stresses affecting this crop in Pakistan.

Existing and potential areas of groundnut production are shown in Figure 7. Low rainfall appears to be the major constraint to expanding groundnut cultivation into new areas.

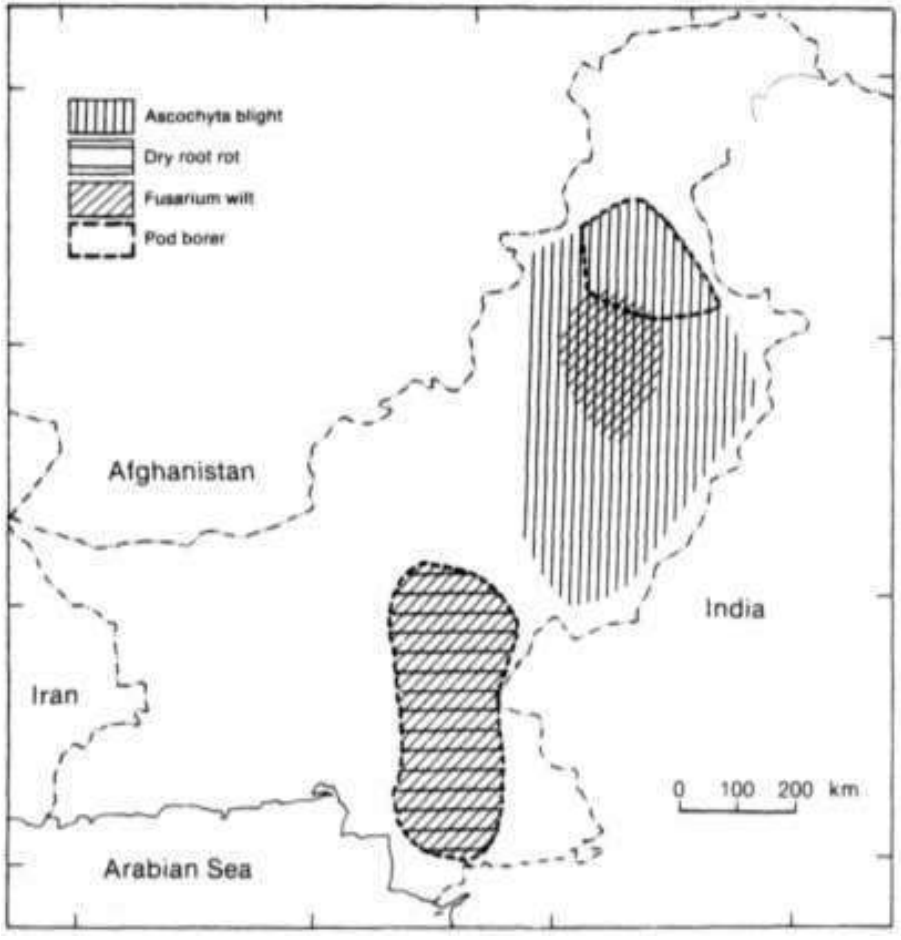


Figure 8. Biotlc stresses of chickpea in Pakistan.

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The Philippines[1]

Introduction

The administrative divisions and important urban centers of the Philippines are shown in Figure 1. The country consists of 7 107 islands and islets scattered over 1 295 000 km^2 of ocean, with a total land area of 300 000 km^2. There are three major island groups, Luzon, Visayas, and Mindanao, that are subdivided into 12 Agricultural Development Regions (Fig. 1).

Chickpea and pigeonpea arc seldom cultivated in the Philippines (Fig. 2).

Groundnut is the most widely cultivated AGLN crop in the Philippines, covering an area of 54 620 ha in 1987. The overall average yield of groundnut in 1987 was 0.86 t ha^{-1}; the highest average yield, 1.80 t ha^{-1}, was obtained from Agricultural Development Region (ADR) I (Ilocos), as shown in Table 1. The crop is grown mostly in ADR II (Cagayan Valley), where it covers 30 130 ha, or about 55% of total groundnut area (Fig. 3). The second most important growing area is in ADR I, with 12% of the total groundnut area.

The comparatively low yields obtained are due to the use of low-yielding cultivars, low inputs, and the fact that groundnut is more commonly grown as an intercrop than as a sole crop. Of total groundnut production, 66% is consumed as food, 26% as feed, and 8% is used as seed.

Table 1. Groundnut urea, production, and productivity bv region in the Philippines, 1987.

Agricultural Development Region		Area ('000 ha)	Production ('000 t)	Average yield (t ha^{-1})
I	Ilocos	6.32	11.39	1.80
II	Cagayan Valley	30.13	21.73	0.72
III	Central Luzon	1.54	1.76	1.14
IV	Southern Tagalog	3.53	3.10	0.88
V	Bicol	1.33	1.06	0.79
VI	Western Visayas	2.05	0.97	0.47
VII	Central Visayas	3.07	2.06	0.67
VIII	Eastern Visayas	1.75	0.79	0.45
IX	Western Mindanao	2.13	1.20	0.56
X	Northern Mindanao	0.66	0.56	0.86
XI	Southern Mindanao	0.86	0.61	0.71
XII	Central Mindanao	1.25	1.75	1.40
	All of the Philippines	54.62	46.98	0.86

Source: Bureau of Agricultural Statistics, The Philippines.

Crop Distribution in Relation to Agroclimatic Factors

In the Philippines, groundnut can be grown throughout the year. In general, the dry-season crop sown in Oct or Nov gives higher yields and nuts of better quality than the rainy-season crop. This is because adequate radiation is available during the dry season, which the crop needs for reproductive development. Groundnut grown during the rainy season tends to produce fewer pods, and these are more likely to rot and germinate in the field.

Groundnut fits well into many cropping systems. Although researchers agree that yields are reduced when groundnut is intercropped, owing to competition, the overall productivity of the system has been found to be higher than that of sole cropping. In the Philippines, a common practice is to intercrop groundnut between rows of maize. Although groundnut yields arc reduced by 20 to 30% when intercropped, the combined productivity of the two crops is 30 to 50% higher than when either is sole cropped. Further, the incidence of maize borer *(Chilo partcllus)* infestation is significantly reduced in the maize-groundnut intercropping system.

Groundnut is sometimes intercropped with sugarcane, cassava, and okra, or may be sown between rows of coconut, papaya, and young citrus trees.

Soils suitable for groundnut include Orthic Luvisols, Ochric Andosols, Orthic Acrisols, Dystric Nitosols, and Eutric Cambisols. Generally, soils suitable for groundnut cultivation are well drained, medium textured (loam, silt loam, silty clay loam, sandy clay loam, sandy loam), moderately to slightly acidic (pH 5.5 to 6.5), deep (about 50 cm topsoil), and relatively fertile. Poorly drained soils should be avoided, since groundnut cannot tolerate excessive soil moisture during growth.

1. This section was prepared by C.R. Escano, Philippine Council for Agriculture and Resources Research and Development, Los Banos; C.A. Cabrido Jr, Department of Agrarian Reform, Quezon City, and R.C. Aladin, College of Agriculture, Isabela State University, Isabela, the Philippines, in cooperation with the following resource persons from ICR1SAT: D.O. Faris and P.W. Amin.

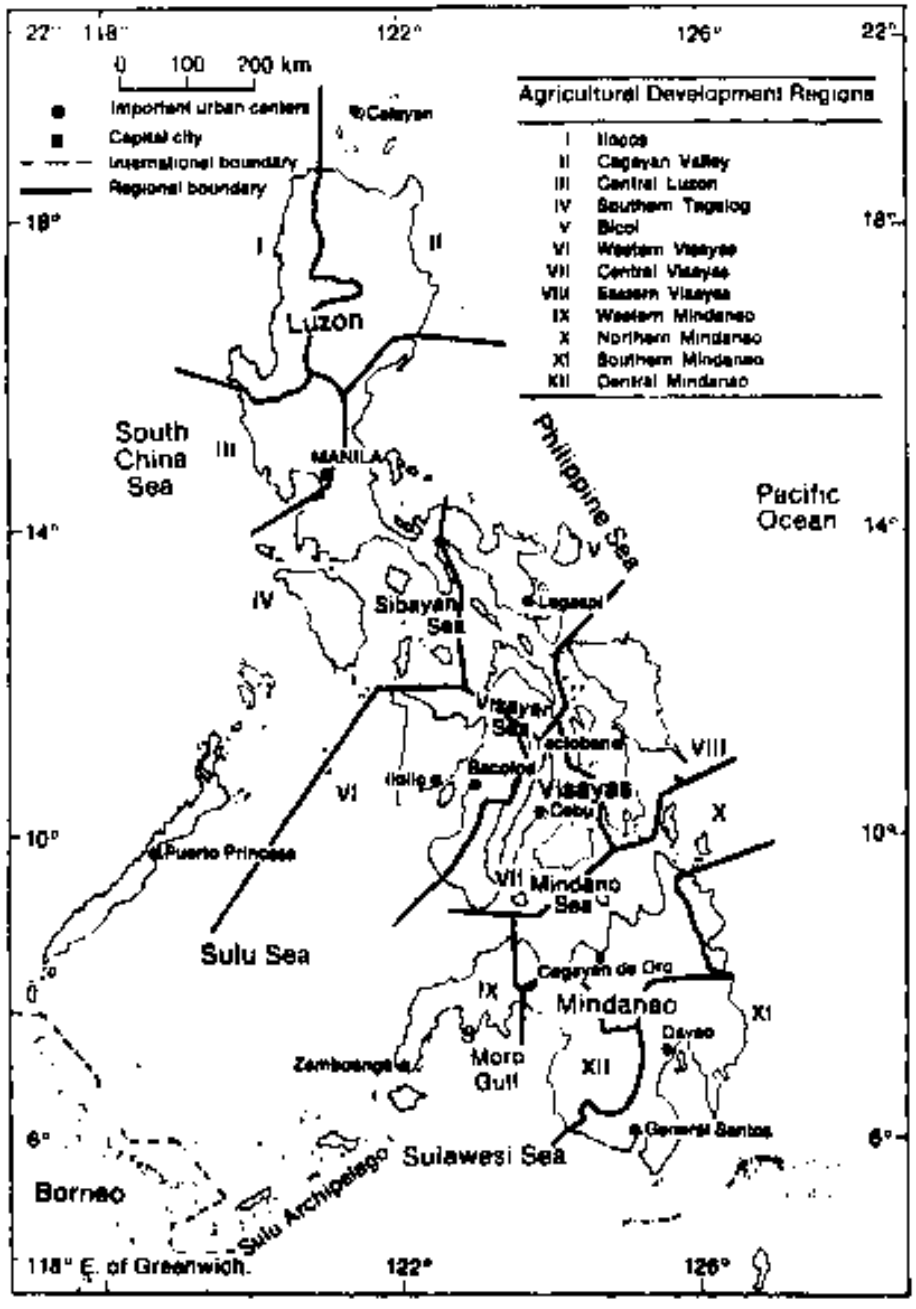

Figure 1. Administrative divisions of the Philippines.

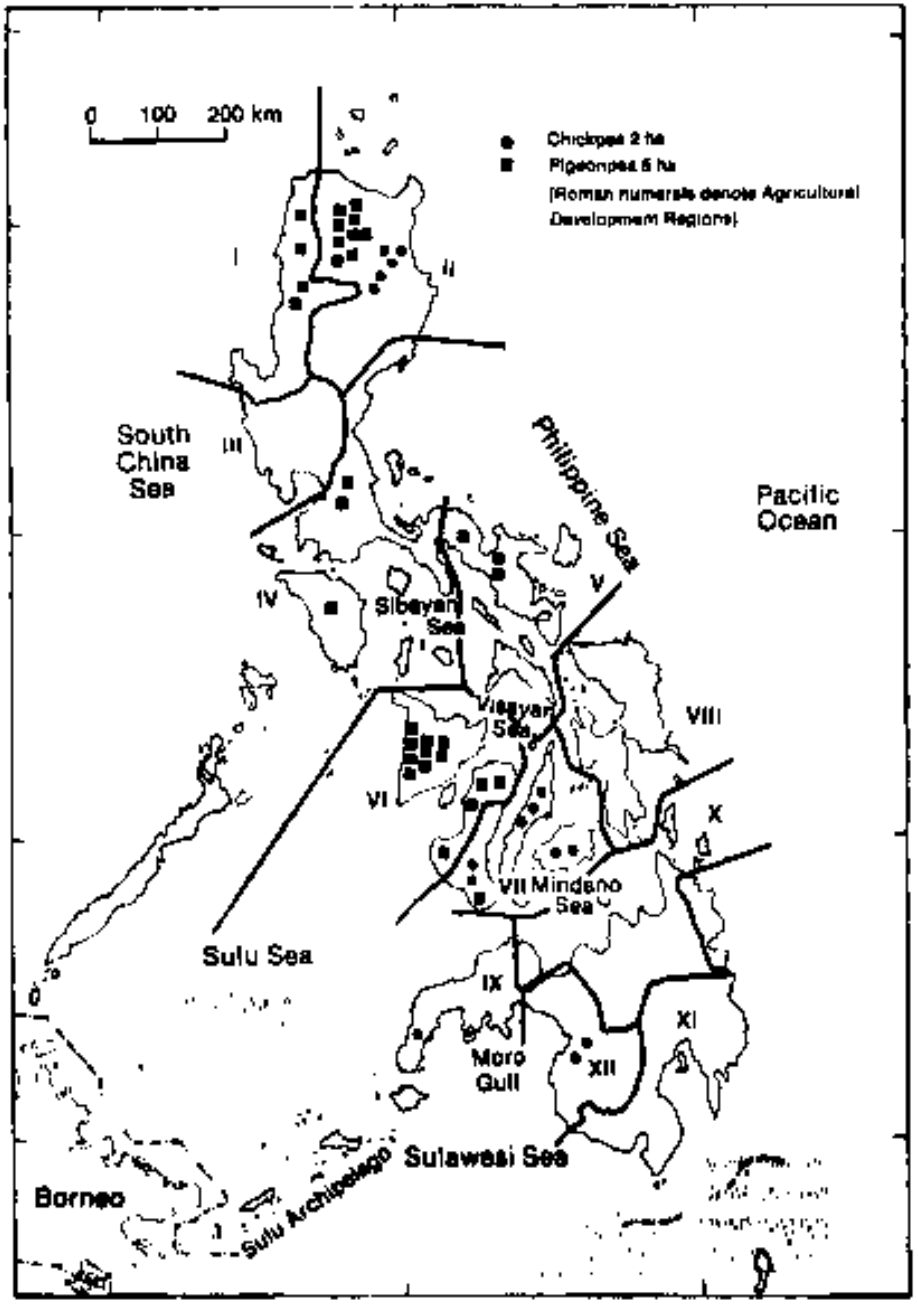

Figure 2. Chickpea and pigeonpea distribution in the Philippines.

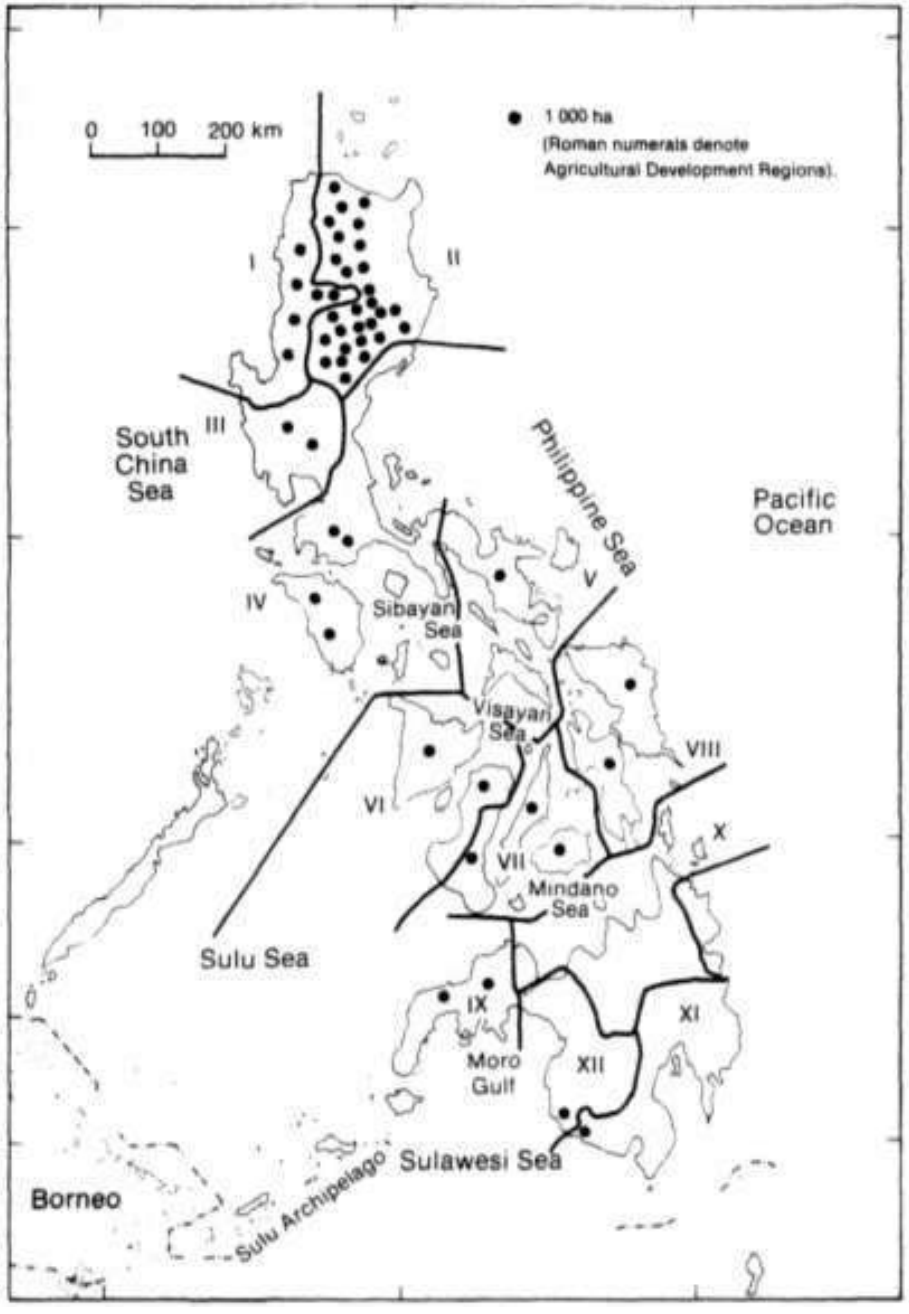

Figure 3. Groundnut distribution in the Philippine*.

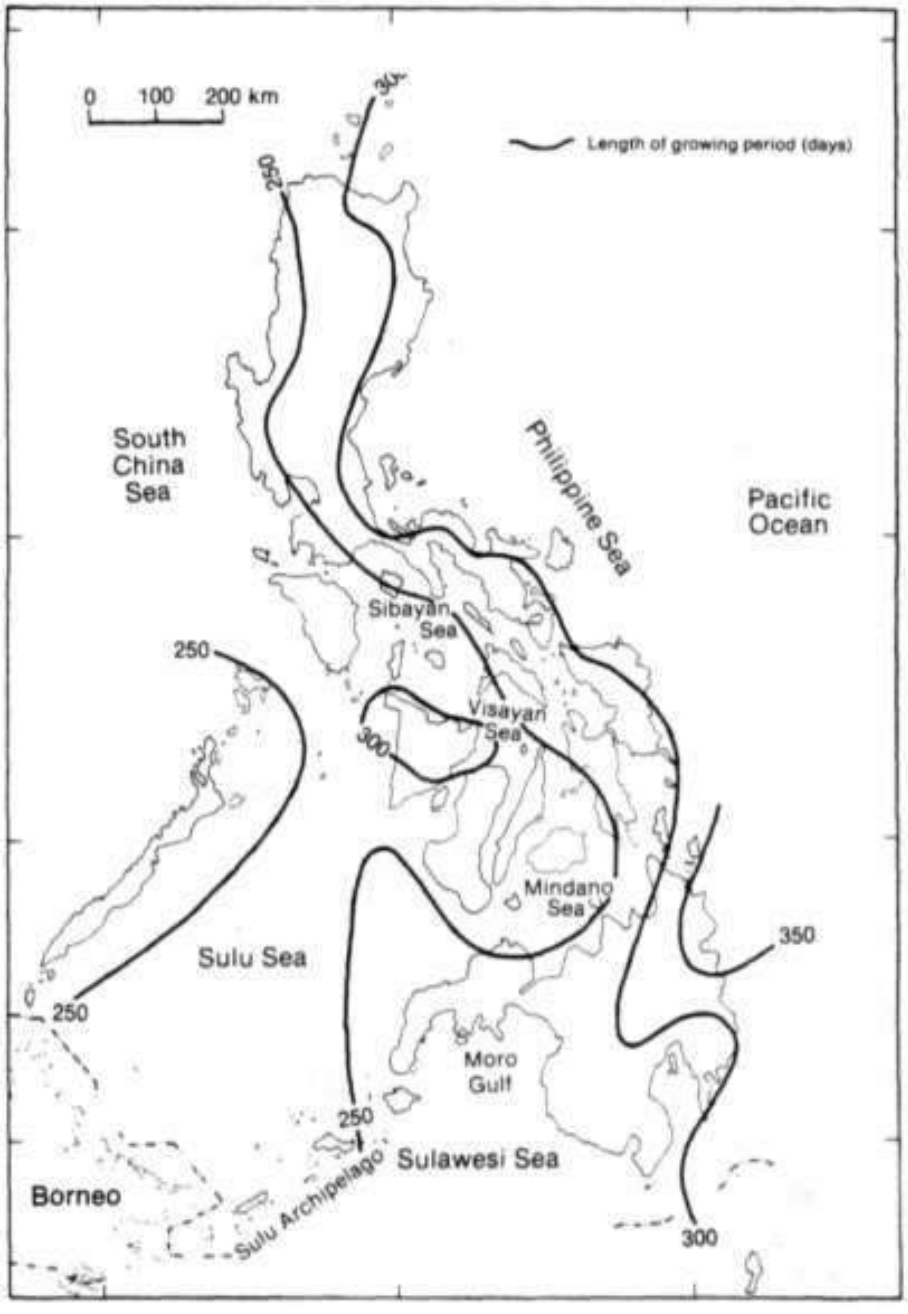

Figure 4. Length of growing period In the Philippines.

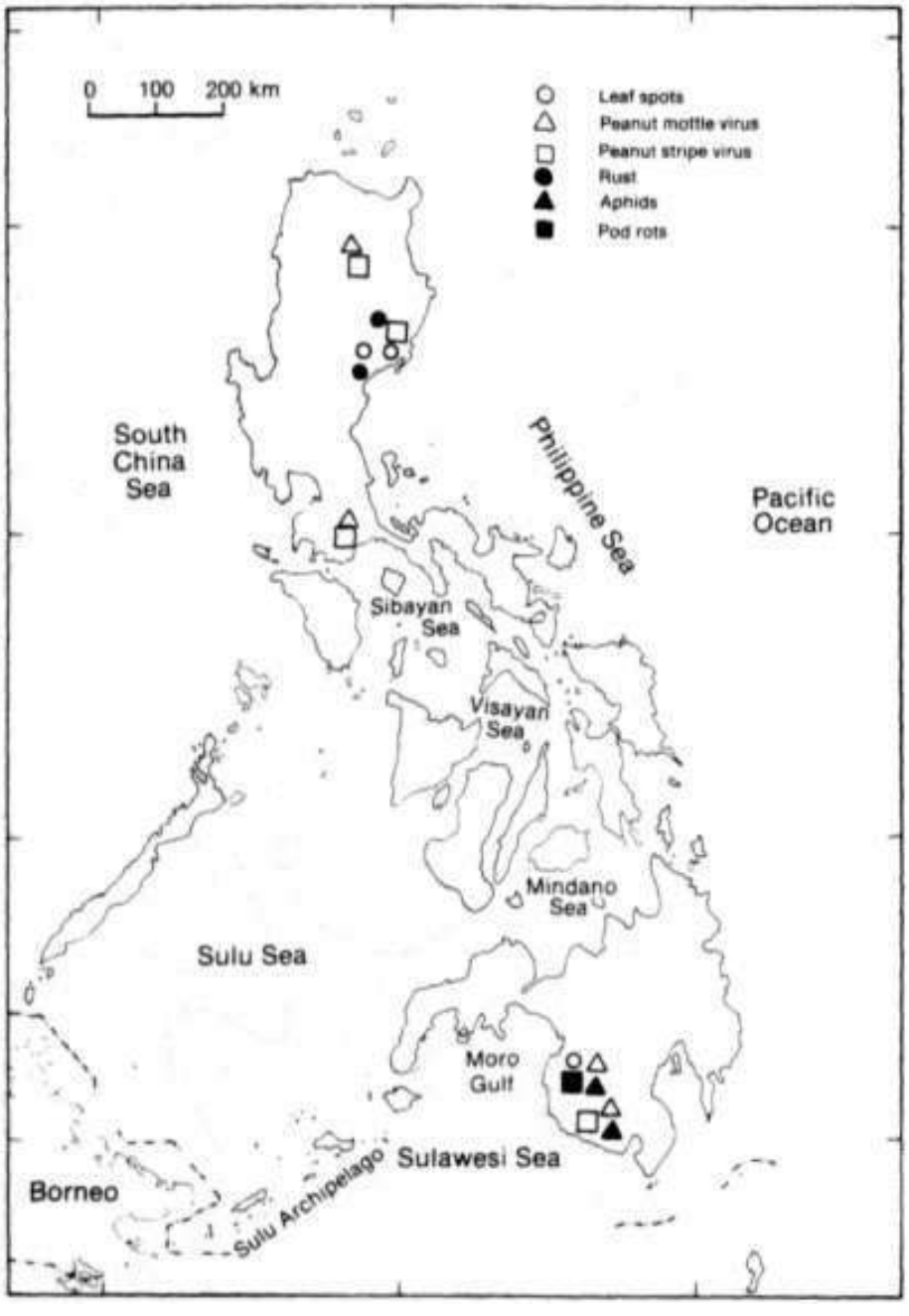

Figure 5. Biotic stresses affecting groundnut production In the Philippines.

In the Philippines, the average length of the growing period is 270 days. The three major zones identified on the basis of length of growing period are: more than 300 days; 250-300 days; and less than 250 days (Fig. 4). Mean annual temperature ranges from 25 to 27'C. The minimum growing period for groundnut is 90-140 days and the optimum temperature range is 25 to 30℃.

Major Stress Factors

Figure 5 shows the geographical occurrence of widespread diseases and insect pests of groundnut in the Philippines. Leaf spots *(Cercospora arachidicola* and *Phaeoisariopsis personata)* and peanut stripe (PStV) and mottle (PMV) viral diseases are common and occur in practically all groundnut-growing regions of the country. Rust *(Puccinia arachidis)* occurs in the north and pod rots in the south of the country. Aphids *{Aphis craccivora)* are the most common insect pest identified.

Future Prospects

As Figure 6 indicates, large parts of the country are suitable for groundnut cultivation, and production could be expanded. Chickpea and pigeonpea will remain minor crops, although the socioeconomic and marketing assessments currently being carried out by the Government may reveal some potential for expansion.

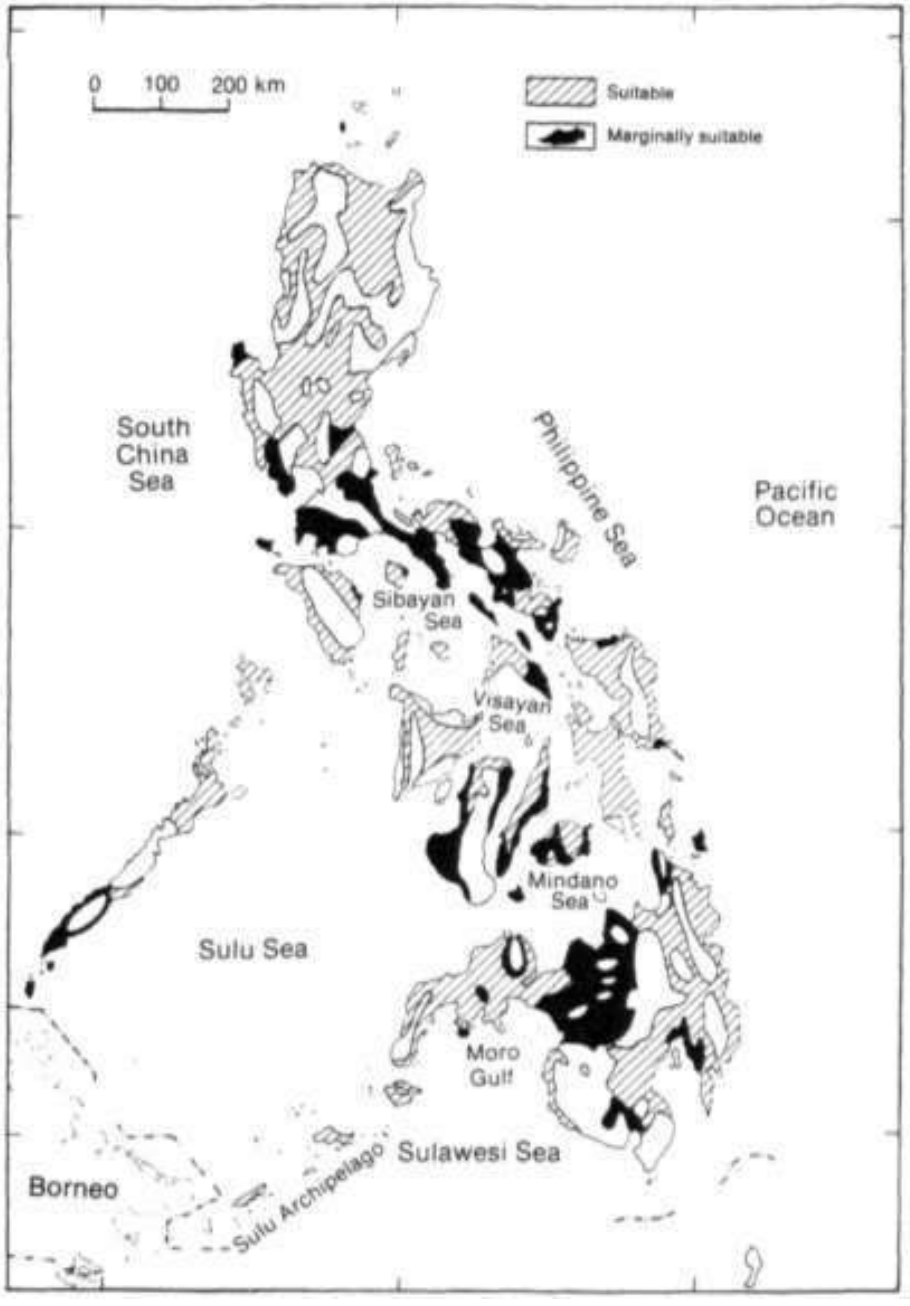

Figure 6. Potential areas for expanding groundnut cultivation in the Philippines.

Sri Lanka[1]

Introduction

The administrative divisions and important urban centers of Sri Lanka are shown in Figure 1. The country is divided into 24 districts.

Groundnut, mung bean, cowpea, and black gram are the most important grain legumes traditionally grown under subsistence farming conditions, mainly in the dry and intermediate zones (Fig. 2).

Among AGLN crops, hardly any chickpea is grown in Sri Lanka, but attempts are underway to test its suitability in some areas. Pigeonpea is ideally suited to the rainfed farming conditions of the dry zone. Prior to 1974, the crop was cultivated on 1300 ha. Attempts to popularize the crop in subsequent years failed owing to heavy losses caused by insect pests, particularly pod borers *(Maruca testulalis, Helicoverpa armigera,* and *Lampides boeticus).* Presently, long-duration pigeonpea is grown on small homestead plots for domestic consumption. However, there is a great potential for this crop in Sri Lanka provided effective and economically viable pest control methods are introduced. Groundnut is grown on about 8 000 ha. Most of it is consumed locally as snacks, but a small proportion is exported to the Middle East.

Crop Distribution in Relation to Agroclimatic Factors

There are three main climatic zones in Sri Lanka: wet, dry, and intermediate (Fig. 2). These three climatic zones are divided into seven major agroecological regions on the basis of agroclimate and altitude. While the wet and intermediate zones range from 'low country'(< 300 m above sea level) and 'mid country' (300-900 m) to 'up country' (> 900 m), the vast dry zone lies exclusively in the 'low country'. The low country is flat or undulating, while the mid and up country varies from undulating, through rolling, hilly and steeply dissected, to mountainous. The dry and intermediate climatic zones are divided into 10 agroecological zones and sub-zones (Table 1), each with its unique pattern of rainfall, elevation, land form, and soil type (Fig. 3). All of these are suitable for legume production (Table 1)

Table 1. Characteristics of agroecological zones identified as suitable for legumes in Sri Lanka.

Climatic zone	Agroecological zones and subzones	Major soil groups	Landform
Intermediate	Up country (IU2)[1]	Red-Yellow Podzolic soils and Mountain Regosols	Mountainous, steeply dissected, hilly and rolling
Intermediate	Up country (IU3)	Red-Yellow Podzolic soils	Steeply dissected, hilly and rolling
Intermediate	Mid country (IM2)	Red-Yellow Podzolic soils	Steeply dissected. hilly and rolling
Intermediate	Mid country (IM3)	Immature Brown Loams, Reddish Brown Latosolic soils, and Reddish Brown Earths	Steeply dissected, hilly and rolling
Intermediate	Low country (ILI)	Red-Yellow Podzolic soils with strongly mottled subsoil, Low Humic Gley soils, with soft and hard laterite, and Regosols on red and yellow sands	Rolling, undulating, and flat
Intermediate	Low country (IL2)	Reddish Brown Earths, Non Calcic Brown soils, and Low Humic Gley soils	Rolling, hilly, and undulating
Intermediate	Low country (IL3)	Reddish Brown Earths, Non Calcic Brown soils, and Low Humic Gley soils	Undulating

Continued

1. This section was prepared by S.J.B.A. Jayasekera. Department of Agriculture, Pallekele. and R.P.K. Kannangara, Department of Agriculture. Peradeniya, Sri Lanka, in cooperation with the following resource persons from ICRISAT: B.C.G. Gunasekera and C.L.L. Gowda.

Table 1 continued

Climatic zone	Agroccological zones and subzones	Major soil groups	Landform
Dry	Low country (DL1)	Reddish Brown Earths and Low Humic Gley soils	Undulating
		Non Calcic Brown soils, Reddish Brown Earths, soils on old alluvium, Solodized Solonetzes, Low Humic Gley soils, and Regosols	Undulating and flat
Dry	Low country (DL3)	Red-Yellow Latosols and Regosols	Flat to slightly undulating

1. Items in parentheses are subzones (see Figure 3)

In Sri Lanka, pigeonpea and groundnut are grown mainly in the dry zone and in some parts of the intermediate zone. The most important production (actor in the dry zone is sufficiency and reliability of rainfall. Rainfall generally increases from the low country to the up country and from coastal areas towards the heartland (Fig. 4). The mean annual rainfall of the dry zone ranges from 1250 mm to 2000 mm. Rainfall follows a bimodal pattern in most parts of the dry zone, under the influence of the northeast and southwest monsoons, which form the two cropping seasons, *maha* (Oct-Jan) and *yala* (Mar-Jul). About two-thirds of the total annual rainfall is received during the *maha* season. There are two distinct dry spells, from Feb to Mar and from May to Sep. The length of the growing period is presented in Figure 5. In most parts of the dry zone, the growing period is more than 180 days.

The predominant soil groups in the dry region are the Reddish Brown Earths that have low water-holding capacity and harden quickly after rain. The Non Calcic Brown soils on the east coast have very low fertility. The Red-Yellow Latosols on the northern tip of the island, where groundwater is close to the surface, are intensively cultivated with high-value crops. Some saline and alkaline soils are found along the coastal belt (Fig 6).

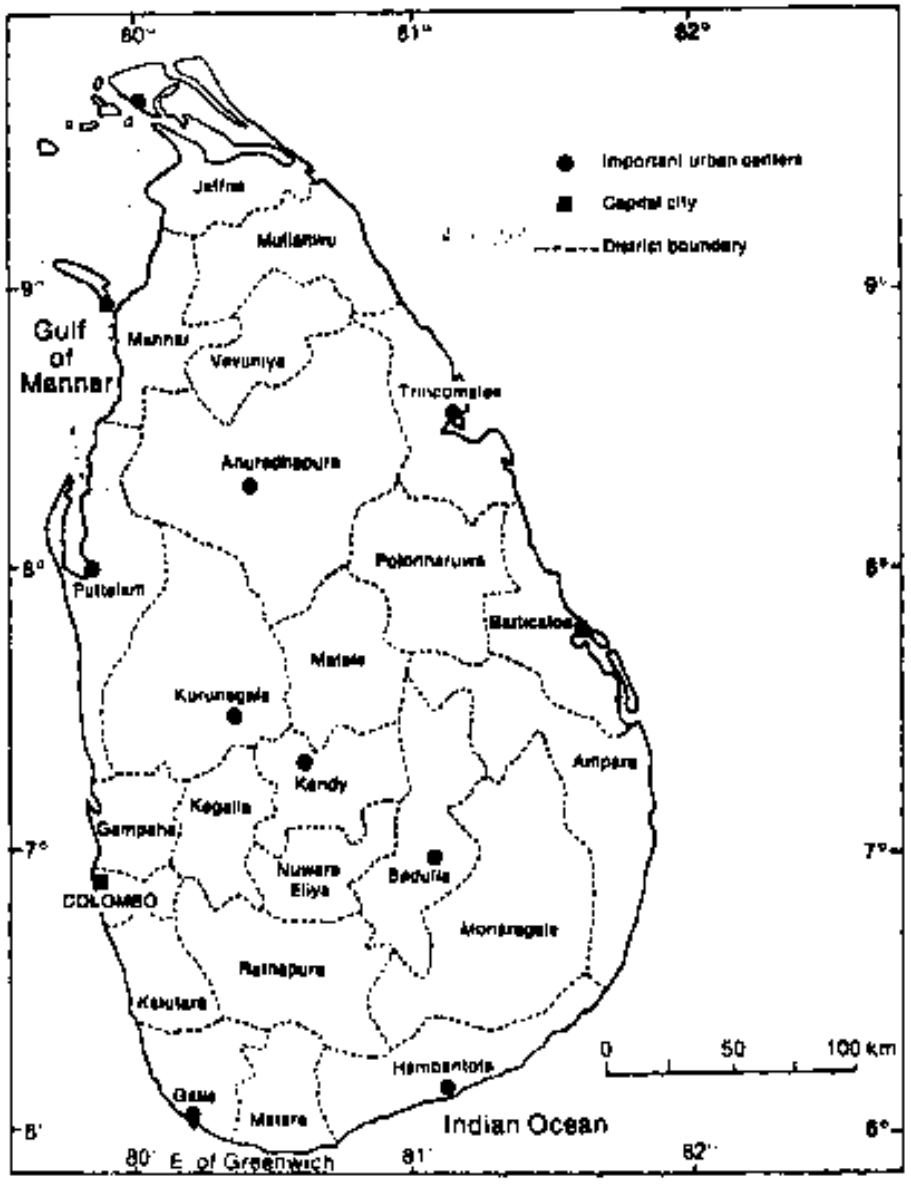

Figure 1. Administrative divisions of Sri Lanka.

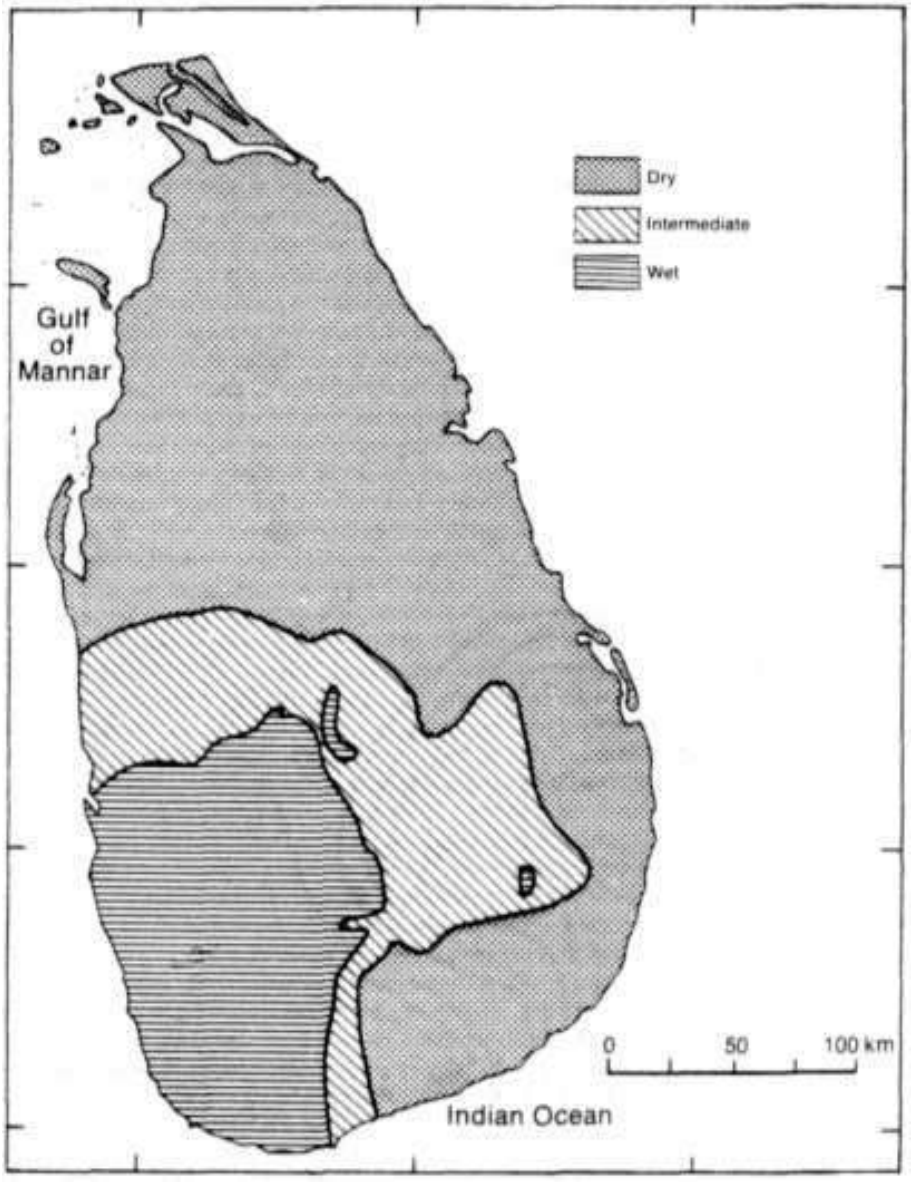

Figure 2. Climatic zones of Sri Lanka.

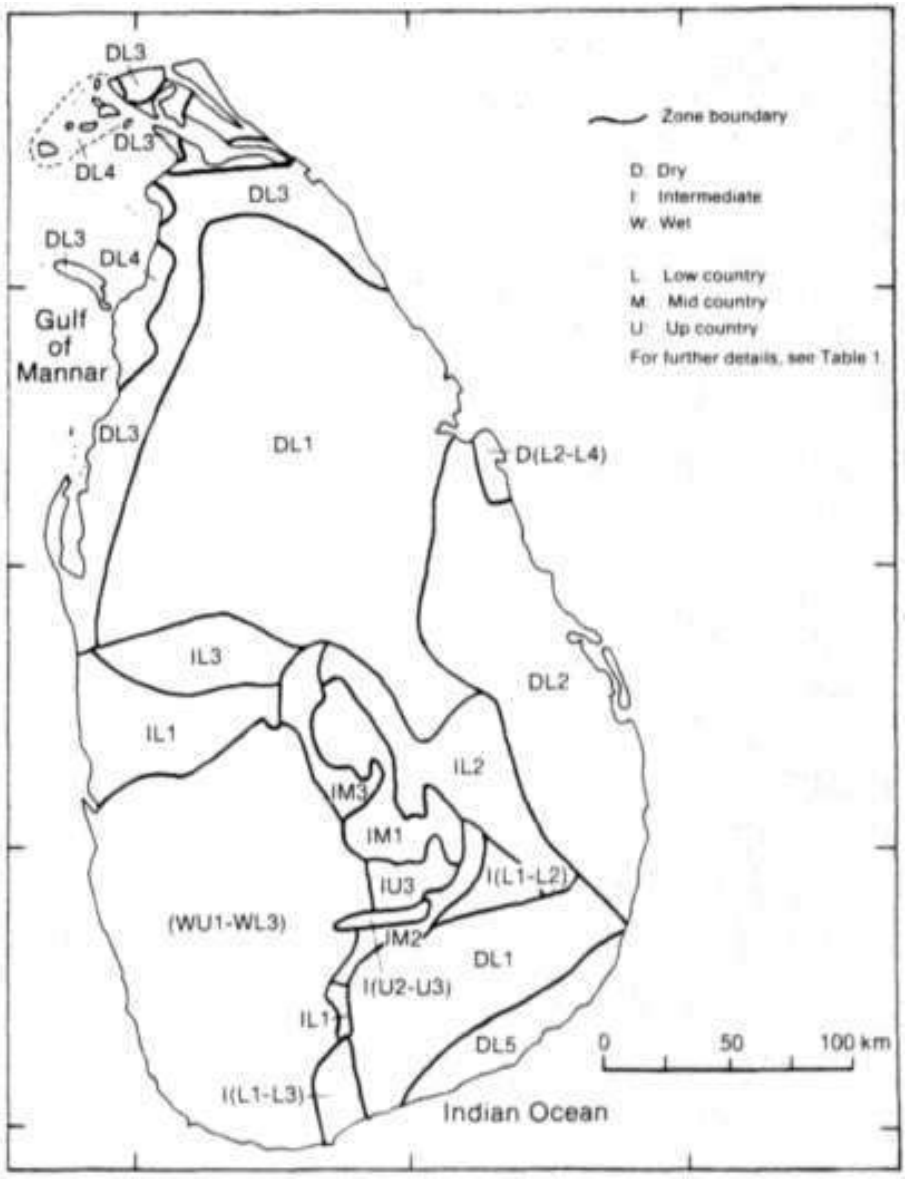

Figure 3. Agroecological zones of Sri Lanka.

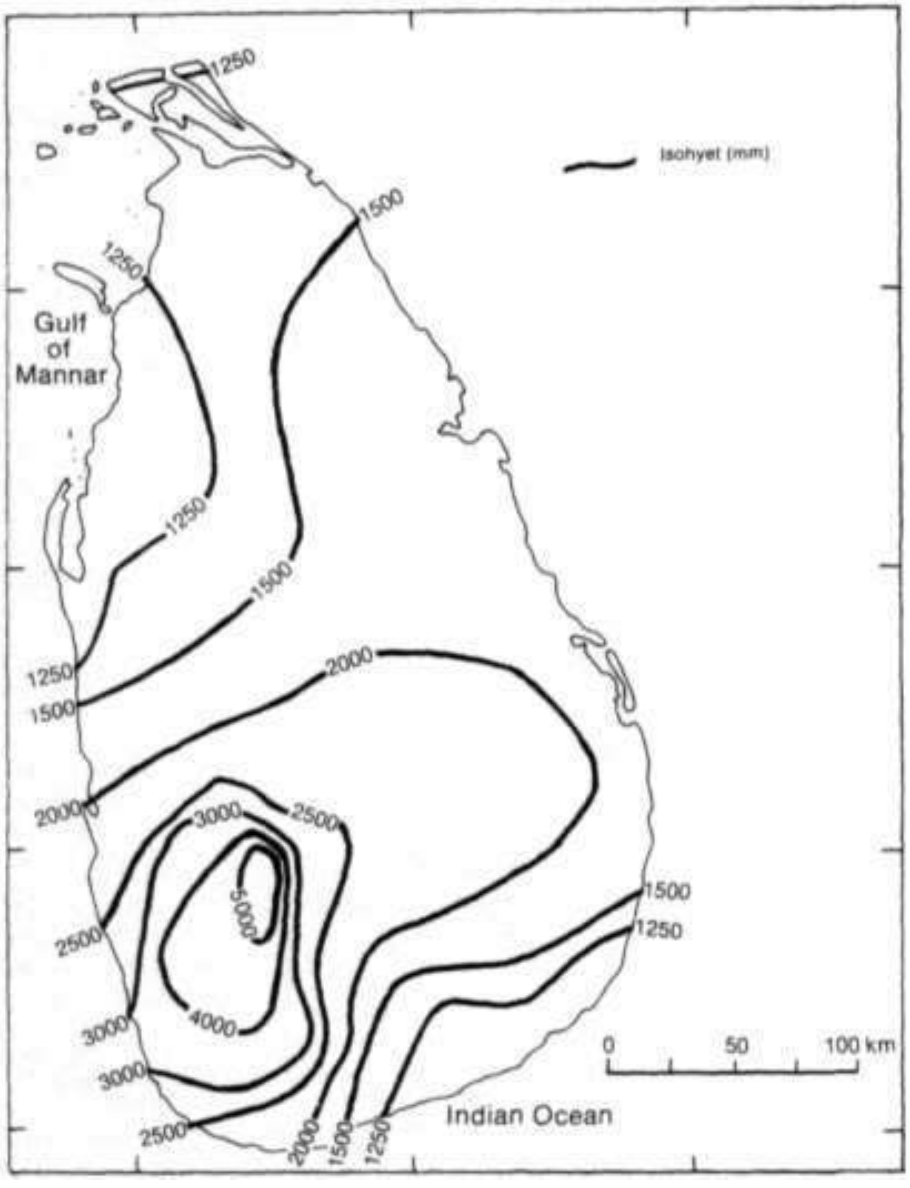

Figure 4. Mean annual rainfall in Sri Lanka.

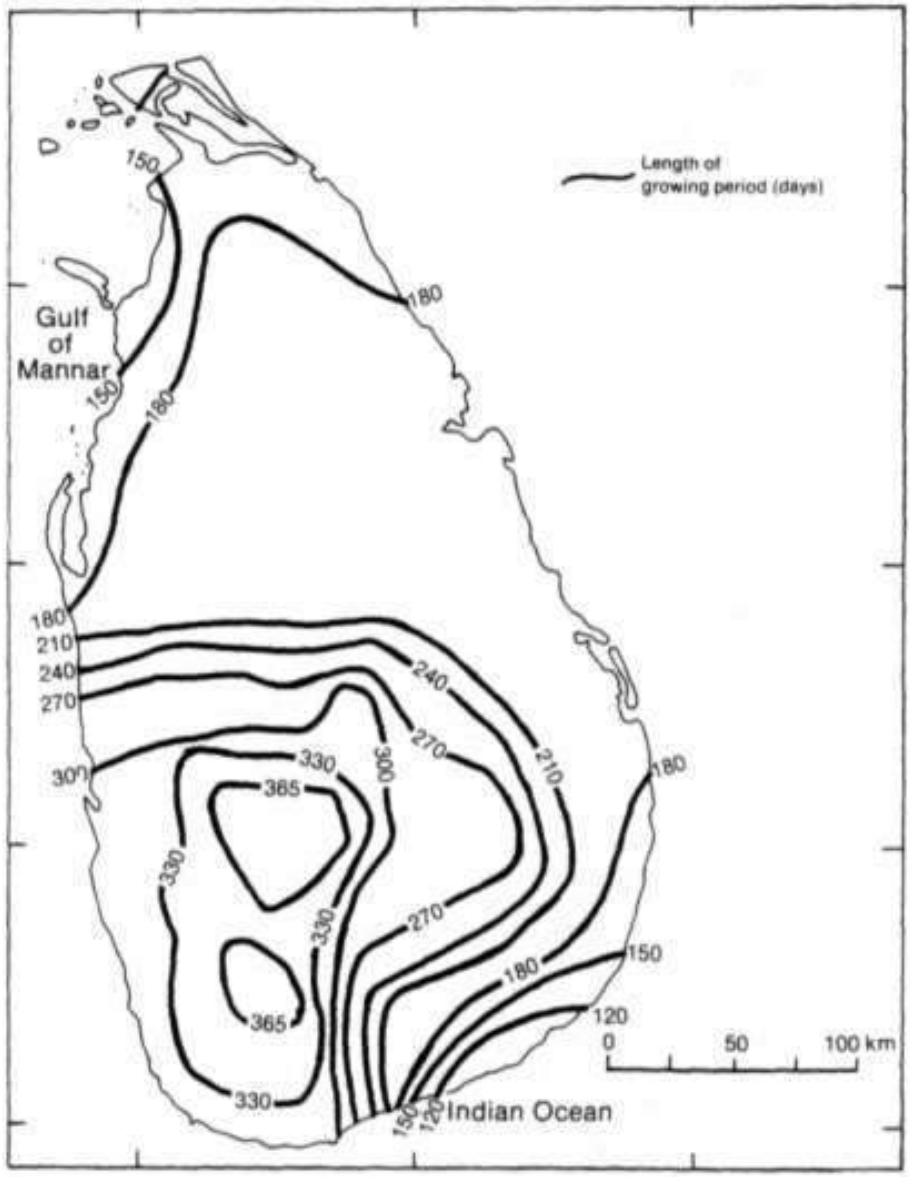

Figure 5. Length of the growing period in Sri Lanka.

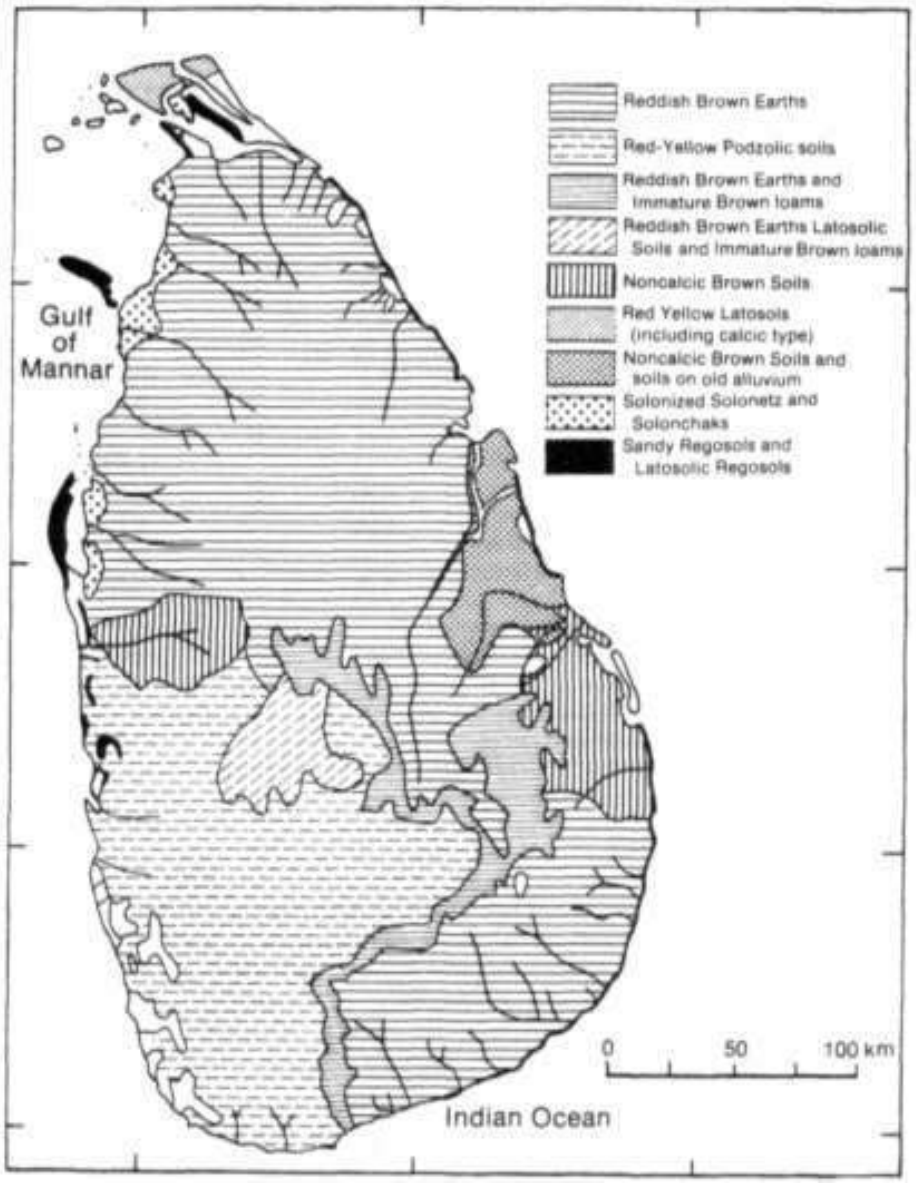

Figure 6. Distribution of major soil types in Sri Lanka.

Since chickpea is thermosensitive and requires cool night temperatures for pod development, most parts of the country are not suitable for chickpea cultivation. However, northern areas of the dry zone (DL3 and DL1) and some parts of the intermediate zone (IU2 and IU3) experience low temperatures with low humidity during Dec, Jan, and Feb. Chickpea is a potential maha-season crop in these areas (Fig. 7).

Decorticated split seeds of pigeonpea are sometimes used as a substitute for imported lentils to make *dhal* in Sri Lanka. Pigeonpea has wide adaptability and thrives under marginal conditions, where most legumes cannot be grown. Further, the wide range of maturity groups, perennial growth habit, and ratoonability, increase its adaptability to different farming systems. Resistance to drought, lodging, and shattering, combined with its ability to enrich soil through nitrogen fixation, make this crop an important candidate for inclusion in the farming systems of the dry zone as a sole crop, and also as an intercrop with coconuts in the intermediate zone. Potential areas for pigeonpea cultivation are shown in Figure 7.

The systems of groundnut cultivation used by farmers in the uplands and lowlands have led to four land use patterns. They arc:

- sole cropping or intercropping systems of the rainfed uplands;
- sole cropping or intercropping systems of the rainfed lowlands;
- major irrigation systems; and
- minor irrigation systems.

Over 80% of the groundnut crop is cultivated under rainfed conditions. Major determinants of yields in rainfed areas are soil type and fertility, and the availability of soil moisture during crop growth. Seedbed preparation, germination, and the early stages of crop growth are entirely dependent on the amount and frequency of precipitation. Groundnut is grown both in the *maha* and *yala* crop seasons. Since the *maha* season receives more rainfall, approximately 70% of cultivation occurs during this season.

Figure 8 shows the groundnut growing areas in Sri Lanka in 1984/85. Area and production by district are shown in Table 2. Monaragala, Puttalam, Ampara, Kurunegala, Hambantota, Badulla, and Mullaitivu are the major groundnut growing districts.

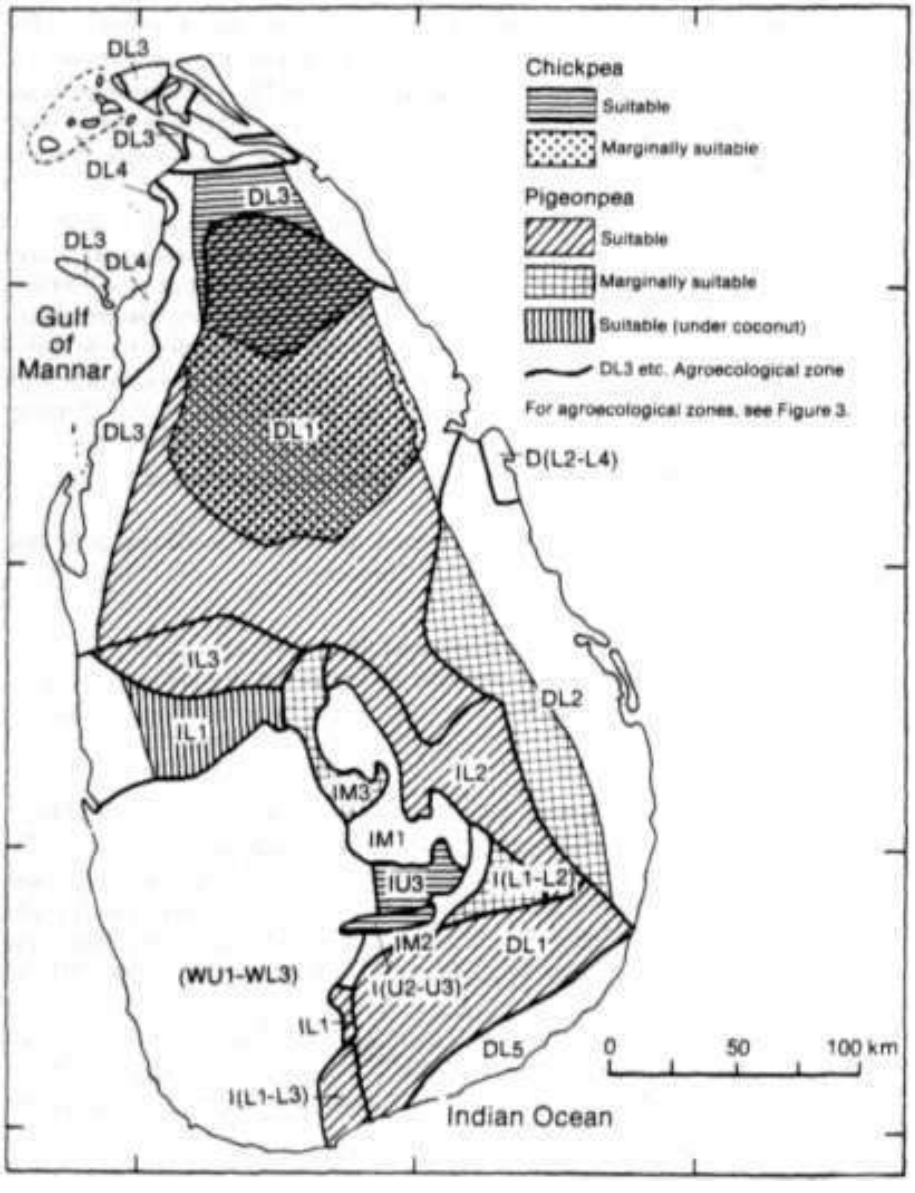

Figure 7. Potential areas tor expanding chickpea and pigeonpea cultivation in Sri Lanka.

Table 2. Groundnut area, production, and productivity by district in Sri Lanka, 1984/85.

District	Area ('000 ha)	Production ('000 t)	Average yield (t ha^{-1})
Monaragala	1.95	2.68	1.37
Puttalam	1.05	1.02	0.97
Ampara	0.96	0.76	0.79
Kurunegala	0.75	0.88	1.17
Hambantota	0.54	0.54	1.00
Badulla	0.52	0.55	1.05
Mullaitivu	0.50	0.50	1.00
Ratnapura	0.43	0.29	0.67
Polonnaruwa	0.41	0.39	0.95
Vavuniya	0.29	0.31	1.06
Anuradhapura	0.20	0.18	0.90
Batticaloa	0.20	0.20	1.00
Trincomalee	0.09	0.08	0.88
Matale	0.07	0.04	0.57
Kandy	0.02	0.03	1.50
Jaffna	0.02	0.02	1.00
Mannar	0.01	0.01	1.00
All Sri Lanka	8.02	8.49	1.05

Source: Department of Agriculture, Sri Lanka.

Major Stress Factors

Drought during establishment and early growth, flash floods, and rains or excessive moisture at harvest constitute the major abiotic stresses.

Biotic stresses to groundnut arc early *(Cercospora arachidicola)* and late *(Phaeoisariopsis personam)* leaf spot, rust *(Puccinia arachidis),* and bud necrosis disease (caused by tomato spotted wilt virus) (Fig. 9). Stem rot *(Sclerotium rolfsii)* has also been observed. The groundnut cultivars grown at present are susceptible to these diseases. Important insect pests include aphids *(Aphis craccivora),* thrips *(Scirtothrips dorsalis, Frankliniella* sp), jassids *(Empoasca* sp), and white grubs *(Lachnosterna sp)* (Fig. 9). Other insect pests, such as leaf feeders *(Spodoptera litura),* and pod borers *(Helicoverpa armigera* and *Anisolubis* sp), occasionally occur.

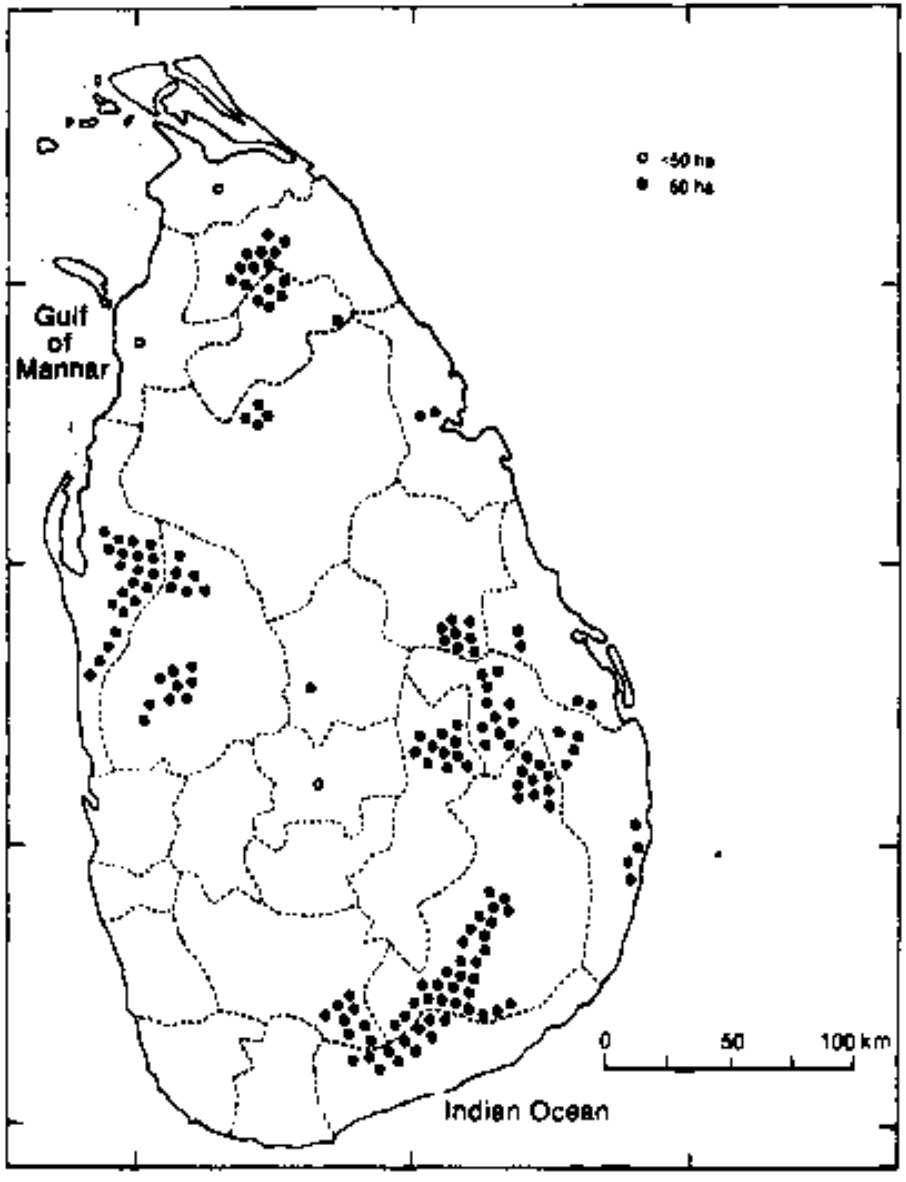

Figure 8. Groundnut distribution (1984/85) in Sri Lanka.

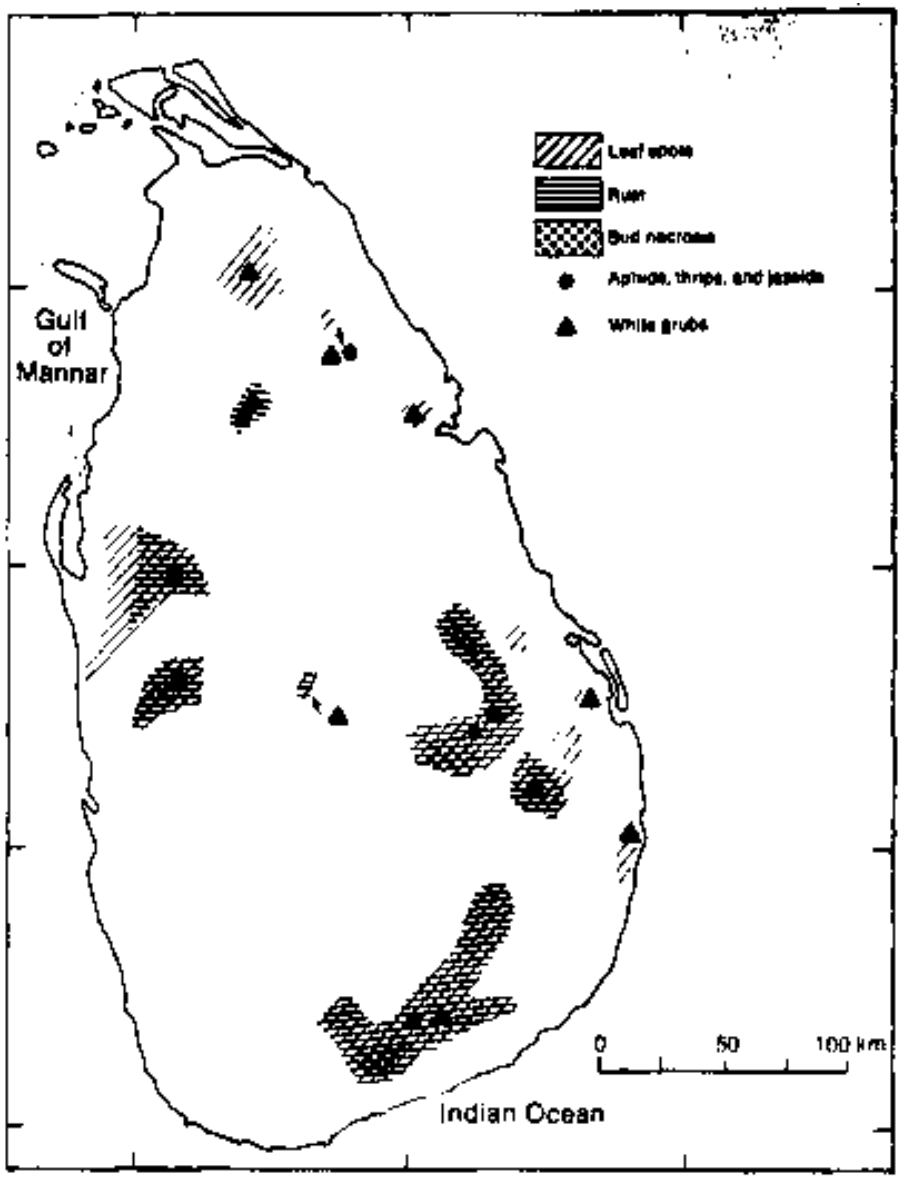

Figure 9. Biotic stresses Affecting groundnut production in Sri Lanka.

Future Prospects

Pigeonpea has great potential in many parts of the dry and intermediate zones of Sri Lanka, but the problem of insect damage, particularly by pod borers *(Maruca testulalis, Helicoverpa armigera,* and *Lampides boeticus)* has frustrated efforts to promote the crop. Considerable importance should be attached to solving this problem.

Groundnut cultivars resistant to early and late leaf spots, rust, and bud necrosis, that combine high yields with strong appeal to consumer tastes are required. Tolerance to common pests would also be valuable. The need for varieties adapted to low levels of management is increasing. Research on the development of early-maturing varieties for cultivation during the *yala* season is needed.

Thailand[1]

Introduction

The administrative divisions and important urban centers of Thailand are shown in Figure 1. The country is divided into the North, Northeast. Central, and South Regions.

The geographical area of Thailand is about 51.4 million ha, of which 16.8 million ha is cropped. Only 17% of the cropped area is irrigated. The Phetchabun mountain range forms a natural barrier between the North and Northeast Regions and between the Northeast and Central Regions. The Tenneserin mountains are on the west coast. Areas of the Northeast and South Regions receiving more than 1500 mm annual rainfall are more agriculturally important than the others.

Groundnut is the most important AGLN crop in Thailand, and most of it is used for producing cooking oil and cake. In the past 10 years production has varied substantially owing to fluctuating prices. Total groundnut area in 1986/87 was 117 000 ha, scattered throughout the country (Table 1).

The major growing area is the North Region, where groundnut covers 55% of the total cultivated area. The second and third most important regions arc the Northeast where groundnut occupies 25% of the cultivated area, and the Central Region where groundnut occupies 15% of the total cultivated area (Fig. 2). In the North, Northeast, and Central Regions groundnut is grown mainly as a sole crop. In the South Region groundnut occupies only 5% of the cultivated area; mostly as an intercrop between young rubber trees.

As Table 1 indicates, most of the total annual production of groundnut is from the North and Northeast Regions. The average yield (dry pods) is highest in the North and Central Regions and lowest in the South Region.

Crop Distribution in Relation to Agroclimatic Factors

Figure 3 shows mean annual rainfall for the 30-year period (1931 to 1961) for Thailand. Rainfall on the west coast of the South Region and on the east coast of the Central Region is relatively high due to the southwest monsoon and the downwind effect of mountain ranges. There are rainshadow areas of lower rainfall (about 800-1000 mm) on the leeward side of the Tenneserin and Phetchabun mountain ranges. The northern part of the Northeast Region, which is prone to cyclonic rain and is influenced by wind from the Gulf of Tonkin, generally receives more rain than the rest of the Region.

The agroclimatic zones of Thailand based on rainfall (R) and soils (S) are shown in Figure 4. By using a water balance model and assuming the soil water holding capacity to be 100 mm, the length of the growing period in different areas has been calculated (Fig. 5). The growing period is longest in the South Region, usually 250-365 days. The Central and North Regions, where groundnut is important, have a growing period of 200-240 days; and in the Northeast Region the growing period is 180-200 days.

The area sown to chickpea in Thailand is very small. The crop is usually grown in the northern highlands, along the Thai-Myanmar border.

In Thailand, pigeonpea is grown mostly as a perennial crop. Many local varieties are grown in village backyards. Farm families consume green pods as a vegetable. In the North Region pigeonpea is grown on about 1000 ha mainly as a host for lac-producing insects. Short-duration pigeonpea is currently being tested on research stations throughout the country. Medium-duration cultivars are being tested in farmers' fields in the Northeast Region.

Groundnut is sown at any time of year, but mainly in May, at the beginning of

Table 1. Groundnut area, production, and productivity by region in Thailand, 1985-87.

	Area ('000 ha)		Production ('000 t)		Yield 0 ha^{-1})	
Region	1985/86	1986/87	1985/86	1986/87	1985/86	1986/87
Northeast	34	33	45	42	1.32	1.27
North	61	61	88	97	1.44	1.59
Central	19	17	29	24	1.53	1.41
South	7	6	9	7	1.29	1.17
All Thailand	121	117	171	170	1.41	1.45

Source: Department of Agriculture, Bangkok, Thailand.

1. This section was prepared by Somporn Isaranurak and Nark Potan, Department of Agriculture, Bangkok. Thailand. in cooperation with the following resource persons from ICRISAT: A. Mohammed (Consultant, Resource Management Program) and S.S. Lateef.

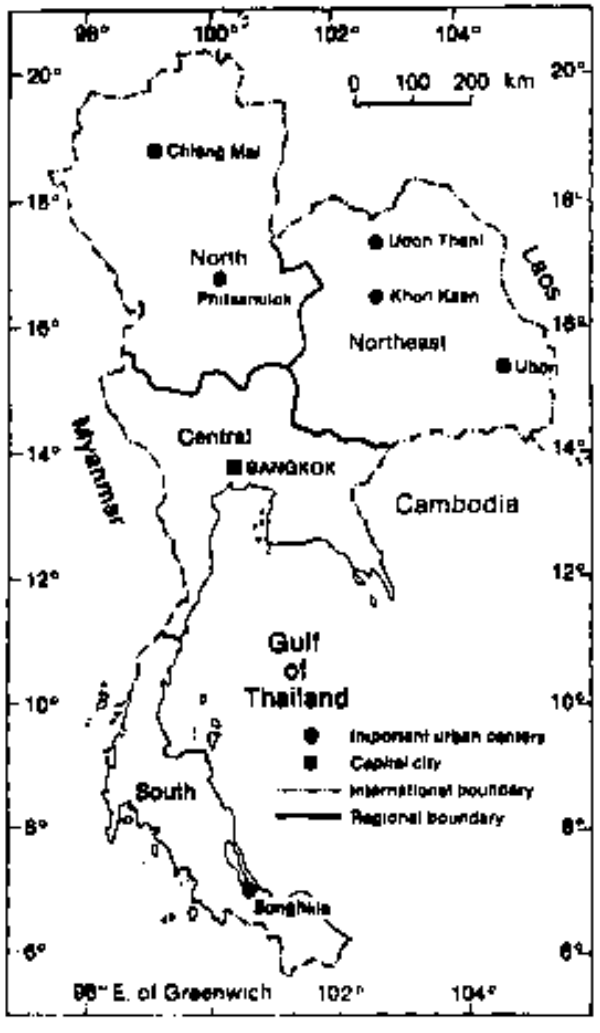

Figure 1. Administrative divisions of Thailand.

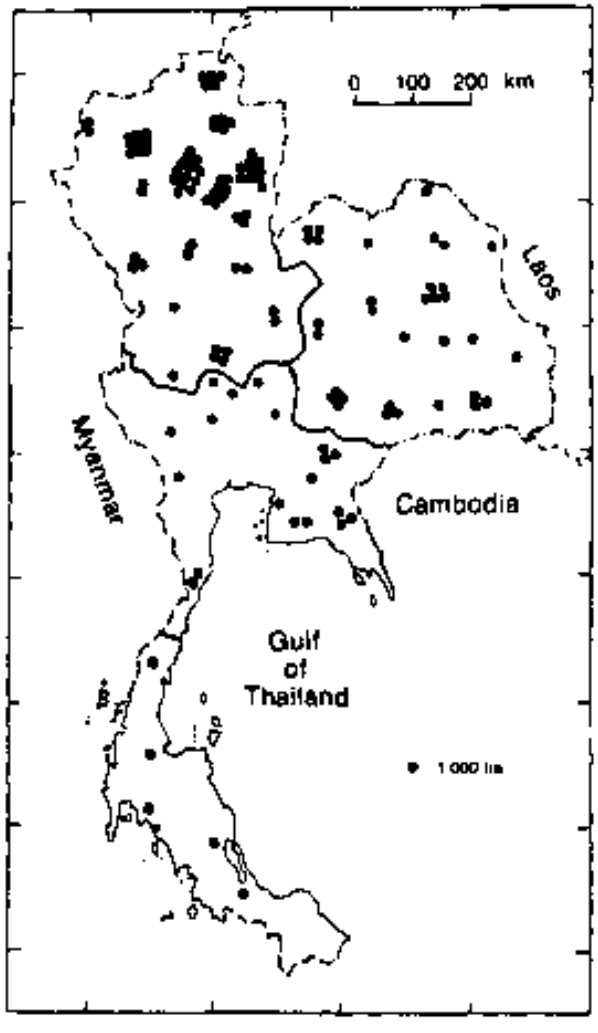

Figure 2. Groundnut distribution In Thailand.

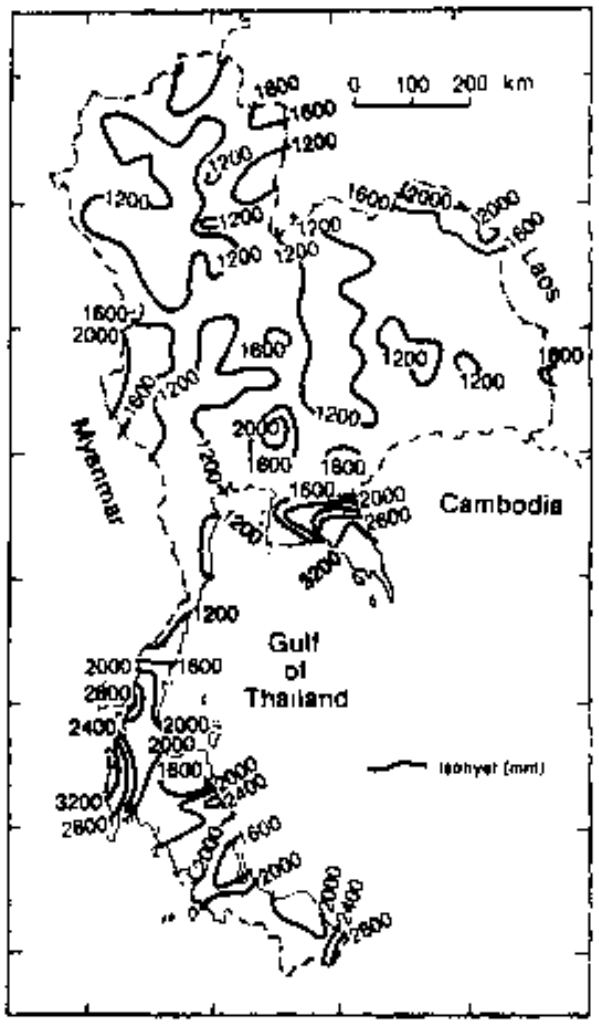

Figure 3. Mean annual rainfall In Thailand

the rainy season. This sowing period applies to 40% of all groundnut-growing areas. The second most important sowing period, accounting for 30% of the total cultivated area, is in the middle or late rainy season in Aug and Sep. A third sowing period, accounting for 15% of the total cultivated area, applies to irrigated areas, mostly in the North and Northeast Regions, where groundnut is sown after rice, in Jan.

Major Stress Factors

The main biotic stresses for pigeonpea in the Northeast Region are lepidopteran webbers *(Grapholita* sp and *Maruca testulalis)* and pod borers *(Helicoverpa* sp and *Maruca* sp), which can cause severe yield loss in short-duration genotypes. Particularly harmful are *Helicoverpa armigera, Maruca testulalis,* and *Grapholita*

(Cydia) critica. Podfly *(Melanagromyza obtusa)* and pod bugs *(Clavigralla* spp) are major yield reducers in the North Region.

More than 80% of the groundnut crop in Thailand is grown on rainfed uplands. Rainfall - either too much or too little - is the main factor limiting yields. Groundnut sown in May is often subject to drought in Jul, which can reduce yield. Groundnut sown in the middle and late rainy season must contend with rapidly receding moisture availability if the rains end early. High rainfall in Aug and Sep inhibits land preparation. Further, waterlogging is also a problem during crop establishment.

Figures 6 and 7 show the extent of incidence of the four most important groundnut diseases in Thailand. Early leaf spot (*Cercospora arachidicola*) is widespread in the rainy season in the Northeast Region (Fig. 6). Late leaf spot

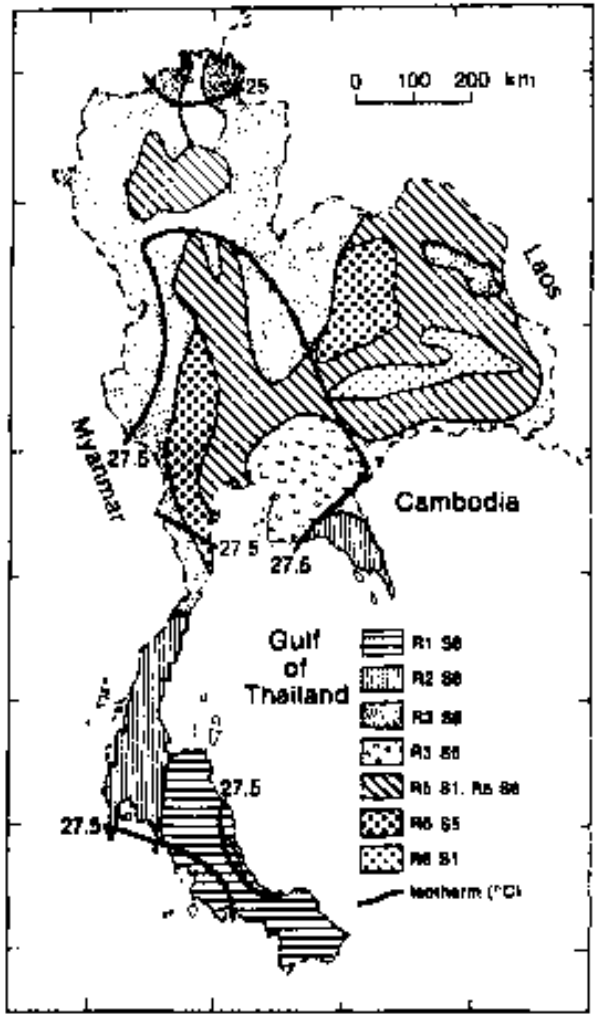

Figure 4. Agroclimatic zones of Thailand.

R1 S6 Adequate or surplus rainfall throughout the year; soils Ultisols and Oxisols.

R2 S6 Adequate rainfall with some dry period during the year; soils Ultisols and Oxisols.

R3 S6 Adequate rainfall during main cropping season; soils Ultisols and Oxisols,

R3 S5 Adequate rainfall during main cropping season; soils mainly Alfisols.

R5 S1 Rainfall received during main cropping season but
R5 S6 variable and some droughts occur; soils mainly Entisols.

R6 S5 High degree of variability of rainfall; soils mainly Alfisols.

R6 S1 High degree of variability of rainfall; soils mainly Entisols

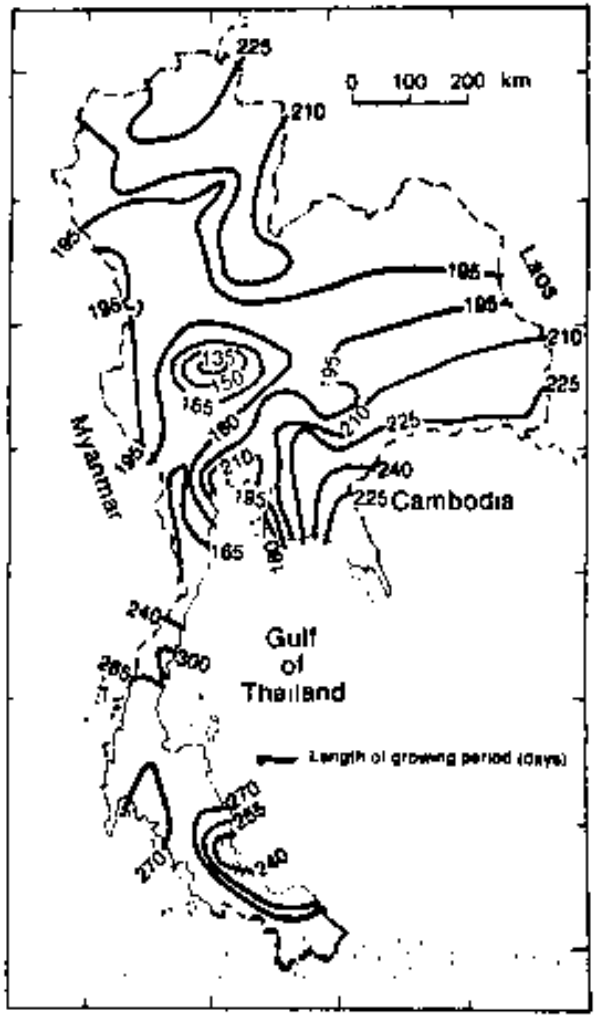

Figure 5. Length of growing period in Thailand.

(Phaeoisariopsis pcrsormta) is a serious disease in the rainy season, but becomes less important in the dry season. It is widespread in the North and Northeast Regions (Fig. 7). The distribution of rust *(Puccinia arachidis)* is similar to that of late leaf spot, but the disease is generally less important. Peanut yellow spot virus (PYSV) is widespread in the North and Northeast Regions in the rainy season, but is less common in the Central Region (Fig. 6). Less important groundnut diseases include peanut stripe virus (PStV), seedling blight *(Asperaillus* spp), peanut mottle virus (PMV), and stem rot *(Sclerotium rolfsii).*

The most important insects of groundnut are leaf miner *{Apwaerema modicella),* jassids *(Empoasca* spp), and thrips *(Scirtothrips dorsalis, Frankliniella* spp); they occur throughout the area sown to groundnut. Subterranean ants *(Dory-Ins* spp) are found in some locations.

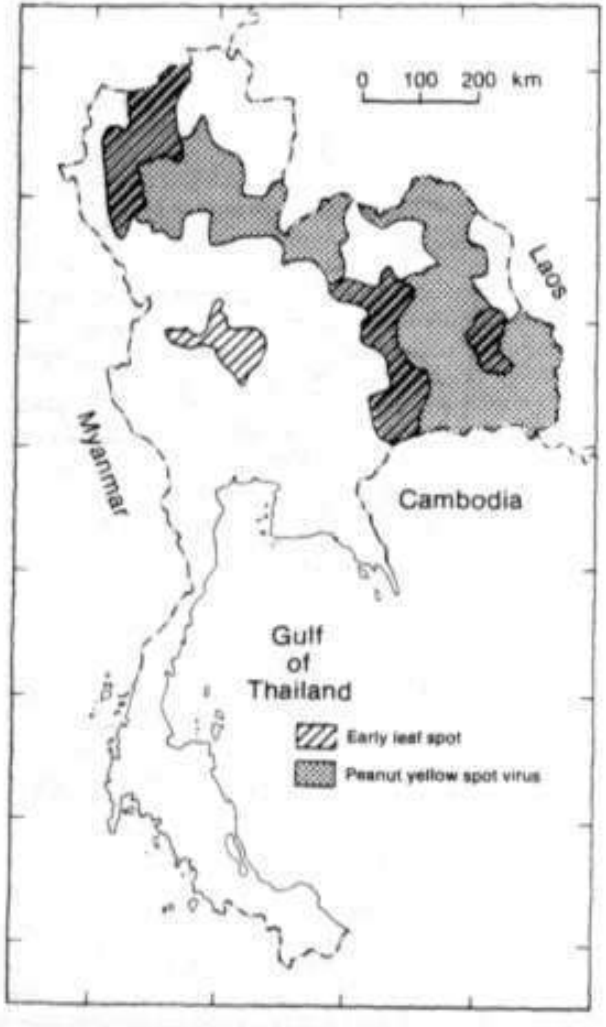

Figure 6. Occurrence of early leaf spot and peanut yellow spot virus diseases on groundnut in Thailand.

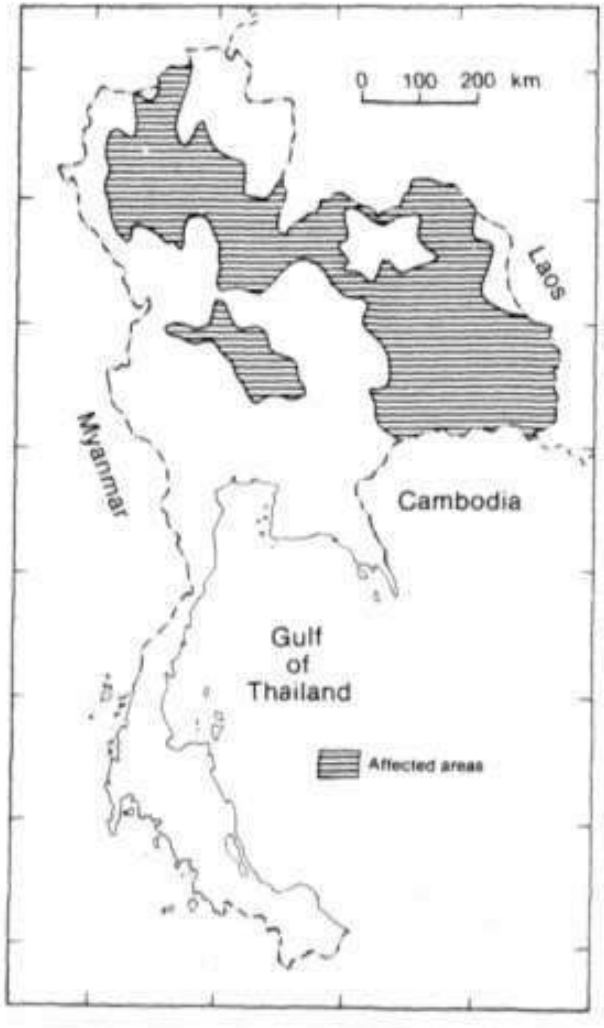

Figure 7. Occurrence of late leaf spot and rust diseases of groundnut in Thailand.

Figure 8. Potential areas for expanding pigeonpea cultivation in Thailand.

Future Prospects

As indicated in Figure 8, there are two main areas in which pigeonpea cultivation could be expanded. These are the drier parts of the North, Northeast, and Central Regions, where upland cropping systems predominate and soils are well drained, although low in fertility, and in the South Region, where there is a distinct dry season. However, pigeonpea is a new crop for Thailand and studies on its introduction must take into account the socioeconomic constraints experienced by farmers. Chickpea is likely to remain a minor crop. Efficient water management could help stabilize and increase groundnut yields.

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