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PAKISTAN-SWISS POTATO DEVELOPMENT PROJECT

POTATO ATLAS AND COMPENDIUM OF PAKISTAN

POTATO PRODUCTION BY AGRO-ECOLOGICAL ZONES

PAKISTAN AGRICULTURAL RESEARCH COUNCIL
ISLAMABAD

December 1991
(Second Edition)

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Urs Zanoni

PAKISTAN AGRICULTURAL RESEARCH COUNCIL
Islamabad

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FOREWORD

The first edition of the Potato Atlas of Pakistan was published by the Pak-Swiss Potato Development Project (PSPDP) of the Pakistan Agricultural Research Council (PARC) in 1989. The Potato Atlas summarized the knowledge about the potato farming systems in Pakistan accumulated mostly since 1984 when the project started its activities.

In the two years since the first edition, more data and information have been collected. Significant changes in the farming systems have occurred. It was therefore felt that a second edition was needed to give an up-to-date picture of the current status, the constraints, and the potential of potato production in Pakistan.

It is hoped that this publication will serve as a reference and working paper for researchers, planners, policy makers, and members of the farming community.

(Dr. Zafar Altaf)
Chairman, PARC

Islamabad
December, 1991

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I am grateful to Dr. K. Naumann-Etienne who accompanied me during two field trips, who guided me in technical matters concerning potato production, and whose knowledge about Pakistan's flora, fauna, climate, and farming systems helped to refine the agro-ecological zones.

I am also very grateful to Mr. R. Eberlin whose editing skills helped to improve this edition. Without his effort the atlas would still be in the draft stage.

My special thanks also go to the numerous drivers who drove us safely around during the last six months.

Last but not least I want to thank the Swiss Federal Institute of Technology, Zürich, the Swiss Development Corporation, Mr. A. Jäckle, Intercooperation, Bern, and Dr. A.E. Smith, Chief Technical Advisor, for the financial and logistical support to carry out this study.

Dr. U. Zanoni
Islamabad
November, 1991

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PREFACE

The second edition of the Potato Atlas of Pakistan follows the same conceptual framework as the first edition. The information is presented according to eight agro-ecological potato production zones. These zones were initially defined in the first edition, were thoroughly discussed in a project internal workshop, and then were further refined during this study.

The information presented is a result of reviewing secondary data, visiting the different agro-ecological zones of Pakistan, and interviewing researchers, traders, staff in the agricultural offices, and farmers.

Potato farming systems in Pakistan are quite complex and diverse due to the wide variability of climatic, socio-economic, cultural, and agronomic conditions. Thus, it was not possible to visit and complete all eight zones as thoroughly as wished in the six months of this study. However, the information within each zone is presented in the same way so that more information can be added later as it becomes available.

For those who wish to have a general overview of the potato farming system in Pakistan, they may consult the first part of this edition which summarizes and compares all eight agro-ecological zones as a quick reference.

Dr. U. Zanoni
Islamabad
November, 1991

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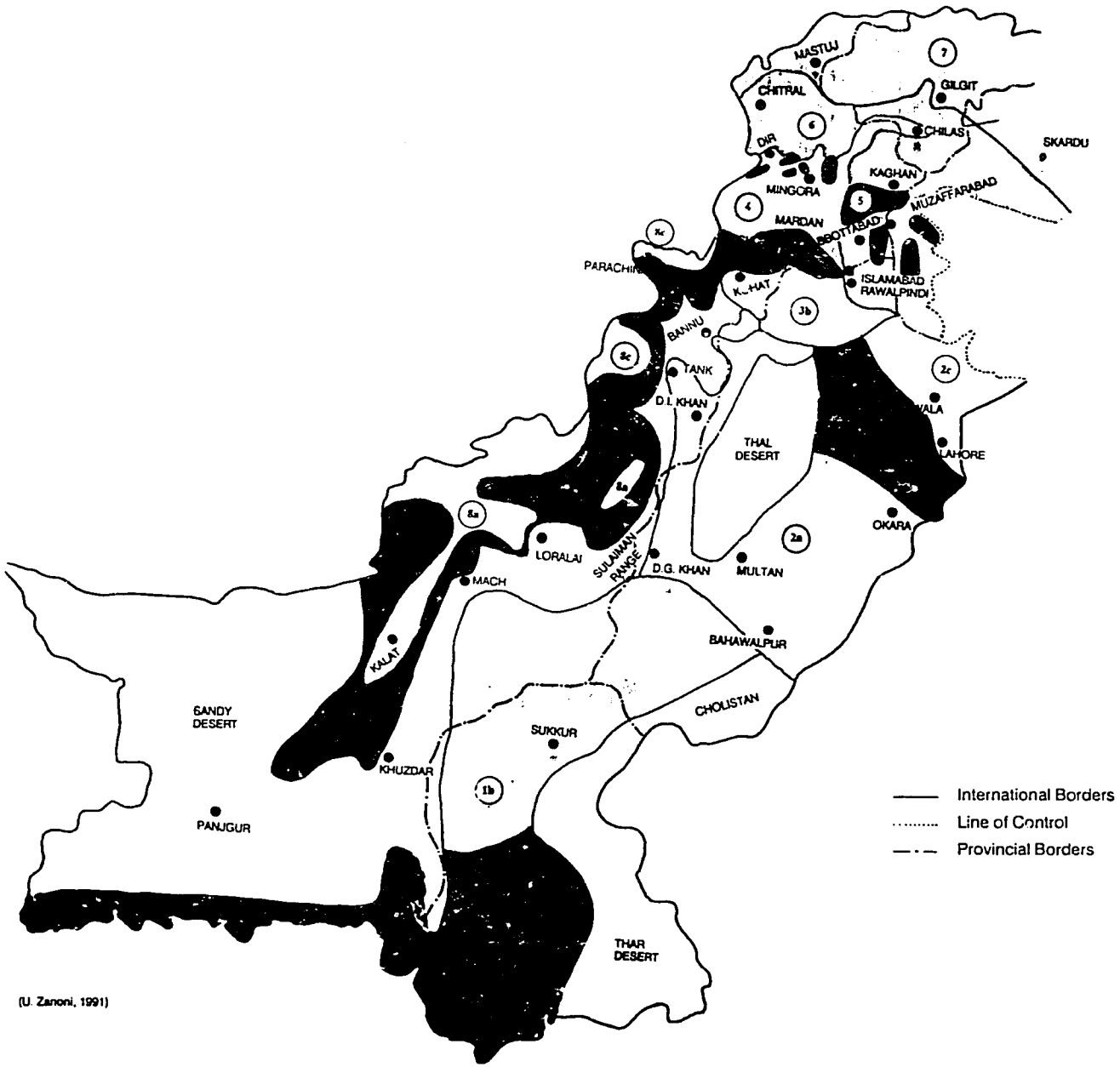


(U. Zanoni, 1991)

AGRO-ECOLOGICAL ZONES FOR POTATO PRODUCTION IN PAKISTAN

Key to Map:

1. Irrigated plains of Sindh, Southern Punjab, and Balochistan,
   - a) Southern part of the zone, south of Nawabshah, frost free, hot and arid climate, more than 125 mm annual rainfall,
   - b) Northern part of the zone, north of Nawabshah, probability of frost, very hot and arid climate, less than 125 mm annual rainfall,
2. Irrigated plains of Central Punjab and South East NWFP,
   - a) Southern part of the zone, late planting of the autumn crop because of high temperatures, hot and arid climate,
   - b) Central part of the zone, early planting of the autumn crop possible, warm and semi-arid climate,
   - c) Northern part, early planting of the autumn crop not always possible because of monsoon rain, warm and sub-humid climate.
3. Irrigated and rainfed plains of NWFP and Northern Punjab,
   - a) Mainly irrigated, important potato production,
   - b) Mainly rainfed, little potato production,
4. Irrigated lower valleys of NWFP,
5. Rainfed high valleys and hillsides of NWFP, Northern Punjab, and Azad Kashmir,
6. Irrigated high valleys of NWFP, Northern Areas around Chilas, and Azad Kashmir,
7. Irrigated high valleys of Northern Areas and NWFP around Mastuj,
8. Irrigated high valleys of Balochistan, South and North Waziristan,
   - a) Higher altitudes, main planting of potatoes in April/May,
   - b) Lower altitudes, early planting in March is possible,
   - c) Tribal areas of South and North Waziristan, and Parachinar (Kuram Agency).

1. OVERVIEW: POTATO PRODUCTION IN PAKISTAN

1.1. AGRO-ECOLOGICAL ZONES

Previous efforts have been undertaken to subdivide Pakistan into different agro-ecological regions based on physiography, climate, soils, and land use (Khan, 1980). Agro-ecosystem zoning specific to maize production was accomplished by the PARC (1985). Likewise, for potato production Pakistan can be divided into eight agro-ecological zones which differ significantly in altitude, latitude, longitude, topography, climate, soils, and irrigation infrastructure. Consequently, these factors together with socio-economic and cultural factors have an impact on the farming system. Some of the zones can be further subdivided into sub-zones. The eight zones and their sub-zones are as follows, see Fig. 1 "AGRO-ECOLOGICAL ZONES FOR POTATO PRODUCTION IN PAKISTAN" (folding map):

1 Irrigated plains of Sindh, Southern Punjab, and Balochistan:
   a) Southern part of the zone, south of Nawabshah. Frost free, hot and arid climate, more than 125 mm annual rainfall.
   b) Northern part of the zone, north of Nawabshah. Probability of frost, very hot and arid climate, less than 125 mm annual rainfall.

2 Irrigated plains of Central Punjab and South East NWFP:
   a) Southern part of the zone. Late planting of the autumn crop because of high temperatures, hot and arid climate.
   b) Central part of the zone. Early planting of the autumn crop possible, warm and semi-arid climate.
   c) Northern part of the zone. Early planting of the autumn crop not always possible because of monsoon rain, warm and sub-humid climate.

3 Irrigated and rainfed plains of NWFP and Northern Punjab:
   a) Mainly irrigated. Important potato production.
   b) Mainly rainfed. Little potato production.

4 Irrigated lower valleys of NWFP.

5 Rainfed high valleys and hillsides of NWFP, Northern Punjab, and Azad Kashmir.

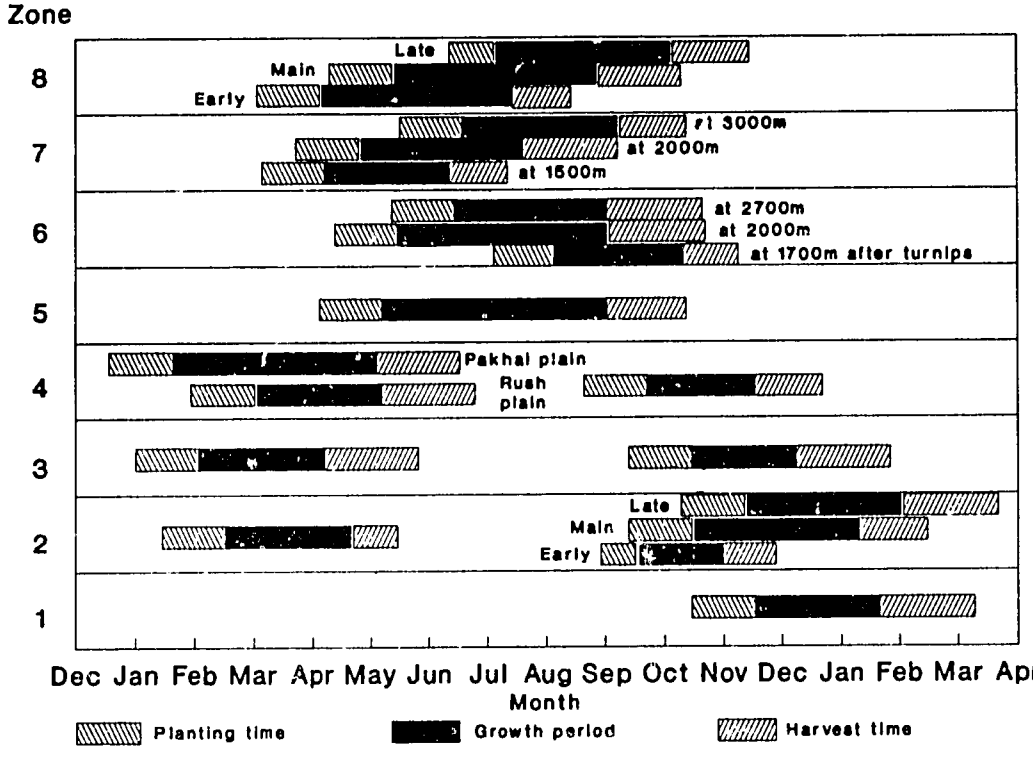
6 Irrigated high valleys of NWFP, Northern Areas around Chilas, and Azad Kashmir.

7 Irrigated high valleys of Northern Areas and NWFP around Mastuj.

8 Irrigated high valleys of Balochistan, South and North Waziristan:
   a) Higher altitudes. Main planting of potatoes in April/May.
   b) Lower altitudes. Early planting in March is possible.
   c) Tribal areas of South and North Waziristan, and Parachinar (Kuram Agency).

Altitude, latitude, longitude, topography, and exposure to the sun determine planting time, length of the growth period, and harvest time for potatoes in each zone (Fig. 2).

Fig. 2: Planting time, growth period, and harvest time of potatoes in the different production zones of Pakistan.



With an altitude below 150 m and southerly latitude, the temperatures in zone 1 are too high in spring and summer, thus, only one winter crop of potatoes is grown. Summer is too hot for potato production in zones 2, 3, and 4, therefore, potatoes are grown in spring and autumn. There seems to be a transition zone anywhere between 1250 m and 1500 m where no potatoes are cultivated, possibly because a system of summer and winter crop is preferred. Above this transition zone, there is only one cropping season for potatoes in zones 5, 6, 7, and 8.

The salient features of the agro-ecological zones are summarized in table 1.

1.2. PRODUCTION FACTORS

Farm size, land tenure, labor requirement and availability, and access and utilization of credits for buying inputs vary considerably between agro-ecological zones (Table 2).

1.2.1. Farm size

The average farm size is higher in zones 1, 2, and 8 as compared to the other zones. Farms are particularly small in zones 4, 5, 6, and 7. In many areas, farm size owned by each household is decreasing because of the increasing population and the custom to divide land among the offspring. Thus, it becomes increasingly difficult to make a living from agricultural production only. Members of the family engage in other activities to earn an additional income or lease their land to other family members or farmers. In some areas, for example the Murree hills, growing potatoes became altogether unattractive as more convenient alternatives became

Table 1: Altitude, latitude, longitude, topography, climate, soils, and irrigation infrastructure in the different agro-ecological potato production zones of Pakistan.

Zone	Altitude/ Latitude/ Longitude	Topography	Climate	Soils	Irrigation infra-structure
1	Below 150m 24°-29° 62°-69°	Open, very flat flood plains	South of Nawabshah: hot and arid, frost free, more than 125mm annual rainfall; north of Nawabshah: very hot and arid, probability of frost from December to February, less than 125mm annual rainfall; whole zone: maximum temperatures stay above 35°C from April to October, no snowfall, most rainfall in July, August	Mainly calcareous, silty loams and clays with weak structure and good porosity, pH 7.8-8.3, about 0.5 % organic matter, some salinity problems	Mainly canals
2	Below 300m 29°30'-33° 70°30'-74°30'	Open, mostly flat flood plains	Southern part: hot and arid; central part: warm and semi-arid; northern part: warm and sub-humid; whole zone: mean temperatures decrease with increasing latitude, probability of frost from December to February, no snowfall, 200-1000mm annual rainfall, increasing from south west to north east, most rainfall in March, July, August	Mainly calcareous, silt loams with weak structure in the southern and central part, non-calcareous, loams, clay loams, and clays in the northern part, loamy soils occur in high lying areas, clayey soils in low lying, pH 7.5-8.5, but above 9 for saline soils, less than 1% organic matter, well supplied with N, P, K, but some Zn deficiency, water logging and salinity problems	Tubewells or canals, canal water is less saline, water table is high
3	Below 600m 32°-34° 71°30'-73°30'	Confined flood plains, surrounded by hills and mountains, terrain is partly rolling and rugged	Warm and semi-arid in the south west, warm and sub-humid in the north east, hot summers and cool winters, highest temperatures in June, probability of frost from December to February, frost risk increasing northwards, no snow, 400-900mm annual rainfall, increasing towards the north east, most rainfall in March, August	Alluvial, sandy/silty or silty clay loams, some clays, pH around 8, less than 1% organic matter, soils respond well to N, P, K, and Zn application, some water logging and salinity problems	Mostly canals in the irrigated subzone 3a, some tubewells and Persian wells in the rainfed subzone 3b
4	700-1500m 34°-35° 71°30'-73°30'	Confined, but moderately open flood plains, plateaus, bowls, and rolling hills	Warm-temperate, with hot and sub-humid summers and mild winters, mean temperatures decrease by 1°C per 100m increase in altitude, probability of frost from December to February, little snowfall, 900-1600mm annual rainfall, most rainfall in March, July, August	Alluvial, heavy clay in Abbottabad and Buner, pH above 8, silty/sandy loam and clay loam in Mansehra, pH above 7	Small springs, surface water from the town around Abbottabad, canals around Mansehra, canals and tubewells in Buner

(Continued)

Table 1 (Continued)

Zone	Altitude/ Latitude/ Longitude	Topography	Climate	Soils	Irrigation infra-structure
5	1500-2700m 34°-35° 71°30'-73°30'	Hilltops, more or less steep slopes on alluvial fans or moraines, and plateaus, terraced fields, natural vegetation is abundant due to monsoon	Cool-temperate and humid, mild summers and winters, climate is more continental farther west with more extreme temperatures, mean temperatures decrease with altitude, probability of frost from December to February, but less risk than other zones at similar altitude, snowfall from November to March at higher altitudes, from January to February at lower altitudes, 1000-2000mm annual rainfall, most rainfall in July, August	Variable, heavy red clay-loess at lower altitudes, sandy/silty black organic soil at higher altitude, acid, pH below 7, nutrient content is variable with no apparent Zn deficiency, chemical and physical erosion are important	Mostly rainfed
6	1700-3000m 34°30'-35°30' 72°-74°	Confined bowls, plateaus, slopes, enclosed by high mountains and rivers, more or less open valleys receiving more or less sunshine, terraced fields, natural vegetation, especially pine forests	Cold-temperate and semi-arid, mild summers and cold winters, maximum temperatures stay usually below 30°C, mean temperatures decrease with altitude, probability of frost from November to April, maximum temperatures reach a plateau from June to August, snowfall from mid-October to end of May possible, 3-7m, important for refilling soil moisture, total precipitation is below 1000mm, but variable and erratic	Variable, silty/sandy loams to clay loams, dark in low lying fields, light-colored in high lying fields due to chemical and physical erosion, pH 7-8, except for black soils which are acid, less than 1% organic matter, soils respond well to N, P, K application	Gravity-fed channels collecting melt water from glaciers, snowfields, springs, and rivers, water availability depends on glacier and snowmelt, water is loaded with silt, low saline content
7	1500-3100m 35°-37° 72°-75°	Confined bowls, plateaus, slopes, enclosed by high mountains and rivers, screes, glacial moraines, alluvial fans, and terraces, less natural vegetation than zone 6, mostly steppe of Artemisia	Very cold, dry, continental, mean temperatures decrease with increasing altitude and stay usually below 30°C, probability of frost from November to February at 1500m, from October to April at 3100m, rain shadow of wintery depression and monsoon rains, little snow in the zone, but considerable snow in the surrounding mountains, less than 500mm annual precipitation	Variable, silty/sandy loams to loams, less than 15% clay, contain gravel and stones, pH 7-8, less than 1% organic matter	Gravity-fed channels collecting melt water from glaciers, snowfields, springs, and rivers, water availability depends on glacier and snowmelt, water is loaded with silt, low saline content
8	1500-2500m 28°-34° 66°-71°	Wide open valleys, plateaus, foothills, and hillslopes, surrounded by steep and arid mountains covered with sparse natural vegetation	Cold-temperate, arid to semi-arid, continental, highest temperatures in July, probability of frost from October to March at 2100m, from November to February at 1700m, snowfall from November to March, less than 500mm annual precipitation, mostly in winter in the form of snow and rain	Sandy loams to loamy sands, highly calcareous, shallow, pH above 8, less than 0.5% organic matter on mountain slopes, highly calcareous, deep, pH above 7.5, less than 1% organic matter in the valley bottoms, low to medium P content, medium to high K content, some soils are deficient in Zn, fixation of P and micronutrients, wind erosion, and crust formation are major problems	Tubewells, open-surface wells, streams, and *karezes*, water table is between 30-60m, decreasing constantly

available. Some land is destroyed through overgrazing and cutting of the forests which leads to wind and water erosion. Other land, especially in zones 7 and 8 can be reclaimed by catching silt-laden water from glaciers and flood water and by installing new irrigation facilities.

1.2.2. Land tenure

Ownership and tenancy are both common in potato-growing areas. However, the majority of land in zones 5, parts of 6, and 7 is owner-operated. Share-cropping with different arrangements depending on the region and tradition is still the most wide spread form of tenancy. This traditional system of sharing the risk usually benefits both the owner and tenant. In the Kaghan valley, some tenants have to pay royalties for each bag of potatoes produced. In zone 8, the majority of landowners provide all the inputs and the tenant only the labor. The landowner is mostly also the main decision maker. Thus, tenants are paid for their labor in kind instead of being paid in cash. Leasing land is already quite common in zone 2 and is becoming more and more important in other zones too. Business-minded farmers in particular seem to prefer this type of arrangement as they reap all the benefits of good management practices.

1.2.3. Labor

Much of the work in potatoes is still done manually. Planting, weeding, earthing-up, and harvest are labor intensive. Labor is paid in kind through a share of the produce or in cash. Labor availability depends on population density and alternative job opportunities. Women in some areas seem to share a big burden of the farming operations. However, except for zone 7, they are hardly observed in the field. Seasonal migration is common in the hilly areas of Pakistan where much snow falls.

1.2.4. Credit

Resource-poor farmers usually rely on informal credits to buy inputs, especially seed which covers about 30-40% of the production costs. In 1991, the high seed potato price was the single most important factor for farmers not to grow potatoes. The traders, commission agents, and shopkeepers are vital for the seed flow towards the farmers, especially in the hills. Where they provide seed on credit, more farmers are able to grow potatoes. They charge higher prices for seed sold on credit, or they charge higher commissions and the farmers are bound to sell their produce to them.

1.3. FARMING PRACTICES

1.3.1. Cropping pattern

The crops grown in the different zones are basically a function of the cropping seasons and vary considerably between zones (Table 3). In the plains and lower valleys of Pakistan, three consecutive crops can be grown per year. Thus, farmers have ample choice to substitute potatoes with other crops and the area under potatoes fluctuates depending on supply and demand of potatoes in the market. Small farmers are more flexible and react to gluts by switching to other crops. This behavior has been observed for example in zone 3 in 1991, where farmers grew more tomatoes and less potatoes because of the high tomato and low potato price in the previous year. Medium and large farmers, especially in zone 2, are very much autonomous in their seed supply, they are potato specialists, have also invested in potato

specific machinery and they can take advantage of the governmental intervention system. Therefore, they switch much less to other crops when potato prices are low. Between 1250 m and 1500 m, the growth period is reduced so that only two cropping seasons, a summer and a winter crop, are feasible. The winter crop is mainly wheat or barley. Potatoes have to compete with other vegetables such as tomatoes and onions and with rice or maize. At about 1800 m, wheat can no longer be grown and maize, potatoes, and some vegetables (turnips, cabbage, peas) are grown in a single summer season. The farmer's choice of crops becomes very limited. Above 2300 m, the presently available maize varieties are no longer adapted, thus monoculture of potatoes becomes very common.

1.3.2. Potato varieties

The choice of varieties being grown by farmers depends on the following factors: (1) list of commercial varieties available, (2) distance to different markets and connections to traders and commission agents, (3) seed availability, (4) adaptation of the different varieties to the agro-ecological conditions, (5) tradition.

There is a limited number of commercial varieties available in Pakistan (Annex 1). Desiree, Cardinal, and Ultimus are the main red-skinned varieties Diamant, Patrones, Ajax and Multa are the main white-skinned varieties. In some remote areas, different local varieties, which have evolved in more or less complete isolation from previous introductions, can still be found. They usually vary in skin color.

White varieties are more popular among consumers in the south, thus, they are sold mainly in Karachi, Hyderabad, and Sukkur. Red varieties are sold in all the other markets. In zones 4, 5, and 6, mainly red varieties are grown. White and red varieties are grown in zones 2, part of 3, 7, and 8. In zone 1, mainly white varieties are grown.

Many medium and large farmers have better connections to traders and commission agents in the main markets, for example to sell white varieties in Karachi, and better access to transport facilities than small farmers. Smaller farmers are often forced to sell in the local market, where mainly red varieties are sold, for a number of reasons: (1) they have taken loans from traders or commission agents, (2) they offer only small quantities to sell, or (3) they lack access to transport facilities.

The seed distribution system in Pakistan is quite complex (see also section 1.3.3.). In some areas and markets, only certain varieties are offered by the traders who sell the seed. Only those farmers who directly contact farmers in other zones, store their own seed, or buy certified seed know the exact source and variety. Even if farmers know that a certain variety is better adapted to their specific needs, for example Cardinal for the nematode-infested Utror valley, they might not get what they want. In addition, seed sources and varieties are very often mixed in the market.

Farmers very often know by experience which varieties suit the agro-ecological conditions prevailing in the zone. Ultimus is an old, low to medium yielding, but robust variety which is also adapted to pit storage and hot temperatures. It is preferred by farmers in the hilly areas, for the spring crop in the Pabbi area, and for the early autumn crop in zone 2. Other varieties such as Desiree are better suited for a high yielding environment and good management practices. White varieties such as Ajax and Diamant are reportedly more susceptible to late blight in the Hazro area.

Table 2: Farm size, land tenure, labor requirement and availability, access and utilization of credits in the different agro-ecological potato production zones of Pakistan.

Zone	Farm size	Land tenure	Labor	Credit
1	Small, medium, and large farmers, average size about 20-30 ha	Owners and tenants, land usually rented for cash, few share-croppers, inputs and produce are equally shared between tenant and owner	Most work is done by hand, labor is hired for planting, weeding, earthing-up, and harvesting	Many farmers rely on credits from commission agents or traders, seldom from the ADBP
2	Mainly medium and large farmers who own more than 5 ha, some very large farmers, especially in the Okara district, in some areas small farmers are also present, farms are made bigger units by renting land, average size about 20 ha	Owners and tenants, renting land seems to be more common than share-cropping, rents vary depending on region, Rs. 2000-10,000/ha per year	Labor is hired for planting, weeding, earthing-up, and harvesting, some farmers plant mechanically	Seed is sometimes bought on credit from commission agents or traders, farmers have to sell through an agent who charges 6% commission as compared to 3-3.25% when seed is bought for cash
3	Mostly small and medium farmers, landowners in Mardan, Swabi, Hazro, and Taxila may also operate large farms (>10 ha), tenants usually operate small farms (<5 ha), average size is 5 ha in Pabbi, 10 ha in Mardan, Swabi, Hazro, and Taxila, 4 ha in the rainfed subzone 3b	Mainly irrigated land is given to tenants, 4 tenancy forms: (1) landowner is operator, (2) tenant receives one third for providing labor, (3) inputs and produce are equally shared, (4) land is rented for cash; the majority are owners in the Pabbi area and the rainfed subzone, tenancy, especially on a rent basis is common in Mardan and Swabi, the majority are tenants on a 50/50 share basis in Hazro and Taxila	Own family labor, in addition seasonal labor is hired by tenants and owners for planting, weeding, earthing-up, and harvest, laborers are paid in cash, some mutual exchange (*ashar*) among farmers in Mardan, seasonal migrants from the upper Swat valley provide labor in Mardan and Swabi	Seed is usually paid in cash, farmers bound to sell through commission agent if they buy seed on credit
4	Mostly small farmers, except for the Rush plain around Abbottabad, average size about 1 ha in the Pakhal plain, about 3 ha in Buner, about 2 ha in the Malakand area	Owners and tenants, on share-basis varying from one fifth to one half depending on the crop and amount of input provided, or on a lease basis, rent is about Rs. 10,000 in the Pakhal plain	Mostly family labor, some better-off farmers hire additional labor for cash, Rs. 30/day, some mutual exchange in Buner	Many farmers rely on credits from commission agents or traders
5	Very small farmers, farmers might also own some uncultivated land, average size about 0.5 ha, largest in Kaghan (1.5 ha), and Usherai (1-2 ha), smallest in Malam Jabba (0.1-0.2 ha) and Miandam (0.25 ha)	Majority are owners	Mostly own family labor, some better-off farmers hire additional labor for cash, Rs. 30-60/day for adults, Rs. 15/day for children, off-farm income from tourism, mines, and forest royalties, some seasonal migration to lower areas	Many farmers rely on commission agents or traders to get credit on inputs, most areas except for Dir are well covered by traders

(Continued)

Table 2 (Continued)

Zone	Farm size	Land tenure	Labor	Credit
6	Mainly small farmers, average size: 1.5 ha in Kaghan, 0.5 ha in Kalam, 1 ha in Lawari, 2 ha around Drosch and Chitral, 1.3 ha around Garam Chasma, 0.5 ha in Darel, 1.5 ha in Thal, many fields are small and scattered, most of the land at higher altitude is community land	Mostly owners, except for parts of the Kaghan valley, some tenants in this valley pay royalties for each bag of potato produced	Mainly own family labor, some better-off farmers hire additional labor for cash, Rs. 30-40/day for planting and weeding, Rs. 50/day for harvest, mutual exchange in Kalam, important off-farm employment are tourism, transport business, government jobs, shop-keeping, seasonal migration is common	Many farmers rely on commission agents, traders and shopkeepers to get credits on inputs and consumer goods (about 70% in Battakundi), all items are more expensive due to higher transport costs, traders cover most areas well except Dir, they charge 30-60% higher prices for seed bought on credit, the Aga Khan Rural Support Program provides loans and grants in Chitral
7	Mainly small farms, average size: about 1 ha in the double crop areas and 2 ha in the single crop areas around Gilgit and in Baltistan, 1.3 ha in Mastuj (Chitral), uncultivated land is mainly owned by the whole community	Mainly owners	Mostly family labor, mutual exchange, some better-off farmers hire additional labor for cash, Rs. 40-50/day, women in this zone bear a major burden of the farm work and are seen more often in the field than in other zones	Seed companies provide farmers participating in seed schemes with inputs, the Aga Khan Rural Support Program provides loans and grants
8	Strong joint family system, most survey data does not indicate whether farm size relates to joint or nuclear family, whether it includes uncultivated or grazing land, and whether landless people renting land are also included, most surveys indicate an average size of about 15-20 ha	Generally landowners hire tenants at will and pay their labor in kind, one fourth to one third of the produce, landowners seem to be the primary decision maker, some land is rented for a share of one seventh, some farmers provide water, others land and then share the produce equally	Mostly tenants and their family members, labor seems to be short, some mutual exchange	Most farmers rely on commission agents, traders and friends to get credits for inputs, formal credits are used for the installation of new wells and to buy tractors, agents charge a higher price (5-25%) for seed bought on credit, commissions in Quetta are higher than in markets in the Punjab

Table 3: Cropping pattern, potato varieties, and seed sources in the different agro-ecological potato production zones of Pakistan.

Zone	Cropping pattern	Potato varieties	Seed sources
1	Wheat, vegetables, pulses, fodder compete with potatoes in winter, rice, cotton, sugarcane, fruit trees are important summer crops	Mainly white varieties, Patrones, Diamant	Mainly previous autumn crop of the Punjab (Okara)
2	Potatoes, vegetables, maize for grain, tobacco are important spring crops, main summer crops are rice, maize for fodder, cotton, or land is left fallow, potatoes, wheat, and vegetables are important autumn/winter crops, sugarcane is also important, about 10-20% of the cultivated area is under spring potatoes, 30-50% under autumn potatoes, some intercropping of potatoes with sugarcane, water melons, gourds, farmers own mainly buffalos and cows	Red varieties are more common than white ones, small farmers prefer red varieties for local markets, some big farmers in Okara and the southern districts grow preferably white potatoes, Desiree is the most popular variety, followed by Diamant, Cardinal, Patrones, Ultimus is preferred for early planting	**Spring crop**: imported seed from Holland, certified seed from Hunza, uncertified hill seed from Balakot, Balochistan, Swat, the Galis; **autumn crop**: spring seed, previous autumn crop, summer crop from Hunza, imported seed is multiplied two to three times, uncertified seed once or twice
3	Potatoes, irrigated maize, tobacco, sunflower, vegetables are important spring crops, water melon, groundnuts, rainfed maize, rice, sunflower, cauliflower, are the main summer crops, potatoes, vegetables, wheat, fodder, sugarbeets are the main autumn/winter crops, sugarcane is also important, spring and autumn potatoes are equally important in Pabbi, Nowshera, Hazro, covering up to 50% of the cultivated land in Pabbi and more than 50% in Hazro, the spring crop is more important in Taxila, covering more than 50% of the cultivated land, the autumn crop is more important in Mardan and Swabi, covering up to 50% of the cultivated land, potatoes are frequently intercropped with sugarcane, arum, livestock is of minor importance for potato farmers	Only red varieties in Pabbi, Mardan, and Swabi, red and white varieties in Hazro, Taxila, Ultimus and Cardinal in Pabbi, Mardan, and Swabi, Desiree, Diamant, Ajax in Hazro and Taxila, market seed is often a mixture of different varieties, Ultimus is preferred in some areas because of its better heat tolerance than Cardinal	**Spring crop**: imported seed from Holland, certified seed from Hunza, uncertified seed from Balakot, South Waziristan, Kalam, Balochistan, Murree, previous spring crop; **autumn crop**: previous spring or autumn crop from own multiplication or from the Punjab, autumn seed is multiplied for several years
4	Onions, sunflower, squashes, tomatoes, tobacco, vegetables are important spring crops, maize, rice, sunflower, radish, turnips, coriander are the main summer crops, turnips, radish, and wheat are the main autumn/winter crops, sugarcane is also important, spring and autumn potato are minor crops, covering 10-30% of the cultivated land of a few farmers, potatoes are sometimes intercropped with sugarcane, or vegetables, livestock is of minor importance to potato farmers	Only red varieties, mainly Desiree in the Rush plain, mainly Ultimus in the Pakhal plain, Desiree and Ultimus in Buner	**Spring crop**: early autumn crop of the Punjab, hill seed from Balakot, Hunza, Swat; **autumn crop**: previous spring or autumn crop of Punjab, previous spring crop from own multiplication

(Continued)

Table 3 (Continued)

Zone	Cropping pattern	Potato varieties	Seed sources
5	Potatoes, maize, wheat, rice, onions, vegetables are the main crops, potatoes may cover more than 50% of the cultivated land in some areas in some years, but in 1991 production was below 10% of the cultivated land, number of livestock is limited because of limited fodder supply	Only red varieties, except for some local or old white varieties in Dir, Kaghan, Roringar, mainly Desiree, Cardinal and Ultimus, Ultimus is well adapted to the climatic and agronomic conditions in this zone	Autumn crop of the Punjab (Sialkot, Okara, Lahore), own seed kept in pits or rooms, Battakundi seed farm, previous summer crop stored outside the production area, seed is multiplied for 2-3 years if pit storage is possible
6	Potatoes, maize, vegetables, some fruit trees are main crops, the percentage of cultivated area under potatoes increases with increasing altitude, in Kaghan, 50-95% is under potatoes above 2300m, in the Kalam, area 25-100% is under potatoes, in Thal, 25-50% is under potatoes, in Chitral and the Indus side valleys around Chilas, potatoes are mainly grown for own consumption, potatoes are often intercropped with maize and/or beans, pumpkins, squashes, the number of livestock is limited because of limited fodder resources	Red varieties are dominant, in Lawari, Darel, Chitral, some local varieties are white skinned, main varieties are Ultimus, Cardinal, and Desiree, until recently, Ultimus was more common than Desiree or Cardinal because of its good adaptation to the climatic and agronomic conditions in this zone, many different local varieties can still be found in Chitral, Lawari, and side valleys of the Indus	Previous summer crop stored in pits, autumn crop of the Punjab or maybe from zone 3 (Peshawar), Battakundi seed farm
7	Wheat, barley, maize, beans, alfalfa, clover, and fruit trees are the main crops, potatoes have been grown for home consumption until recently, since 1984, seed schemes in Hunza have increased the importance of potatoes as a cash crop, livestock is important for the livelihood of the people but their number is restricted by the limited fodder supply	Until 1984, mainly local varieties with different skin color, since 1984, commercial varieties, mainly Desiree, Cardinal, Ultimus and Diamant are produced in Hunza and Skardu	Local varieties are stored in pits, commercial varieties come from imported basic seed
8	Potatoes, onions, maize, are the main summer (*kharif*) crops, wheat, barley, alfalfa, cumin are the main winter/spring (*rabi*) crops, fruit trees are also very important, much land is left fallow up to two years, potatoes cover up to 30% of the cultivated land, potatoes are often intercropped with young orchards	White varieties are more common than red ones, except at higher altitudes, Diamant, Patrones, and Desiree are the main varieties	Mainly Punjab autumn crop, some pit and room stored seed from own multiplication or from farmers at higher altitudes

The white variety Multa was reportedly introduced in the Roringar valley from Peshawar about 45 years ago. Then it was continuously multiplied for 25 years using room storage. About 20 years ago, the red variety Ultimus was introduced in the valley. Thus, farmers switched from growing a white variety to a red one. In some remote areas, local varieties which vary in skin color can still be found. This is an evidence that at different times, different varieties with different skin color were grown. In Hunza, farmers used to prefer their local variety instead of the commercial varieties because of its better taste and good-keeping quality. Nowadays, commercial varieties have almost completely replaced local ones.

1.3.3. Seed sources

Seed flows in Pakistan are very complex and difficult to survey. Only about 2% of the total seed required for planting all the crops is certified seed, both imported or locally produced (Naumann-Etienne, 1990). The majority of seed potatoes are in fact table potatoes bought in the different markets through commission agents and traders (about 23%) or multiplied and stored by the farmers themselves (about 75%). The major seed flows for spring, summer, and autumn crops are presented in figures 3, 4, and 5.

Since seed covers about 30-40% of the total production costs, which is expensive compared to other vegetables, those farmers who buy their seed in the market and lack cash react to high table potato prices by growing less potatoes. This reaction is typical for farmers in the hilly areas of NWFP and Balochistan who usually sell in a year of shortage and high prices all their produce at the end of the season to pay back their loans. If the following season the price of potatoes is high they do not have enough cash to buy new seed. Those farmers who store their own seed in cold stores or pits from one season to the next are less dependent on the market. Many of the medium and large farmers in zone 2 and farmers in remote areas without road access store their own seed.

1.3.4. Land preparation

The first operation in land preparation is usually to irrigate the field in order to facilitate the consecutive operations and to obtain a fine-structured seed bed. This applies to all zones except for zone 5 which is rainfed. Then it may be necessary to level the field which is important for a proper water management.

Tractor-drawn cultivators or bullock-drawn wooden ploughs are then used to plough the field. Bullocks are still used in areas where fields are difficult to reach, or too steep, or when the farmer cannot afford to hire a tractor. On very steep slopes, fields are prepared with simple hand-hoes. After the first ploughing(s) chemical fertilizer and farm yard manure (FYM) are broadcast. Sometimes FYM may be applied before any ploughing. If the potatoes are intercropped with beans or maize, the seed (bean, maize is also broadcast at the same time. After this, the field is ploughed more times and fertilizer and seed get mixed with the soil. The total number of passes with the cultivator varies from 5 to 20 times depending on the soil and moisture content. The wooden plough is only passed two to three times. A wooden beam called *sohaga* is usually attached behind the cultivator to level the field and to break clods. One man stands on the beam to increase its weight and to break clods. Generally two ploughing are followed by one planking. Some farmers pull a bundle of branches across the field to level it.

Some farmers in zone 2 use disc ploughs to crush and bury vegetative remains of the previous crop, or they pass a chisel plough over to break hard pans.

Some additional irrigations during land preparation might be given to achieve a fine-structured seed bed.

1.3.5. Fertilizer

Generally, chemical and organic fertilizers are used by potato growers. Urea, ammonium nitrate (AN), ammonium sulfate (AS), single superphosphate (SSP), nitrophos (NP), diammonium phosphate (DAP), triple superphosphate (TSP), and sulfate of potash are the most common chemical fertilizers sold on the market. In 1991, urea, nitrophos, DAP, and sulfate of potash were the main fertilizers used in all zones (Table 4). Farm yard manure, chicken manure, city sweepings, waste of flour mills, and branches, leaves from the forests are the common organic fertilizers used.

The amount and type of fertilizer vary between and within zones depending on the availability and price of fertilizers, and the knowledge of the farmers. Fertilizers are generally more expensive in remote areas because of the higher transport costs and because farmers very often buy them on credit. Comparable to the problem of getting seed of different varieties, certain fertilizers are not available, thus, limiting the choice of the farmer. Therefore, many farmers apply whatever fertilizer is available independent of its specific nutrient composition. The quantity applied varies from 0 to 2 bags per bag of seed planted. Consequently, the total amount of nutrients applied varies depending on the seed rate and type of fertilizer. Nitrogen and phosphorous are more often applied than potash. Considering soil analysis results and fertilizer trials, potash seems to be available in sufficient quantities in many soils.

All fertilizers, including the first dose of nitrogen, are applied during land preparation. The second dose of N is applied before earthing-up or at the first irrigation. Manual labor is used for broadcasting the fertilizers.

Organic fertilizer is very important in all zones considering the low organic matter content of most soils. The amount of FYM produced depends very much on the number of livestock and the alternative use as fuel. Farmers in zones 3, 4, and 7 seem to apply reasonable amounts of FYM. In zone 3, farmers purchase FYM from cattle farms in the neighborhood while in zone 4 chicken manure is applied. In zone 7, cattle are kept inside sheds during winter time, thus producing the FYM. In zone 2, FYM or city sweepings are only applied every 3-4 years. In most parts of zones 5 and 6, the amount of FYM produced is limited because of the limited fodder supply for the animals and because many farmers migrate with their animals to lower areas during winter. Thus, FYM is mainly applied to fields close to the house. In zone 8, FYM is mostly dried and used as fuel. Only a few farmers apply organic fertilizer several months before planting, which would considerably enhance the efficiency of the fertilizer.

1.3.6. Planting

After the last ploughing, rows for planting the potatoes are marked by hand with a hoe or shovel, or by foot, or by using an animal-drawn single plough, or a tractor-drawn cultivator. Most planting is still done manually, except in zone 2 where some semi-automatic and automatic planters are in use. Tubers are put on the flat ground or on pre-made ridges. Seed rate, seed type, row-to-row and plant-to-plant distance vary depending on the season and the agro-ecological conditions (Table 4).

Fig. 3: Main seed flows for planting the spring crop in Pakistan

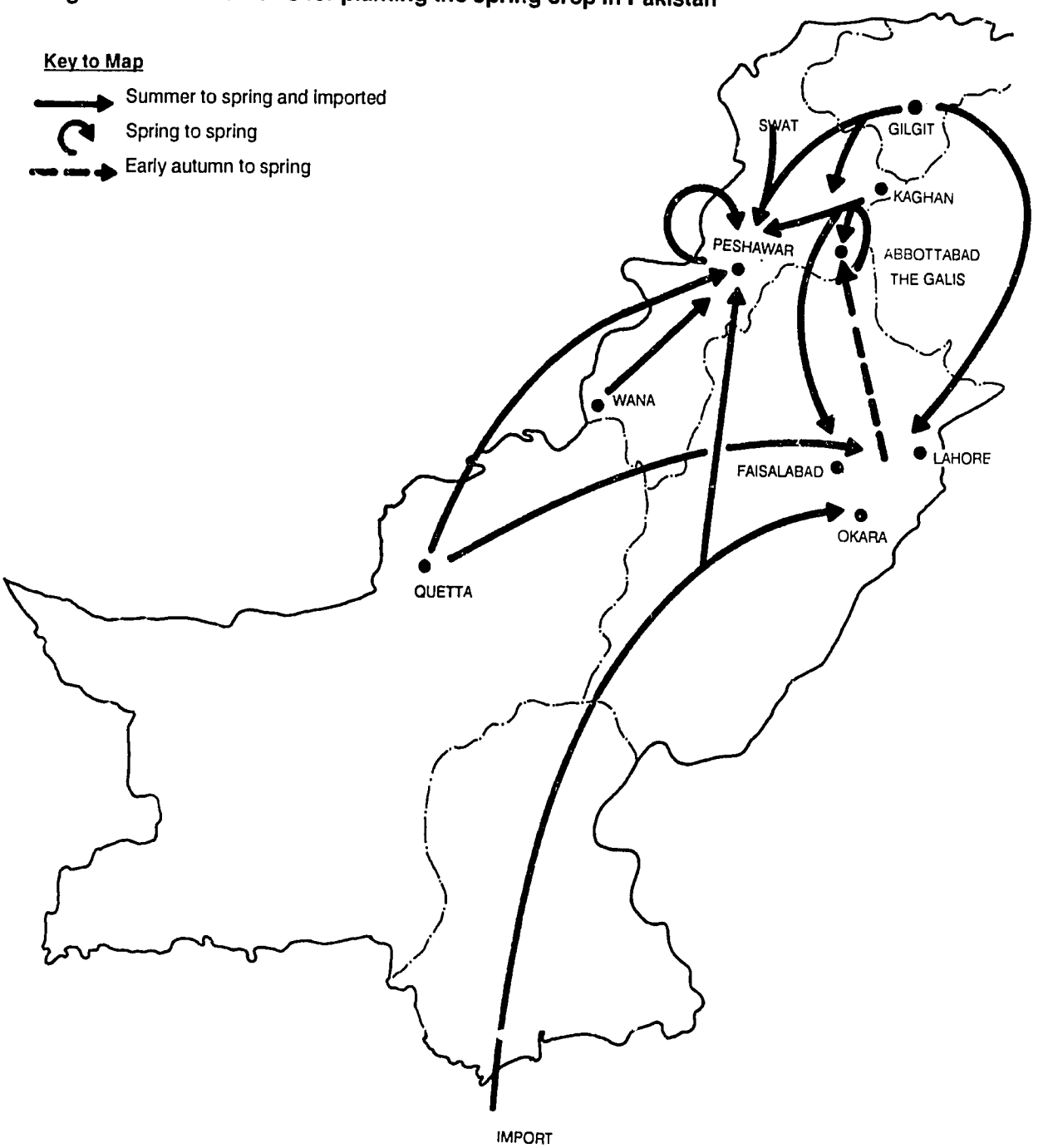


Fig. 4: Main seed flows for planting the summer crop in Pakistan

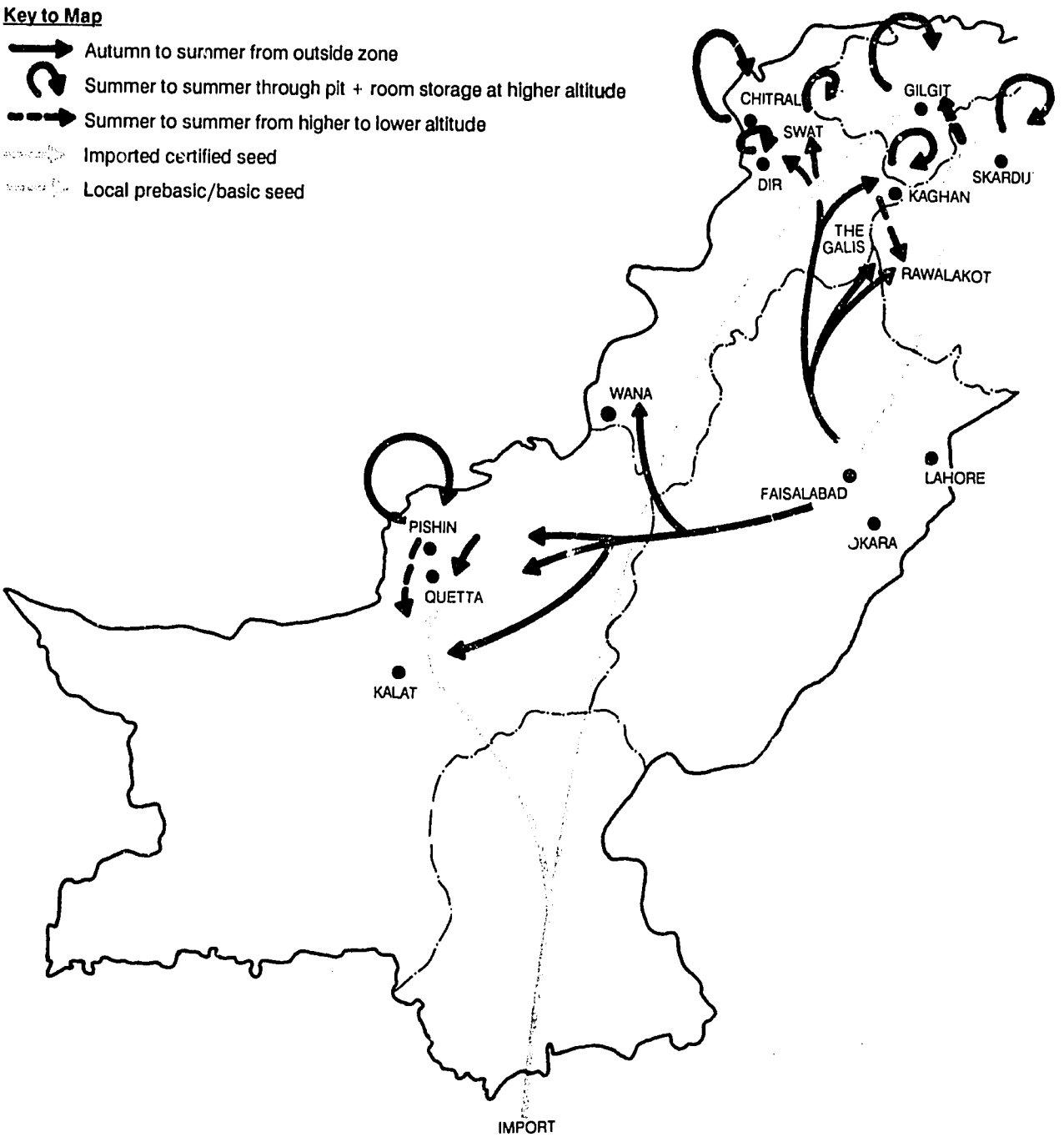
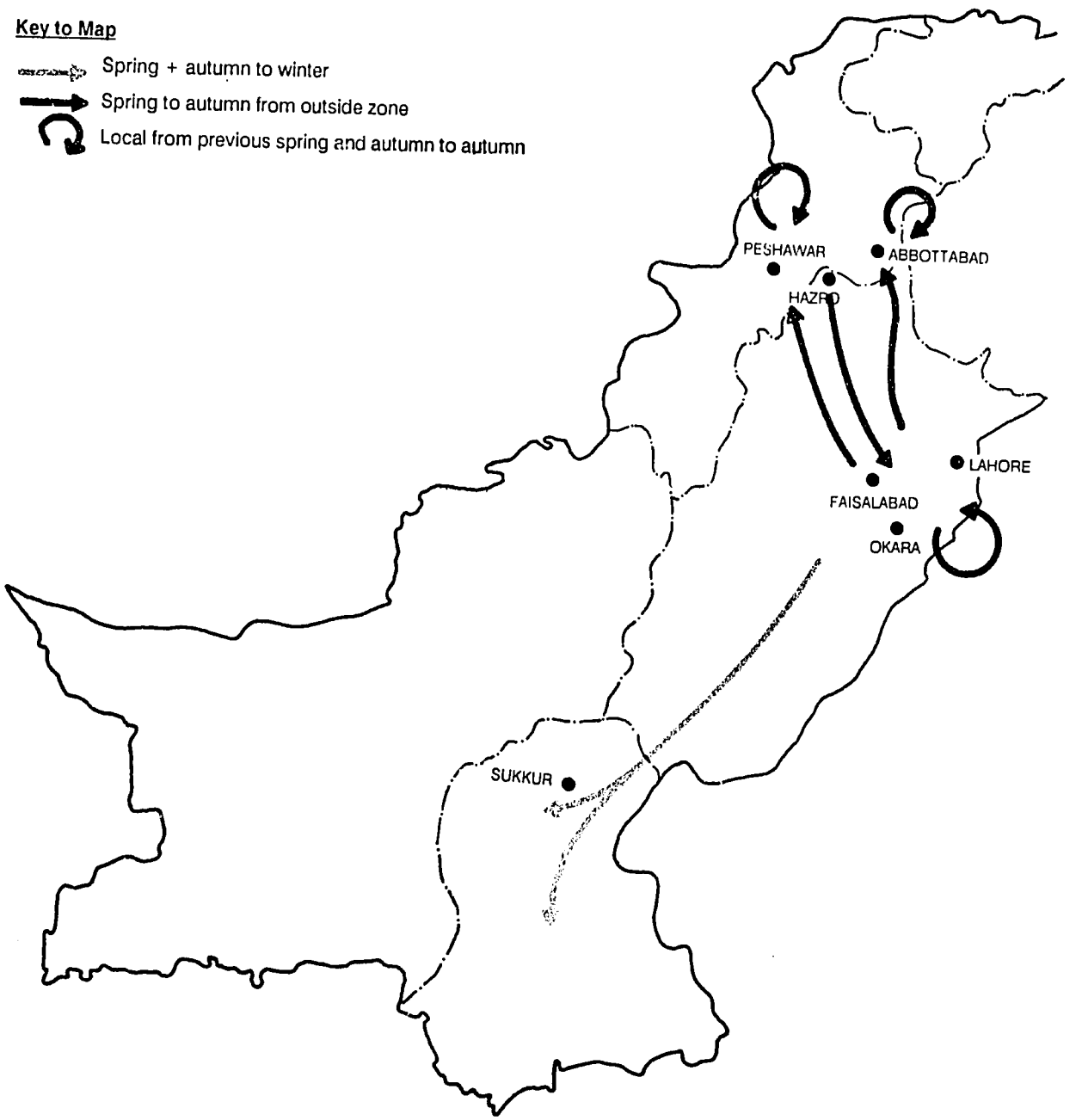


Fig. 5: Main seed flows for planting the winter/autumn crop in Pakistan



Seed rates are lower when cut seed is used, when the seed quality is good (certified seed), and when the climatic conditions are favorable. In autumn, there is a higher risk of seed rotting because of the high temperatures. Seed size tubers are usually planted in autumn and also in the winter crop in zone 1, while cut pieces of different size are used for the spring and summer crops. Most farmers use row-to-row distances between 60-75 cm, and plant-to-plant distances between 20-30 cm. In the whole Kaghan valley, in Lawari, and South Waziristan, single hills are made instead of ridges resulting in variable planting distances. In zone 8, row-to-row distance is larger but plant-to-plant distance smaller than in other zones.

Ridges in most zones are formed manually using broad toothed wide spades (*pulkra*, or *chaull*) or shovels. In zones 2, 3, and 4, tractor-drawn ridgers (*jandra*, with two discs) are used, or ridges are formed during the mechanical planting. In most areas, some specific pattern of ridges and tie-ridges are formed for water management.

1.3.7. Weeding and earthing-up

After about one to one and a half months following emergence, and if there was no pre-emergence herbicide applied, potatoes are manually cleaned from weeds using different tools or by pulling them. If the field is too dry it is pre-irrigated once. In most areas, only one weeding is done as it requires labor. In zone 7, potatoes fields are cleaned two to four times, mostly by women. The weeds are then used as fodder for the animals.

At the time of weeding, an additional dose of nitrogen may be applied and mixed with the soil. Then the ridges are earthed-up again using different tools (spades, hoes, shovels) or tractor-drawn ridgers.

1.3.8. Water management

Potatoes in all zones except zone 5 are irrigated using different sources of irrigation water (Table 1). First irrigation, irrigation interval, and last irrigation depend on the amount and distribution of rain, the evapo-transpiration, the water holding capacity of the soil, and the amount of irrigation water available during the growth period. Some farmers start irrigating right after planting, others delay the first irrigation until emergence to delay germination of weeds. Intervals of about 5 days are common in zone 7 where water is abundant, while the interval is about 10-15 days in zone 8. There are less constraints with tubewells than with canals

Most farmers use some system of ridges and tie-ridges to manage irrigation. In the Kaghan valley and Lawari, single-hill ridges are used and fields are just flooded.

1.3.9. Diseases, pests, weeds and their control

The importance of diseases, pests, and weeds changes between agro-ecological zones (Table 4).

Some farmers use pesticides to control the major diseases, pests and weeds. Fungicides and insecticides are used more often than herbicides. In many areas weeds are still used as fodder for the animals and enough labor is usually available. Many farmers do not seem to actually know the most important disease and pest problems of their crops and the dosage and type of pesticide, or management practices needed to control them. In some areas, as for

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Table 4: Fertilizer type and rate, seed rates, seed type, row distance, main diseases, pests, and weeds in the different agro-ecological potato production zones of Pakistan.

Zone	Fertilizer rate/Fertilizer type	Seed rate/Seed type/Row distance	Main Diseases/Pests/Weeds
1	Mean levels of N, P, K were 146-106-55 kg/ha among 21 surveyed farmers	3.2 t/ha, whole tubers, row-to-row distance 65-75cm	Viruses, early blight, mites, cutworms, leafhoppers (jassids)
2	Mean levels of N, P, K were 238-182-50 kg/ha among 398 farmers, large farmers tended to apply higher rates than small farmers, rates for autumn and spring were the same, urea, DAP, and sulfate of potash were the most common fertilizers used, FYM or city sweepings are applied every three to four years	1.3-1.6 t/ha, cut tubers in spring, 2-3 eyes/piece, 3-3.5 t/ha, whole tubers in autumn, slightly higher seed rates are used for early planting, row-to-row distance 62-75cm	Potato leaf roll virus, potato virus Y, Verticillium and Fusarium wilts, powdery and common scab, late blight, Rhizoctonia, aphids, leafhoppers (jassids), mites, cutworms, common nutsedge
3	Variable quantities of 0-230 kg/ha N, 0-184 kg/ha P, no potash, and 0-80 t/ha FYM were applied by 11 farmers for the spring crop, 0-460 kg/ha N, 0-230 kg/ha P, no potash, and 0-40 t/ha FYM were applied by 10 farmers for the autumn crop, urea and DAP were the main fertilizers, FYM was applied at least once a year, and was mostly purchased, some farmers in Hazro used waste of flour mills	1 t/ha (range: 1-3 t/ha), cut tubers in spring, 1-2 eyes/piece (3-6 pieces/tuber), 2 t/ha (range: 2-5 t/ha), whole tubers in autumn, row-to-row distance 75-90cm, plant-to-plant distance 15-20cm	Potato leaf roll virus, potato virus Y, bacterial wilt, powdery scab, late blight, Verticillium and Fusarium wilts, aphids, cutworms
4	Variable quantities of 138-320 kg/ha N, 58-230 kg/ha P, no potash, and 25 t/ha chicken manure were applied by surveyed farmers in the Rush and Pakhal plains, it is not clear whether different rates are applied for spring and autumn crop, urea and DAP were then main fertilizers used	2 t/ha, cut tubers in spring, 3 t/ha, whole tubers in autumn, row-to-row distance 75-90cm, plant-to-plant distance 20-30cm, a higher seed rate for spring crop in the Pakhal plain is required because of planting in December	Viruses transmitted through poor seed, late blight, Verticillium and Fusarium wilts
5	Variable quantities of 0-690 kg/ha N, 0-345 kg/ha P, no potash, and some FYM, branches and leaves were applied by the surveyed farmers, urea, nitrophos, DAP, or ammonium sulfate were the main fertilizers used	2 t/ha for pure stands, 0.7-1 t/ha for intercropped stands, cut tubers, 1-2 eyes/piece, variable row-to-row and plant-to-plant distances for single hill planting and ridging, otherwise 60-70cm, 20-30cm	Late blight, Verticillium and Fusarium wilts, common and powdery scab, cutworms

(Continued)

Table 4 (Continued)

Zone	Fertilizer rate/Fertilizer type	Seed rate/Seed type/Row distance	Main Diseases/Pests/Weeds
6	Variable quantities of 180-690 kg/ha N, 65-258 kg/ha P, 65-166 kg/ha K were applied by the interviewed farmers in Kaghan, 50-400 kg/ha N, 0-263 kg/ha P, no potash were applied by surveyed farmers in Kalam in 1987, and 105-960 kg/ha N, 0-253 kg/ha P, no potash in 1991, in intercropped fields rates were reduced, urea, nitrophos, DAP, ammonium sulfate, sulfate of potash were the main fertilizers used, AS was often used by resource-poor farmers, some FYM, branches and leaves were applied, mainly close to the cattle-sheds	2 t/ha for pure stands, 0.7-1 t/ha for intercropped stands, cut tubers, 1-2 eyes/piece, variable row-to-row and plant-to-plant distances (usually almost square) for single hill planting and ridging, otherwise 60-75cm, 20-30cm	Common and powdery scab, late blight, Verticillium and Fusarium wilts, cutworms, cyst nematodes
7	Variable quantities of 230-460 kg/ha N and P, no potash are recommended by the seed companies for the farmers participating in the seed schemes, many seemed to apply more than that, farmers also adopted this practice for the home grown crop, about 40 t/ha FYM was applied, sometimes chemical fertilizer was not available and farmers applied FYM instead, nitrophos and urea were the main fertilizers used in 1991	2 t/ha, cut tubers, some farmers used higher seed rates as they overestimated the field surface, row-to-row distance 60-100cm, plant-to-plant distance 10-30cm	Potato viruses X, S, and Y in local varieties, potato leaf roll virus is an additional problem in commercial seed, Verticillium wilts, leafhoppers, cutworms, European vegetable lygus bug, wireworms, white grubs
8	Variable quantities of 60-166 kg/ha N, 40-115 kg/ha P, no potash, little FYM were applied by farmers questioned in different surveys, larger farmers seemed to apply more fertilizer than small farmers, urea, DAP, and nitrophos were the main fertilizers used	2-2.5 t/ha, cut tubers, row-to-row distance 90-100cm, plant-to-plant distance 10-15cm (very narrow)	Potato leave roll virus, potato virus Y, Verticillium and Fusarium wilts, powdery scab, cutworms, broom rape, dodder

example around Kalam and some Swat side valleys, PSPDP has been successful in training farmers in the use of Dithane M-45 to control late blight.

1.3.10. Harvest

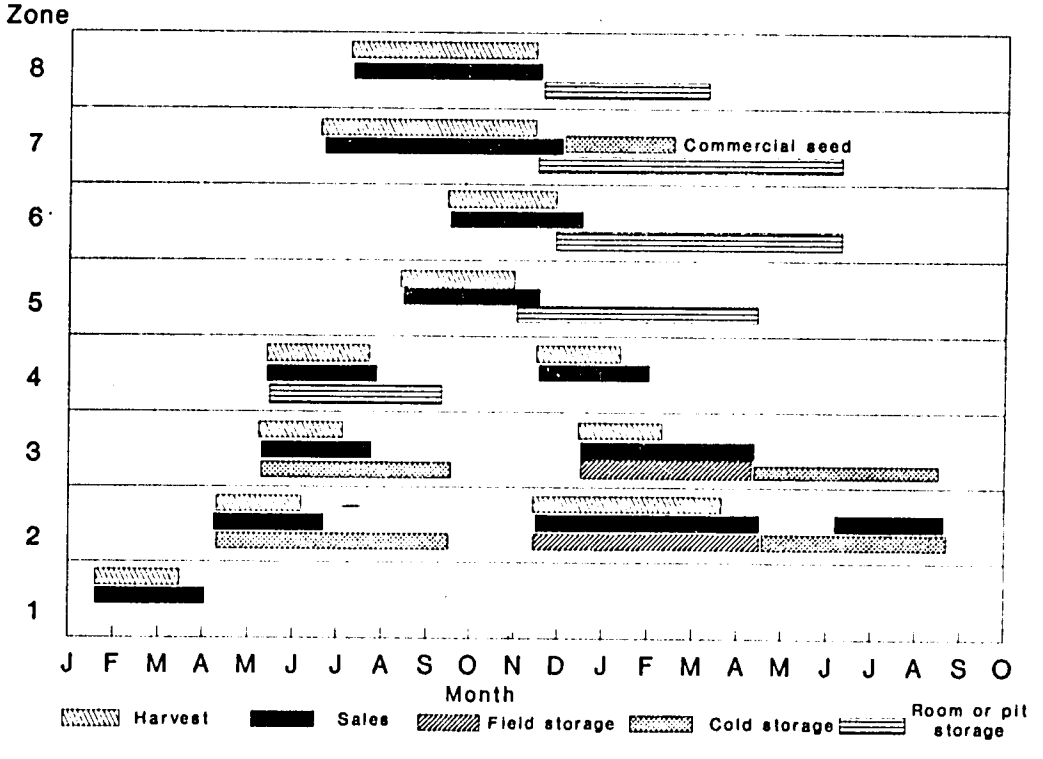
Potato vines are often cut off before harvest. They are used as fodder in some areas, taken off the field, or left as green manure. In all zones except zone 2, potatoes are mainly harvested by hand, using different tools (hoes, spades, small, flat hand-trowels called *khurpas*, or shovels). In zone 2, some farmers use ridgers, diggers, spinners and even automatic harvesters.

If the farmer wants to keep seed for his next crop he grades the potatoes in small and big tubers, and diseased and cut tubers are also separated. If no seed is kept, potatoes are usually not graded since grading standards for consumption are not in use. Some traders may grade the potatoes later on to sell the small tubers as seed and to separate the damaged, diseased and malformed tubers. They sell those at a lower price. Most potatoes are put into jute bags which have a capacity of 85-110 kg.

1.3.11. Post harvest handling

Most table potatoes are sold within one or two months after harvest (Fig. 6). The autumn crop in zones 2 and 3 can be stored in the field in heaps covered with vines or straw until about mid-April. About two-thirds of the crop in zone 2 is sold fresh (Monninkhof et al., 1985). Table

Fig. 6: Post harvest handling in the different production zones



potatoes from the autumn crop in zone 2, which are not sold immediately (about one-third), are put into cold stores to be released in June, July, and August before the fresh potatoes from the summer crops in the hills arrive on the market. They are often very sweet after some time because of the increased sugar content due to the low storage temperature and inadequate handling and warming up when removed from the store. This sweetness is disliked by most consumers (Kokab and Hussain, 1988).

Table potatoes from the spring crops reach the markets between April and June. Seed size tubers from the spring and autumn crop in zones 2 and 3 are put into cold stores to be used as seed for the next autumn crop. About 80% of the spring crop and 15-20% of the autumn crop in zone 2 is kept as seed.

Potatoes from the summer crop in the hills reach the markets between July and November. In the hilly areas of NWFP, Balochistan, and the Northern Areas where road access is difficult, potatoes for seed and home consumption are stored in pits. The rest of the potatoes are sold within a short time as winter approaches and areas become inaccessible. Many of the farmers in those areas need the money for buying provisions, funding marriages etc, or they have to pay back their loans.

The total flow of potato in Pakistan in 1990 combined over spring, summer and autumn season is presented in figure 7.

Most of the cold storage capacity is in zones 1, 2 and 3. There are about 403 cold stores with a total capacity of 600,000 t in the Punjab, 18 with 31,400 t in NWFP, 25 with 29,500 t in Sindh, 2 with 1,000 t in Balochistan, and 1 with 550 t in Azad Kashmir (Source: AMSL, 1991).

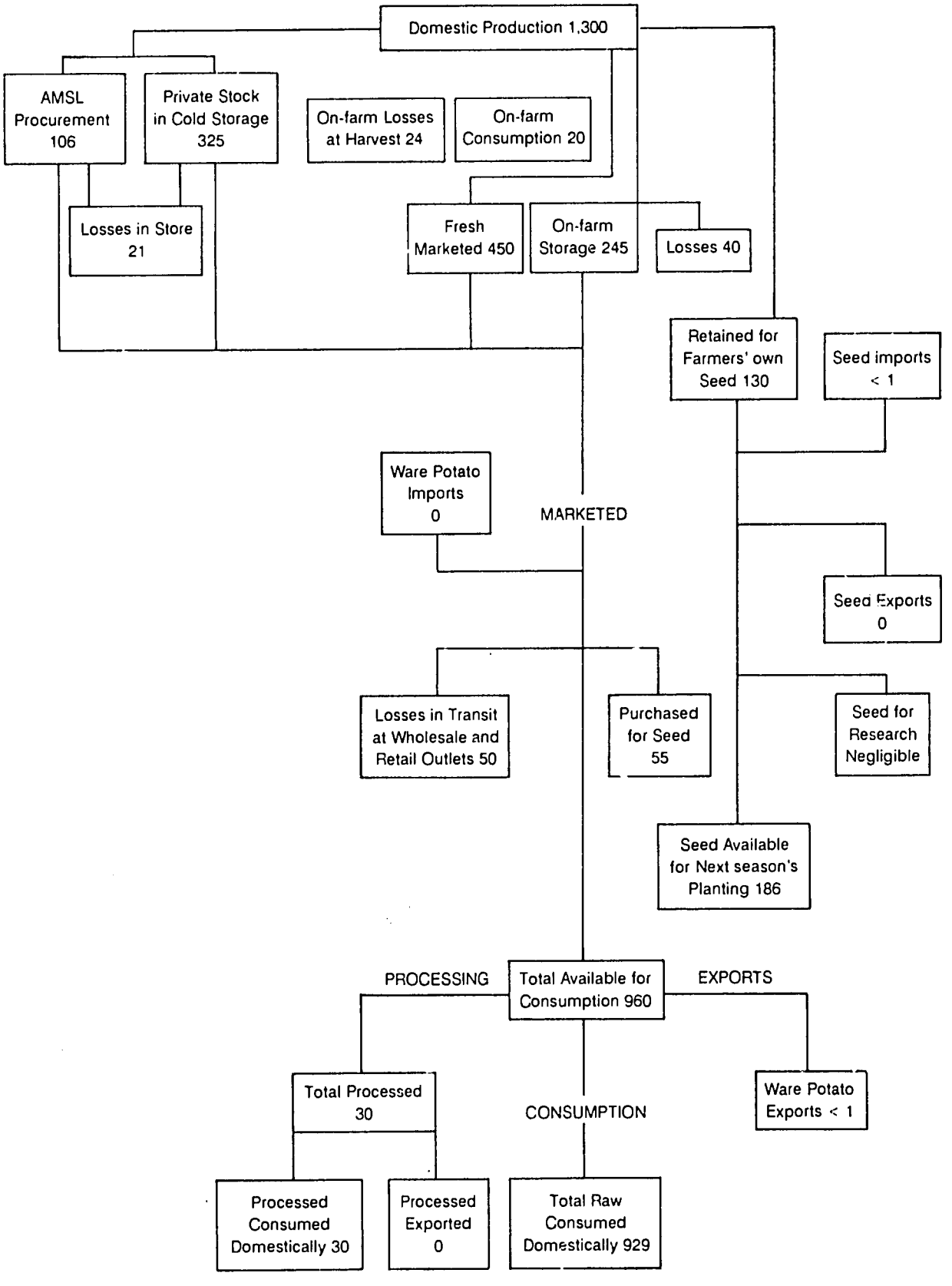
1.4. MARKETING

The marketing of potatoes in Pakistan is complex because: (1) potatoes are grown in spring, summer, and autumn, (2) potatoes are grown in eight different agro-ecological zones, (3) there are large numbers of buyers and sellers, (4) there are many markets, (5) the major production and consumption areas are not identical, especially for the summer crop, (6) table and seed potatoes are marketed through the same channels, and (7) there are big movements of potatoes within and between zones, and some traders buy directly from the field and some farmers sell directly in the markets.

Potatoes are transported from the field to the road side on human back, by camel or donkey. Small vehicles such as jeeps (in Kaghan) and pick-ups are used to transport potatoes for short distances. Trucks with 10 t loading capacity are used for long distances. The major marketing channels for potatoes with the different persons involved are presented in figure 8. Major wholesale markets within each zone and major markets where potatoes are sold from each zone are presented in table 5.

Growers distant from the major wholesale markets sell their produce in local markets, or to traders from outside, or directly to the major markets by organizing their own transport. In zone 8, 57% of the produce is sold directly to traders from outside the province, while 43% passes through the wholesale market in Quetta (Mahmood et al., 1989). Fifty percent of the potatoes sold in Quetta are eventually consumed in the area, the other fifty percent being sold to outside traders. Ten percent of the potatoes from the Kalam area in zone 6 are sold in the

Fig. 7: Flow of potato in Pakistan during 1990 (Estimated figures in '000' tons)

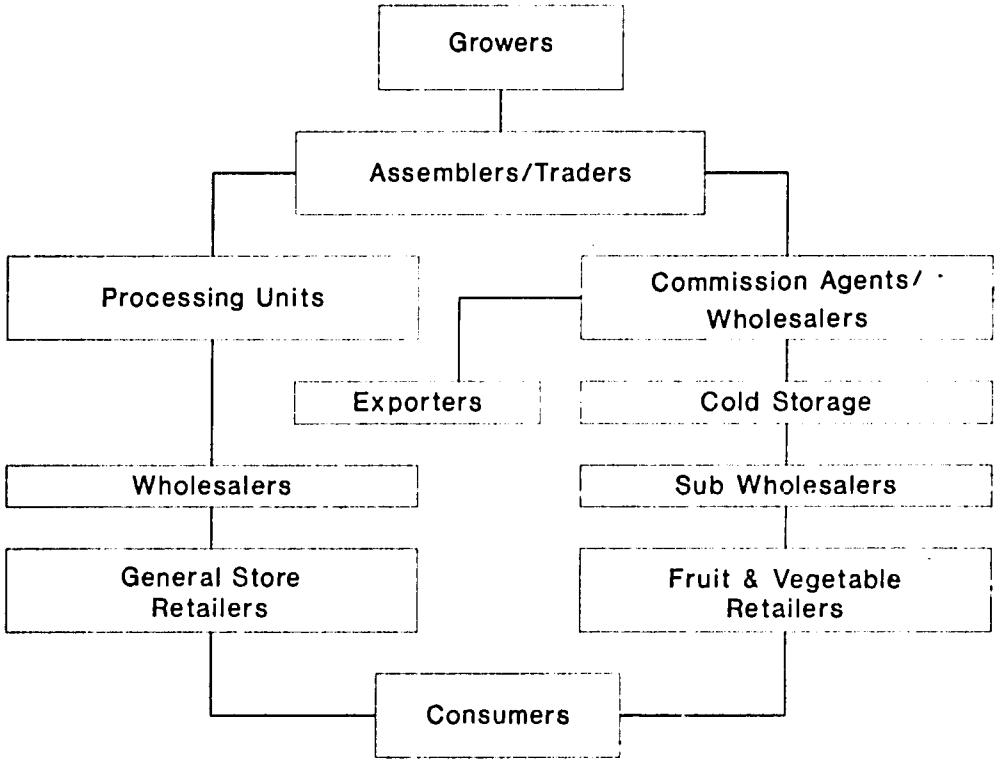


Notes:
- Processed potato products are quoted as raw potato equivalents.
- Since the individual estimates within the above data are subject to errors varying in degree, these should treated with reserve.
- Sources: PSPDP, AMSL.

Mingora market (Kokab, 1989). The other 90% are sold in the street in front of the market directly to traders from Punjab. Growers sell at the local market because of better price expectations, close distance to the market, credit arrangements and contacts with commission agents, and difficulties in arranging transport (Mahmood et al., 1989).

Growers close to the wholesale markets, for example in zone 2, sell directly through commission agents without the intervention of traders. In the wholesale markets, potatoes are sold by auction to sub-wholesalers, retailers, or consumers (especially in the case of seed). Sub-wholesalers then sell to retailers and retailers sell to consumers. Consumers in the north prefer red-skinned varieties, while those in the south prefer white-skinned ones.

Fig. 8: Major marketing channels of table potatoes in Pakistan (Kokab and Smith, 1989)



Exports have declined from over 40,000 t in 1979-80 to practically nil at present (Kokab and Smith, 1989). The main reasons are that the trade with Afghanistan and Iran ceased because of war and that exporters from Pakistan have a poor reputation for quality and reliability.

The main industrial product is chips, but only about 2% of the total production is processed (Kokab and Smith, 1989).

Table 5: Principal seed and table potato markets in each agro-ecological production zone and major markets where produce is sold from each zone.

Zone	Principal seed and table potato markets in the zone[1]	Major markets where produce is sold[2]
1	Karachi, Sukkur, Hyderabad, Larkana	Karachi, Sukkur, Hyderabad, Larkana
2	Lahore, Faisalabad, Gujranwala, Depalpur (during season), Kasur (during season), Leiah (during season), Multan, Okara, Sahiwal, Sialkot (during season), D.G. Khan, Gujrat,	Karachi, Sukkur, Hyderabad, Quetta (seed) for white potatoes, Lahore, Faisalabad, Gujranwala, Rawalpindi/Islamabad, and other Punjabi markets for red potatoes
3	Rawalpindi/Islamabad, Mardan, Peshawar	Peshawar, Mardan, Pabbi, Swabi, Attock for Pabbi, Mardan and Swabi areas, Karachi, Sukkur, Hyderabad for white potatoes from Hazro and Taxila, Rawalpindi/ Islamabad, Lahore, Mardan, Hazro, Peshawar, Taxila for red potatoes from Hazro and Taxila
4	Abbottabad, Mansehra, Mingora	Lahore, Abbottabad, Mansehra for Rush and Pakhal plains, Suwarai, Daggar, Mardan, Mingora for Buner
5	Balakot, Dir	Balakot, Lahore, Faisalabad for the Kaghan valley, Rawalpindi/Islamabad, Abbottabad for the Murree hills and the Galis, Mingora, Lahore, Rawalpindi/Islamabad, Peshawar for the Swat side valleys, Dir, Mingora, Mardan for Dir, Rawalakot, Rawalpindi/Islamabad for Azad Kashmir
6	Chitral	Balakot, Lahore, Faisalabad for the Upper Kaghan valley, Mingora, Lahore, Rawalpindi/Islamabad, Peshawar for the upper Swat valley, Dir, Mingora, Mardan for Thal and Lawari

(Continued)

Table 5 (Continued)

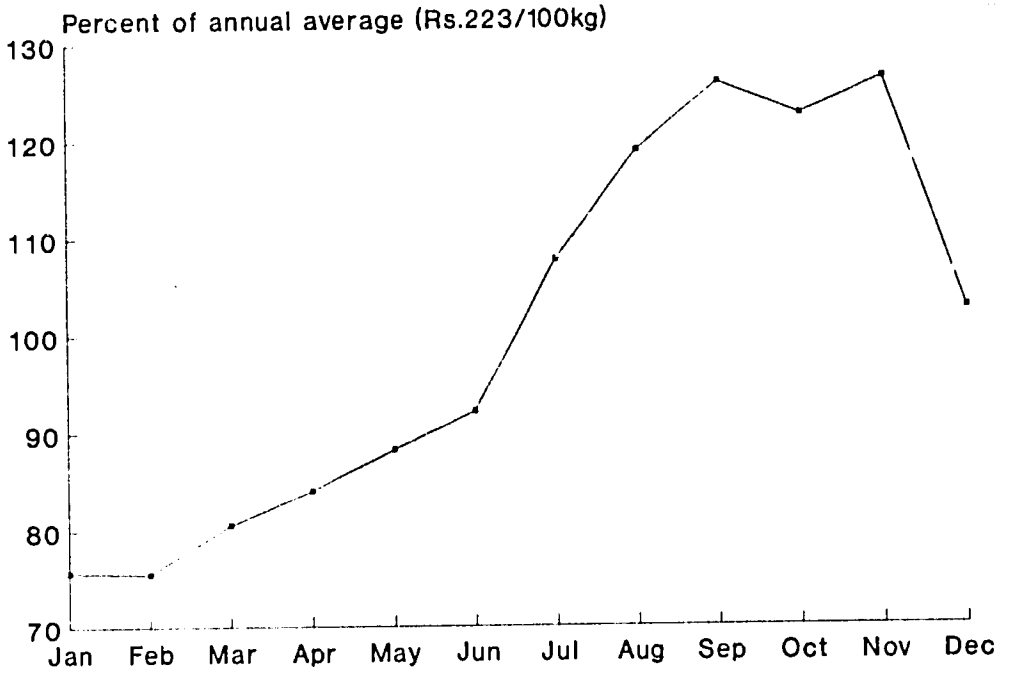
Zone	Principal seed and table potato markets in the zone[1]	Major markets where produce is sold[2]
7	Gilgit, Skardu	Gilgit, Skardu, Chitral, and local exchange of seed among farmers, traders from Lahore, Peshawar, Rawalpindi/Islamabad, Hazro come to farmers field, seed companies take seed to Punjab and Taxila
8	Quetta, Parachinar	Karachi, Sukkur (for Kalat) for white potatoes, Lahore, D.G. Khan, Multan, Faisalabad for red potatoes, about 40% of the potatoes pass through Quetta, 60% go directly to major markets, Lahore, Wana, Tank, Peshawar for potatoes from S. Waziristan

[1]Source: Jamil and Smith, 1990.
[2]Main marketing channels are underlined.

The margins for each link in the marketing chain vary depending on how many intermediaries are involved in the sale of the potatoes. The producers generally get between 55 and 65% of the potato retail price, traders 10%, commission agents 2-12%, sub-wholesalers 10-15%, and retailers 17-23% (Kokab, 1989; Kokab and Smith, 1989; Mahmood et al., 1989). Thus, the producer's share of the retail price is high and of all the intermediaries the retailer receives the highest share of the retail price. Traders and commission agents play another important role in the marketing system by providing credits and seed to farmers.

The long term trend of potato prices in Pakistan was found to be slightly negative (Monninkhof et al., 1987). Like so many other commodities, potatoes are subject to cyclical price fluctuations between high and low prices. It has been found that this cycles from low to high prices are about three years in Pakistan. Smith (1989) attributed these fluctuations to relative elasticity of supply coupled with price inelasticity of demand, and also discussed the policy options to overcome these fluctuations. Potato prices vary also within each season (Fig. 9). The lowest prices are observed in January, February and March when the autumn harvest, which represents about two-third of the total production in Pakistan, reaches the market. The spring harvest, which represents about 14% of the total production, reaches the market from April to June, thus keeping the price relatively low. Then, prices increase steadily until November as only the summer crop, which represents about 20% of the total production, and cold stored potatoes reach the market.

Fig. 9: **Grand seasonal index for potato prices in Karachi, 1954-86**



(Source: Mughal et al., 1987)

The Agricultural Marketing and Storage Ltd. (AMSL), a parastatal organization backed by the Federal Cooperative Bank, is entrusted by the Government of Pakistan to buy potatoes when prices fall below an intervention level set annually by the Agricultural Price Commission (Kokab and Smith, 1989). This intervention system has not been very efficient so far and usually benefits the large farmer only.

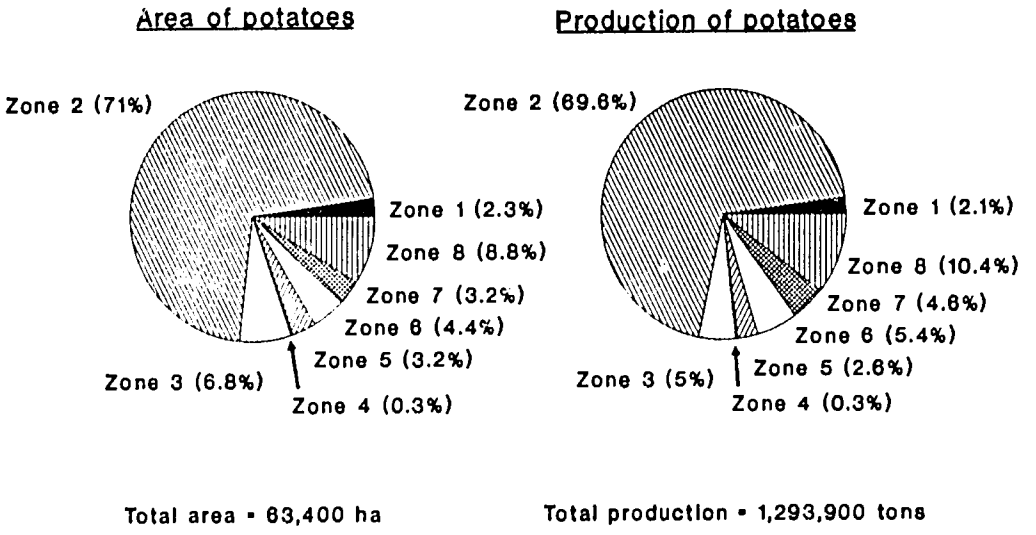
1.5. AREA, PRODUCTION, YIELD, AND CONSUMPTION OF POTATOES

In 1947-48, potato was planted on about 2000 ha with an estimated production of 27,000 t (Geddes et al., 1989). Area, production, yield, and consumption of potatoes vary between zones (Fig. 10; Annexes 2, 3).

Zone 2 is the leading zone for the area and production of potatoes followed by zone 8. Areas under potato are difficult to estimate accurately and fluctuate from year to year, especially in the hilly areas of NWFP and Balochistan. This was particularly evident in 1991, when the area planted under summer crop in the hills decreased sharply because of the high prices for seed potatoes in spring 1991. The estimated area and production of potatoes in zone 7 were calculated, assuming that there are about one hundred thousand farmers growing 0.02 ha (200 square meter) for own consumption. Zones 3 and 6 are other important zones for potato growing. An estimated 20% of the total area is planted with a spring crop, 20% with a summer crop, and 60% with autumn and winter crops (Kokab and Smith, 1989: Naumann-Etienne, 1990).

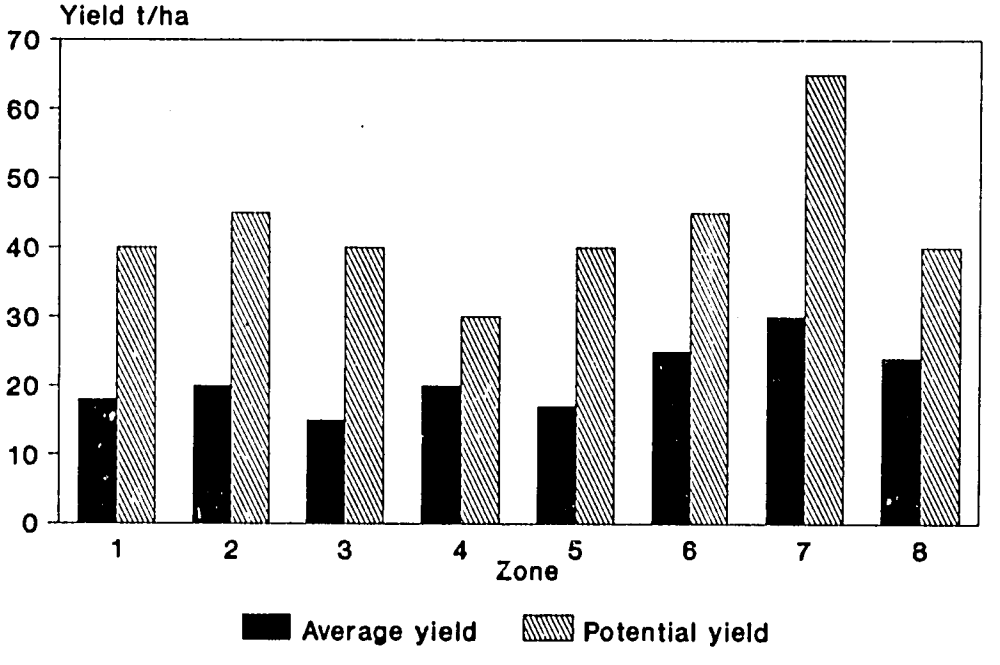
Average yields are low if compared to potential yields but are very similar from zone to zone (Fig. 11). Yield surveys in zone 2 have shown that the autumn crop is on the average

Fig. 10: Estimated area and production of potatoes in Pakistan



(Source: see Annex 3)

Fig. 11: Current average and potential yield in the different production zones of Pakistan



higher yielding than the spring crop because of the favorable climatic conditions and less disease pressure. Likewise, the summer crop seems to be higher yielding than the autumn and spring crop considering the actual average yield and potential yield. This could be explained by the more favorable climatic conditions.

The rural population in the high valleys of NWFP and Northern Areas seem to consume more potatoes per month and per capita than the people in urban areas of big cities (Table 6). Consumption is particularly high in Hunza and Chitral where potatoes traditionally have been produced for home consumption, which are far from major markets and which are less accessible in winter. Farmers, for example in Kaghan and Kalam, who migrate during winter tend to eat less than those who stay behind. In years of shortage, farmers tend to sell most of their produce, thus own consumption is likely to be smaller. People in the high valleys consume potatoes only during 6 to 8 month while potatoes are being stored in pits.

In urban areas, more potatoes are consumed during winter (December to February) when they are fresh than in summer when they are sweet (Kokab and Hussain, 1988). The average consumption per person and year is more or less constant as people tend to use potatoes as vegetables and not as a staple food. Freshness, price, and skin color were the most important characteristics considered by consumers when buying potatoes. Shape and size were less important, which may explain why table potatoes are not graded after harvest.

Table 6: Monthly per capita consumption of potatoes in urban and rural areas of Pakistan.

City/area	Average monthly consumption (kg)	Range of monthly consumption (kg)
Karachi[1]	0.9	0.5-1.2
Lahore[1]	0.9	0.5-1.2
Multan[1]	1.2	0.5-1.4
Peshawar[1]	1.2	0.6-1.6
Quetta[1]	1.1	0.6-1.4
Rawalpindi[1]	1.1	0.4-1.3
Pakhal plain	0.8	
Kaghan valley[2]	1.3-2.7	
Kalam[2]	1.7	
Darel valley[2]	3.3-5	
Chitral[2]	1.7-7	
Hunza[3]	6.3-12.5	
Balochistan[4]	5.3	

[1]Source: Kokab and Hussain, 1988, assuming an average family size of 8 persons per family.
[2]Only 6 months of the year because of pit storage.
[3]Only 8 months of the year because of pit storage.
[4]Only 4 months of the year because of pit storage.

1.6. CONSTRAINTS, RESEARCH AND DEVELOPMENT OPPORTUNITIES

Major constraints, research and development opportunities are summarized in table 7.

Table 7: Constraints and research and development opportunities in the agro-ecological potato production zones of Pakistan.

Zones	Constraints	Research and development opportunities
1, 4	Limited information available about potato farming systems	Farming system surveys
1, 2, 3, 8	Limited supply of good quality seed	Integration of zones 1, 2, 3, and 8 into a national seed distribution system, survey of the seed sources and flows, especially market seed, survey and description of seed quality from different areas, especially market seed and distribution of this information to farmers and traders, survey of aphid populations and degeneration rates in different areas to predict seed quality, foster contacts of farmers and traders with reliable seed suppliers and producers in zone 2 and hilly areas of Balochistan, NWFP, and Northern Areas, research in seed storage and multiplication within zones 1 and 8, research in seed type and rate in zone 1, improve farmers' own seed multiplication system, integrate domestic pre-basic seed units into commercial system
1, 2, 3, 5, 6, 7	Cyclical and seasonal price fluctuations contribute to loss of income, especially of small farmers, limited marketing opportunities and access to major markets of producers in Pabbi, Mardan and Swabi districts, and zones 5, 6, 7, potatoes in zone 1 arrive on the market after the autumn crop of zone 2	Survey of marketing channels, foster contacts of producers with local traders and major markets, taking full advantage of shorter transport distances in zone 1, the higher seasonal prices in zones 5 and 6, and zone 7 as a seed production area, research in planting and harvest dates in zone 1, gathering of market information including consumer habits and distribution of the information to farmers and local traders, study of storage possibilities for table and seed potatoes in zones 5 and 6, research in planting and harvest dates, study of profitability of potato within the existing farming system as compared to other crops considering experience of farmers in Hazro and Taxila with white potatoes, in Kalam with turnips and in Battakundi with peas, encourage market-led production and flexible cropping response, survey of transport facilities, research in post harvest handling, survey of credit facilities both formal and informal, support storage of inputs and seed production in zone 7
1, 4	Limited importance of potato crop	Farming system surveys to optimize potato in the existing systems, study of profitability of potatoes within the existing system, research and demonstration plots with optimal agronomic practices, survey of climatic conditions in different areas, socioeconomic survey, consumer survey, market opportunity studies, product promotion
2, 3, 4, 5, 6, 7	Inefficient use of inputs such as fertilizer, pesticides, and water	Research in optimal use of fertilizers, pesticides and water, distribution of results to farmers, extension staff, and fertilizer and pesticide dealers, study of the marketing channels of inputs, survey of diseases, pests, and soils to recommend optimal control measures and fertilizer rates for different areas, erosion control, training of extension staff, and seed company representatives (zone 7), development of extension media, erosion control in zone 5

(Continued)

Table 7 (Continued)

Zones	Constraints	Research and development opportunities
2, 3, 5, 6, 8	Disease and pest build-up	Study of optimal crop rotations and intercropping within the existing farming system, survey of diseases, pests, and their control in different areas, all seasons and for different varieties, research in economical thresholds of diseases and pests, distribution of results to farmers, extension staff, and pesticide dealers, improve seed quality, study of profitability of the potato crop within the existing farming system under increased disease and pest pressure
3, 5, 6	Limited cash flow, limited access to credit facilities	Survey of credit facilities including formal and informal sources, foster contacts between farmers and traders who supply inputs on credit, study of the profitability of potatoes compared to other crops within the existing farming system, study of storage opportunities of seed in pits in zones 5 and 6, socioeconomic survey to study cash flows, consumption habits, and decision making within farming families and their interaction with shopkeepers, traders and landlords
4, 5, 7, 8	Climatic conditions: limited water resources in zones 7 and 8, heavy rains in spring in zone 4, dependence on rainfall in zone 5	Study of planting and harvest dates, seed type and seed rate, planting techniques and water management, seed treatments, survey of climatic conditions in different areas, study of the profitability of potatoes compared to other crops in the existing farming system and off-farm employment opportunities, control of water and wind erosion
8	Landlords are main decision makers	Socioeconomic survey to study interaction between tenants and landlords, distribution of research and extension results to landlords and tenants

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Potatoes play a minor role in the Sindh Province but other vegetables (squash, chillies, tomatoes, lettuce etc.) are grown more commonly.
Malir (district Karachi), a once important potato growing area.

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Female labour plays a important role In agriculture, not only in the Sindh province.

2. ZONE 1: IRRIGATED PLAINS OF SINDH, SOUTHERN PUNJAB AND BALOCHISTAN

2.1. GEOGRAPHICAL COVERAGE

2.1.1. Altitude

Zone 1 covers the southern part of the Punjab, the Sindh province excluding the Thar desert, the Kachhi and Nasirabad district of Balochistan, and the southern coastal land of Balochistan which are below 150 m a.s.l. (Table 1).

Table 1: Approximate altitudes (m a.s.l.) of important cities in zone 1.

City	Subzone	Altitude (m a.s.l.)
Nawabshah	1a	40
Sibi	1b	132

2.1.2. Latitude and longitude

Zone 1 spans five degrees of latitude (24°to 29°) and seven degrees of longitude (62°to 69°).

2.1.3. Topography

The potato growing areas in this zone are open, very flat flood plains.

2.1.4. Potato production areas

At present there is a very small potato production in this zone. What little there is, can be found mainly in the areas of Shikarpur, Sukkur, Khairpur, Nawabshah, and Sibi (Fig. 1). Some experimental cultivation has been tried by the Balochistan Department of Agriculture in the Balochistan coastal plains and around Sibi.

This agro-ecological zone can be further subdivided into two subzones: (a) southern part of the zone, south of Nawabshah city, frost free, hot and arid climate, more than 125 mm annual rainfall, and (b) northern part of the zone, north of Nawabshah city, probability of frost, very hot and arid climate, less than 125 mm annual rainfall.

2.2. ECOLOGY

2.2.1. Temperature

The climate in this zone is hot and arid in the subzone 1a, however the nearer to the sea, the more humid and less hot it becomes. In the subzone 1b it is very hot and arid. The maximum temperatures stay above 35°C from April to October (Fig. 2). Mean temperatures in subzone 1b, especially around Sibi, are higher than in subzone 1a (Syed, 1985). The highest temperatures occur in May, June and July, and the lowest in December, January, and February. The frost risk is highest from December to February in the subzone 1b, increasing from south east to north west, and is very low in subzone 1a.

2.2.2. Precipitation

Most rainfall is in July and August, and very little rain falls from October to June as the westerly depression in winter does not affect this zone (Fig. 3). The total annual rainfall is below 125 mm in subzone 1b, and above 125 mm in subzone 1a (198 mm for Nawabshah averaged over 1931-60). Some areas, especially in subzone 1a, might get some more rainfall due to the monsoon.

2.2.3. Irrigation infrastructure

With little rain, the entire potato crop is grown under irrigation. Nearly all the water is supplied from canals. Both the amount of water and the distribution system are often rather inadequate. The time for irrigation is fixed, usually once a week. The quantity of water allocated to each farmer depends on the size of his holding. Several times before harvest, people from the Revenue Department come and check how much area of each crop is grown and consequently fix the amount to be paid for irrigation water. Tubewells are not common. The water table in the main potato growing areas is at about 15-30 m.

Canals are shut for cleaning in January for two weeks, and this period is sometimes extended. Consequently, there is usually a period of severe water stress during bulking which will cause lower yields.

2.2.4. Soils

The main soils are calcareous silty loams and silty clays with weak structure and good porosity. The pH varies from 7.8-8.3, organic matter content is about 0.5%, and salinity and water logging are major problems (Khan, 1980).

2.2.5. Cropping season

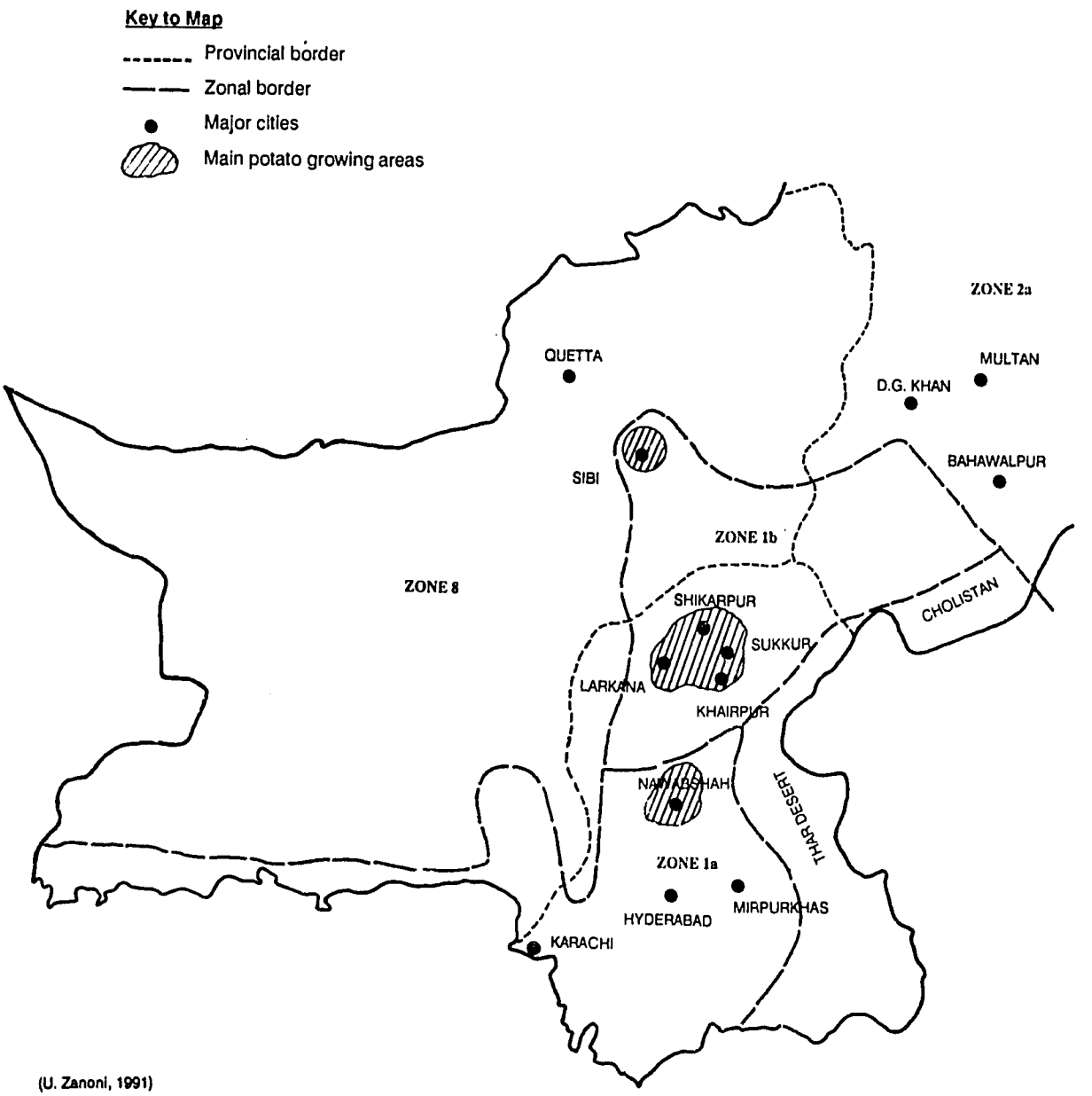
Normally crops are grown in winter (*rabi* season) and summer (*kharif season)*. With an altitude below 150 m, and a southerly latitude, this zone experiences a largely frost free winter. Conversely, the temperatures rise fast early in the season and the summer heat persists longer than in other zones. Thus, spring and summer crops of potatoes are not possible (Rizvi and Shaikh, undated). Temperatures drop sufficiently for planting of potatoes to start in the second half of October and the cropping season extends through to March, with the main crop harvested between late January and the end of February. Cool nights and moderately warm days during these months are favorable for potato production. With this long period, planting can be delayed without reducing yield. In the northern part of the zone there is some danger of frost in January and planting and harvesting are a little earlier.

2.3. PRODUCTION FACTORS

2.3.1. Farm size

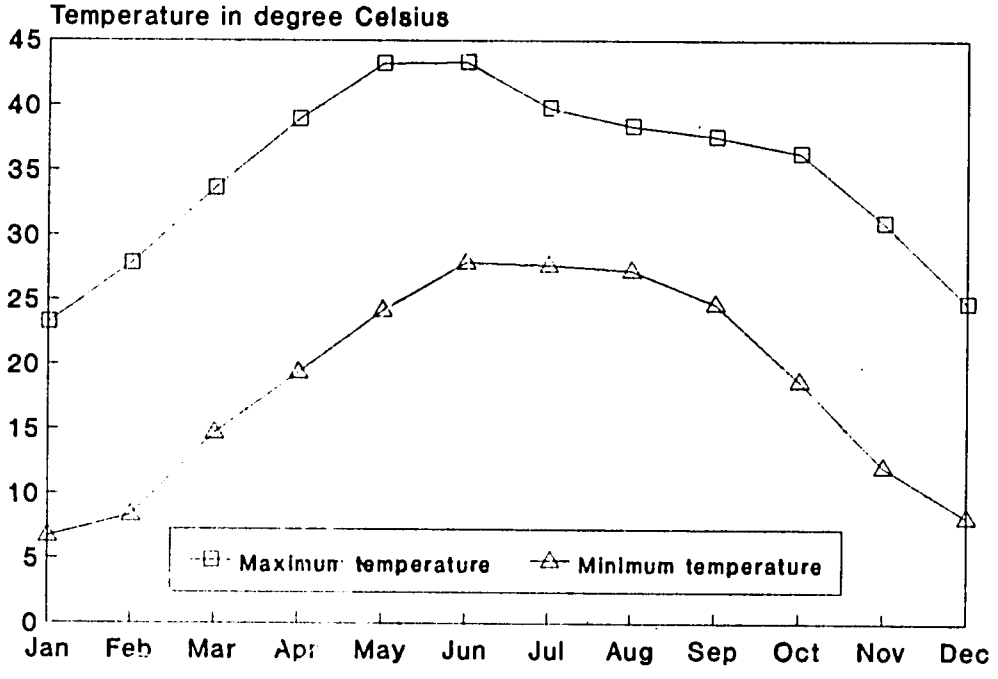
Potatoes are grown by small, medium and large farmers. The sparse information available suggests a mean size of holding of 20-30 ha (Wadhayo, undated).

Fig. 1: Main potato growing areas in zone 1



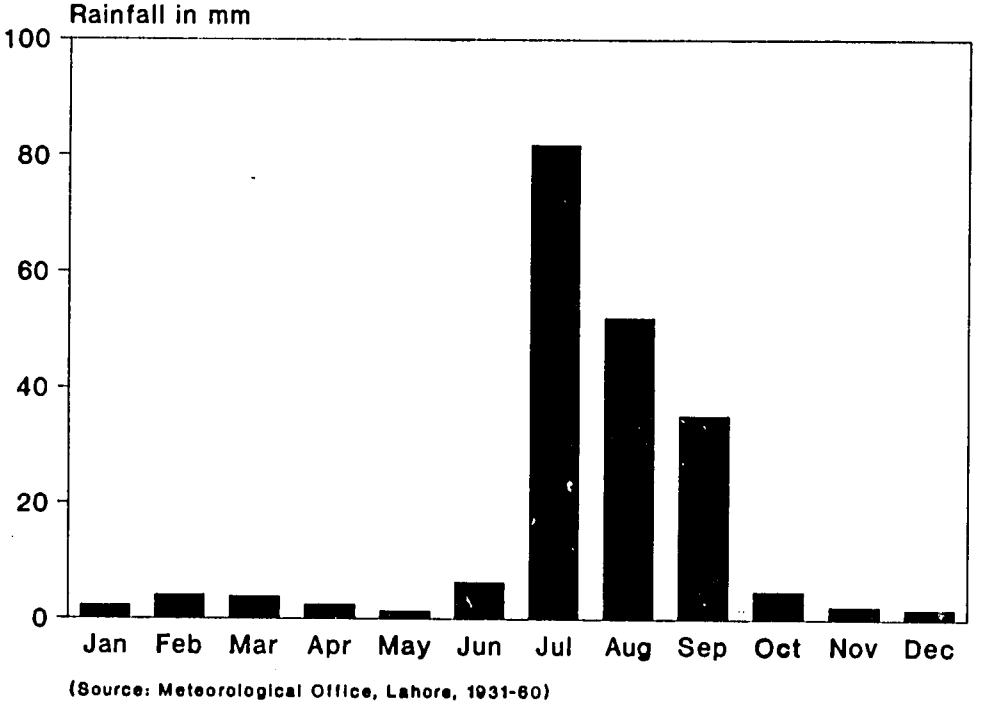
(U. Zanoni, 1991)

Fig. 2: Mean monthly temperatures at Nawabshah (zone 1)



(Source: Meteorological Office, Lahore, 1931-60)

Fig. 3: Mean monthly rainfall at Nawabshah (zone 1)



(Source: Meteorological Office, Lahore, 1931-60)

2.3.2. Land tenure

Potatoes are grown by both owners and tenant farmers. Land is usually rented for cash rather than on a share-crop basis. If they are grown on a share-crop basis, then inputs and produce are equally shared among owner and tenant.

2.3.3. Labor

Most work, except land preparation, is done by hand, mainly with own family labor. Additional labor may be hired for planting, earthing-up, and harvest.

2.3.4. Credit

Farmers might purchase seed on credit through commission agents and traders, rarely they get credit from the ADBP.

2.4. FARMING PRACTICES

2.4.1. Cropping pattern

Wheat, vegetables (turnips, radish, carrots), pulses and fodder (berseem, *Trifolium alexandrinum*) compete with potatoes in the winter. Sugarcane and bananas, which occupy the ground the whole year, are also competitors. Rice, cotton, maize and chillies are grown as purely summer crops. Sweet potatoes are also competitors. Rice is grown in the northern areas, and cotton and sugarcane more in the southern areas.

Tree crops are important cash crops, particularly mango.

2.4.2. Potato production

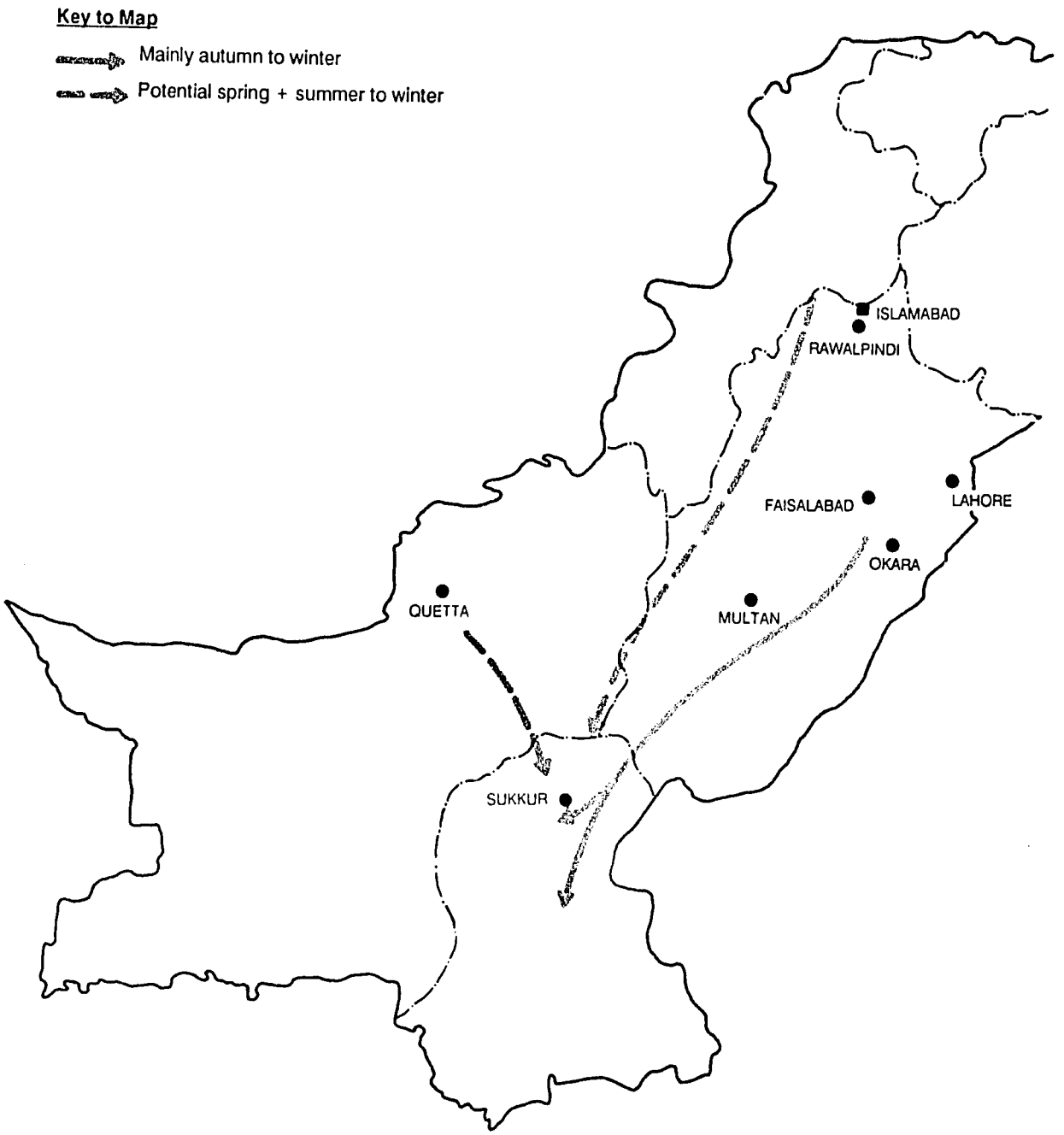
2.4.2.1. Varieties

Mostly white varieties are used as this is the main type preferred by consumers in the zone. Diamant and Patrones are the most commonly grown white varieties. The only red variety at all common in 1983 was Desiree (Wadhayo, undated).

2.4.2.2. Seed sources

Most of the seed is obtained from the autumn crop in the Punjab (Naumann-Etienne, 1990; Fig. 4). It is stored in the Punjab and then brought to the zone by traders after storage. Okara district, which grows more white potatoes than red, is the main area of supply. Some of the seed may come from the early summer crop in Balochistan or the spring crop in Hazro and Taxila through the Sukkur market. Few, if any, farmers are thought to multiply their own seed, presumably due to their lack of access to a reliable source of healthy seed to start the cycle, and the subsequent high rate of degeneration caused by vector-transmitting aphids. Also the access to cold stores may play a role but this requires further investigation.

Fig. 4: Main seed sources for zone 1



(U. Zanoni, 1991)

2.4.2.3. Land preparation

Primary tillage is mainly done by tractor. A spring tine cultivator is used for ploughing and about eleven passes over the field are made in the ploughing operation. Some planking and levelling is also done.

2.4.2.4. Fertilizer

FYM and chemical fertilizer are both used. The FYM is spread on the fields before ploughing. In the 1983/4 survey of 21 farmers the mean levels of N, P and K used were 146-106-55 kg/ha (Wadhayo, undated). Urea and DAP are the most common fertilizers used.

2.4.2.5. Planting

The potatoes are placed in rows about 65-75 cm apart and then ridges formed over them by spade. Whole tubers are usually planted at an average seed rate of 3.2 t/ha (Naumann-Etienne, 1990).

2.4.2.6. Weeding and earthing-up

No information available.

2.4.2.7. Water management

Rizvi and Shaikh (undated) recommended to start irrigating right after planting to avoid seed rotting and poor emergence. Water is probably applied once a week according to the quantity of canal water allocated and as recommended by Rizvi and Shaikh. A system of ridges and tie-ridges is used to manage the water flow.

2.4.2.8. Diseases, pests, and their control

Farmers complain of the virus level in their crops but no survey to assess the degree of infection has been reported. Since they rely on market seed rather than multiplying their own, a generally higher level of virus than in the adjacent zone 2 can be expected.

Early blight (*Alternaria solani*) is reported to be common, particularly in Northern Sindh but this has to be confirmed. Late blight (*Phytophthora infestans*) does not seem to cause problems as it attacks too late in the season to cause damage (Rizvi and Shaikh, undated).

In southern Punjab mite attack is confused with early blight. The incidence for Sindh is reported to be 25% (Mughal, 1981). Cutworms are also common and to a lesser extent, jassids.

Most farmers use some form of chemical to control pests and diseases including systemic insecticides (Thiodan) and the fungicides Bordeaux Mixture and Dithane M-45. The insecticide Malathion is also used. The extent to which the right chemicals are selected to match the problems is not known, nor is their effectiveness.

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2.4.2.9. Harvest

Harvest is done manually.

2.4.2.10. Yield

There is sparse information available on yield. In other zones official yield statistics have been shown to be far too low. The only yield surveys known to have been carried out are that of twenty farmers in 1977/8 (Siddiqi, 1979) and twenty one farmers in 1983/4 (Wadhayo, undated). Both surveys were confined to Sindh and they estimated yield by simply asking the farmers what yield they got. In these surveys in Sindh the yield estimates were 18 and 20.6 t/ha.
(Note: The survey report by Siddiqi misquotes the mean yield as 104.69 maunds/acre instead of 194.69 maunds/acre. Assuming 37.4 kg per maund, the latter gives 18 t/ha).
Lower yields were obtained at the Sindh Horticulture Research Institute, Mirpurkhas (Mughal, 1981). Rizvi and Shaikh (undated) reported average yields over 4 years of Multa and Patrones at Mirpurkhas to be about 18 t/ha. Some varieties yielded as much as 40 t/ha in 1970, which apparently was a favorable year.

2.4.2.11. Post harvest handling

Very little of the potato crop from the zone is stored before sale. There is no seed crop to store, but it is not known why farmers do not cold store table potatoes to sell them later in the year when prices are higher. In 1991, there were about 25 cold stores with a total capacity of 29,500 t in Sindh (Source: AMSL, 1991). However, in a former survey in 1984/85 the stores were used mainly to store fruit. From April/May to September the cold stores were virtually empty.

2.4.2.12. Marketing

Farmers normally sell their produce to small wholesalers in their local growing area. These small wholesalers transport the potatoes to the main markets for sale to larger wholesalers. The latter sell to retailers. The main potato wholesale markets in the zone are Karachi and Sukkur. Karachi is the largest potato market in Pakistan. The wholesale markets at Hyderabad, Larkana, Khairpur, Mirpurkhas and Thatta also deal in potatoes. Only about one fifth of the potatoes consumed in the zone are produced in it. The rest come from zones 2 and 3 from December to August, and from zone 8 from August to November. Sukkur is an important market for potatoes coming from Balochistan.

2.5. PRODUCTION SUPPORT PROGRAMS

Sindh Horticulture Institute, Mirpurkhas: The only potato program in the zone is the research program of this research institute located at Mirpurkhas. From 1974 to 1985 useful research work was done by the institute under the PL-480 program, but since this ended, the provincially funded program has had too few resources to develop the work sufficiently to have much impact on farmers' production. In future, collaborative work with PSPDP is planned.

Sariab Agricultural Research Institute, Quetta: This is the provincial institute near Quetta. They are carrying out trials in the Balochistan plains to see if a plains-hills seed cycle can be implemented within the province.

2.6. CONCLUSIONS

There is at present very little potato production in this zone. Little information is available about the farming systems involving potatoes. The major constraints to potato production in this zone appear to be seed quality and the relatively low prices at harvest (seasonal low).

Seed is mainly supplied from the Punjab and seems to be of poor quality. Farmers in this zone do not seem to multiply their own seed.

Since potatoes are harvested end of January, and in February, when the major markets are already inundated by the Punjab autumn crop, prices are at a seasonal low.

The only research done with potatoes in the Sindh has been the screening of germplasm during the PL-480 project. Little is known about the limitations in agronomic practices.

The greatest potential for the development of production seems to lie in improved seed by integrating this zone into a national seed distribution system whereby improved, certified seeds becomes available to the farmers.

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Farmyard manure (FYM) is laid out in heaps to be spread out and ploughed in near Gujranwala, Punjab. FYM, if available, is in many areas one of the most important factors to maintain soil fertility.

A good looking crop during mid-season (autumn) near the Chenab river, Chiniot, Punjab.

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Spraying of insecticide and fungicide in mid-November near Okara, Punjab.

Harvesting of potatoes with tractor driven spinner, Sahiwal, Punjab.

3. ZONE 2: IRRIGATED PLAINS OF CENTRAL PUNJAB AND SOUTH EAST NWFP

3.1. GEOGRAPHICAL COVERAGE

3.1.1. Altitude

Zone 2 covers the central part of the Punjab and the south eastern part of NWFP which are below 300 m a.s.l. (Table 1).

Table 1: Approximate altitudes (m a.s.l.) of important cities in zone 2.

City	Subzone	Altitude (m a.s.l.)
Bahawalpur	2a	112
Multan	2a	123
D.I. Khan	2a	172
Faisalabad	2b	186
Lahore	2c	215

3.1.2. Latitude and longitude

Zone 2 spans three and a half degrees of latitude (29° 30' to 33°) and four degrees of longitude (70° 30' to 74° 30').

3.1.3. Topography

The potato growing areas in this zone are open, mostly flat flood plains.

3.1.4. Potato production areas

At present about 70-80% of the potato crop of Pakistan is produced in this zone. Potatoes are grown in most districts of the Central Punjab, except for the Thal desert and most part of the Bahawalnagar district (Fig. 1). The most important districts are Okara, Sahiwal, Faisalabad, Kasur, Sialkot, Gujranwala, followed by Lahore, Sheikhupura, T.T. Singh, Jhang, Gujrat, Sargodha, and parts of Khushab, Multan, Vehari, and Bahawalnagar. A few farmers also grow potatoes around D.I. Khan in NWFP (Khan and Hussain, 1990). Production is concentrated around towns, close to cold stores and markets (Geddes et al., 1985). There is also a very small production in Azad Kashmir at Mirpur, with agro-ecological conditions similar to Sialkot (Punjab).

This agro-ecological zone can be further subdivided into three subzones: (a) southern part of the zone, late planting of the autumn crop because of high temperatures, hot, arid climate, (b) central part of the zone, early planting of the autumn crop possible, warm, semi-arid climate, (c) northern part, early planting of the autumn crop not always possible because of monsoon rain, warm, sub-humid climate.

3.2. ECOLOGY

3.2.1. Temperature

The climate in this zone is hot and arid in the subzone 2a, warm and semi-arid in the subzone 2b, and warm and sub-humid in the subzone 2c. All locations display the same longtime seasonal pattern of temperatures (Fig. 2, 3 - 5). However, the mean temperature decreases with increasing latitude. Therefore, the summer is milder in subzones 2b and 2c (Faisalabad and Lahore) than in subzones 2a (Multan). The highest temperatures occur in June and the lowest in December and January. The frost risk is highest from December to February.

The maximum temperature decreases sharply in July with the onset of the monsoon rains and reaches a plateau until September. The decrease is more pronounced in Lahore because of higher rainfall than in Faisalabad and Multan. The mean minimum temperatures in Lahore do not mount as high nor drop as low as in the other stations.

3.2.2. Precipitation

Most rainfall is in March, July, and August, and the driest months are October, November, and December (Fig. 6). The total annual rainfall increases from the south west of the zone to the north east (Table 2).

Table 2: Total annual rainfall for different stations in zone 2 (Source: Meteorological Office, Lahore, 1977-86).

Station	Subzone	Total annual rainfall mm
Bahawalpur	2a	152
Multan	2a	224
Faisalabad	2b	447
Lahore	2c	699

3.2.3. Irrigation infrastructure

Insufficient rainfall makes irrigation necessary. All potato production is irrigated by tubewell and/or canal. Canal water is usually less saline, but the supply is interrupted for canal cleaning in December/January. Tubewells give better control of the irrigation schedule and the quantity of water applied. Tubewells are therefore more commonly used (see also Bajwa and Eberlin, 1991).

In some areas tubewells may be collectively owned and maintained by the farmers (Tariq et al., 1991b). Funds are collected from about 4 to 20 households with adjacent fields to pay for the installation of new tubewells.

Fig. 1: Main potato growing areas in zone 2

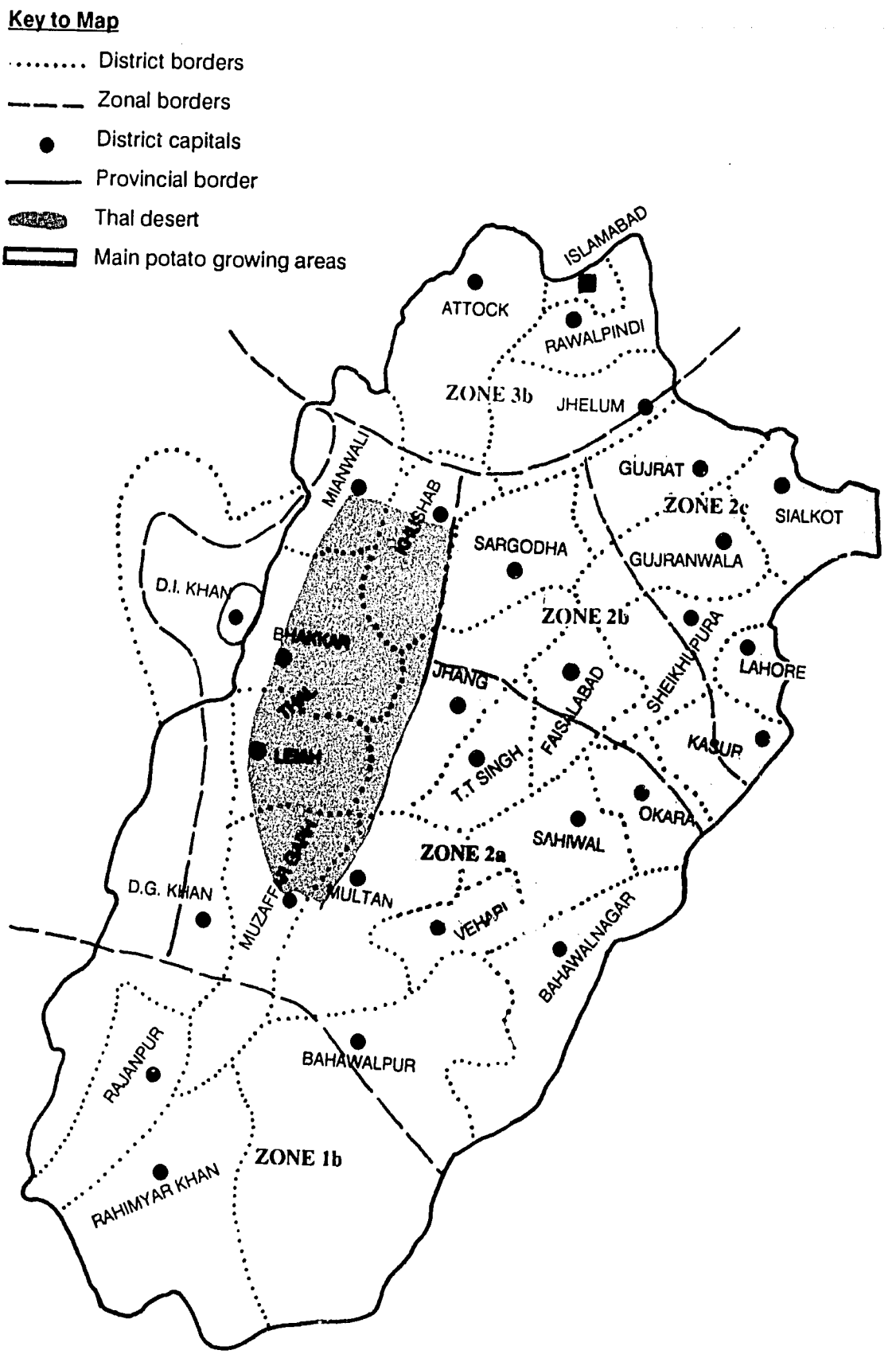
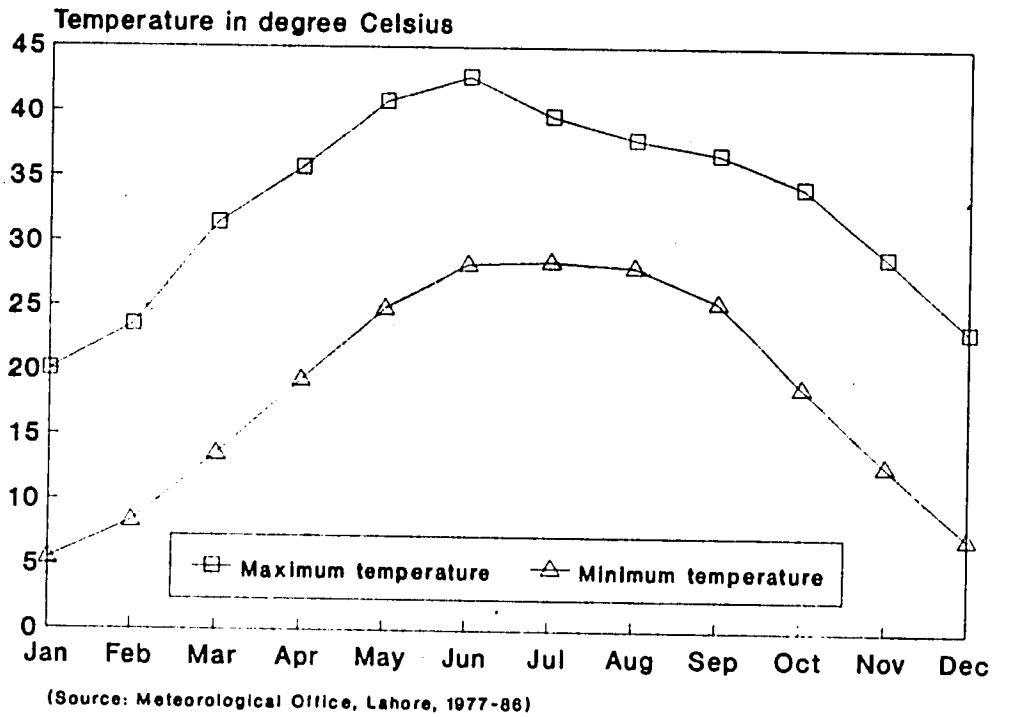
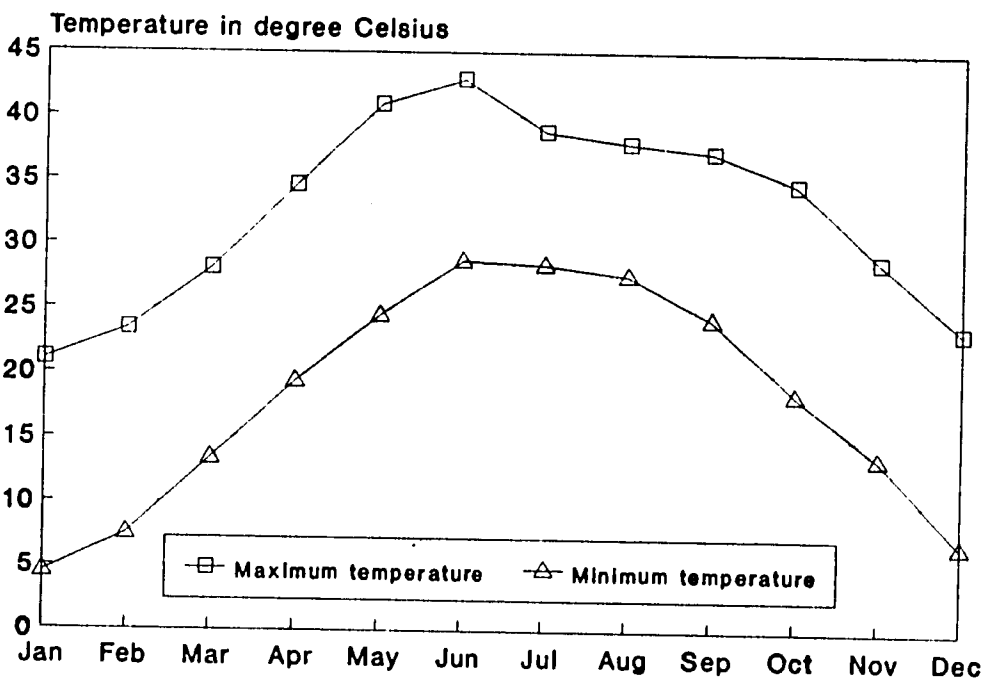


Fig. 2: Mean monthly temperatures at Bahawalpur (subzone 2a)



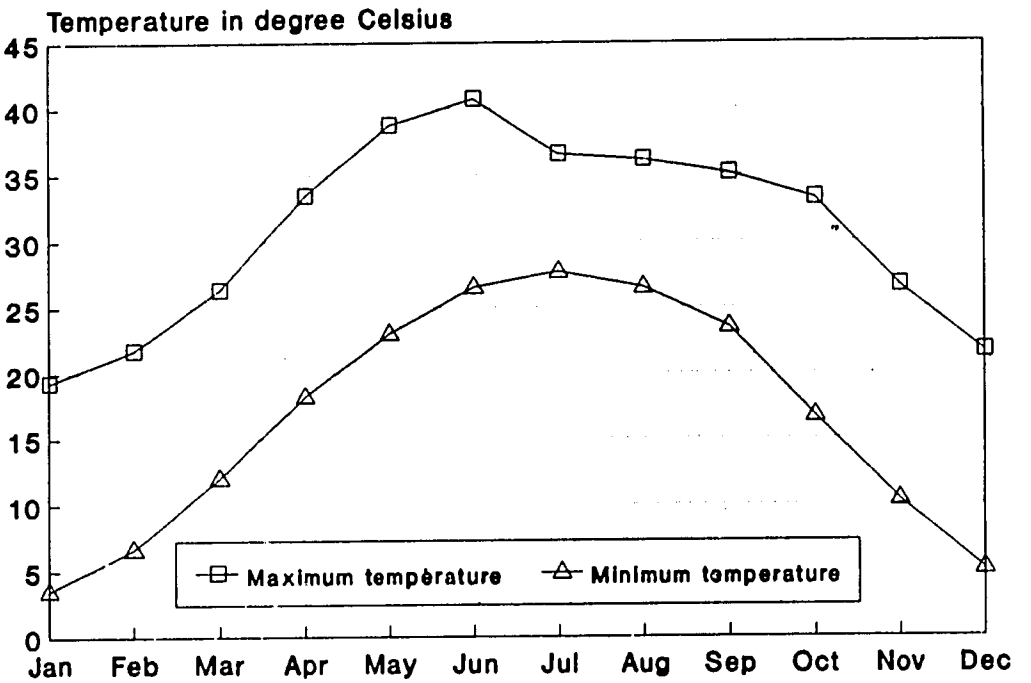
(Source: Meteorological Office, Lahore, 1977-86)

Fig. 3: Mean monthly temperatures at Multan (subzone 2a)



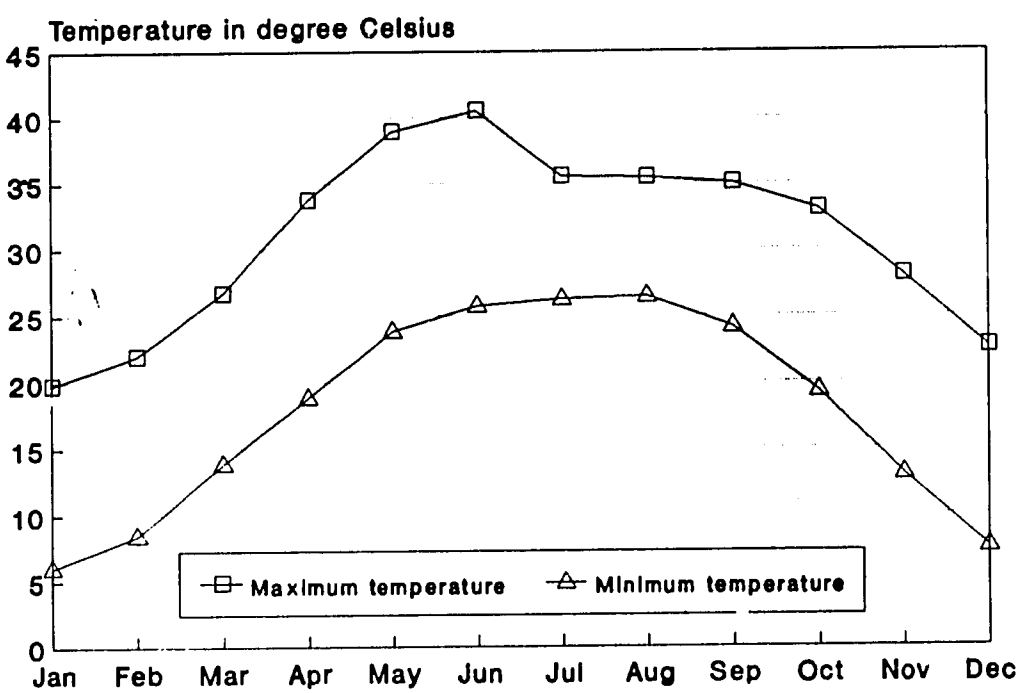
(Source: Meteorological Office, Lahore, 1977-86)

Fig. 4: Mean monthly temperatures at Faisalabad (subzone 2b)



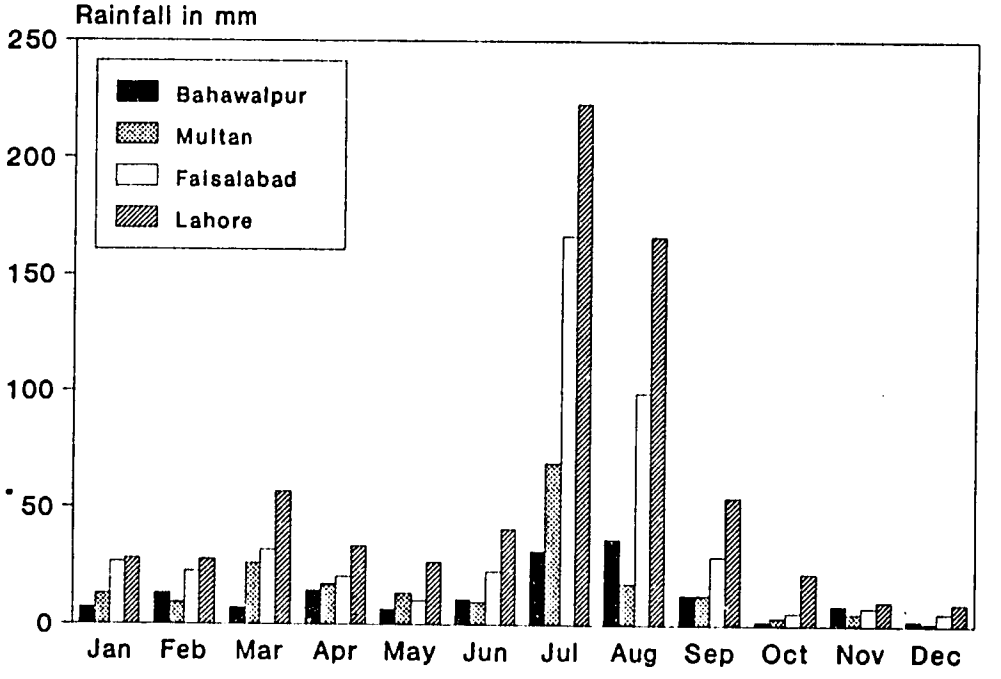
(Source: Meteorological Office, Lahore, 1977-86)

Fig. 5: Mean monthly temperatures at Lahore (subzone 2c)



(Source: Meteorological Office, Lahore, 1977-86)

Fig. 6: Mean monthly rainfall in zone 2



(Source: Meteorological Office, Lahore, 1977-86)

3.2.4. Soils

Soils in this zone vary from calcareous sandy/silty loams with weak structure near rivers to non-calcareous clay loams. A survey among 60 potato growers in the main potato growing districts showed that about 60% of the soils are loams, 30% rich loam/clay soils (heavy soils), and 7% sandy loams (light soils), and 3% soils with problems (Geddes et al., 1985). Silt loams are dominant in the southern and central part, while loams and clay loams are dominant in the northern part (Khan, 1980). Loamy soils occur on higher areas, clayey soils on lower areas. The organic matter content is low (<1%). The pH is generally between 7.5 and 8.5, but may be above 9, especially for soils with salinity problems (Khan and Webb, 1984; Turkensteen, 1987). Thus, phosphorous and micronutrient fixation may be a problem.

Banaras (1985) found that soils in Okara and Sahiwal were well supplied with N, P, and K, and that consequently lower fertilizer rates gave the same yield as compared to the farmers' practice. Zinc deficiency is a problem in this zone (Turkensteen, 1987). Therefore, zinc is applied to sugarcane and rice. Potatoes seem to respond to zinc applications as well.

Imperfect drainage, water logging, and salinity can be a problem in this zone.

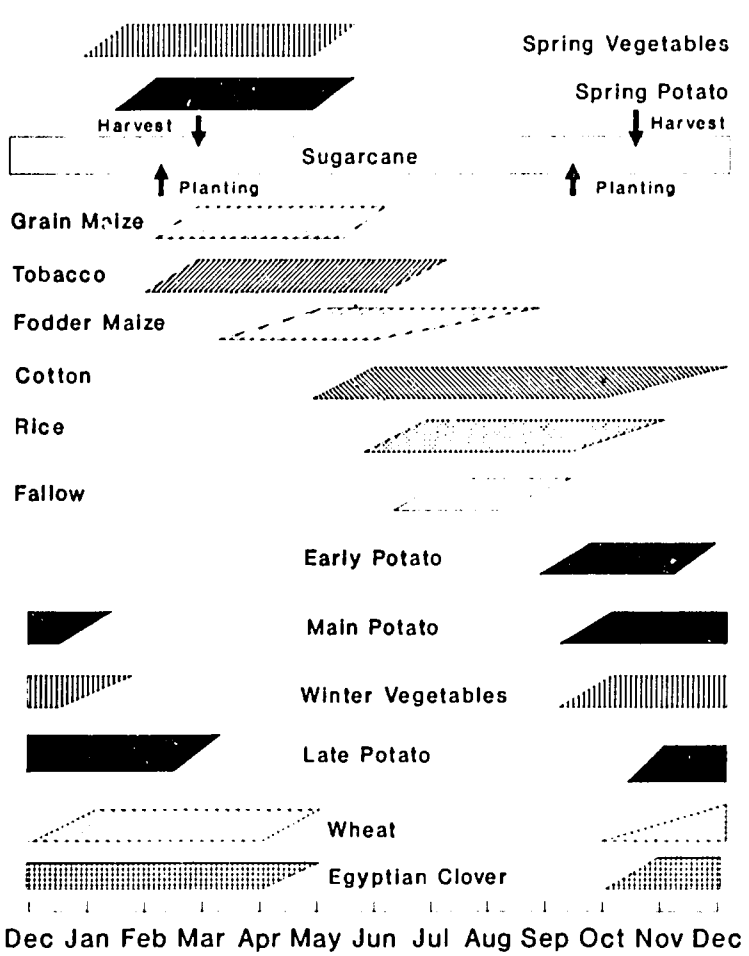
3.2.5. Cropping season

There are three cropping seasons in this zone. The main crops and their planting and harvest dates are summarized in figure 7 and table 3.

With the entire zone below 300 m, the summer is too hot for potato production, so potatoes are grown in spring and in autumn. Planting of the spring crop starts in January, and 80% of the planting is completed in January (Khan and Naumann-Etienne, 1989). Usually the whole crop is planted by the second week of February. Planting time in spring is critical as late frosts in early February and very high temperatures after the 10th of April limit the production potential. Approximately 20% of the spring crop is harvested before the end of April (Khan and Naumann-Etienne, 1989), and the remaining 80% are harvested in early May. The southern districts start and finalize the spring harvest somewhat earlier than the northern districts.

The autumn season is more favorable as the hot weather at planting encourages fast emergence and fast foliage development, and the sunny days and cool nights towards harvest promote bulking. With frost incidence and severity increasing from south to north, the superiority of the autumn crop over the spring crop lessens. The autumn season can be divided into an early, main, and late crop. In the subzone 2a an early crop is not possible because of

Fig. 7: Common planting and harvest dates for main crops



high temperatures in August, in the subzone 2c an early crop is often not possible because of heavier rainfalls in August. Some farmers in the Jhang and Faisalabad districts (subzone 2b) plant the autumn crop by the end of August to harvest in mid-November when prices are still high (Bajwa and Geddes, 1988; Khan and Naumann-Etienne, 1989). In some districts farmers harvest their potatoes earlier in order to plant a late wheat crop (Kokab, 1986). The period from September to the end of January is the main planting and harvesting period for the autumn crop in this zone. The late crop for autumn potatoes lasts from mid-October to March, generally after rice as the previous crop. The seed potatoes are preferably planted later than the ware potatoes to avoid seed rotting, to get higher percentage of seed size tubers, and to prevent mite damage to the crop (Khan and Naumann-Etienne, 1989). From 232 farmers surveyed in 1984, 20% had finished planting before the 20th September, 38% planted between 21st September and 1st October, and 42% planted after 1st October (Khan and Devaux, 1987). From 77 farmers surveyed in 1988, 32% harvested their crop in December, 64% in January, and 4% in February (Khan and Naumann-Etienne, 1989).

Table 3: Common planting and harvesting dates for main crops in zone 2.

Crop	Planting date	Harvesting date
spring vegetables[1]	Jan.	May
spring potato	Jan.-Feb.	Apr./May
sugarcane	Feb./Mar.	Oct.-Mar.
grain maize	Feb./Mar.	May-June
tobacco	Feb.	May
fodder maize	Mar.-May	June-Sept.
cotton	May/June	Oct.-Dec.
rice	June (transp.)	Sept.-Nov.
fallow	June	Aug.
early autumn potato	end of Aug.	mid-Nov.
main autumn potato	Sept.	Jan.
sugarcane	Sept.	Oct.-Mar.
winter vegetables[2]	Sept.	Jan.
late autumn potato	mid-Oct.	Mar.
wheat	Oct.-Jan.	Apr./May
Egyptian clover	Oct.	Dec.-May

[1]cucumber, tomatoes, ladyfinger, gourds, eggplants, pepper, onions, chillies, cucurbits.
[2]carrots, radish, turnip, spinach, peas, cauliflower.

3.3. PRODUCTION FACTORS

3.3.1. Farm size

Potatoes are mainly grown by medium and large farmers which own >5 ha of cultivated land (Tables 4 and 5). However, the size distribution depends on the district. Smaller farmers (<5 ha) do exist but they might not have been sampled by the surveys which were mainly conducted around the district and tehsil headquarters (Geddes et al., 1985; Geddes and Anwar, 1985; Kokab, 1986). In fact, there is increasing evidence that more small farmers are involved in potato production in this zone than previously thought. In addition, such farmers see potato as an important crop capable of generating sufficient income for them, despite the risks. In Salara

Table 4: Size of holding in different areas of zone 2.

Survey area	Average size	Reference
Sialkot, Gujranwala, Sahiwal, Okara, T.T. Singh, Kasur, Faisalabad, Sheikhupura	19.5ha	(Geddes et al., 1985)
Sialkot, Gujranwala, Sahiwal, Okara, T.T. Singh, Kasur, Faisalabad, Sheikhupura, Multan, Lahore, Jhang	22.0ha	(Geddes and Anwar, 1985)
Sialkot, Gujranwala, Sahiwal, Okara, T.T. Singh, Kasur, Faisalabad, Gujrat, Vehari, Multan, Lahore, Jhang, Khanewal	36.2ha	(Kokab, 1986)
Gujranwala tehsil	14.9ha	(Bajwa and Eberlin, 1991)
Wazirabad tehsil	9.5ha	(Bajwa and Eberlin, 1991)

Table 5: Percentage of small, medium, and large potato growers in different areas of zone 2.

Area	Small farmers			Medium farmers			Large farmers		
	---------- % ----------								
	a	b	c	a	b	c	a	b	c
Southern zone	10			20			70		
Multan	0			20			80		
Khanewal	14			43			43		
Vehari	13			0			87		
Central zone	14			17			69		
Okara	0	31		15	4		85	65	
Sahiwal	17	47		33	26		50	26	
Jhang	20			0			80		
T.T. Singh	17			0			83		
Faisalabad	13			13			74		
Lahore	13	42		37	39		50	18	
Kasur	50	80		17	13		33	7	
Northern zone	20			20			60		
Gujranwala	25		29	25		38	50		33
Sialkot	0	61		25	16		75	23	
Gujrat	60			0			40		
Average	15	45		18	18		67	36	

a Kokab (1986): small farmers (<5 ha cultivated land), medium farmers (5-10 ha), large farmers (>10 ha).
b Khan and Devaux (1987): small farmers (<5 ha potatoes), medium farmers (5-10 ha), large farmers (>10 ha).
c Bajwa and Eberlin (1991): small farmers (<5 ha cultivated land), medium farmers (5-10 ha), large farmers (>10 ha).

Note: Survey b is not directly comparable to a and c. Assuming that 50% of the cultivated area is under potatoes, the category of small farmers (<5 ha potatoes) also includes medium farmers. The average farm size may also change depending on the year of the survey, since many small farmers are opportunistic potato growers increasing and decreasing production depending on the market prices, and thus may not be included in some surveys.

(Faisalabad district) for example, the average farm size is about 4 ha, and 30% of the farmers own less than 2 ha (Tariq et al., 1991b). In addition, smaller farmers may rent or acquire land or grow potatoes jointly with other small farmers, increasing their farm operations (Bajwa and Geddes, 1988). However, it is clear that some farmers, especially in the Okara district, operate very large farms and that the average farm size in this zone is larger than in any other zone.

3.3.2. Land tenure

In this zone, land is either operated by the owner, or leased for cash or on a share-basis to a tenant. There are considerable variations in the percentage of owners, tenants on a lease basis, or share-croppers from area to area. Bajwa and Eberlin (1991) found only few share-croppers in the Gujranwala district. There seem to be more share-croppers around Faisalabad. In this area, agro-investors rent land from small farmers who work outside their farms. Then the agro-investors rent the land out to landless share-croppers. The lease was between Rs. 5000 and 10,000 per ha per year in Okara, Chiniot, and Salara (Faisalabad district) in 1991, and between Rs. 2000 and 4000 per ha in Gujranwala and Wazirabad in 1989. Medium and large farmers are able to rent more land (Bajwa and Eberlin, 1991). The majority of land is still owner-operated (Table 6). However, the share of rented land is likely to increase with increasing population, i.e. increasing number of landless people, and decreasing farm size.

Table 6: Percentage of owners, tenants, and owner-cum-tenants in zone 2.

Owner	Tenant	Owner-cum tenant	References
50	28	22	(Geddes et al., 1985)
67	14	19	(Geddes and Anwar, 1985)
36	29	31	(Bajwa and Eberlin, 1991)[1]

[1]There were 4% share-croppers.

3.3.3. Labor

Labor is hired for planting, except those farmers who plant mechanically, weeding, earthing-up and harvest. The mean number of man-days per ha required for planting, hoeing, and earthing-up are 33, 30, and 36 (Bajwa and Eberlin, 1991). The number of man-days per ha required for harvest is about 25 when using diggers or spinners, and up to about 100 when digging and collecting is done by hand. Contractors charge about Rs. 1000-1200/ha for planting and harvest.

3.3.4. Credit

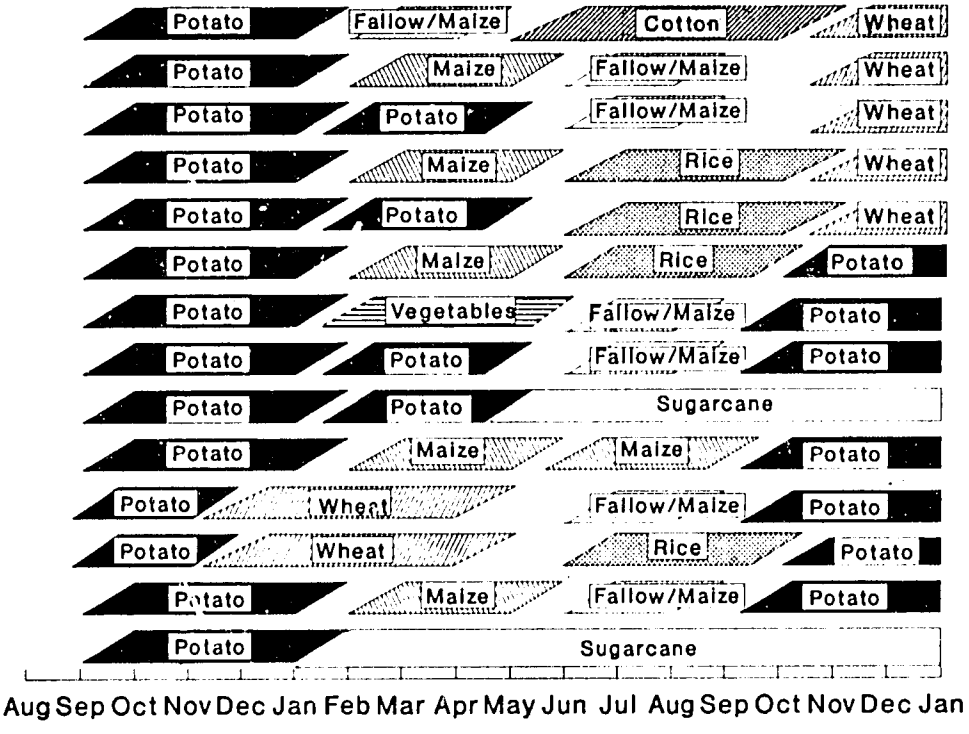
Seed is about 30-40% of the total production costs (Bajwa and Eberlin, 1991). However, no formal credits are used for buying this input. Some farmers buy the seed on credit from commission agents. The farmer then has to sell the produce through the same agent who charges a commission of 6% instead of 3-3.25% (Bajwa and Geddes, 1988; Eberlin et al., 1990). In addition, the farmer might be compelled to sell his produce soon after harvest, or even harvest earlier to pay back the commission agent (Bajwa and Geddes, 1988; Tariq et al., 1991b).

3.4. FARMING PRACTICES

3.4.1. Cropping pattern

Some common crop rotations with potatoes are summarized in figure 8.

Fig. 8: Common rotations with potatoes in zone 2



Wheat usually follows an early crop of autumn potatoes, rice, cotton, fallow, or maize. The main crop of autumn potatoes generally follows maize harvested for fodder, green manure, or fallow. The late autumn crop follows rice. The main summer crops are rice, maize for fodder, cotton, or the land is left fallow. The spring crop is usually maize harvested as grain, spring potatoes, vegetables, or sugarcane. Potatoes are frequently grown at least once a year on the same piece of land.

About 70-80% of the potatoes produced in Pakistan is grown in this zone. Potato growers tend to be specialists, with potatoes as their main crop. The spring crop is smaller than the autumn crop, as it is mainly u[illegible] seed production purposes (about 80%), and is usually less yielding. About 30-50% of the cultivated land is under autumn potatoes in the main potato growing areas while between 10-20% are under potatoes in spring (Geddes et al., 1985; Geddes and Anwar, 1985; Kokab, 1986). Small and medium farmers seem to put a higher percentage of their cultivated area under potatoes than large farmers (Kokab, 1986).

In some rare cases, potatoes are intercropped with sugarcane, cauliflower, egg plants, water melons, or gourds (Tariq et al., 1991b). As many as four different crops may be growing in the same field at a given time. Most large farmers do not intercrop potatoes.

Since potato growers are specialized with potatoes there are few crops which may compete with them: sugarcane, vegetables, maize, fodder, rice, cotton. Cotton is mostly grown south of Faisalabad/Lahore and rice north of Faisalabad/Lahore.

Farmers in this zone own mostly buffalos and cows. However, the number is limited and insufficient amounts of FYM are produced.

3.4.2. Potato production

3.4.2.1. Varieties

Red varieties are most commonly used, except in the Okara district where most of the crop is grown by large farmers who prefer white varieties (Khan and Devaux, 1987). Smaller farmers may prefer the red potatoes because they can be easily sold in the local markets nearby. Desiree is presently the most popular variety followed by Diamant, Cardinal, and Patrones (Khan and Naumann-Etienne, 1989). However, there are differences between districts in the varieties grown. In a survey in the Gujranwala district, conducted in 1990, Desiree, Multa, and Ultimus were the most popular varieties among farmers (Bajwa and Eberlin, 1991). The southern districts close to the main market for white potatoes in Karachi prefer Diamant, Patrones and Ajax. The preference for Ultimus in Faisalabad seems to be related to the tolerance of this variety to the high temperatures at early autumn planting practised in this area. The preference for certain varieties is changing over time.

3.4.2.2. Seed sources

Imported seed, locally produced certified seed, mainly from Hunza, or uncertified hill seed mainly from Balakot and Balochistan is used to plant the spring crop (Khan and Naumann-Etienne, 1989; Fig. 9). The Galis and Murree hills are no longer important seed sources for the Punjab. A few farmers might also use seed from the previous spring crop (Kokab, 1986). Another source is tissue culture derived seed. The size of the market for quality seed has fluctuated from 1300 to 5000 tons in the past depending on the financial situation of the farmers and the number of importers/traders operating in the market. The Balakot seed is easily available from the Faisalabad market, while the imported seed has to be bought from Jaffar Brothers Ltd. (JBL), Punjab Seed Corporation (PSC) Okara Cooperative Society (OCS), or through traders. Farmers in Faisalabad, Jhang and Multan prefer hill seed. In all cases seed from the spring crop is stored in cold stores over the summer and used to plant the autumn crop and start an autumn-to-autumn multiplication cycle. Nearly all the produce of the spring crop from imported seed is kept as seed for the autumn, even the large tubers. The large tubers from the spring crop produced with hill seed are sold as table potatoes and the small tubers kept as seed. Due to virus infection in spring, late blight, and the availability of other seed sources for the autumn crop, the quantity of seed produced in spring might decrease in the future.

Spring seed, seed from the previous autumn crop, or seed from Hunza directly introduced into the autumn is used for planting the autumn crop. The seed source is dependent

on the variety grown. The main source for Ultimus for example is the Kaghan valley (Balakot). Hunza seed can be directly introduced into the autumn cycle if it is planted early in April, its haulms are cut end of July, and it is not planted before October in the plains (Devaux, 1988b). Diamant and Cardinal perform better than Desiree. Imported seed is usually multiplied two to three times in the autumn, occasionally more, and hill seed is multiplied once or twice (Kokab, 1986). That may be the reason why a great majority of the medium and large growers (87%) covered in the 1988 survey imported seed every year (Khan and Naumann-Etienne, 1989). More medium and large farmers rely on imported seed while the small farmers buy their seed mainly from the market and surrounding farmers (Kokab, 1986). The main seed source for D.I. Khan is Faisalabad (Khan and Hussain, 1990).

3.4.2.3. Land preparation

The first operation in land preparation is usually to irrigate the field in order to facilitate the consecutive operations and to obtain a fine-structured seed bed. The second operation is to level the field which is important for the water management.

Tractor-drawn cultivators, disc ploughs and chisel ploughs are then used to plough the fields (Khan and Naumann-Etienne, 1989). The fields are first ploughed about four times before fertilizers are broadcast. After this, the field is ploughed and planked more times. The total number of ploughings varies from 6 to 11 times, but can be as high as 20 times (Bajwa and Geddes, 1988; Khan and Naumann-Etienne, 1989). The differences reported are probably due to different soil types and moisture contents. Generally two ploughings are followed by one planking with a wooden beam (*sohaga*) attached to the cultivator. Many passages are required to achieve a fine textured and well levelled seed bed. Some farmers use a disc plough twice to crush and bury vegetative remains of the previous crop, or they pass a chisel plough to break hard pans.

One or two irrigations are given during the period of ploughing to facilitate the preparation of a good seed bed.

3.4.2.4. Fertilizer

Heavy doses in excess of recommended doses of chemical fertilizer are used (Table 7). Growers of seed potatoes use less fertilizer to control the size of the tubers (Khan and Naumann-Etienne, 1989). Large farmers tend to use more chemical fertilizer (Bajwa and Eberlin, 1991). There is no difference in the amount of fertilizer applied to table potatoes produced in spring or autumn.

FYM or city sweepings are usually applied every three to four years.

Urea, DAP, and sulfate of potash are the most common forms of chemical fertilizer. Nitrogenous fertilizer may be applied at planting or in two or three doses. All other types of fertilizer are applied before planting. Most farmers use manual labor to broadcast the fertilizer (Khan and Naumann-Etienne, 1989).

Fig. 9: Main seed sources for zone 2

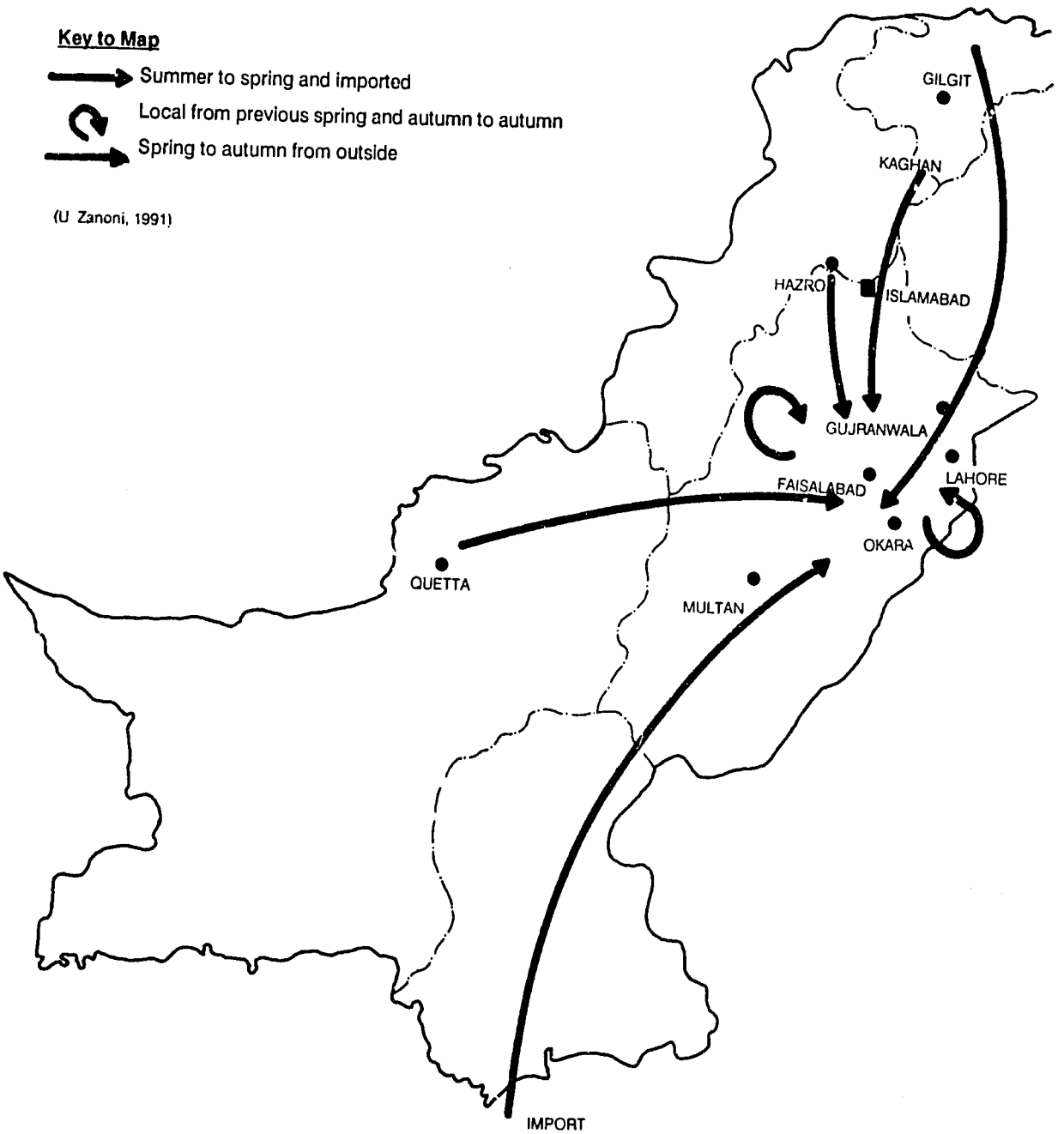


Table 7: Amount of fertilizer applied in different seasons.

Season	Number of farmers	N	P	K	S	FYM	Reference
		kg/ha				t/ha	
Autumn	60	246	170	36	26	16	(Banaras, 1985)
Spring	190	242	193	48	-	28	(Geddes and Anwar, 1985)
Autumn	10	200	135	77	-	-	(Banaras, 1985)
Autumn	57	229	179	145[1]	-	-	(Bajwa and Eberlin, 1991)
-	77	235	170	30	-	-	(Khan and Naumann-Etienne, 1989)
Mean		238	182	50			

[1]Average of 25 farmers who applied K.

3.4.2.5. Planting

A survey among 77 medium to large potato growers showed that 33.8% planted and made the ridges by hand, 28.6% used a tractor-drawn cultivator with the tines at a given row spacing to mark the rows and a tractor-drawn ridger to make the ridges, but still planted by hand, 23.4% used a semi-automatic planter, and 14.3% used an automatic planter (Khan and Naumann-Etienne, 1989). It has to be noted that smaller farmers probably use manual planting more often. Between 1.5 and 2 hectares of potatoes can be planted per day with the semi-automatic planter, 3 to 3.2 hectares with the automatic planter, and depending on the amount of labor available, as many or more hectares by hand (6 ha for example, as mentioned by Mr. Naseem, a potato grower in Chiniot).

Inter-row distance varies from 62 to 75 cm (Khan and Naumann-Etienne, 1989). Cut seed (2-3 eyes/piece) is planted in spring and whole seed in autumn. The seed rates for the spring crop vary from 1.3 t/ha for imported seed to 1.6 t/ha for hill seed (Geddes and Anwar, 1985). Some higher rates of 1.9 t/ha have been observed (Bajwa and Geddes, 1988). Occasionally, whole seed from the previous spring crop is used at a rate of 2.1 t/ha. The autumn seed rates are 3-3.5 t/ha (Geddes et al., 1985) but occasionally might be as low as 1.7 t/ha or as high as 4.5 t/ha. The seed rate in autumn is higher because whole tubers are used and because of the higher risk of seed rotting. A higher seed rate is also used for the early planted autumn crop.

3.4.2.6. Weeding and earthing-up

In 1983/84, the majority of farmers were weeding manually. A survey in 1988 among seed producers showed that most of these farmers are using herbicides (Khan and Naumann-Etienne, 1989). Other farmers, especially the small ones, still seem to use less herbicides (Bajwa and Eberlin, 1991). The pre-emergence herbicide Stomp and the contact herbicide Gramoxone are most often used. Large potato growers use a tractor mounted spraying boom while smaller ones use hand pumps. In Kasur, Vehari, and Multan, where manual weeding by hoeing has been abandoned, the common nutsedge (*Cyperus rotundus*) has become a problem.

Many farmers think that earthing-up is only required for weed control. Consequently, they do not earth-up after the use of ridgers and planters but use a herbicide (mainly Stomp) for weed control (Khan and Naumann-Etienne, 1989).

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Very few farmers are reported to rogue their seed potato plots to eliminate diseased and undesired plants to improve seed quality (Khan and Naumann-Etienne, 1989). The main reason seems to be the additional labor costs involved.

3.4.2.7. Water management

The first irrigation for seed bed preparation is given 7-20 days before planting depending on when the previous crop was harvested (Khan and Naumann-Etienne, 1989). One or two irrigations are given during ploughing. The first irrigation after planting is given one to four days later (Bajwa and Eberlin, 1991). Delaying the first irrigation for more than one day during the autumn season increases the chances of seed rotting. After germination, the potatoes are irrigated at an interval of 8-10 days until 10-12 days before harvesting or until the vines are killed by frost. The mean number of irrigations given to the potato crop in spring was 11 and in autumn 9.5 (Geddes et Al., 1985; Geddes and Anwar, 1985). Due to lower temperatures in autumn, the autumn crop needs less irrigation. To control the tuber size and to prevent frost damage, the seed potatoes are irrigated more often (Khan and Naumann-Etienne, 1989).

3.4.2.8. Diseases, pests, and their control

PLRV and PVY are the most common viruses in the Punjab plains. Yield decreased from 25.9 t/ha (mean of 53 farmers) for seed which was multiplied the first time in autumn, to 22.1 t/ha (mean of 40 farmers) for seed which was multiplied the second time, to 19 t/ha (mean of 15 farmers) for seed which was multiplied for the third time (Khan and Devaux, 1987). This would be a decrease of about 14% for each consecutive multiplication. However, this study did not take into account the initial level of virus infestation, the source of seed, and the variety grown. Kokab (1986) also concluded that yield decreased by 9.7% after the first multiplication and by 3.4% after the second multiplication. However, in his study yield was not measured, but assessed from the subjective comments of interviewed farmers.

Black leg (*Erwinia chrysanthemi*) and bacterial wilt (*Pseudomonas solanacearum*) were found in a survey in autumn 1986, but seem to be of minor importance (Turkensteen, 1987).

Fungal wilts caused by *Verticillium* spp. and *Fusarium* spp. are considered the most important diseases after the viruses (Turkensteen, 1987). The most prevalent species were *Fusarium oxysporum* and *solani*, *Verticillium dahliae* and *nigrescens* while *Fusarium avenaceum* and *Verticillium albo-atrum* were less frequent. Wilts are more frequent under excess irrigation. Farmers tend to use a lot of water to compensate for salinity, and towards the end of the autumn season they irrigate more often to reduce frost damage, even though the crop needs less water due to the lower temperatures.

Deep pitted powdery scab (*Spongospora subterranea*) was observed for the first time in Okara and Faisalabad districts in 1986 (Turkensteen, 1987). In January and February 1991 at the time of harvesting the autumn crop, two surveys were conducted in Okara, Pakpatan, Sahiwal, Faisalabad, Jhang, Lahore/Sheikhupura, and Sialkot/Gujranwala areas (Soomro et al., 1991). Out of 39 locations visited, 97% had common scab (*Streptomyces scabies*) and 61% had powdery scab. No powdery scab was found in the Lahore/Sheikhupura area. The highest incidence (percentage of tubers infected) and severity (percent tuber surface infected) of powdery scab was observed in Jhang, the lowest in Sialkot/Gujranwala. Like Verticillium, powdery scab is encouraged by excessive and irregular irrigation. Deep planting subjects

tubers to more free water and this also increases infection by powdery scab. In autumn, tubers are planted deep to avoid the higher soil temperatures close to the surface. Powdery scab does not usually affect yield, but market value is reduced and affected tubers are more prone to late blight and storage rots. In addition powdery scab is a reservoir and vector of mop top virus which has occasionally been observed in the Punjab. The variety Desiree appears to be particularly susceptible to powdery scab.

Late blight (*Phytophthora infestans*) occurs with varying intensity. It is more prevalent in spring than in autumn and its severity increases from south west to north east. Relatively low temperature and dry conditions in autumn are not conducive for severe disease development.

Rhizoctonia solani is widespread and is encouraged by the humid field conditions, deep planting and lack of rotations. Presprouting of seed would help reduce Rhizoctonia as the sprouts are very susceptible before emergence. Rhizoctonia has little affect on yield but the tubers become disfigured with black scurf which may reduce their market value. It is more prevalent in spring when emergence is delayed by cold temperatures.

Myzus persicae, which transmit PLRV and PVY, start building up from October to January and reach their peak between the end of February and the 15th of March (Mirza et al., 1982). No aphids have been captured from July to September in the plains. The peak of aphid population coincides with the spring potato crop and therefore, affects the seed quality of potatoes produced in spring. It has been shown that seed produced in spring degenerates much faster than seed produced in autumn (Kokab, 1986; Khan and Devaux, 1987; Table 8). One multiplication in spring is enough to get a high infestation of PLRV, independent of the seed source (Table 9). Some PVY may also be transmitted by occasional peaks of migrating aphids, especially *Aphis gossypii*, *Aphis fabae*, and probably *Brachyungis hamalae*. In December/January, potato roots may be severely attacked by *Rhopalosiphum rufiabdominalis*. Whether this results in virus transmission is not known, but occasional transmission of PVY is suspected.

Leafhoppers (jassids), especially *Amrasca devastana* and *Amrasca fabae*, attack the early autumn crop soon after germination (Tariq et al., 1991a).

Mites, especially the hot weather mite *Polyphagotarsonemus latus*, attacks the early planted autumn crop (Tariq et al., 1991a).

Armyworms (*Spodoptera* spp.) occasionally migrate from cotton or vegetable fields and cause damage in germinating potato crops in October. Large outbreaks of white flies (*Bemisia tabaci*) in cotton growing areas from Faisalabad to Multan may infest the borders of potato crop in November.

Cutworms, especially *Agrotis ipsilon*, *segatum*, and *flamrnatra*, can cause heavy damage in the spring crop.

Most farmers take pest control measures, particularly those producing seed. Insecticides such as Thiodan or Tamaron, and fungicides such as Dithane M-45 are sprayed two to three times during the spring and slightly less during the autumn (Geddes et al., 1985; Geddes and Anwar, 1985).

Table 8: Seed degeneration of different seed sources through the autumn-to-autumn cycle in the Punjab plains, 1985-87 (Devaux, 1988a).

Seed Source	Autumn 85		Autumn 86		Autumn 87		
	Visual PLRV	Visual PLRV	ELISA PLRV	ELISA PVY	Visual PLRV	ELISA PLRV	ELISA PVY
	%						
PSC autumn 84[1]	8.2	7.4			3.2		
PSC spring 85[2]	6.6	8.0			4.0	0.0	45.0
Imported 84[3]	35.3	51.2	52.5	35	21.0	38.0	32.0
JBL Hunza 84	1.9	9.0	2.5	5	1.1	2.8	7.5
KIDP[4] Kalam 84	5.2	5.2			4.8	0.0	100.0
Imported 85[5]	54.9	60.1	70.0	20			
KIDP Kalam 84[6]	54.2	72.4					
JBL Hunza 84[7]	62.1	70.7	72.5	25	26.9		

[1]Derived from clonal selection.
[2]Seed plot was rogued in spring.
[3]Multiplied once in spring 84 and autumn 85.
[4]Kalam Integrated Development Project.
[5]Multiplied once in spring 85.
[6]Multiplied once in spring 85.
[7]Multiplied once in spring 85.

Table 9: Percentage infection with PLRV for different levels of seed contamination at Faisalabad, averaged over 1985-87 (Mirza and Anwar, 1991).

Initial contamination	Infection after one multiplication in spring
%	
0	7.3
1	10.7
2	13.3
5	20.7
10	31.7

3.4.2.9. Harvest

The haulm destruction for skin maturity purposes is not a common practice (Khan and Naumann-Etienne, 1989). Some growers cut the haulms c. ...ture or frost killed crops and use it as fodder for their cattle. The haulms could be destroyed at no cost if the female workers are allowed to keep them as fodder.

Manual harvesting with a spade or *khurpa* (a small flat hand trowel) was preferred by 57% of the farmers in a survey of seed growers conducted in 1988 (Khan and Naumann-Etienne, 1989). Female laborers collect the dug tubers. Proportionally more small farmers harvest manually. Occasionally a bullock-drawn or tractor-drawn ridger is used for digging (3% of the farmers). The ridger usually lea es some tubers in the ground so that after the first collection, two tractor-drawn harrowings are used to dig the remaining tubers. Multan and Kasur are the least mechanized districts.

The spinner is a very popular digging equipment among large growers (26% of the farmers in the survey). The digger with 5-6 blades is not as popular (13% of the farmers). Both tools are of the single row type and the tubers have to be collected manually, usually by female laborers.

In the Jhang district two automatic harvesters were found. Some labor is still required to remove stones, vines, mother tubers and clods by hand. This equipment can cost up to Rs. 1 million.

With the spinner, about 1.6 ha can be harvested per day. The capacity of the digger is about 0.8 ha. Manual harvesting will still be widespread as long as sufficient labor in due time is available. In 1991, contractors charged about Rs. 1000-1200/ha for the harvest.

3.4.2.10. Yield

Average yields of 20-25 t/ha for the autumn crop and 10-15 t/ha for the spring crop are common (Table 10). However, maximum yields between 40 and 50 t/ha have been observed in the same surveys. The average yield for the spring crop is generally lower, even though the maximum yield obtained by some farmers is the same. The yield level changes, depending on the year, season, district, and farmer. Smaller farmers seem to obtain less yield than medium and large farmers, probably due to less inputs (Khan and Devaux, 1987; Bajwa and Eberlin, 1991; Hussain et al., 1991). Yields for the spring crop seem to fluctuate more (Monninkhof et al., 1985). Early harvested crops are expected to yield less (Khan and Devaux, 1987).

At an average seed rate of 1.5 t/ha in spring and 3.2 t/ha in autumn and an average yield of 15 t/ha in spring and 25 t/ha in autumn, the seed multiplication rates would be 1:10 and 1:8, i.e. the spring crop would be more efficient. However, seed costs for spring planting are higher, and the autumn crop produces less seed sized tubers than the spring crop.

Table 10: Yield levels at different seasons in zone 2.

Season	Number of farmers	Yield level t/ha	Range	Reference
Autumn 83	60	24.3	4.3-43.5	(Geddes et al., 1985)
Spring 84	190	11.9	1-45	(Geddes and Anwar, 1985)
Autumn 84	232	24.8	5-50	(Khan and Devaux, 1987)
Autumn 90	144	19.6		(Hussain et al., 1991)
Mean	Spring	11.9		
	Autumn	23.0		
	Overall	19.6		

3.4.2.11. Post harvest handling

Grading for seed and ware potatoes is usually done in the field before cold storage. Recharging is in 100-110 kg second hand jute bags. Even though they are very heavy to handle and increase the risk of crushing and bruising the produce, traders prefer this size.

In spring the farmers transfer the seed potatoes to the cold store immediately after harvesting because of the high temperatures at harvest. About 80% of the spring crop is used for seed (Monninkhof et al., 1985). About 20% of the total produce is marketed. Cold stored seed leaves the cold store in September.

With the autumn crop, the main bulk of the harvest is sold in the first quarter of the year (60%). If the crop is not sold soon after harvest, it is stored in the field in large, longitudinal heaps covered with a very thick layer of rice straw which protects it from the weather (frost, sunburn, rain). The storage period in the field ranges from 1 to 2 months until mid-April (Khan and Naumann-Etienne, 1989). Later than this it is too hot for field storage. Farmers report storage losses on farm till April to be low but, if there is excessive rain, losses are somewhat higher. In years of glut when cold stores are full, potatoes are stored much longer in the field, sometimes until July in the case of the autumn crop and until August in the case of the spring crop. In these cases, the storage loss may be as high as 80%. On farm storage has several purposes: later sale in the hope of a price rise; skin hardening before grading of the tubers; delayed loading of cold stores to reduce running costs. Those farmers producing their own seed retain about 20% of the autumn crop, i.e. the small tubers, as seed. Autumn crop potatoes are released from the cold store from June to September.

There were 403 cold stores in the Punjab in 1991 with a total capacity of 600,000 t, (Source: AMSL, 1991). There is also one cold store in D.I. Khan (Khan and Hussain, 1990).

Cold stores are normally kept at the exceptionally low temperature of about 1-2°C without control of the humidity. This has the advantage that losses in store are negligible and satisfactory temperatures are maintained during power cuts. The disadvantage is that the potatoes become sweet and less attractive to customers. They are also unsatisfactory for chip (crisp) production as the high sugar content causes browning of the chips.

The majority of potatoes in the rural cold stores belong to the producers, not to traders (63%). It is not uncommon for the store owner to be a potato grower as well, with some of his own produce in the store. With many lots belonging to different owners, the system of storage must allow easy access to individual lots and their unloading whenever the owners demand. Hence a racked storage system is used with a relatively low storage capacity per cubic meter of store and high costs per bag. In 1990, charges for storing the autumn crop were about Rs. 90-100/bag of 110 kg. Storage costs increase in case of glut.

Instead of allowing the potatoes to warm up gradually over a period of about 2 to 4 days before unloading, potatoes are generally taken straight out of the store into temperatures which are often above 40°C. The result is heavy sweating which if the tubers are used for seed, may increase rotting during the subsequent period of planting and emergence. However, the extent to which losses from this apparently bad practice actually occur is uncertain. Most trader who sell seed from the cold store for transport to the hill areas, transport in February, latest in March, to avoid shipping in the hot temperatures. Even then, most seed will be transported overnight in the cooler night temperatures.

3.4.2.12. Marketing

Lahore is the main market for red potatoes and Karachi for white potatoes. Faisalabad, Gujranwala Multan and Rawalpindi are also important markets for red potatoes. Within the

zone, consumer demand is mainly for red potatoes. Farmers either take their potatoes to the wholesale market to be auctioned by commission agents or the agents collect the potatoes at the field. The produce is sold by the bag, not the weight.

The produce of the autumn crop is also sold to traders as seed for the summer crop in the hills. White seed potatoes are marketed to Balochistan while red potatoes go mainly to Faisalabad and Lahore, and from there to the hills of NWFP. Produce of the summer crop is then used as seed for the spring crop, so the health of the Punjab autumn crop has a fundamental affect on potato production in Pakistan. This is particularly so for small farmers: they predominate in the hills and the chief buyers of uncertified domestic hill seed for the spring crop are also small farmers.

3.5. PRODUCTION SUPPORT PROGRAMS

Ayub Agricultural Research Institute, Faisalabad: Within AARI Faisalabad, both the Vegetable Research Institute and the Virology Department have been working on the potato crop for many years. Under the Vegetable Research Institute comes the Potato Research Station at Sialkot and a small potato breeding unit in the Murree hills.

Much of the Vegetable Research Institute's work has been on the development of improved varieties. The most promising material selected under the earlier PL-480 program is now in its final stage of trials and it should be possible to release one or two improved white varieties soon. One red variety with good adaptation for autumn planting, Lal-e-Faisal, was released in 1986. The Institute has also worked on agronomy including recent recommendations for chemical weed control, and on low-cost storage.

In the field of seed multiplication, the Institute has demonstrated that autumn seed can be cold-stored for about twelve months and then planted in the following spring. This is a way of providing cheaper certified seed than that available from seed schemes in the hills. Its reliability has yet to be proved on a commercial scale.

The Virology Department has monitored the level of *Myzus persicae* and shown that the autumn crop can be grown in a period free of this principal virus-transmitting aphid, provided the growing period does not extend beyond about mid January. It has also developed a unit for pre-basic seed production, based on tissue culture and rapid multiplication techniques, and supplies pre-basic seed to the Punjab Seed Corporation and some private growers.

With its work on aphid monitoring and autumn crop degeneration trials, AARI was able to demonstrate the feasibility of the spring-autumn-to-autumn seed multiplication system and contributed to its adoption by farmers. As a result, the autumn-to-autumn seed production technique was approved by the Punjab Crop and Technique Approval Committee in the early seventies.

Pakistan-Swiss Potato Development Project (PSPDP): This project has been working in the zone since autumn 1984 when it set up a sub-unit located at the Agricultural University, Faisalabad. In its research work at Faisalabad it has collaborated with both the AARI and the University, with research plots at both locations. It has also carried out on-farm research, mostly with farmers in Okara from the Okara Cooperative Society.

The main emphasis of PSPDP's work in the zone has been on the improvement of seed production. It has demonstrated the feasibility of introducing early harvested seed from the summer crop in Hunza directly into the autumn crop. It has been able to quantify the degree of virus control achieved by spraying systemic insecticide in the spring and to demonstrate the benefits of roguing. It has measured degeneration rates with various systems of supplying improved seed. It has also investigated optimum seed rates.

At Faisalabad PSPDP has carried out trials of promising material from its germplasm selection programme at Kalam (zone 6) and also undertaken research into fertilizer applications, plant spacings, micronutrient deficiencies, and various other aspects of cultivation.

Punjab Seed Corporation (PSC): The Corporation is engaged in the supply of certified autumn seed produced through an improved autumn-to-autumn multiplication system. It started at Sahiwal in 1979 with the direct introduction of seed from a summer crop which had been grown with imported seed in the hills of Azad Kashmir. This then went through successive autumn multiplications and was supplemented with imported seed grown in the spring under muslin to protect it from aphids. From 1980 to 1986 the main crop was based on massive single plant clonal selections from the material above. In 1987 PSC started pre-basic seed production through rapid multiplication from tissue culture. PSC's tissue culture unit comprises a tissue culture lab, ELISA equipment, growth chambers, and glass and screen houses. PSC produced 10,000 mini tubers in 1987, 50,000 in 1988, 60,000 in 1989, and 100,000 in 1990. Out of 50 ha planted at Sahiwal, 36 ha were tissue culture derived material. Mainly Desiree, Cardinal, Diamant, and Patrones are multiplied.

PSC has a target of producing 1200 t of certified seed according to the capacity of its cold store. Sale prices are fixed according to the table potato market at the end of August. PSC has now expanded its own seed production at Sahiwal and Khanewal and adopted a three year rotation as advised by the Federal Seed Certification Department.

PSC has also been one of the three principal agencies for importing certified seed for spring planting. Seed is imported from Holland on the demand of growers who have to book the seed in advance. The quantity of imported seed has decreased in recent years due to the high costs and the production of healthy seed in Pakistan.

Okara Cooperative Society: This is a cooperative of 100 farmers, many of them with very large farms. It is another principal agency for importing seed for spring planting. It has supplied seed to hill farmers and is interested in producing certified seed in autumn for sale for autumn planting.

Society farmers have begun to adopt both roguing spring and autumn crops and planting Hunza seed in the autumn to improve their seed multiplication system.

Jaffar Brothers (Private) Ltd. (JBL): This company is the third principal importer of certified seed for spring planting. In 1985 it started marketing certified seed grown in the Northern Areas (Zone 7) seed schemes for spring planting in Zone 2 and 3 and in smaller quantities for autumn planting in these zones. In 1990/91 it supplied about 750 tones of certified seed from zone 7 and hopes to expand considerably in future years. It is also interested in marketing certified seed from the Zone 2 autumn crop.

3.6. CONCLUSIONS

Farmers in this zone include the most experienced, progressive, and well-off potato growers of Pakistan. Collectively the zone contributes about 70-80% towards the total production of potatoes in Pakistan. The majority of the farmers have medium to large land holdings, use considerable amounts of inputs (pesticides, fertilizers, water) and capital (credits, machinery, land), have access to quality seed from abroad or produced in Pakistan, and have easy access to major markets and cold stores. However, land resources are decreasing and the number of landless people is increasing, making land more expensive thus increasing production costs. Small farmers, who have only recently been identified by PSPDP, are more vulnerable to high production costs.

The major constraints to potato production in this zone are fluctuating potato prices in the market, seed quality, agronomic practices, and high input costs.

Fluctuating prices influence production and vice versa. Potato farmers need to have sufficient financial reserves to tide them over seasons in which they make a loss. Small farmers are especially vulnerable to low market prices for table potatoes or high prices for seed. It is also difficult for them to take advantage of the intervention system as they are diversified and individually have only relatively small quantities to offer. They increase and decrease potato production depending on the prices. Large farmers can buffer low prices because of the better bargaining power for larger quantities, better access to favorable markets and the intervention system, cold storage and generally have more cash. Some farmers argue that the only way to recover money lost with potatoes in a low price year is by keeping on growing potatoes.

Even though imported seed was first introduced into this zone and farmers have access to certified seed from JBL, or PSC, many farmers still rely on market seed because of the lower price. The aphid population has its peak in spring so that PLRV and PVY are rapidly spread leading to a rapid degeneration of seed multiplied in spring.

Farmers generally apply high doses of fertilizer without regard of the specific requirements of the soil. Deficiencies such as zinc might also contribute to lower yield. The high percentage of potatoes grown without proper rotation or plant control measure might lead to an increase in soil-borne diseases and pests.

Potato is a relatively expensive crop to produce. The major cost factors are seed, fertilizer, and land rent. Without proper crop management, high inputs and therefore high production costs are wasted.

The potential for the development of production lies in the adaptation of improved agronomic practices through knowledge about the main problems and their correct countermeasures. Seed quality might be improved through increased production of certified seed and improved distribution systems. The autumn-to-autumn seed cycle should be encouraged to eliminate the virus-infected spring seed crop.

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Making ridges after planting potatoes, Narshik, NWFP.

Livestock plays an important role in the farming systems of most of the areas, not only for the supply of milk, meat, cash, etc., but also of farmyard manure for maintaining soil fertility.

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Canal irrigation of potatoes, Pabbi, NWFP.

As labour is abundant in some area (e.g. afghan refugees), the harvesting of potatoes is done by hand.

4. ZONE 3: IRRIGATED AND RAINFED PLAINS OF NWFP AND NORTHERN PUNJAB

4.1. GEOGRAPHICAL COVERAGE

4.1.1. Altitude

Zone 3 covers the Potohar plateau and the Peshawar valley. Areas along the Kabul and Indus river such as Charsadda, part of the Grand Trunk Road (G.T. Road) between Peshawar and Nowshera, Nowshera, and Attock are below 300 m a.s.l. The largest part of the zone covering Peshawar, Swabi, Haripur, Mardan, Hazro, and Taxila is between 300-600 m a.s.l.

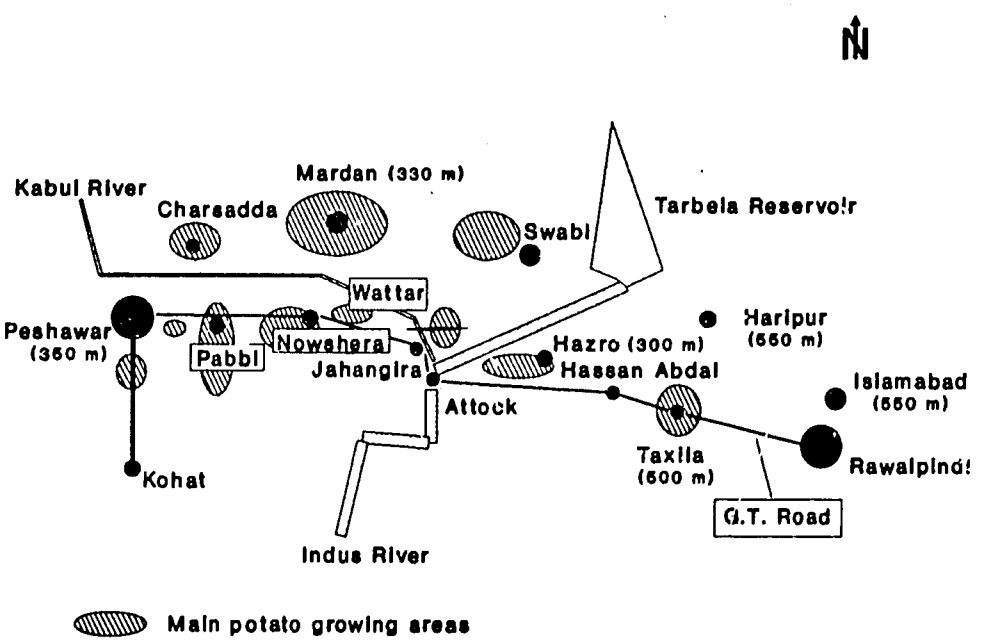
4.1.2. Latitude and longitude

Zone 3 spans two degrees of latitude (32° to 34°) and two degrees of longitude (71° 30' to 73° 30'). However, most potato growing areas are around 34° along the G.T. Road.

4.1.3. Topography

The potato growing areas in this zone are flood plains surrounded by hills and mountains. The terrain is rolling, at times rugged, with generally small confined fields flat enough to allow irrigation through flood water from canals or wells.

Fig. 1: Main potato growing areas in zone 3



4.1.4. Potato production areas

In this zone, potatoes are grown in the districts of Peshawar, Mardan, Swabi, Attock, Rawalpindi and Abbottabad.

In Peshawar district, the main area is around Pabbi and Nowshera (Fig. 1 - 4). Potatoes are also grown south of Peshawar along the Pesnawar-Kohat road, north east of Peshawar around Charsadda (Nisatta, Saudhin, Mond Nasi, Bokhata, Utmanzai, Tangi), east of Peshawar along the G.T. Road, and east of Nowshera in the Wattar village.

Fig. 2: Main potato growing villages in Pabbi area

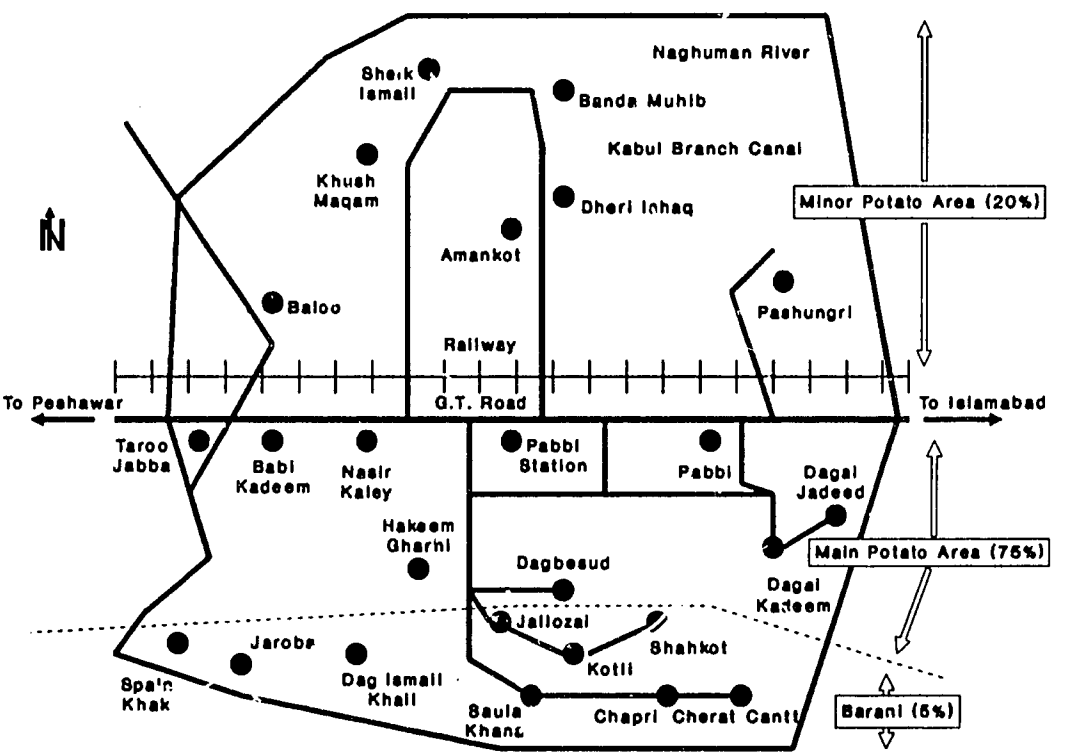


Fig. 3: Main potato growing villages in Nowshera area

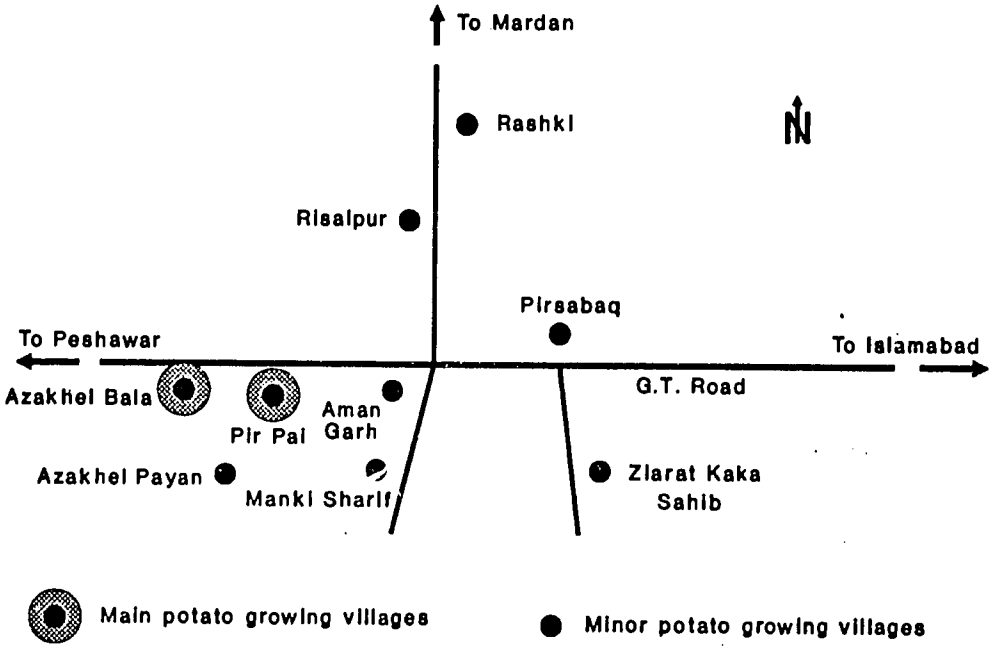
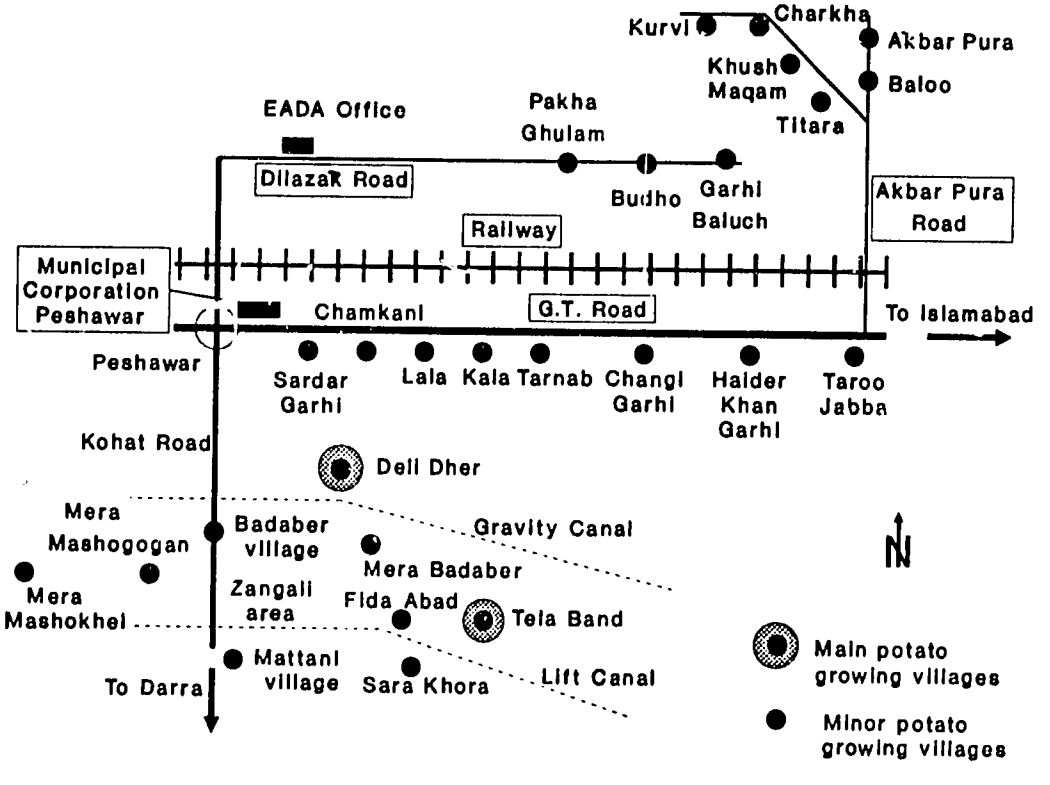
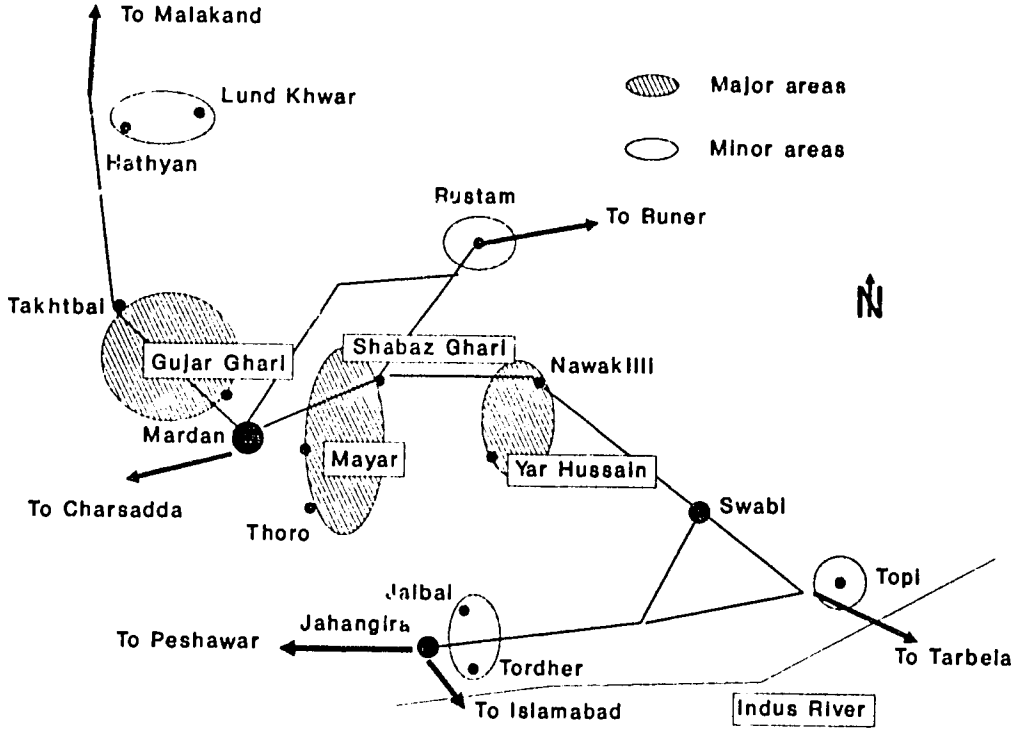


Fig. 4: Main potato growing villages in Peshawar area



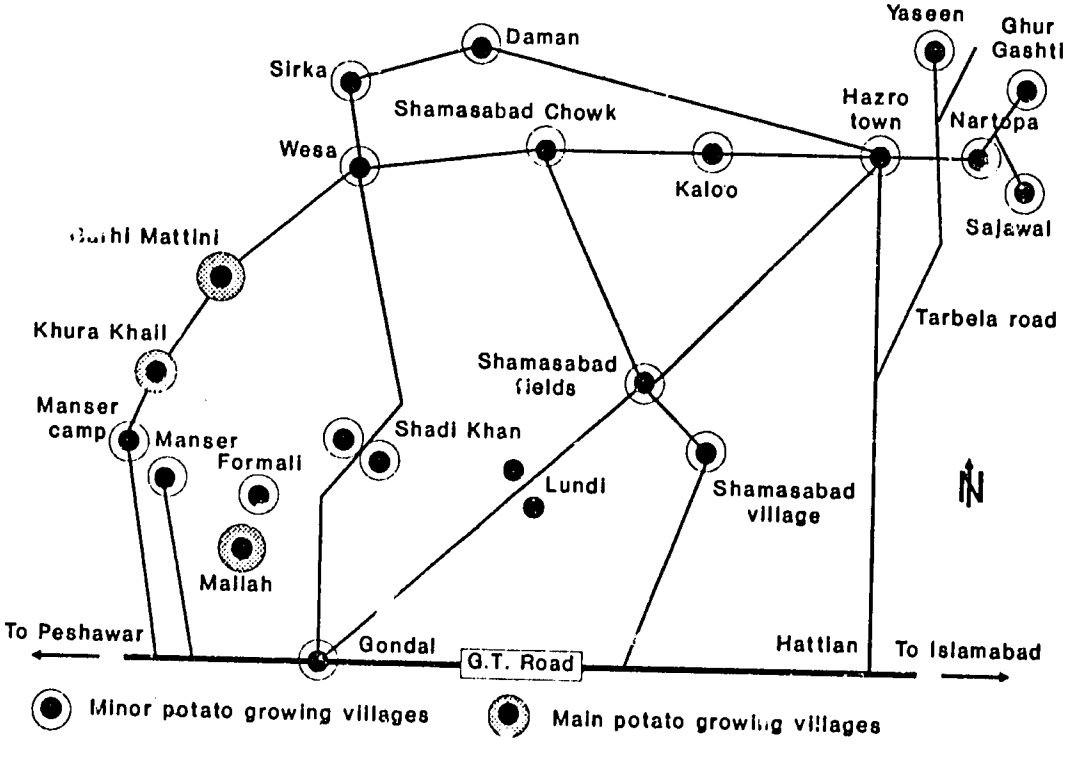
In Mardan and Swabi districts, potatoes are grown around Mardan, Swabi, and Jahangira (Fig. 1 and 5).

Fig. 5: **Main potato growing areas in Mardan and Swabi district**



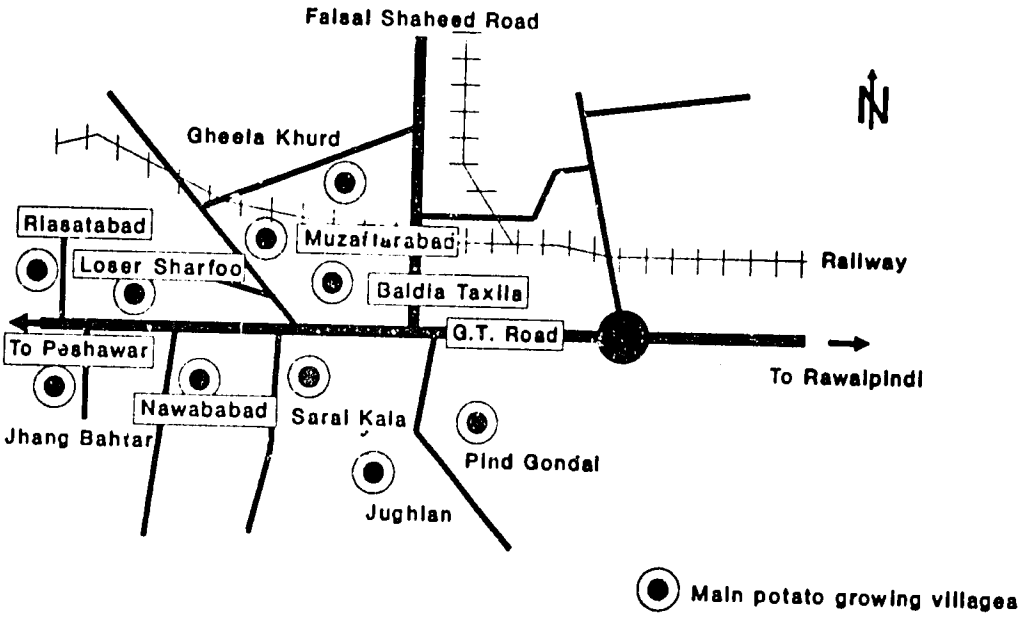
In Attock district, production is concentrated to the west of Hazro, between the Indus river and the G.T. Road (Fig. 1 and 6). Some potatoes are also grown north east of Hazro.

Fig. 6: **Main potato growing villages in Hazro area**



In Rawalpindi district, the main production is in the Taxila tehsil (Fig. 1 and 7). Some potatoes are also grown around Hassan Abdal (Fig. 1).

Fig. 7: Main potato growing villages in Taxila tehsil



In Abbottabad district, some scattered fields are found in the vegetable and orchard belt of Haripur (Fig. 1). However, no survey has been done in this area.

All these irrigated, potato growing areas are defined as subzone 3a within the agro-ecological zone 3. Farmers in these areas often also own some rainfed *(barani)* land. The other areas of zone 3 which mainly depend on rain for growing crops and where no commercial potato fields have been detected so far are defined as subzone 3b.

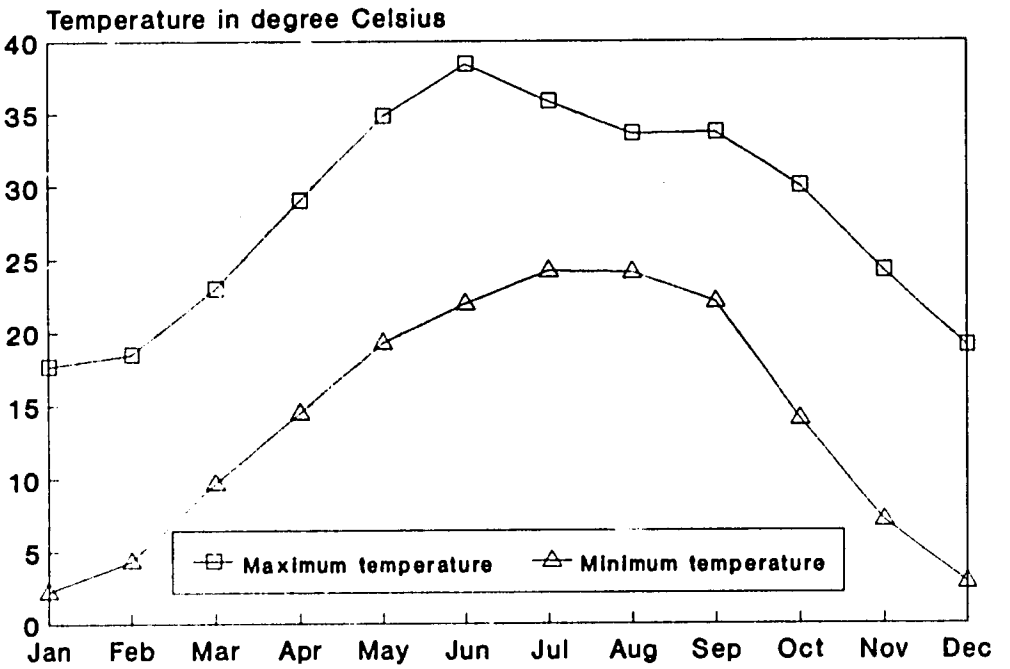
The southern parts of the Peshawar district, Attock district, except for the Hazro area, the northern part of Mardan and Swabi districts, the whole Rawalpindi district, except for the Taxila area, and the Chakwal district belong to subzone 3b.

4.2. ECOLOGY

4.2.1. Temperature

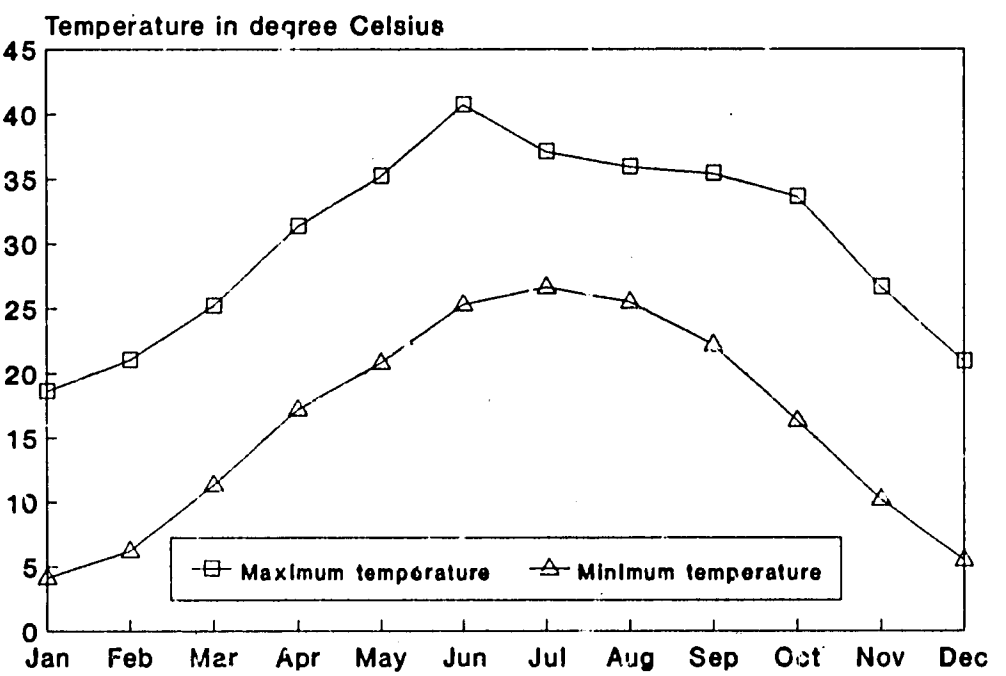
The climate in this zone is warm and semi-arid in the south west and warm and sub-humid in the north east, with hot summer and cool winters. At Tarnab and Peshawar, the highest temperatures occur in June and the lowest in January and February (Fig. 8 and 9). The frost risk is highest in December, January, and February. In the more southern rainfed areas, there seems to be less frost risk.

Fig. 8: Mean monthly temperatures at Tarnab (zone 3)



(Source: Gohar and Noor-ur-Rehman, 1990)

Fig. 9: Mean monthly temperatures at Peshawar (zone 3)



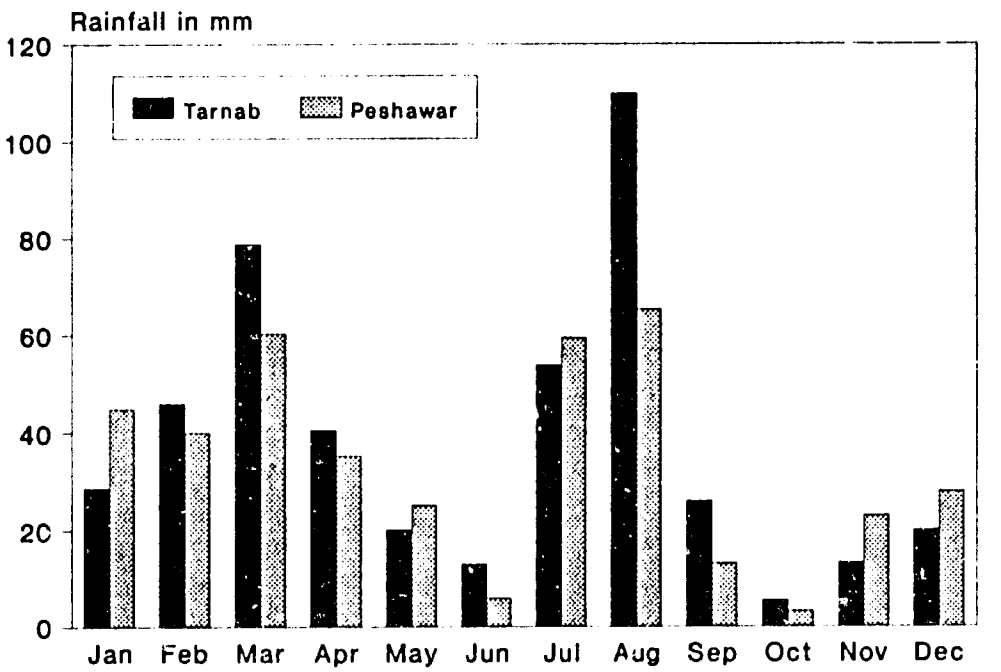
(Source: Meteorological Office, Lahore, 1977,79,81,85,86).

4.2.2. Precipitation

There is no record of snowfall in the whole area of zone 3.

The average annual rainfall of the last 20 years in Tarnab is 450 mm, and in Peshawar it is 403 mm averaged over the years 1977, 79, 81, 85, 86. The area receives most rain in March, July and August (Fig. 10).

Fig. 10: Mean monthly rainfall in zoine 3



(Source: Meteorological Office, Lahore, 1977,79,81,85,86; Gohar and Noor-ur-Rehman, 1990)

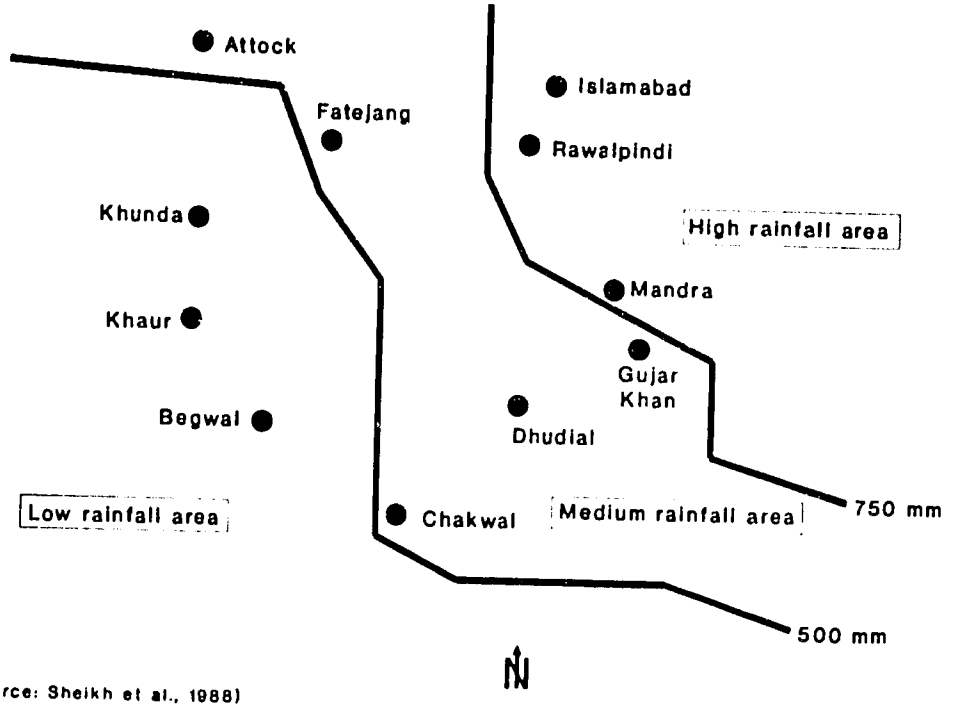
The average rainfall varies from 450 mm in the south west corner of the Mardan district up to 900 mm in the north eastern areas of Mardan and Swabi district (Scholz, 1989). The two districts receive most rain in March, July and August.

The rainfed subzone 3b can be further subdivided into a high rainfall (>750 mm of annual rainfall), medium rainfall (500-750 mm), and low rainfall (<500 mm) area (Fig. 11).

4.2.3. Irrigation infrastructure

Most potato fields around Pabbi, Nowshera, Peshawar, Mardan, and Swabi are irrigated by canals. The Mardan district is irrigated by the upper and lower Swat canals. The canals are shut down in winter during about 40 days. The farmer has to pay a fixed rate for using canal water to the revenue department according to the size of his holding and depending on the crop grown. In 1986-87, the water charges were Rs. 47/ha for wheat and maize, Rs. 85/ha for tobacco, Rs. 162/ha for sugarcane, and Rs. 34/ha for berseem (Longmire et al., 1990). The timing of irrigation and the amount of water are also fixed in advance according to the land

Fig. 11: Rainfall zones in the barani areas of zone 3



(Source: Sheikh et al., 1988)

holding. Usually farmers are allocated irrigation water once a week, but the interval may be extended to two weeks in case of shortage. The average allocation in the Mardan district is about 40 mm per ha per week. When there is not enough water for all fields, farmers leave some fields without irrigation and plant mainly *barani* crops. Some farmers in the Dagai Jadeed village (Pabbi) reported to make arrangements on a friendly basis to obtain some water from their neighbors.

In the *barani* area in the southern part of the Pabbi and in the northern parts of Mardan and Swabi districts, in the Wattar village east of Nowshera, in the Hazro and Taxila areas, Persian wells and tubewells are used for irrigation. The water table is at about 0-20 m in Mardan and Swabi (Scholz, 1989), at about 10-15 m in Hazro and Wattar, and about 30-50 m in Taxila.

In Mardan and Swabi, the tubewells are owned and operated by the government. Farmers in the other areas irrigated by wells have to pay for electricity when they are using electrical pumps. The costs per month are lower (in 1991 about Rs. 500-1000) than in Balochistan (in 1991 about Rs. 2000) where water has to be pumped from deeper levels. Small farmers in the Wattar village do not have their own tubewell. They use water from their neighbors and pay at an hourly rate.

In Mardan, there were some problems with salinity because of poor water management.

The subzone 3b (*barani*, probably very few potatoes) depends entirely on rainfall.

4.2.4. Soils

Soils in this zone are alluvial, sandy, silty loams, or silty clay loams with pH around 8 (Devaux and Anwar, 1989). They have low organic matter content around 1%, and respond well

to the application of N, P, K, and Zn (Ghani et al., 1990; Ghani and Rehman, 1990). Zinc deficiency is common particularly in Pabbi, but farmers are not aware of this problem (Turkensteen, 1987).

The irrigated soils in Mardan and Swabi vary from very good to poor, but no information is available about the nutrient content (Scholz, 1989). They vary in texture from lighter clay loams to heavier clays (Longmire et al., 1990). Some areas suffer from waterlogging and salinity.

Around Hazro, soils are very sandy.

4.2.5. Cropping season

There are three cropping seasons in this zone. The main crops and their planting and harvest dates are summarized in table 1 and figure 12. Summer in this zone is too hot for potato production and potatoes are grown in spring and autumn. Planting of the spring crop can be delayed due to rain, and the spring crop season is limited by high temperatures in May and June. The autumn season is limited by frost in December.

Table 1: Common planting and harvesting dates for main crops in zone 3.

Crop	Planting date	Harvesting date
spring potato	Jan./end of Jan.	end of May/June
winter pulses	Jan.	May/June
irrigated maize	Feb.	June
tobacco	Feb. (transplanted)	May/June
sunflower	Feb./March	May/June
spring vegetables[1]	Feb./March	June
sugarcane	Feb.	Oct.-March
arum (*Colocasia* sp.)	March	Oct.
watermelon	March/Apr.	July/Aug.
groundnuts	Apr.	Sept.
barani maize	May/June	Sept./Oct.
rice	June/July	Oct./Nov.
sunflower	June/July	Sept./Oct.
cauliflower	July/Aug.	Oct.-Dec.
summer pulses	July	Oct.
autumn potato	mid-Sept./Oct.	mid-Dec./Jan.
winter vegetables[2]	Sept./Oct.	Dec.-Apr.
wheat	Oct.-Dec.	May
fodder (*shaftal*)	Oct.	May/June
sugarbeet	Oct.	May/June
sugarcane	Nov.	Oct.-March

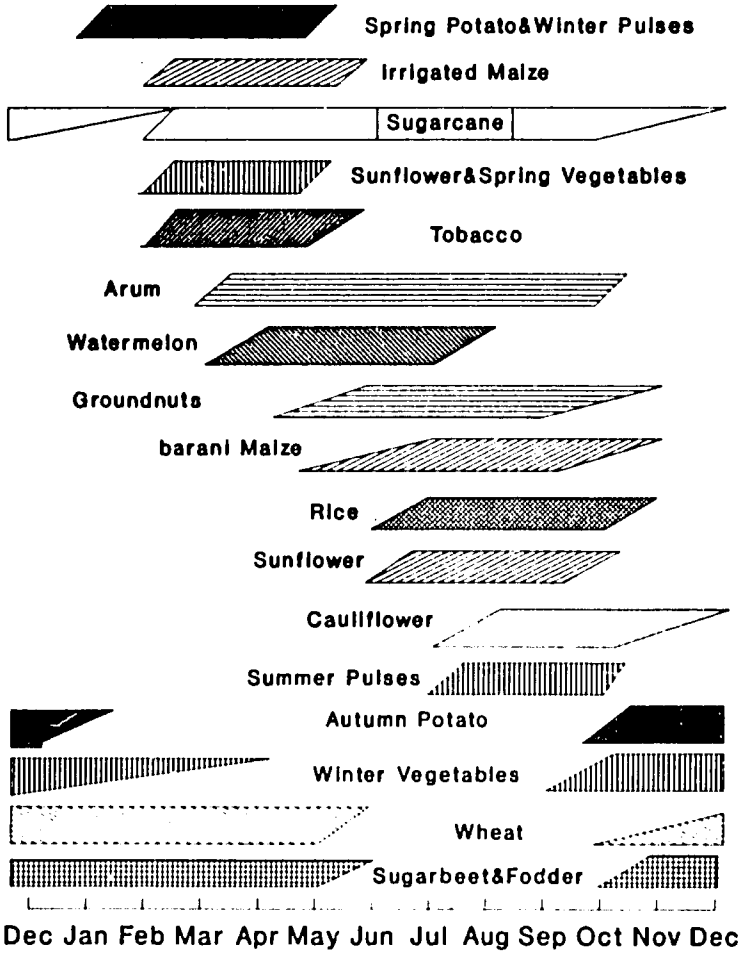
[1]cucumber, tomatoes, ladyfinger (okra), gourds, eggplants, pepper.
[2]carrots, radish, turnip, spinach.

4.3. PRODUCTION FACTORS

4.3.1. Farm size

The majority of farms are smaller than 5 ha in the Pabbi area (Anwar et al., 1986; Table 2). In the Wattar village east of Nowshera and in the Peshawar area farms are very small and only

Fig. 12: Common planting and harvesting dates for main crops



few bags of potatoes are planted. Some farmers cannot afford to have their own tubewell and/or are dependent on other off-farm sources of income.

In Mardan and Swabi districts, farmers may own small to big farms, but tenants usually operate farms with less than 5 ha of irrigated land. Longmire et al. (1990) found an average size of 4.4 ha cultivated land in the Hathyan area. Tenants in Shahbaz Ghari have 1-2 ha of land. Farms located north west of Mardan towards Takhtbái are larger than those located between Mardan and Swabi.

In the Hazro and Taxila areas, landowners generally have less than 10 ha of irrigated and *barani* farmland combined. The irrigated land is often managed by tenants. The size of the tenants' landholding is small (0.5-2 ha). The *barani* land in these areas is generally managed by the owner because less labor is required for the *barani* crops.

The *barani* areas (subzone 3b) are characterized by small farm size of about 4 ha (Sheikh et al., 1988). Farmers in the drier zones own larger farms than those in the wetter zones.

Table 2: Farm size and land tenure in the different areas of Zone 3.

Area	Farm size	Land tenure
Pabbi	5 ha	mostly owners
Mardan and Swabi[1]	10 ha	mostly tenants, often on a rent basis
Hazro[1]	10 ha	mostly tenants on 50/50 share basis
Taxila[1]	10 ha	ditto
Barani area	4 ha	mostly owners

[1]Tenants usually operate less than 5 ha.

4.3.2. Land tenure

Many landowners give their irrigated land to tenants because of the high labor required. Four main forms of tenancy exist: (1) the landowner manages the holding; (2) the tenant *(baghban)* receives one third of the produce, the owner provides all the inputs except labor; (3) inputs and produce are equally shared between tenant and owner except labor which is fully provided by the tenant; (4) tenants rent land for cash with leasing contracts varying in duration. Besides these four main forms, different arrangements for sharing inputs and outputs are possible.

In the Pabbi area, the majority of potato growers own their land, but tenancy is also quite common, especially in the Wattar village east of Nowshera (Table 2). The owner takes 50% of the harvest, but also pays for 50% of the inputs (seed, fertilizer, spraying, electricity, land preparation). Decisions about the farm management are mainly taken by the tenant himself.

In the Mardan and Swabi districts, tenancy seems to be more common than ownership. Tenancy on a rent basis is common because of the different cash crops being grown in the area. Longmire et al. (1990) found that in the Hathyan area 47% of the farms were owner operated, 20% leased by owner-cum-tenants, and 33% were operated by landless tenants. Land rents were Rs. 3000/ha in 1985. In the *barani* areas of Mardan and Swabi, land is mainly rented on a share-crop basis because mustard is the only cash crop grown, and risks of crop failure are higher.

In Hazro and Taxila, tenancy seems to be more common than ownership, especially for the irrigated land. One landowner may have several tenants. The produce is equally shared by the landowner and the tenant except when the land is rented on a cash basis. Inputs are generally also shared. However, expenses for fertilizer, spraying, land preparation, electricity may either be paid fully by the owner or tenant. The tenant is responsible for the labor. Tenants rely very often on the landowner for taking decisions. Some landowners are entirely responsible for getting the seed or arranging plant protection measures. Therefore, tenants do very often not know, for example, which variety or pesticide was used.

In the *barani* areas, the majority of farmers own their land (Sheikh et al., 1988). One third of the farmers in the Attock district are tenants. In these cases, outputs and purchased inputs are shared equally between owners and tenants, except in the drier areas where the tenant pays all the inputs.

4.3.3. Labor

The landowner and tenant hire seasonal labor for the planting, weeding, earthing up, and harvesting of potatoes, but they irrigate the fields themselves. Potatoes require less labor than some other cash crops, for example tobacco. The laborers are paid in cash. In Taxila, labor is more expensive than in other areas because people have other job opportunities (e.g. stone crushing industries). There seems to be no shortage of labor in the zone. On the smaller farms, proportionally more labor might be provided by the family itself.

In Mardan and Shahbaz Ghari, tenants help each other for planting and harvesting, therefore requiring less hired labor. This system is called *ashar*. Seasonal migrants from the upper Swat valley provide labor in Mardan and Swabi, especially for the sugarcane harvest starting in November. Many laborers are also paid in kind, receiving grain or fodder (Longmire et al., 1990). In Taxila, laborers and share-croppers also come from the Swabi district.

Most farmers in this zone have many years of experience of growing potatoes. In Hazro, farmers have been growing potatoes for the last 20 years and in Pabbi for the last 50 years (Anwar et al., 1986). They get their knowledge about potatoes from other farmers, landowners, dealers, or by listening to the radio and watching television (for example fertilizer advertisements). Some farmers also transfer knowledge from other potato growing areas, as for example a tenant from Hazro who rented land in Taxila and started growing white potatoes instead of the usual red varieties. In Mardan and Swabi, the Pak-German Integrated Rural Development Project (IRDP) also promoted potato cultivation.

4.3.4. Credit

Seed is usually paid in cash. Some poorer farmers might rely on the seed trader, commission agent, or the landowner to get credit on their inputs, especially for seed. In that case, the farmer has to pay for the inputs once he sells his produce. If seed is bought on credit from commission agents, the farmer is bound to sell his produce through the creditor. In many cases, the commission agents pay the farmers by instalments. Thus, if farmers need more inputs they can get them from the commission agents. The commission agents function as banks without taking interest on their loans but making money with the commission. The sugarmill and tobacco company in Mardan provide farmers with credits for the inputs of their sugarcane, sugarbeet, and tobacco crops, thus promoting these crops. In the Hathyan area of Mardan district, 42% of the farmers borrowed money (Longmire et al., 1990)

4.4. FARMING PRACTICES

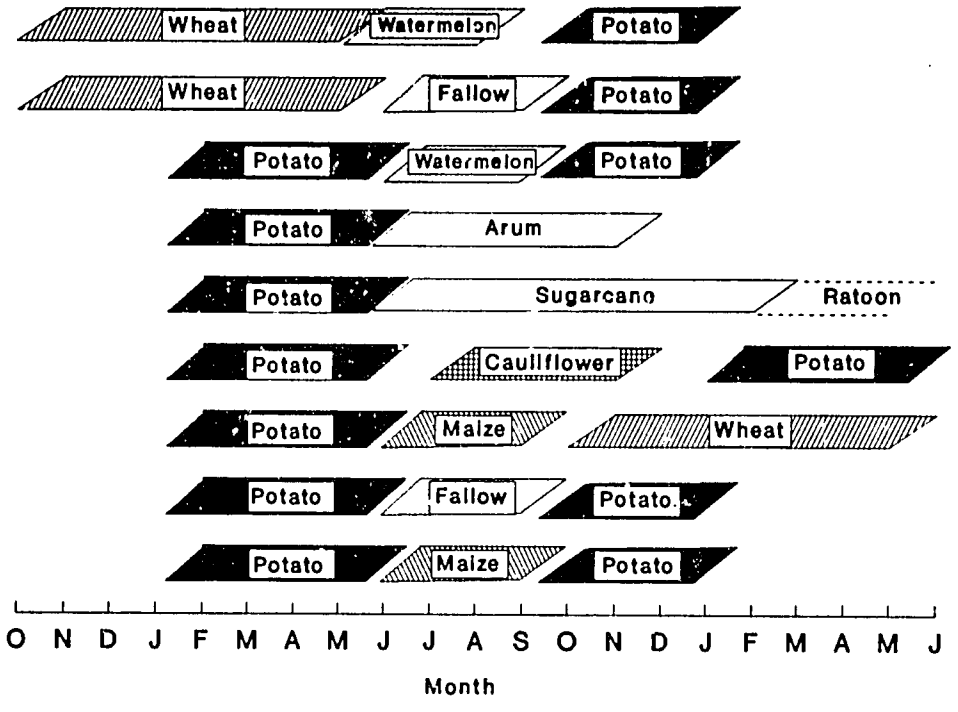
4.4.1. Cropping pattern

Some common crop rotations with potatoes are summarized in figure 13.

In the Pabbi area, the spring and autumn potato crops are equally important (Anwar et al., 1986; Table 3). The spring crop is used for producing seed for the autumn crop as well as for table potatoes.

Potatoes are a major cash crop in the Pabbi and Nowshera areas and compete mainly with sugarcane. They can cover up to 50% of the cultivated land depending on the price of potatoes and sugarcane. In 1985 for example, 33% of the cultivated area was under potatoes (Anwar et al., 1986). Sugarcane is generally sold on the local market as soft cane for chewing purposes.

Fig. 13: Common crop rotations with potatoes in zone 3



Potatoes are often planted in the spring with potatoes on the ridges and sugarcane in the furrows. Therefore, the potato cultivation has to be adapted to the wider row spacing of the sugarcane (1 m). The sugarcane grows slowly in the early months after planting, so there is probably little competition and no direct reduction in potato yield (Iqbal, 1991).

In the minor potato growing areas around Peshawar, Charsadda, in the *barani* area of Pabbi, and in the Wattar village, potatoes are less important. Sometimes they are only grown for own consumption. In the Wattar village, potatoes are intercropped with arum. Orchards, sugarcane, and vegetables are the major crops in those areas. Around Charsadda (Tangi), as there is less frost on the southern edges of the hills, mango and autumn crops of ladyfinger and tomatoes are grown.

Maize is often grown between the spring and autumn potato crops or the land is left fallow (see Fig. 13). Wheat is a major winter crop usually planted after sugarcane. Cucumber is the main spring vegetable competing with potatoes. Tomatoes, ladyfingers, eggplants, gourds are grown on a smaller scale.

In Mardan and Swabi districts, spring and autumn potatoes are grown (Table 3). However, the spring crop has to compete with tobacco (Virginia and local), sugarcane, sugarbeets, and vegetables. Marketing of sugarcane, sugarbeets and tobacco is easier because a sugarmill and tobacco company are located in Mardan. Sugarcane may be sold to the mill or marketed as brown sugar *(Gur)*. *Gur* often fetches a higher price. Sugarbeets are grown close to the mill. About 90% of the total production of tobacco in Pakistan is produced in Mardan. These crops are a safe source of income for the farmers in the area who own or operate small land holdings. They grow tobacco under contracts of the tobacco company. In 1990, tomatoes were sold at high prices (Rs. 20/kg). Thus, less potatoes and more tomatoes were planted in the area in 1991.

Maize and sugarcane are the most important summer crops, but sunflowers (more recently) and rice are also grown. Sugarcane is planted in February and also November, sometimes intercropped with sugarbeets and wheat in autumn, or potatoes in spring.

In the Hazro area, between the Indus river and the G.T. Road in the main potato growing villages, potatoes are an important cash crop and may cover more than 50% of the cultivated land in some farmers' field (Table 3). In 1985 for example, about 20% of the cultivated land was under potatoes (Anwar et al., 1986). The spring and autumn crops of potatoes are equally important but may vary depending on the price of potatoes in the preceding year.

Maize and watermelons in summer, and wheat and carrots in winter are the only other important crops. Some fields are left fallow in summer. Sunflower and maize are also grown in spring. In this case, the maize has to be irrigated.

In the north east of Hazro, potatoes have to compete in spring with tobacco and vegetables (e.g. gourds, cucumber, ladyfinger, garlic, carrots) and with cauliflower in autumn. Thus, areas under potatoes fluctuate according to the historic price of potatoes and problems experienced in growing the crop. Tobacco is sold to the tobacco company in Mardan. It is used for *hookahs* (traditional pipes). Cauliflower can be grown as an early, mid-late, or late crop in this area and fetches high prices in the Punjab markets, mainly in Lahore. Maize is an important summer crop.

In the Taxila area, the spring crop of potatoes is more important than the autumn crop because cauliflower fetches a higher price in the Lahore market (Table 3). The spring crop may cover more than 50% of the cultivated land depending on how many other vegetables (e.g. pepper, eggplants, onion, cucumber) are grown. Maize is grown as a summer crop and wheat for own consumption in winter.

In all these areas, farmers grow some fodder (*Trifolium alexandrinum*) for their own cattle or to sell to other farmers who own more cattle, however, livestock are of minor importance to potato farmers. Draft bullocks and buffalos for milk are the most common livestock in irrigated farming systems of Mardan district. Most farmers had two buffalos or cows, two heifers, and 12 chicken (Longmire et al., 1990). Sheep and goats were less common. Thus, farm yard manure has to be purchased.

Table 3: Importance of spring and autumn crop, percent cultivated area under potatoes, and main competitive crops for potatoes in the different areas of zone 3.

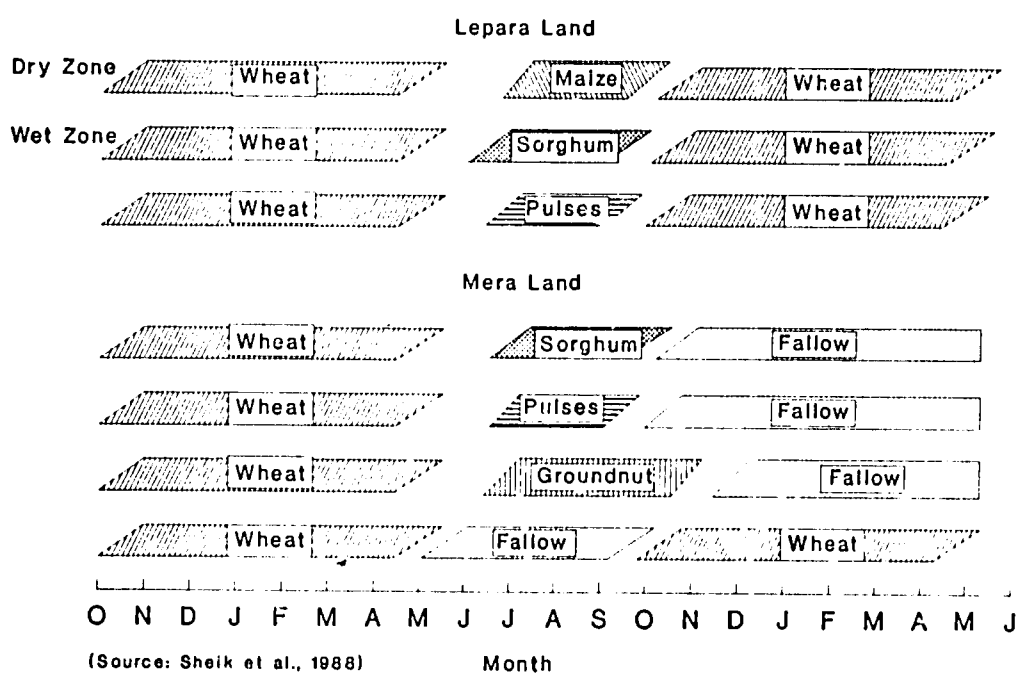
Area	Spring crop	Autumn crop	Percent under potatoes	Main competitive crops
Pabbi & Nowshera	++[1]	++	<50%	sugarcane, wheat, vegetables
Rest of Peshawar district	+/-	+/-	small	orchards, sugarcane, vegetables
Mardan & Swabi districts	+	++	<50%	sugarcane, sugarbeet, tobacco, vegetables
West of Hazro	++	++	>50%	wheat
North east of Hazro.	+/-	+/-	small	tobacco, cauliflower, other vegetables
Taxila tehsil	++	+/-	>50% (spring)	cauliflower, other vegetables

[1] ++ very important, + important, +/- less important or changing

Wheat is dominant during winter in the cropping pattern of the *barani* areas (Fig. 14). Mustard is an important cash crop. Maize, sorghum/millet (as monsoon crops) are also grown by the majority of the farmers. Pulses and groundnuts are grown by farmers in especially suitable areas. No potatoes have been reported in these areas.

Livestock are important in the *barani* areas (Sheikh et al., 1988). The animals produce farm yard manure (FYM) which is used to fertilize the fields close to the village (*lepara* land). Fields far from the village receive less FYM (*mera* land).

Fig. 14: Common rotations in barani areas of zone 3



(Source: Sheik et al., 1988)

4.4.2. Potato production

4.4.2.1. Varieties

In the Pabbi area, only red varieties are grown, even though some farmers remember having grown some white varieties in the past, probably Multa (Table 4). The stated main reasons for not growing white potatoes anymore are the large distance from the Sindh markets and the difficult access to good seed of white potatoes.

Ultimus and Cardinal are mainly grown. However, farmers seem to be growing a mixture of several red varieties and even some white potatoes since most get their seed from Balakot. Desiree seems to be the preferred variety in the Wattar village. The availability of affordable seed of one or the other variety influences which variety is grown in a given year. Some farmers seem to prefer Ultimus for the spring crop because of its better heat tolerance compared to Cardinal. On the other hand, Cardinal seems to become more important than Ultimus because of its higher market value and the difficulty in getting healthy Ultimus seed.

In Mardan and Swabi districts, only red potatoes are grown (Table 4). Cardinal seems to be the main variety grown. Ultimus might be more important for the spring crop when seed comes from Balakot. Cardinal was introduced to these areas through the Pak-German IRDP project in 1985.

White potatoes are more important than red potatoes in the Hazro area (about 80% white potatoes). White potatoes were introduced into the area about 20 to 30 years ago. Only smaller producers (1-8 bags planted) north east of Hazro prefer red varieties because they can be more easily sold in the local market. However, if the small farmers could collectively fill one truck they may also grow white potatoes. The most commonly grown white variety seems to be Diamant, because Ajax has been very susceptible to late blight attack in the past (Table 4). Desiree is the favoured red variety. However, some farmers, especially those who buy the seed in the Hazro market, do not always know which variety they are growing. A mixture of different varieties, even red and white together, has been observed in the field.

About two thirds of the potatoes in the Taxila area are red varieties (Table 4). White potatoes are concentrated in one village (Muzaffarabad). There is less tradition of growing white potatoes in this area than in Hazro. The main red variety is Desiree while Diamant and Ajax seem to be equally important among the white varieties. Some other varieties such as Ultimus, Cardinal, Patrones, and Multa may also be grown.

In Hazro and Taxila, red and white potatoes are managed the same way except for spraying against late blight, against which white potatoes need to be sprayed more often. Since fungicides such as Dithane M-45 are cheap, the production costs for red and white potatoes are not significantly different.

Table 4: Common red and white potato varieties grown in the different areas of zone 3.

Area	Red varieties	White varieties
Pabbi	Ultimus, Cardinal, (Desiree)[1]	none
Mardan & Swabi	Cardinal, Ultimus[2]	none
Hazro	Desiree	Diamant, (Ajax)[3]
Taxila	Desiree	Diamant, Ajax

[1]In Wattar village.
[2]Probably more important for spring crop.
[3]Importance has declined because of late blight susceptibility.

4.4.2.2. Seed sources

For planting the spring crop in Pabbi, the farmers purchase seed grown in the hills in the previous summer (Table 5; Fig. 15). It is bought from traders in local markets in Pabbi or Peshawar or farmers go themselves to Balakot. The "Balakot" seed is principally grown in the Kaghan valley but may also come from other areas. The seed bought in the local markets may also come from different areas. Some seed comes from the high hills of South Waziristan and is marketed through either the Tank or Bannu market to Peshawar. Seed potatoes are also supplied from the Tirah area (Kohat district) through the Kohat market to Peshawar.

Mardan farmers buy their seed on the local market or go themselves to Lahore or Faisalabad (Table 5). Seed for the spring crop probably comes from Balakot or Kalam.

Hazro farmers purchase summer grown hill seed in the local market, Rawalpindi/Islamabad and Attock (Table 5). This seed is said to come from Quetta, Balakot, Swat, Murree or Hunza. Quetta seed (both red and white) is supplied through the Peshawar market to Hazro. But farmers do not know where the seed actually comes from. They also buy certified imported seed from Jaffar Brothers (Private) Ltd. (JBL) and the Punjab Seed Corporation, but much less than in the past because of the high price of imported seed and the good quality of JBL and Abdul Ghafoor Bhatti Corporation (AGBC) seed from the Northern Areas. JBL and AGBC seed is about 50% of the imported seed price (in 1991, Rs. 10-13/kg as compared to Rs. 25/kg). Farmers in this area also keep some potatoes from their spring crop as seed for the next spring crop. This might be a more recent development due to the high seed prices and the possibility to store seed in the Hattian cold store, which operates the whole year. Seed from the local market resulted in poor emergence in spring 1991. Some big farmers sell some of their potatoes as seed to other smaller farmers in the area.

In the Taxila area, an increasing amount of seed is provided by JBL (Table 5). This seed comes from Hunza or is imported seed. JBL seed has to be booked in advance and is not available on credit. Some farmers buy seed from the markets in Hazro, Rawalpindi/Islamabad, or go themselves to Balakot. Market seed is believed to come from Quetta, Balakot or other places in the hills.

In all four areas the autumn crop is planted with small tubers from the spring harvest which have been kept in cold store or at the farm during the summer (Table 5). There is autumn-to-autumn multiplication in the zone, especially from farmers in Pabbi, Mardan and

Hazro. Autumn seed is multiplied for several cycles. In Mardan, farmers use cold stored seed from the Punjab for the autumn crop. They go themselves to buy the seed or buy it through traders in Mardan.

Table 5: Common seed sources of red and white potatoes and multiplication cycles in the different areas of zone 3.

Area	Seed sources and markets	Spring to autumn	Autumn to autumn	Spring to spring
Pabbi	Markets in Pabbi, Peshawar, Balakot, Tank, Bannu, Kohat	yes	yes	no
Mardan & Swabi	Markets in Mardan, Peshawar, Balakot, Kalam, Punjab[1]	yes	yes	no
Hazro	Markets in Hazro, Attock, Rawalpindi/Islamabad, Peshawar, JBL, AGBC, PSC[2]	yes	yes	yes
Taxila	Markets in Hazro, Rawalpindi/ Islamabad, JBL, Balakot	little	little	no

[1]Mainly for autumn crop
[2]Imported seed

4.4.2.3. Land preparation

A couple of days before ploughing, if the soil is too dry, farmers irrigate once. Primary tillage is done in the area by the usual tractor drawn spring tine cultivator with planking equipment called *sohaga* attached behind. In Mardan, bullocks are used as well. The number of ploughings and plankings depends on the soil type and moisture content. Up to ten ploughings and five plankings in heavier soils are common. Fields are generally prepared alternately clockwise and anticlockwise.

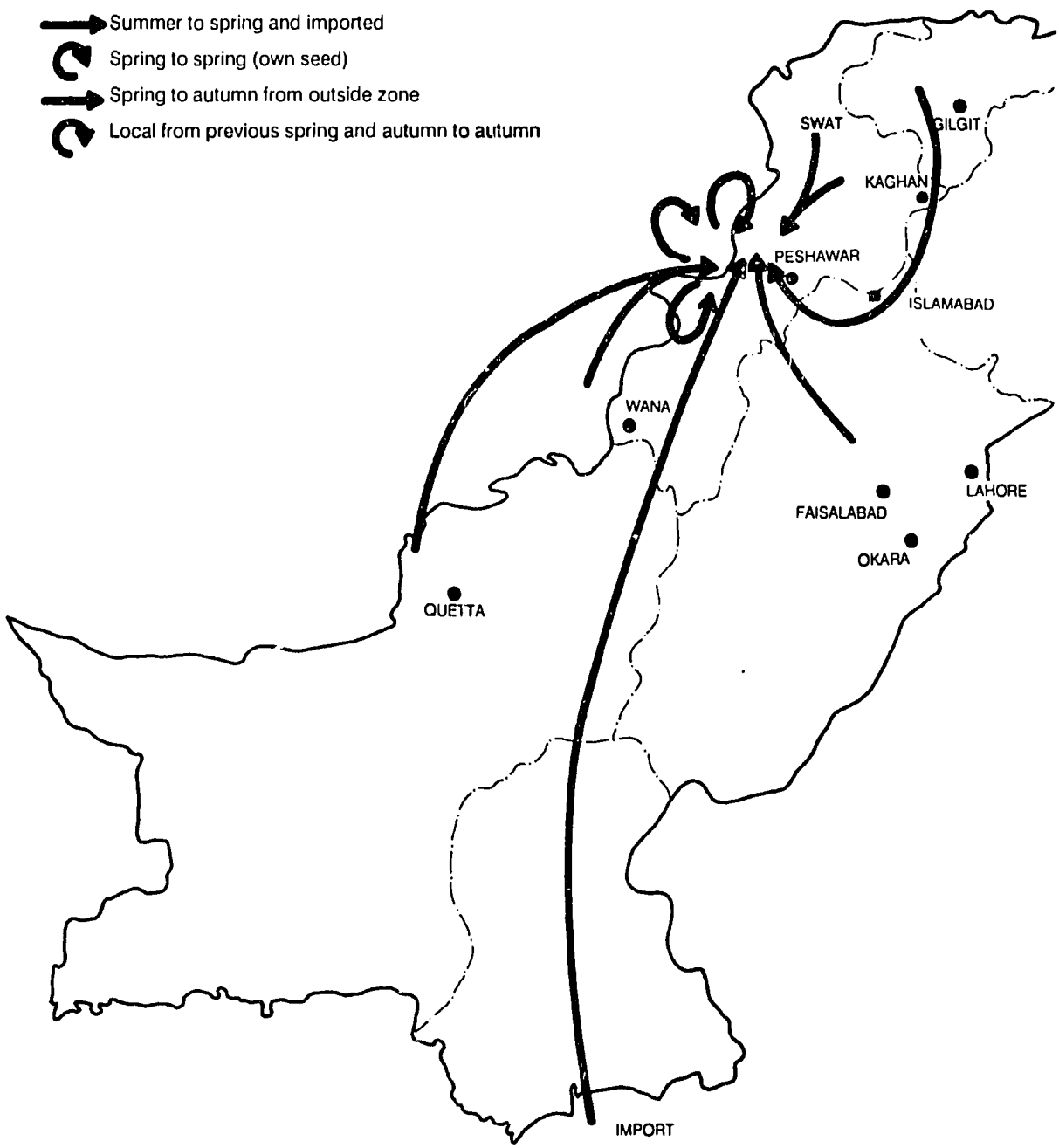
4.4.2.4. Fertilizer

Farmers apply variable doses of nitrogen, phosphorous, FYM, and usually no potash (except for one farmer in Taxila) for the spring and autumn crop (Table 6). A few farmers apply even higher doses than shown in the table. No micronutrients are applied. Some farmers argue that they have to apply high doses of fertilizer because of the three crops grown in a year. Other apply no fertilizer at all because of the costs involved (Sabir et Al., 1991).

Table 6: Quantity of nitrogen, phosphorous, potash, FYM applied by farmers in on-farm trials in the Pabbi area in spring and autumn 1986 (Devaux and Anwar, 1989).

Season	Number of farmers	N	P	K	FYM
		kg/ha			t/ha
Spring	11	0-230	0-184	0	0-80
Autumn	10	0-460	0-230	0	0-40

Fig. 15: Main seed sources for zone 3



DAP and urea are the fertilizers most often used. In Mardan, some farmers use ammonium nitrate instead of urea. Potash might not be available on the open market for the farmers because all K fertilizers have to be imported, or the benefits of using this nutrient have not been proved yet. However, in Mardan it is provided to tobacco growers. DAP is applied before planting. Half of the urea or ammonium nitrate is generally applied at planting and half at earthing-up.

FYM is applied at least once a year before planting. It has to be bought from dairy farms in the neighborhood or in surrounding urban areas. In Hazro, some farmers use waste from the flour mills instead of cattle manure. Prices vary according to the weight of the trolley and the distance to the farm (around Rs. 250/t). Not all farmers can afford to apply high amounts of FYM twice a year.

FYM is usually applied shortly before ploughing. We met only one farmer in Taxila who applied it 2-3 months before planting the potatoes which gives the highest benefit to the potato crop.

4.4.2.5. Planting

The furrows are marked out with an animal-drawn single plough and the seed potatoes placed between the furrows by hand. The ridges are then formed over the rows of potato by two men with a *pulkra* (a broad toothed wide spade), one digging into the furrow and the other pulling on a rope. A few farmers probably use tractor-drawn three-row ridgers.

Cut seed is planted in spring at a rate of 1 to 3 t/ha and whole seed is planted in autumn at a rate of 2 to 5 t/ha depending on the tuber size, seed source, and planting density (Devaux and Anwar, 1989). But most farmers use seed rates of 1 t/ha in spring and 2 t/ha in autumn. For cut seed, tubers are usually cut into pieces having 1-2 eyes (3-6 pieces per tuber). Certified seed is sold in 50 kg bags, while all other sources are in 90 to 110 kg bags.

The row-to-row distance varies between 75 and 90 cm. Thus, at an intra-row distance of 15 cm the plant density varies from 75,000 to 90,000 plants per ha. In Hazro, row distances between 50-60 cm have been observed and in Taxila, intra-row distance was larger (30 cm) resulting in lower plant density and bigger tubers. Potatoes intercropped with sugarcane are planted in rows 1 m apart. Row spacing for potatoes intercropped with arum was 75 cm.

4.4.2.6. Weeding and earthing-up

Weeding and earthing-up of potatoes is done about 30 days after planting when the plants have emerged. Spades and hand-trowels (*khurpas*) are used. Herbicides are rarely applied and no further weeding or hoeing is done until harvest, thus potato fields are covered with weeds at harvest time. However, some farmers, especially in Taxila, do use Stomp for chemical weeding.

4.4.2.7. Water management

Water is applied at weekly intervals according to the soil moisture content, rainfall, and availability of water from the canals. Sometimes farmers arrange with neighbors to obtain more water.

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Farmers with tubewells in the minor potato growing areas have less constraints in irrigation intervals. In the Wattar village, fields have to be irrigated more often due to sandy soil. Irrigated fields in December are better protected from frost thus prolonging the cropping season.

4.4.2.8. Diseases, pests and their control

In Pabbi, the virus level (mostly PLRV and PVY) is frequently high, due to the poor quality of the seed. Better seed is used in Hazro so there is less virus. In Taxila only some small farmers planting Rawalpindi/Islamabad market seed suffer from virus problems. The aphid build-up in the spring is sometimes very heavy so that an autumn-to-autumn multiplication cycle could only be started successfully with spring grown seed if good quality seed was used for the initial spring crop.

An unidentified disease resembling mycoplasma producing many stems and small tubers has been observed in Mardan.

Black leg like symptoms associated with *Erwinia chrysanthemi* have been identified in 1986 (Turkensteen, 1987). Bacterial wilt seems to be widespread affecting the spring crop at Hazro and Taxila. Poor crop management and reduced capacity of the local stores and bacterial wilt may be responsible for the observed short seed multiplication cycles.

Late blight (*Phytophthora infestans*) is fairly frequent, but it varies considerably in intensity from year to year and even from area to area. The crop loss is sometimes severe. It is more prevalent in spring than in autumn. Pabbi and Hazro areas seem to be more prone to late blight attacks than Taxila and Mardan. In 1991 for the second consecutive year, the spring crop in Hazro was severely affected by late blight according to information provided by farmers and own observations. Instead of the usual yield of about 20 t/ha, farmers harvested less than 10 t/ha, and in some cases reported the total loss of their crop, especially white potatoes. The spring to spring multiplication of seed practiced in Hazro could aggravate the late blight attack by using infested tubers. Some early blight (*Alternaria solani*) has also been observed at low frequency in 1986 (Turkensteen, 1987).

Fungal wilt caused by *Verticillium dahliae* and *Fusarium* spp. are widespread. Turkensteen (1987) reported visual symptoms of these fungal wilts in 55% of the plants in Pabbi and Hazro, with *Verticillium dahliae* the more important.

Powdery scab (*Spongospora subterranea*) was found in Hazro, but since only few tubers were examined no conclusion could be drawn on the spread and importance of this problem (Turkensteen, 1987).

Cutworm is a common problem, and in Pabbi caterpillars of unknown species sometimes do damage early in the autumn season and also may affect the spring crop.

Only a few larger farmers use a fungicide, usually Dithane M-45, to control late blight. This fungicide is usually applied together with some insecticide, and many farmers start applying it too late when the disease has already started. White varieties are considered to be more susceptible to late blight than red varieties. Ajax seems to be the most susceptible variety. No other plant protection measures are used.

Many farmers do not recognize diseases and have to rely on the advice of seed and pesticide dealers, the landlord or extension officials. In addition, they often do not know which fungicide they have used (Sabir et al., 1991).

4.4.2.9. Harvest

Potatoes are harvested by hand using *khurpas* (flat hand-trowels). Tubers are then put on heaps and covered with potato vines or directly filled into bags. Small tubers are separated from large ones to keep for seed. This grading is done before potatoes are taken to the market.

In Taxila, some farmers sell their potatoes without separating the small tubers as seed since they do not grow an autumn crop. The small tubers comprise only a small part of the harvest and do not affect the sales price. Some *pharias* (retailers, who buy at the auction and sell again to customers) may grade the potatoes later on.

4.4.2.10. Yield

Yield varies depending on farmer, area, season, and year. In the Pabbi area, surveys and yield trials have shown that the mean yield is around 15 t/ha (Anwar et al., 1986; Devaux and Anwar, 1989), however, 30 t/ha or more are achievable according to farmers' own information and direct observations made in the field. The autumn crop seems to yield more due to less disease and pest problems if it is not killed by early frost in December. Farmers in Taxila seem to achieve high yields as was observed in the spring of 1991 and reported by farmers (Sabir, 1991). The Spring crop in Hazro was severely affected by late blight in 1991, wiping out some farmers' field completely. Farmers reported that white varieties were higher yielding than red varieties thus leading to higher net returns. However, no formal yield survey has been done to prove this information. At a seed rate of 1 t/ha in spring and a yield of 30 t/ha and more, farmers achieve high multiplication rates in spring (1:30).

4.4.2.11. Post harvest handling

Table potatoes are not graded into different tuber sizes even though grading may help to get higher prices in the market.

The spring crop is usually sold within a month of harvest because of the high temperatures in May-June. Some farmers like to wait for better prices and store potatoes in cold stores. To catch higher prices, the autumn produce is often stored longer; the hot weather forces the last direct sales in April. Cold storage is mainly used to store spring crop seed potatoes until planting in autumn. These potatoes are stored at about 1 to 2°C and without control of humidity. Some farmers also use their own houses for seed storage.

There is one cold store in Hazro (Hattian), two in Mardan and about nine in the Peshawar area. Thus, in the Pabbi area there is ample choice for the farmer to store his seed and table potatoes and there is stiff competition in years of shortage among store owners. A cold store between Taxila and Hassan Abdal (Rawalpindi district) is also used by Hazro farmers and seed traders. A large cold store is available at Haripur. It was rented by a private company in 1988 which intends to service potato growers in Abbottabad, Hazro and Taxila.

4.4.2.12. Marketing

Farmers in Peshawar district sell their produce in Peshawar on the wholesale market. Most farmers take the potatoes themselves to the market. Some traders from Mardan, Pabbi, Swabi, Attock, and Peshawar buy the standing crop or the bagged produce at the field. When he buys a standing crop, the trader digs out some samples, counts the plants and looks at the general aspect of the crop. He has to pay for harvesting and transport costs.

Commission agents have their own shops at the wholesale market in Peshawar. They employ subagents in nearby villages to bring farmers to the agent. The produce arrives the day before the auction and is stored in front of the shop. The day of the auction, early in the morning, when buyers are assembled one or two bags of each farmers produce are opened and emptied to show the quality of the potatoes. The agent sets a price according to his experience. The highest bider gets the potatoes. If nobody wants to buy, the price is set lower. Sometimes potatoes are not sold the first day. Ultimately, the farmer decides whether he wants to sell at a given price. Tuber shape, color, size, cleanliness, health are only some of the not very well defined quality criteria for sale. Since the potatoes are not graded they are usually very heterogeneous. The auctions in front of each agent are very rapid and hectic and all at the same time. Thus, a potential buyer can only participate at one auction. The agent charges a commission for selling the produce (in 1991 the commission is 4%).

Potatoes produced in Mardan and Swabi districts are sold in the local market in Mardan or brought to the wholesale market in Peshawar. Some traders go to the farmers' field to purchase the standing crop or farmers organize their own transport to the market. When potato prices are high, farmers are willing to pay for transport to more distant markets such as Peshawar. In addition, potatoes are grown close to the roads which allow easy transfer to the market.

Most of the white potatoes from Hazro are purchased by traders and marketed in Sindh (mainly in Karachi, less in Hyderabad and Sukkur) about 1500 km away. There, the predominant demand is for white potatoes. Dealers from Rawalpindi/Islamabad, Lahore and even local markets (e.g. Mardan) come to Hazro to buy potatoes. Traders know the farmers growing white potatoes through the local commission agents. Many come to visit farmers in the area every year. The small tubers (*goli*) are put in cold storage to supply as seed for the autumn planting to farmers in Kasur, Lahore, and Okara (Sabir, 1991). Red potatoes are marketed mainly in Hazro, Peshawar and Rawalpindi/Islamabad but are also sold to Karachi or Lahore. Some farmers seem to be well informed where they can get higher prices for their produce. The smaller farmers in Hazro tend to grow red potatoes as they get paid more quickly in the closer markets and they do not have whole truck loads to sell.

White potatoes produced in Taxila are all marketed in the Sindh, mainly in Karachi. Farmers organize and pay their own transport and sell the produce through commission agents at the wholesale market. Red potatoes are usually sold at the local markets in Taxila (through shopkeepers), or in Rawalpindi/Islamabad (through commission agents), but some farmers also try to sell them in Karachi. In the latter case, trucks transporting white potatoes are completed with bags of red potatoes. Farmers prefer to sell potatoes in the Sindh markets because they can sell the whole truckload at a good price at once. Potatoes are used for making chips and for table purposes. In the local markets, only small quantities of potatoes

over a long period of time can be sold, thus risking adverse price fluctuations and potatoes have to be stored longer on the farm.

Farmers from Taxila and Hazro have as easy and direct an access to Karachi as the farmers from the Central Punjab. They produce white potatoes mainly in spring when some of the potato crop in the Punjab is used for seed and not sold on the market. About 20% of white potatoes supplied to the Karachi market comes from Taxila and Hazro. However, the supply has decreased during the last two years because of late blight attacks and seed supply problems. Traders, in Karachi prefer potatoes from Taxila and Hazro compared to Kasur or Chiniot because of their taste and seed purity. Most white potatoes from these areas are supplied in spring. Demand for red potatoes is increasing in the Karachi market.

4.5. PRODUCTION SUPPORT PROGRAMS

There are extension officers in the potato growing areas. But their working relationship with the interviewed potato growers need improvement. They have some demonstration plots on farmers' fields.

Pakistan-Swiss Potato Development Project (PSPDP): This project carried out a farming systems survey of Pabbi and Hazro in October/November 1985 (Anwar et al., 1986), followed by a small yield survey of ten farmers in Pabbi and ten in Hazro in spring 1986. In conjunction with the local extension service, on-farm trials were then carried out in Pabbi in spring and autumn 1986, 1987 and 1988 and in Hazro in autumn 1986. late blight control was demonstrated in plots in Hazro and Mardan in spring 1988. The trials have covered seed source, autumn-to-autumn and spring-to-spring seed multiplication, late blight control, fertilizer, aphid control and spacing. In September 1988 a rapid survey of comparative costs in Hazro and Pabbi was carried out. In autumn 1990, the production costs were surveyed and seed sources from Tank and Bannu markets were investigated.

Agricultural Research Institute (ARI) Tarnab: Situated close to the Pabbi production area this institute has carried out potato research for many years, much of it variety and germplasm evaluation under the earlier PL-480 program. It has also done research into the processing quality of different clones. Most of their work on zone 3 was performed on the station.

Integrated Rural Development Project, Mardan: This project is supported by aid from Federal Republic of Germany. It is marginally involved in developing potato production in Mardan district in conjunction with PSPDP's research program at Pabbi. Seed of the variety Cardinal was repeatedly supplied to farmers through contacts with the Pak-German Seed Farm in Battakundi.

4.6. CONCLUSIONS

Farmers, traders, and extension officials perceive climatic conditions, seed quality, marketing, social organization, and agronomic practices as the major constraints to potato production in this zone.

Rainfall in spring may delay planting of the spring crop. Climatic conditions in spring are favorable one out of three years for a late blight attack, especially in the Pabbi and Hazro areas.

Hot temperatures in May and June influence tuber quality and shorten storage in the field. The summer is too hot to allow a summer crop to be grown. Frost in December may kill the autumn crop, thus shorten the cropping season.

Seed is provided from different sources, usually from the summer crops in the hills of Pakistan. But farmers do often not know for sure where their seed comes from unless they go themselves to the production areas to buy it. Uncertified seed often germinates poorly, resulting in poor stands. Seed is often a mixture of several varieties, even red and white potatoes are sometimes found in the same crop. The seed price often does not correspond to its quality and cheap seed sometimes produces very poor results.

Not all production areas have an easy access to major markets for potatoes. Pabbi and Mardan rely basically on the local markets, while farmers in Hazro and Taxila go as far as Karachi to sell their produce. Many farmers lack the knowledge about marketing possibilities and trends in market prices. They react to high prices in previous crops by growing more potatoes, thus contributing to gluts.

Most farm operations in this zone are small, adapted to the capacity of the tenants in providing labor for planting, weeding, earthing-up, and harvesting of potatoes. They rely on a few cash crops to provide income for their families. They are often short of cash to buy good quality seed, fertilizers, and pesticides. Many of the tenants rely on landowners, traders, pesticide dealers, and extension officials for technical advice.

Many farmers seem to know little about fertilizer doses, time of application, identification of major pests and diseases and correct plant protection measures, varieties best suited for their environment and cultural practices to achieve high and stable yields.

Most farmers seem to grow potatoes not based on their deep technical know-how of this crop but are rather opportunists, i.e. when the price of the previous year's crop was high all plant potatoes the following year.

The potential for the development of production lies in the adaptation of improved agronomic practices through knowledge about the main problems and their correct countermeasures. Seed quality and marketing might also be improved while the climatic and social conditions can hardly be influenced.

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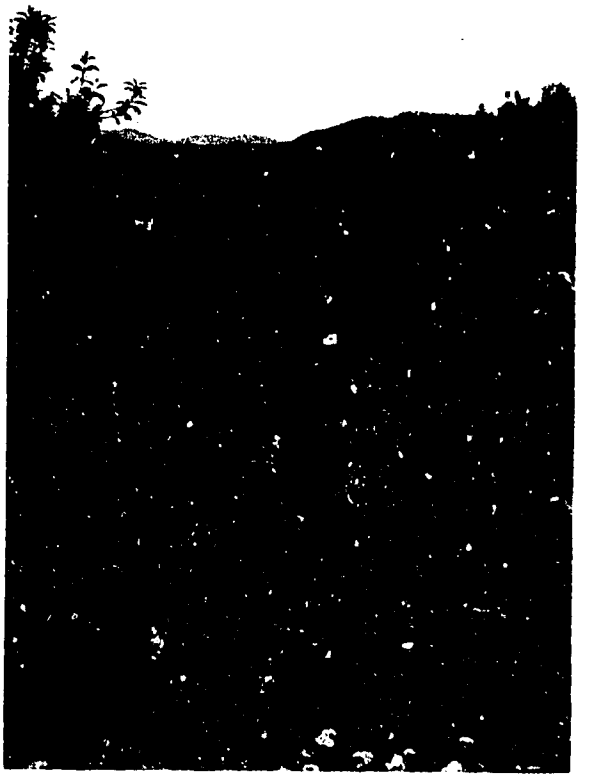

A view of a potato field in the Rush plains, near Abbottabad, NWFP.

The author and PSPDP staff member interviewing farmers in Mansehra district, NWFP.

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A farm near Bajna village, one of the major potato growing areas in the Pakhal plains, NWFP.

Scenic view of the Buner valley, NWFP

5. ZONE 4: IRRIGATED LOWER VALLEYS OF NWFP

5.1. GEOGRAPHICAL COVERAGE

5.1.1. Altitude

Zone 4 covers the irrigated lower valleys of NWFP which range in altitude from about 700 to 1500 m (Table 1). The main difference between this zone and zones 5 and 6 is that two potato crops can be grown in this zone. In the areas at lower altitude than Abbottabad, the two crops are separated by a longer period in summer when it is too hot for potatoes, and planting and harvesting dates are closer to those of zone 3. In the areas at higher altitude, the gap between the two crops diminishes until theoretically at about 1500 m the early autumn crop follows immediately after the late spring crop. In practice, there seems to be a transition zone anywhere between 1250 m and 1500 m where no potatoes are cultivated, possibly because a system of summer and winter crops is preferred. In the lower Kaghan valley for example, wheat would be the winter crop and rice or maize the summer crop. In Shinu (Kaghan valley) at about 1350 m one potato field (summer crop) has been observed in 1991. Thus, the practical limit of zone 4 may be below 1500 m.

Table 1: Approximate altitudes[1] (m a.s.l.) of important cities and villages in zone 5.

City/village	Area	Altitude (m a.s.l.)
Havelian	Abbottabad	800
Abbottabad	Abbottabad	1200
Baffa	Mansehra	850
Bajna	Mansehra	900
Shinkiari	Mansehra	950
Haji Abad	Mansehra	1000
Mansehra	Mansehra	1100
Pir Baba	Buner	700
Daggar	Buner	700
Jowar	Buner	800
Batkhela	Malakand	700
Thana	Malakand	700
Chakdara	Dir	700

[1]Altitudes were measured with altimeter if not indicated otherwise.

5.1.2. Latitude and longitude

Zone 4 spans one degree of latitude (34° to 35°) and two degrees of longitude (71° 30' to 73° 30').

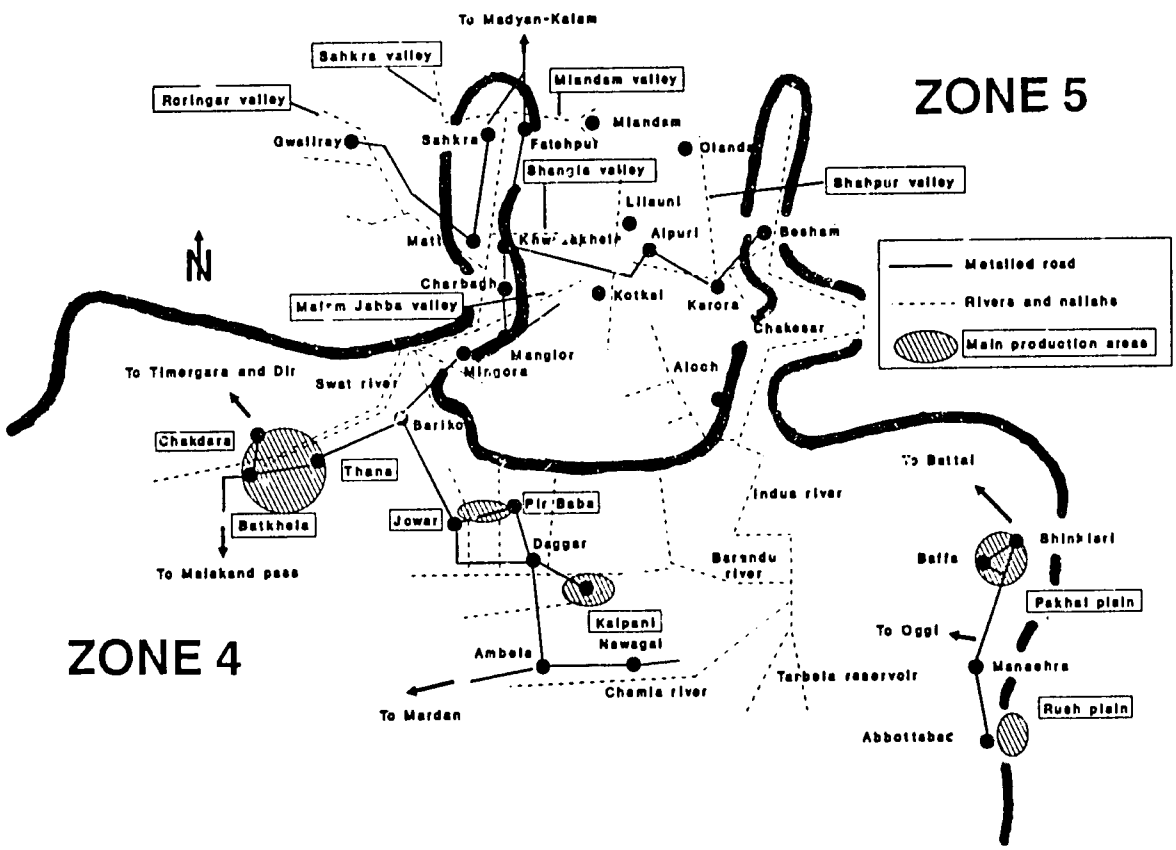
5.1.3. Topography

The potato growing areas in this zone are confined but moderately open flood plains, plateaus, valley bottoms, and rolling hills.

5.1.4. Potato production areas

At present there is very little production in this zone. Potatoes are grown on the Rush plain around Abbottabad, on the Pakhal plain north of Mansehra (Baffa, Bajna, Tanta, Shinkiari, Dhodial, Haji Abad), and in the Jowar, Pacha Kalay, and Kalpani area of the Buner valley (Fig. 1). Habib (1989) reported some potato growers in the Malakand agency around Thana, Rangmalla, and Batkhela. The agricultural office in Timergara has tried to promote potato growing in the Chakdara area. Potential production areas are lower valleys around Muzaffarabad, Bajaur, and the Indus valley from Besham to Dassu. However, there is no information about potato production in these areas.

Fig. 1: Main potato growing areas in zone 4



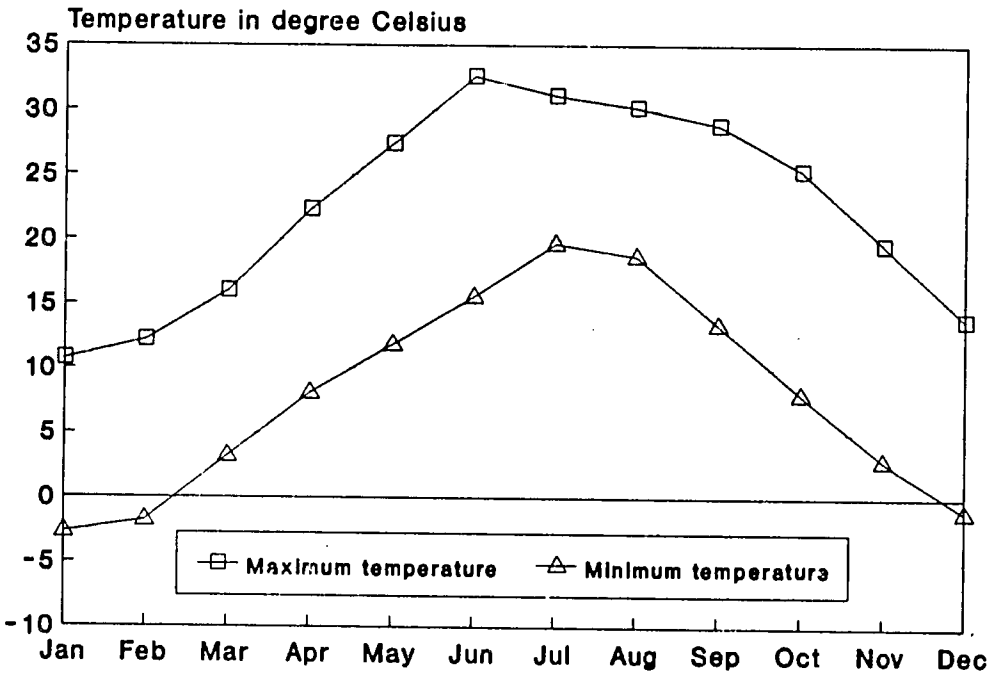
5.2. ECOLOGY

5.2.1. Temperature

The climate in this zone is warm temperate with hot and sub-humid to humid summers and mild winters. All locations display the same longtime seasonal pattern of temperatures

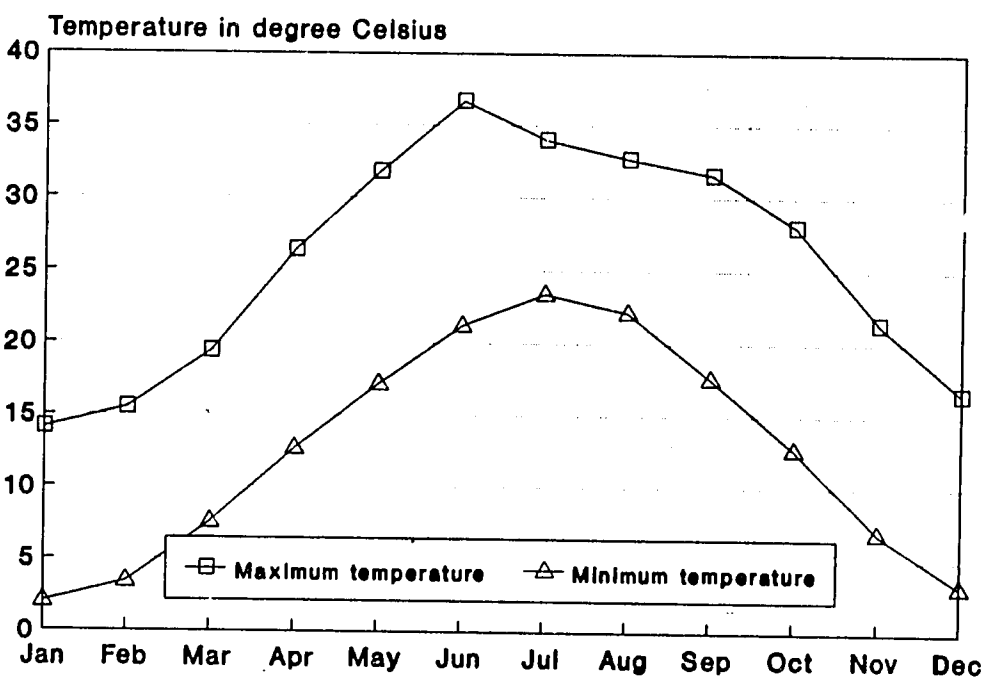
independent of the altitude (Fig. 2 through 5). However, the mean temperature decreases by approximately 1°C per 100 m increase in altitude. Therefore, the summer is milder than in zones 1,2, and 3. The highest temperatures occur in June and the lowest from December to February. The frost risk is highest from December to February.

Fig. 2: Mean monthly temperatures at Dir (zone 4)



(Source: Meteorological Office, Lahore, 1977-86)

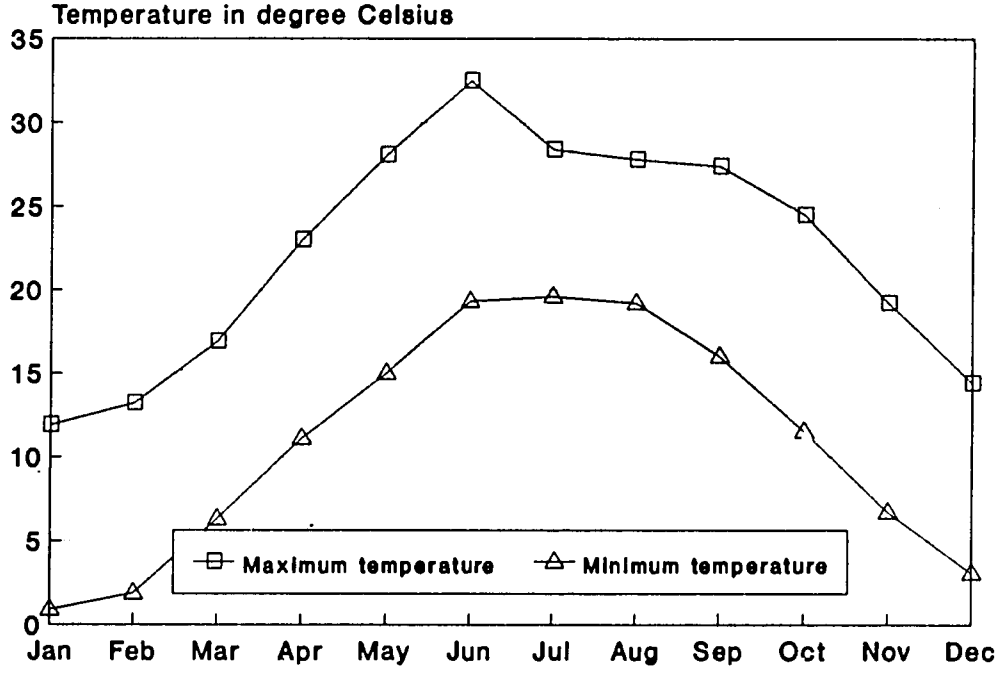
Fig. 3: Mean monthly temperatures at Saidu Sharif (zone 4)



(Source: Meteorological Office, Lahore, 1977-86)

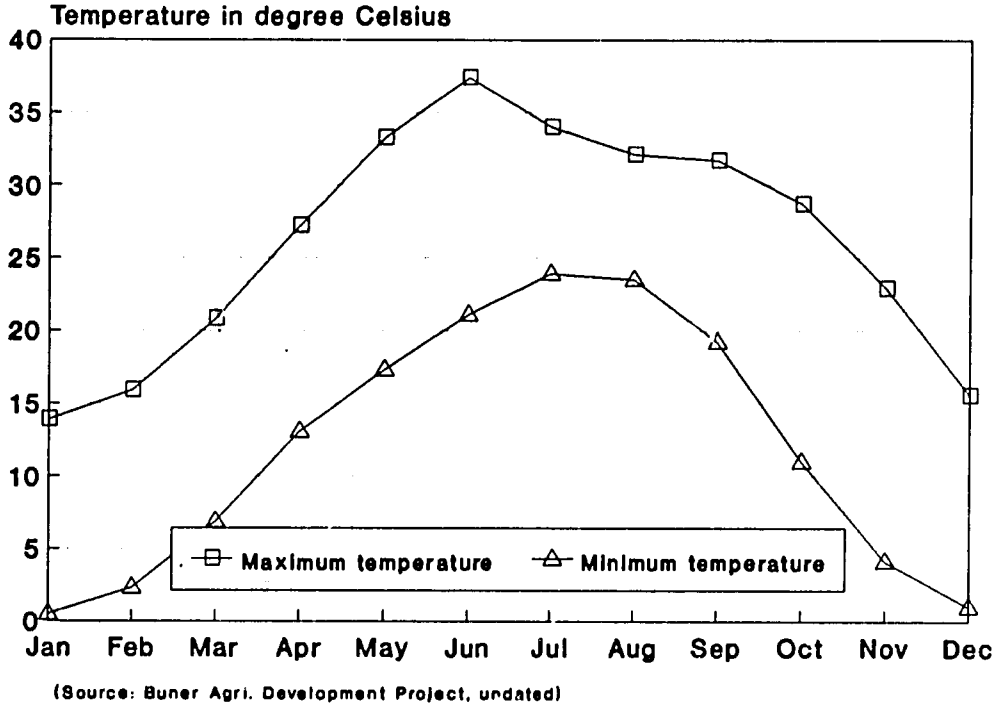
The maximum temperature decreases sharply in July with the onset of the monsoon rains and reaches a plateau until September. Thereafter, the maximum and minimum temperatures decrease sharply.

Fig. 4: Mean monthly temperatures at Kakul (Abbottabad, zone 4)



(Source: Meteorological Office, Lahore, 1977-86)

Fig. 5: Mean monthly temperatures at Daggar (Buner, zone 4)



(Source: Buner Agri. Development Project, undated)

5.2.2. Precipitation

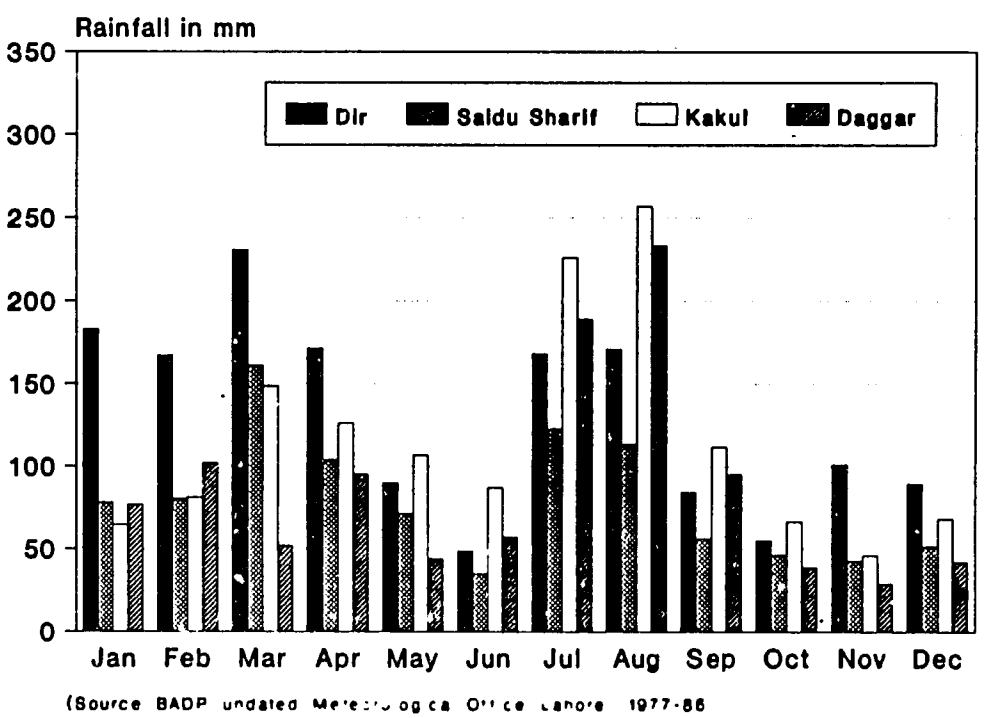
Most areas of zone 4 receive enough precipitation from the monsoon in summer and the westerly depression in winter to allow rainfed crops such as wheat and maize to grow. Little snowfall is reported in this zone, mainly during January and February. Snow usually melts within a short time.

Most rainfall is in March, July, and August, except for Daggar which does not display any clear peak in March (Fig. 6). Dir and Saidu Sharif receive relatively more rain from January to April as compared to the monsoon in July and August while in Kakul and Daggar, the monsoon brings more rain as compared to the winter months. The total annual rainfall varies from 962 mm to 1560 mm (Table 2).

Table 2: Total annual rainfall for different stations in zone 4 (Source: Meteorological Office, Lahore for Dir, Saidu Sharif, and Kakul; Buner Agr. Dev. Project for Daggar).

Station	Total annual rainfall (mm)
Dir	1560
Kakul (Abbottabad)	1389
Daggar (Buner)	1061
Saidu Sharif	962

Fig. 6: Mean monthly rainfall in zone 4



(Source BADP undated Meteorological Office Lahore 1977-86

5.2.3. Irrigation infrastructure

Total rainfall and distribution, considering the higher mean temperatures than in zone 5, are not sufficient to rely on rainfed potato production only. The situation is especially critical from April to June for the spring crop, and after the monsoon from September to November for the autumn crop. These dry months coincide with the main bulking phase of the crop, making supplementary irrigation essential. Around Abbottabad, potato fields are irrigated through small springs, surface water from the town, and tubewells. However, the latter information about tubewells, provided by the agricultural extension staff, could not be confirmed from the farmers. In the Pakhal plain, irrigation is provided through the Siran river canal which was built by the farmers. No restrictions on the water supply was reported. The Buner valley is traditionally rainfed. In the Kalpani area, potatoes are irrigated through the Daggar lift scheme. In the other areas, irrigation is mostly through tubewells and Persian wells. The Buner water is low in sodium and medium in salinity, allowing irrigation on most soils without danger of salinity (BADP, undated). Around Thana, potatoes are irrigated through canals or sometimes through tubewells (Habib, 1989).

5.2.4. Soils

Soils in this zone vary from alluvial, heavy clay soils in Abbottabad and Buner to silty-sandy loams and clay loams in Mansehra (see also BADP, undated). The pH of soils in Abbottabad is above 8, in Mansehra above 7 (PARC, 1985).

5.2.5. Cropping season

There are three cropping seasons in this zone. The main crops and their planting and harvest dates are summarized in table 3 and figure 7. Summers in this zone are too hot for potato production and potatoes are grown in spring and autumn. Planting of the spring crop can be delayed due to rain and the spring crop season is limited by the high temperatures in May and June. In the Pakhal plain, spring potatoes are sometimes planted as early as December to avoid heavy spring rains. Temperatures are high during harvest of the spring crop. The autumn season is limited by high temperatures in summer and frost in December.

Table 3: Common planting and harvesting dates for main crops in zone 4.

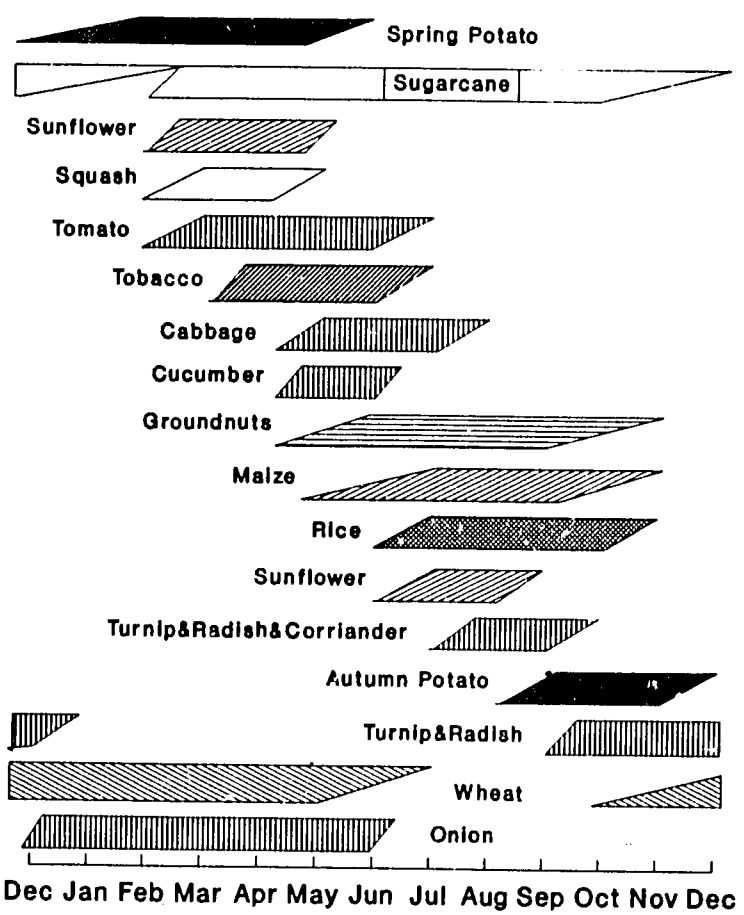
Crop	Planting date	Harvesting date
spring potato	Dec.-Feb.	May/June
sugarcane	Feb.	Oct.-Mar.
sunflower	Feb.	May/June
squashes	Feb./Mar.	April/May
tomatoes	Feb./Mar.	June/July
tobacco	Mar. (transplanted)	June/July
cabbage	Apr.	July/Aug.
cucumber	Apr.	June
groundnuts	Apr.-June	Sept.-Nov.
maize irrigated	May	Sept.

Continued

Table 3 (Continued)

Crop	Planting date	Harvesting date
maize *barani*	June/July	Oct./Nov.
rice	June/July (transp.)	Oct./Nov.
sunflower	June/July	Aug./Sept.
radish	July/Aug.	Sept./Oct.
corriander	July/Aug.	Sept./Oct.
turnips	July/Aug.	Sept./Oct.
autumn potato	Aug.	Nov./Dec.
turnips	Sept./Oct.	Dec./Jan.
radish	Sept./Oct.	Dec./Jan.
sugarcane	Sept.-Nov.	Oct.-Mar.
wheat	Oct.-Dec.	May/June
onions	Dec. (transp.)	June

Fig. 7: Common planting and harvesting dates for main crops



5.3. PRODUCTION FACTORS

5.3.1. Farm size

Most farmers in this zone probably operate farms of less than 5 ha. However, no exact figures are available. In the Rush plain, according to the agricultural office, about 10 big farmers are growing potatoes, but smaller farmers have also been identified. In the Pakhal plain, the majority of farmers seems to operate about 1 ha. The average farm size in Buner is about 3 ha (BADP, 1983). In the Malakand area, Habib (1989) found an average farm size of 500 surveyed farms of 1.7 ha.

5.3.2. Land tenure

Ownership and tenancy are both common. In the Malakand area, there are mostly owners (Habib, 1989). Tenancy is either on a share-basis varying from one fifth to one half depending on the crop and the amount of input provided by the tenant, or on a lease basis (about Rs. 10,000/ha in the Pakhal plain in 1991).

5.3.3. Labor

Most of the work on the farms in this zone is done by the family itself. Some better-off farmers may hire additional labor which is usually paid in cash (Rs. 30/day in 1991). In Buner, labor is also provided through mutual exchange called *ashar*.

In the Pakhal plain, farmers have about 10-15 years experience with potatoes. In the village Haji Abad, potatoes were introduced about 5 years ago. In the Buner valley, farmers have only two or three years of experience.

5.3.4. Credit

Many farmers rely on traders to get credits for their inputs. Traders do not seem to charge any additional costs except when they sell the farmers' produce (commission). In the Malakand area, an estimated 10% of the farmers use credits (Habib, 1989).

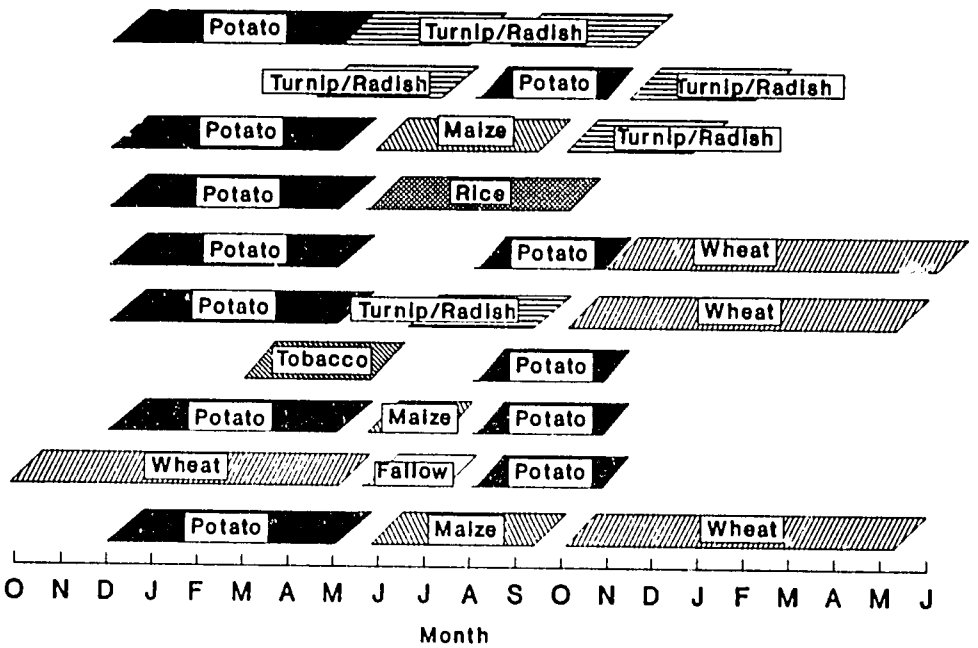
5.4. FARMING PRACTICES

5.4.1. Cropping pattern

Some common crop rotations with potatoes are summarized in figure 8.

At present, potatoes are a minor crop in this zone competing with: (1) wheat and maize, which can be grown under rainfed conditions, (2) other vegetables such as tomatoes, peas, turnips, cauliflower, onions, okra, whose seed is less expensive, (3) tobacco, which is usually grown under contract; and (4) rice, which is better adapted to heavy soils. Winter wheat interferes with spring and autumn crop, potatoes can only be grown as a spring crop before rice, and maize has to be harvested as fodder if an autumn crop of potatoes is to follow.

Fig. 8: Common crop rotations with potatoes in zone 4



The few farmers who grow potatoes around Abbottabad reported that the spring crop of potatoes is as important as the autumn crop. In the Pakhal plain, the spring crop is usually more important, but in 1991, due to the high potato price more autumn potatoes were expected to be grown. In this area, potatoes replaced tobacco, which could no longer be grown because the tobacco company in Baffa was closed down. An estimated 10-30% of the cultivated area was under potatoes. In the Buner valleys, only few farmers grow potatoes which are promoted by the PATA Groundwater Based Irrigation Project and Buner Development Project (BDP) with technical assistance from PSPDP. In 1983, wheat and maize covered 86% of the cultivated land in Buner; 1% was under tobacco (BADP, 1983). Much land was also left fallow. In the Malakand agency, the main crops are tomatoes, onions, okra, rice, and fruits (Habib, 1989).

Some intercropping of potatoes with sugarcane has been tried by PATA in Buner. In the Pakhal plain, potatoes are also intercropped with other vegetables such as tomatoes.

About 10 kg potatoes per person per year are kept for own consumption in the Pakhal plain.

Livestock is of minor importance to potato farmers. Thus, farm yard manure has to be purchased.

5.4.2. Potato production

5.4.2.1. Varieties

Desiree is the most favoured variety in the Rush plain because it is directly marketed to the Lahore market. Ultimus is mostly grown in the Pakhal plain. In both areas, some Cardinal is also grown. In the Buner valley, Desiree, Cardinal, and Ultimus are used.

5.4.2.2. Seed sources

The seed for the spring and autumn crop in the Rush plain comes mostly from the Punjab through the Lahore market (Fig. 9). The seed for the spring crop is from the previous early autumn crop in the Punjab (Naumann-Etienne, 1990). The seed for the autumn crop is from the previous spring crop in the Punjab. Balakot seed has been used for the spring crop, but is reportedly of lower quality and it is difficult to store in Abbottabad. No autumn-to-autumn seed multiplication seems to be practiced probably because no cold storage facilities are available. However, room storage for 2-3 months would be possible, as it was observed in the Pakhal plain in 1991.

The seed for the spring crop in the Pakhal plain comes from Balakot and Hunza. The link to Hunza seems to be more recent. Local dealers sell for example rice in Gilgit and return with potato seed. Planting is in December, therefore no autumn seed from the Punjab autumn crop can be used. Seed from the spring crop is retained, stored in rooms for 2-3 months, and used for the autumn crop. Some seed for the autumn crop may also come from the Punjab.

In the Buner valley, a seed multiplication and storage system is being developed by PATA. Farmers are currently buying seed from Mardan, Mingora, or Suwarai (Buner) markets (van Nieuwkoop and Qayoom, 1989). Seed from Hunza, Kalam, and Taxila has been tried. Farmer's seed from Taxila seems to be the most economical.

5.4.2.3. Land preparation

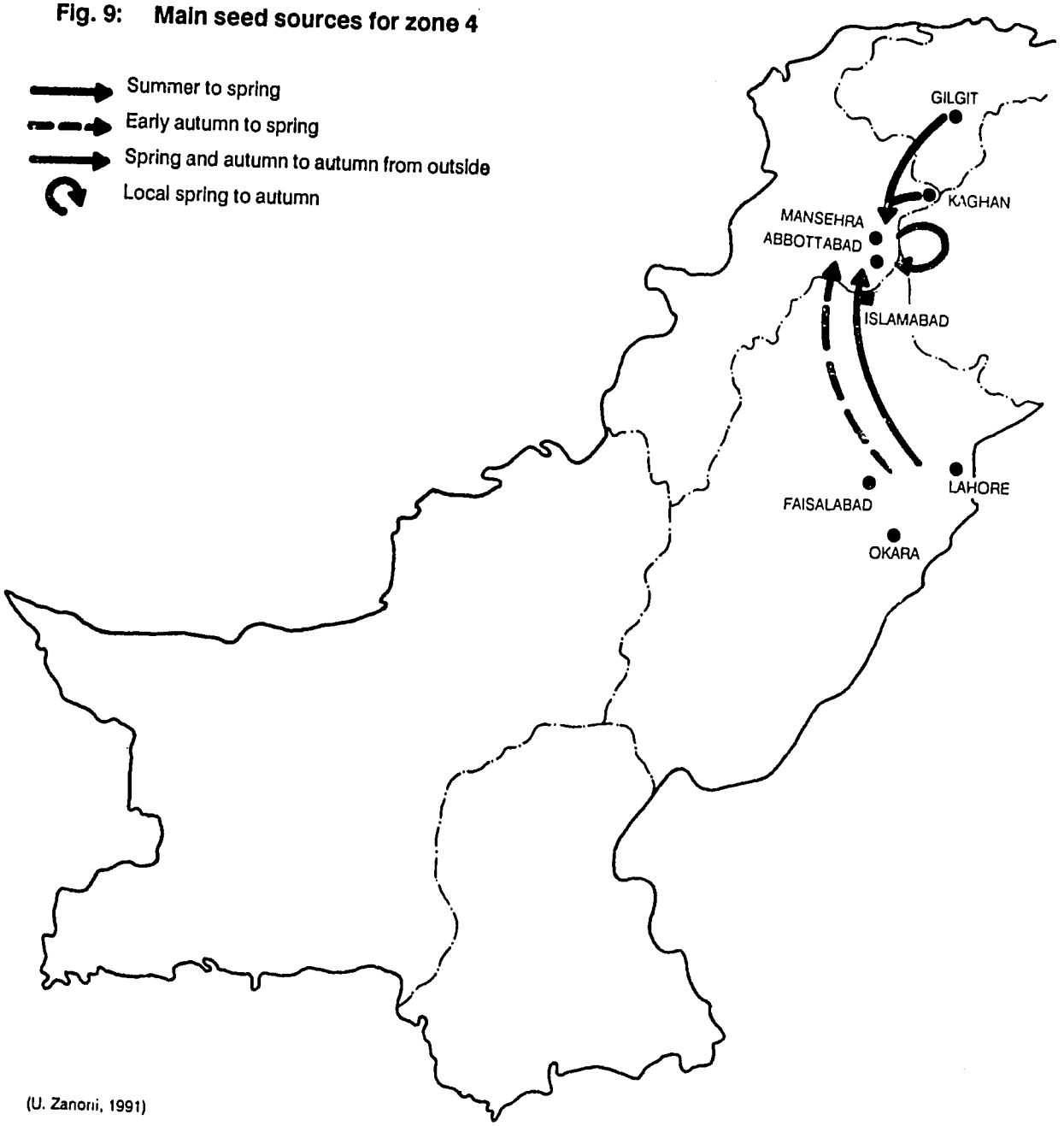
Fields are usually ploughed with a tractor-drawn tine cultivator. More passes are needed in the heavy soils around Abbottabad than in the lighter soils in the Pakhal plain. In the Buner valleys, bullocks and wooden ploughs are still used.

5.4.2.4. Fertilizer

Farmers in the Rush and Pakhal plains, and the Malakand agency use mostly urea and DAP fertilizer, and no potash. The surveyed farmers applied between 138 and 320 kg N/ha, and between 58 and 230 kg P/ha. In Buner, 9 out of 23 interviewed farmers did not use any chemical fertilizer (van Nieuwkoop and Qayoom, 1989).

Most farmers apply chicken manure purchased from surrounding chicken farms. An estimated 25 t/ha is applied. It is not clear whether spring and autumn crop receive the same amount of fertilizer.

Fig. 9: Main seed sources for zone 4



(U. Zanoni, 1991)

5.4.2.5. Planting

Planting is by hand or with a semiautomatic planter. The rows are marked by foot and the tubers are placed on the flat ground. Ridges are made with a tractor-drawn ridger, with too discs (*jandra*). The seed rate is about 2 t/ha in spring using cut seed, and about 3/t ha in autumn, using whole seed (Naumann-Etienne, 1990). The row-to-row spacing varies from 75 to 90 cm, and the plant-to-plant distance from 20 to 30 cm.

The early planting of potatoes in the Pakhal plain may cause poor emergence because of delayed germination.

5.4.2.6. Weeding and earthing-up

In general, weeding and earthing-up are done about two month after planting using spades. Some farmers also use pre-emergence herbicides. Some farmers seem to earth-up twice because the ridges might break down due to heavy rain. The long period of rain in spring might cause problems for timely weeding.

5.4.2.7. Water management

Long ridges with no tie-ridges are used for irrigation in areas with well levelled fields. In some areas around Mansehra, with inclined fields, the ridge/tie-ridge system or zig-zag ridge system can also be found occasionally. The first irrigation starts about one month after planting. The last irrigation is given a couple of weeks before harvest. The autumn crop is said to need less water, probably because of the shorter cropping season and lower temperatures.

5.4.2.8. Diseases, pests, and their control

Since many farmers use fresh "market" seed every year, heavy secondary virus infection is often a result of poor seed quality. The overall infestation with PLRV was estimated to be 51% in Buner in 1989 (van Nieuwkoop and Qayoom, 1989).

Late blight (*Phytophthora infestans*) is the main disease in this zone. Eighty-seven percent of the fields inspected in Buner in 1989 had late blight (van Nieuwkoop and Qayoom, 1989). Its intensity varies considerably from year to year depending on the weather, and in some years losses may be small. Autumn crop is more prone to get the disease.

Verticillium and Fusarium wilts, soft rot, black leg, scab, Rhizoctonia, and cutworm damage were observed in 1991.

Cutworms (*Autographa nigrisigna*, *Agrotis* spp.) are a major problem in Buner, Abbottabad, and Mansehra. Other pests are: Armyworms (*Spodoptera* spp.), bollworms (*Heliothis* spp.). These pests mainly affect the spring crop (March/April).

Farmers spray different insecticides and fungicides, but do not know the exact doses, effect, and disease symptoms. In Buner, where potato cultivation is more recent, most farmers do not spray.

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5.4.2.9. Harvest

Potatoes are harvested by hand using hand trowels (*khurpas*). Vines are cut off, taken out of the field or left in the field.

5.4.2.10. Yield

Multiplication rates varying from 1:5 up to 1:15 were reported by the farmers. At a seed rate of 2 t/ha, yield would range from 10 to 30 t/ha. The spring crop seems to be higher yielding due to the longer growth period and less disease attack. In Buner, 28.7 t/ha were harvested in PATA's extension program, while the best farmer got 20.5 t/ha.

5.4.2.11. Post harvest handling

All potatoes are sold as table potatoes without grading in the Rush plain. Some farmers in the Pakhal plain keep small tubers for the autumn crop.

5.4.2.12. Marketing

The produce of the Rush plain is sold to the Lahore market. According to the farmers in the area, a few traders in Abbottabad and Mansehra buy potatoes from them. Potatoes used for local consumption seem to come mostly from Lahore. The produce from the Pakhal plain is sold to Abbottabad, Mansehra, and Lahore. Transport to Lahore in big trucks is not more expensive than using the small pick-ups for going to the local markets in Abbottabad and Mansehra (Rs. 22/bag in 1991). Thus, most farmers prefer to go to Lahore. In Buner, potatoes are mainly sold in the local market because farmers face high transport charges for going to Mingora and may receive higher prices anyway by selling locally.

5.5. PRODUCTION SUPPORT PROGRAMS

Potato Research Center, Abbottabad: This center worked closely with the Pak-German Potato Project until it ceased operations in 1990. It is now producing some tissue culture derived pre-basic seed, and also continues operating the Battakundi seed farm. From 1992, PSPDP will work with the potato research center.

Agricultural Research Institute (North) Mingora: This institute is at an elevation of about 975 m and would be well placed for working in the lower Swat valley, the largest potential crop area in the zone. From the late 1970s until about 1985 it carried out trials of seed production in the spring and autumn and in April 1984 supplied excellent seed to PSPDP (Battakundi seed multiplied in spring and autumn 1983). In 1989/90, research was done on the following topics (Khan, 1990): cytomorphological studies of colchicine induced mutants; effect of various levels of zinc and boron; inhibition of phellogen activities by haulm destruction; varietal screening; effect of seed age; evaluation of insecticides.

PATA Groundwater Based Irrigation Project in NWFP: This project has been supporting agricultural extension since about 1987 and with technical support of PSPDP has begun to introduce potatoes into Buner.

Buner Development Project: This EEC/PAK funded project has its office in Daggar (Buner). It is promoting potato production in the Kalpani area through improved seed quality and multiplication.

Dir District Development Project (DDDP): If potatoes were shown to be worth developing in the zone, DDDP would probably be interested in promoting them, particularly in the context of poppy eradication. DDDP already has an interest in potatoes in zones 5 and 6 in Dir district.

Pakistan Swiss Potato Development Project (PSPDP): Until 1990, a staff member was posted to Mingora each summer to monitor the projects operations in zones 5 and 6. In the future, activities in Swat will be in collaboration with the ARI at Mingora. PSPDP has also given practical training in potato production to extension staff of the agricultural department and the PATA project based in zone 4 in Swat. A PSPDP field assistant has worked with PATA in Buner to improve farmers' cultivation practices and assist in on-farm trials and farmer survey.

5.6. CONCLUSIONS

Farmers and researchers perceive climatic conditions, accessibility, competition of other crops, and agronomic practices are major constraints to potato production in this zone.

Rainfall is heavy in spring hindering planting, earthing-up and weeding of potatoes. In the Pakhal plain, potatoes are sometimes planted as early as December which might cause poor emergence.

Potato production in Buner is still very limited. Farmers face high transport charges to markets outside the area.

At present, potatoes are a minor crop in this zone because other crops are more competitive due to various reasons: wheat and maize dominate the farming system in Buner because of the lack of irrigation facilities; seed of other vegetables is less expensive lowering the risk to the farmer; in many areas, rice is a major part of the farming system and interferes with the autumn crop.

Diseases and pests are a major problem in this zone. However, farmers lack the knowledge to recognize them and effectively control them. Fertilizers are applied at less quantities than in other zones, but are not balanced in terms of the nitrogen and phosphorous applied.

The potential for the development of production lies in the adaptation of improved agronomic practices, especially plant protection and fertilizer application.

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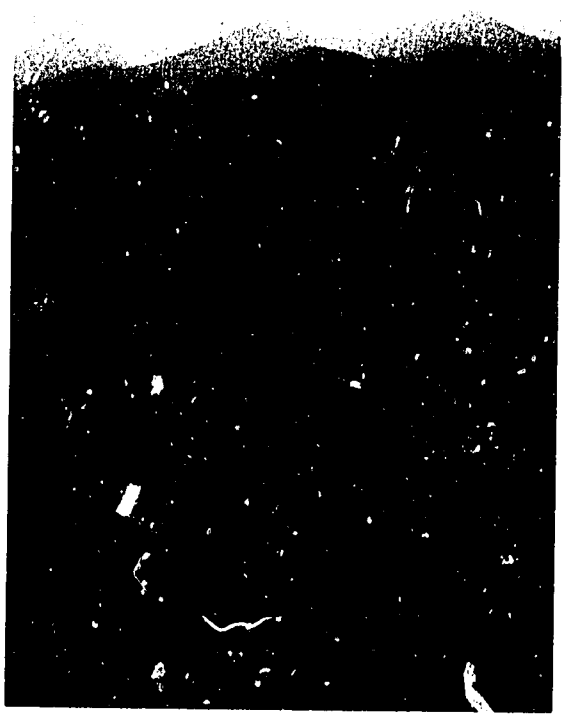
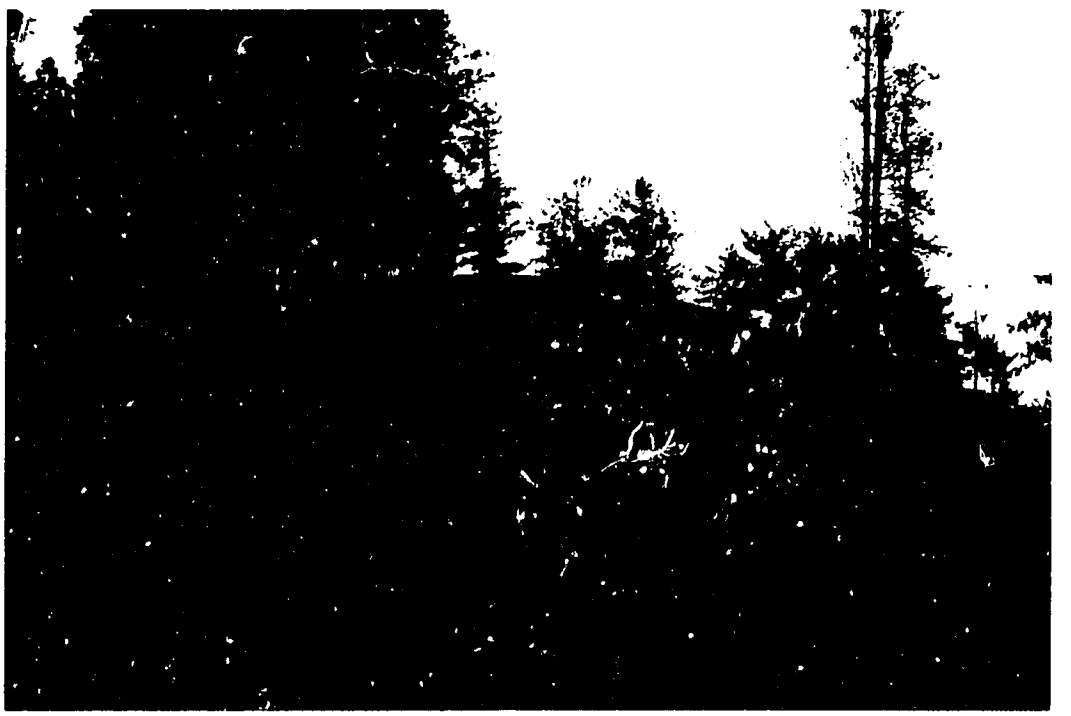
A view of Miandam, NWFP



View of lower Kaghan valley, looking upwards when coming down from Sharan, NWFP.

In this mostly hilly and fragmented areas the pair of bullock pulling the traditional plough is a common picture.



Part of the Sudhan Gali government potato seed farm. AJK.

6. ZONE 5: RAINFED HIGH VALLEYS AND HILLSIDES OF NWFP, NORTHERN PUNJAB, AND AZAD KASHMIR

6.1. GEOGRAPHICAL COVERAGE

6.1.1. Altitude

Zone 5 covers the rainfed high valleys and hillsides of NWFP, northern Punjab, and Azad Kashmir which range in altitude from about 1500 to 2700 m (Table 1).

Table 1: Approximate altitudes[1] (m a.s.l.) of important cities and villages in zone 5.

City/village	Valley	Altitude (m a.s.l.)
Ganur	Kaghan	1350
Kawai	Kaghan	1400.
Kaghan	Kaghan	1900
Shogran	Kaghan	2200
Sharan	Kaghan	2400 (Schreiber and Schütz, 1986)
Gulehra Gali	Murree	1700
Rawat-Burhban	Murree	1900
Kashmiri Bazar	Murree	2000
Murree	Murree	2100
Rati Gali	Galis	1900
Parrian (NWFP)	Galis	2100
Dunga Gali	Galis	2350
Nathia Gali	Galis	2400
Kalabagh	Galis	2400
Shangla Gali	Galis	2550
Manglor	Swat	1000
Balakot	Malam Jabba	1700
Malam Jabba	Malam Jabba	2150
Malam Jabba top	Malam Jabba	2400
Khwâzakhela	Swat	1100
Shangla pass	Shangla	2100
Alpuri	Alpuri	1400
Bazarkot	Kotkai	1700
Bilkani	Shapur	1600
Olandar	Shapur	1700
Fatehpur	Swat	1300
Miandam	Miandam	1800
Matta	Harnuai	1050
Gwaliray	Roringar	1500
Roringar	Roringar	1550
Mandel Daag	Roringar	1700
Chikyatan	Dir	1200
Barawal Bandi	Barawal	1400
Shahi	Barawal	2000

Continued

Table 1 (Continued)

City/village	Valley	Altitude (m a.s.l.)
Tarorra	Dir	1050
Jabai	Usherai	1250
Palam	Usherai	1550
Batal	Usherai	1700
Dandi	Usherai	2100
Wani	Dir	950
Sudhan Gali	AJK	2400 (Turkensteen, 1986)
Leepa valley	AJK	1500-2000

[1]Altitudes were measured with altimeter if not indicated otherwise.

6.1.2. Latitude and longitude

Zone 5 spans one degree of latitude (34° to 35°) and two degrees of longitude (71° 30' to 73° 30').

6.1.3. Topography

The potato growing areas in this zone are hilltops, more or less steep slopes on alluvial fans or moraines, and plateaus. The tiny potato fields lie on terraces supported by stonewalls, on high plateaus, or just along steep slopes without any terraces. Erosion is a major problem. Natural vegetation is abundant due to the heavy spring and monsoon rains.

6.1.4. Potato production areas

In this zone, potatoes are grown in the lower Kaghan valley, around Murree and in the Galis, in the Swat side valleys, in the Dir district, around Mansehra, and in Azad Kashmir. There are many small valleys and side valleys where potato production is possible but which have not been visited. The limits between zone 5 (rainfed) and zone 6 (irrigated) is not always very clear cut, since this distinction mainly depends on the availability of irrigation water (springs, streams, surface water) and the amount and distribution of rainfall. Very often a transition zone exists where supplementary irrigation in at least parts of the cultivated fields is possible (Miandam, Usherai).

In the lower Kaghan valley, potato production starts around Ganur (Fig. 1). This village on the road side lies at about 1350 m a.s.l. Potato fields are higher up on the hills, probably at an altitude of 1500 m. Potato production continues up the valley to Kaghan at 1900 m. Potato fields above Kaghan (including Kaghan) are mainly irrigated, and therefore belong to zone 6. Potatoes are also grown in the Shogran and Sharan areas.

Around Murree and in the Galis, potatoes are grown experimentally on the substation of the Ayub Agricultural Research Institute, Faisalabad, along the Khaquan Abbasi road (villages Kashmiri Bazar, Rawat-Burhban), Dheer Kot and Patriata side, and along the Murree-Abbottabad road starting in Rati Gali and ending in Kalabagh (Fig. 1). According to the agricultural officer in Kalabagh, potatoes are also grown around Thandiani and Ayubia.

Fig. 1: Main potato growing areas in the lower Kaghan valley Chattal area, the Galis, Murree hills, and Azad Kashmir

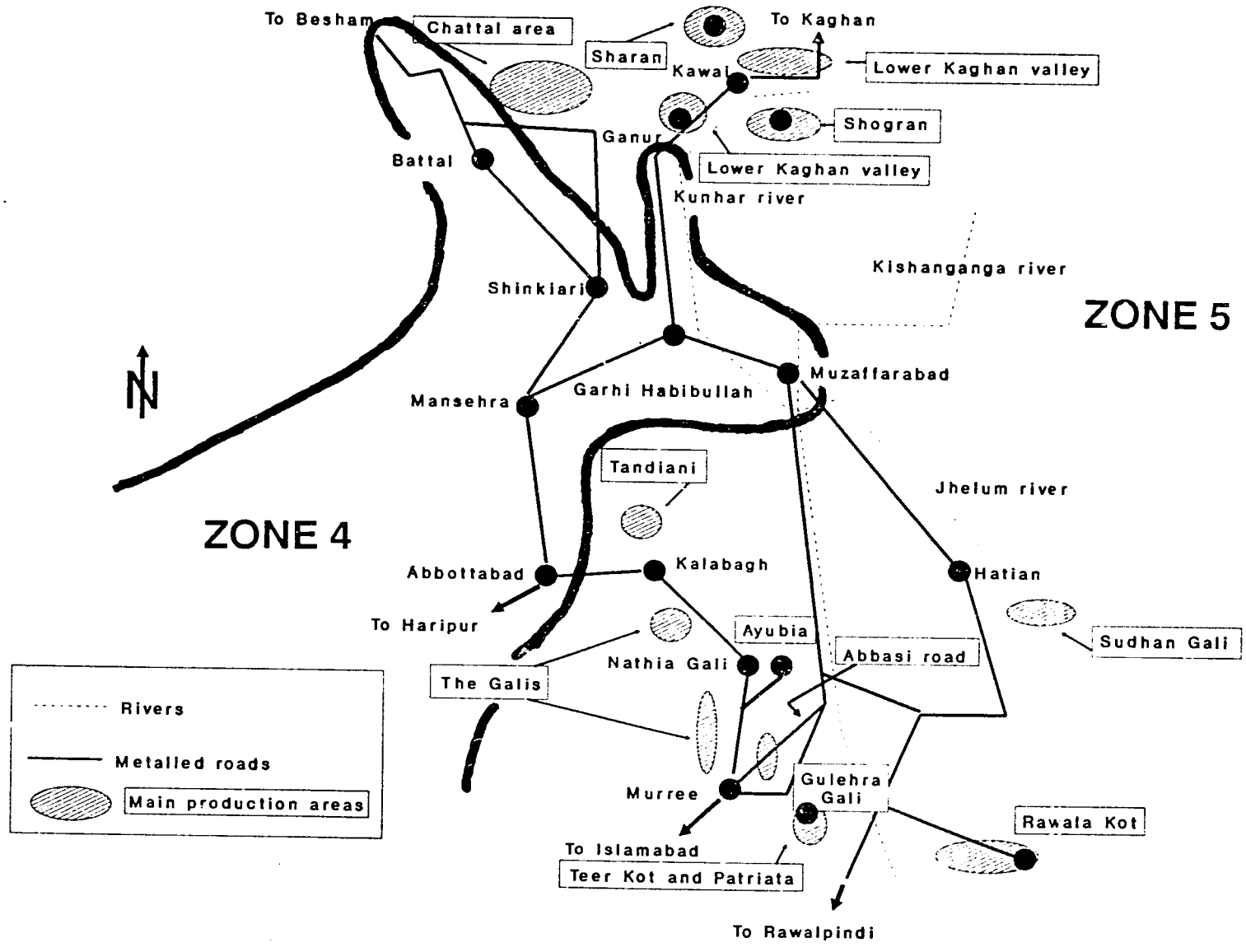


Fig. 2: Main potato growing areas in Swat side valleys

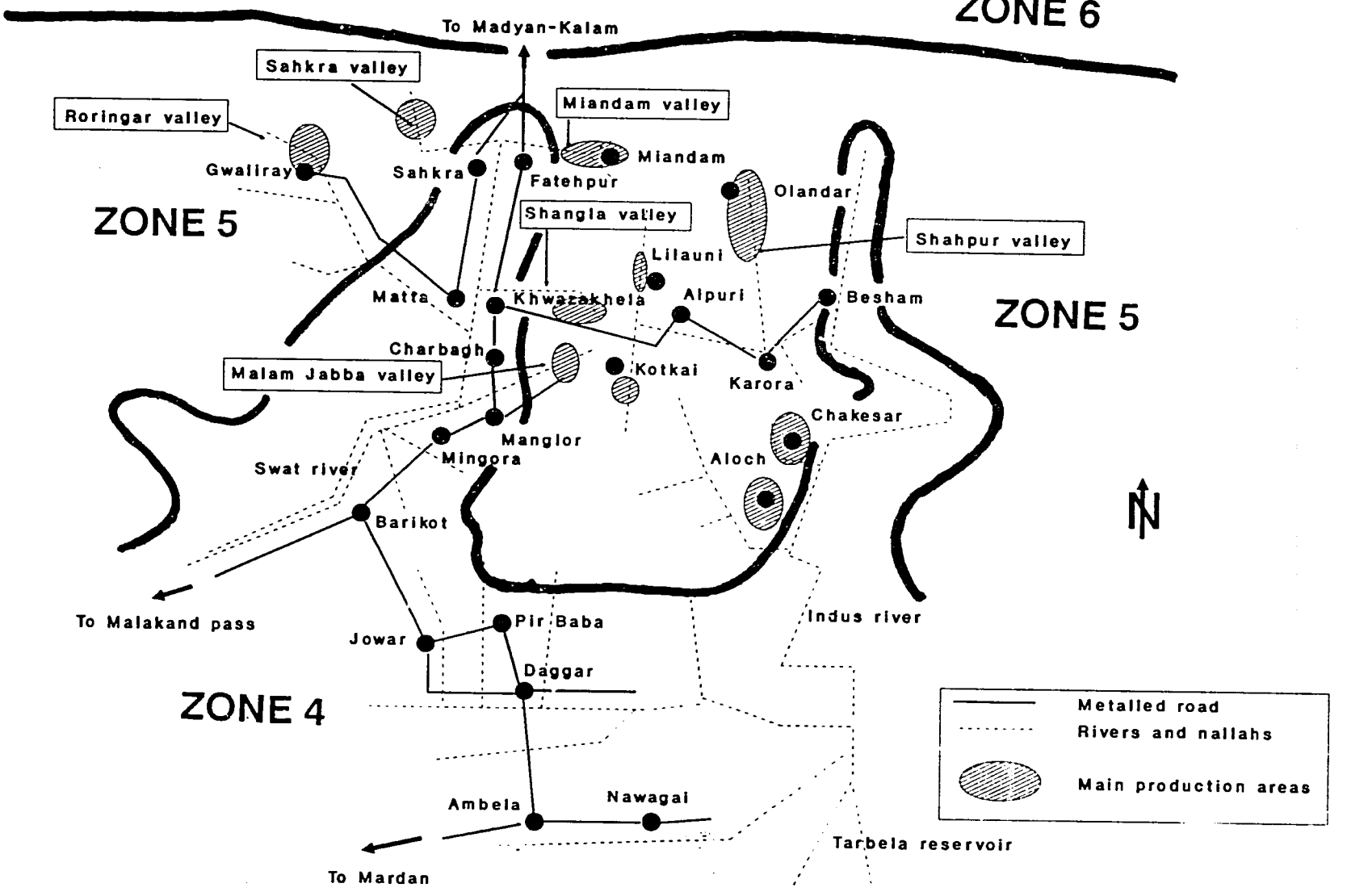
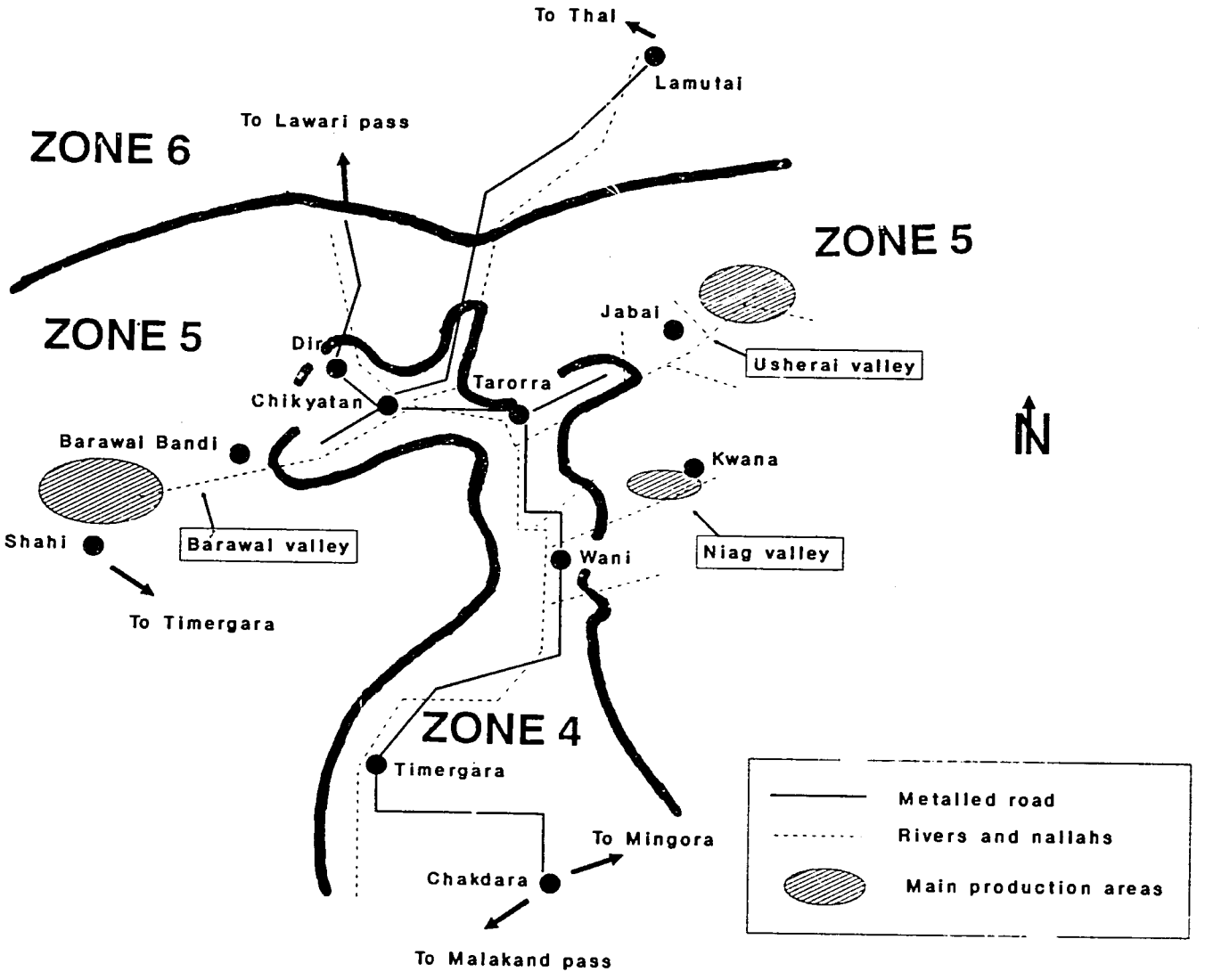


Fig. 3: Main potato growing areas in Dir



In Swat, potatoes are mainly grown in the following side valleys: Malam Jabba, in different valleys in Alpuri subdivision, Miandam, Sakhra, and Roringar (Fig. 2). In the Malam Jabba valley, potato production starts around Balakot at 1700 m and continues up to the top at 2400 m. In Alpuri subdivision, potatoes are grown in the following valleys: Shangla, Kotkai (Bazarkot), Lilauni, Shahpur, around Chakesar, and around Aloch (see also MFVDP, 1988). In the Shangla valley, potatoes start at about 1800 m coming from Khwazakhela (Swat) and continue up to the top of the Shangla pass at 2100 m. In the Shahpur valley, potatoes start at about 1600 m near Bilkani and continue up to Olandar at 1700 m, which is the main potato growing village in this valley. In the Miandam valley, potato production starts at about 1600 m and continues to Miandam and farther up to the hilltop. In the Roringar valley, potato production starts around Gwaliray at 1500 m and continues up to Sulatan (about 2000 m). In the Sakhra valley, potatoes start around Garai and continue up to Bar Laiku.

In the Dir district, potatoes are grown in the following valleys: Barawal, Usherai, and Niag (Fig. 3). In the Barawal valley, potato production starts in Shahi Baagh at 1550 m and continues to the high hill plateau at Shahi (2000 m). Potatoes may also be grown on the surrounding hills. In the Usherai valley, potato production starts in Palam at 1550 m up to Dandi at 2100 m. The Niag valley has not been visited. It bifurcates from the Dir valley at Wani (950 m).

In Mansehra, potatoes are grown up to 2150 m around Battal, Chinoarkot, Nilbanr, Domel, Jachona, Lalari and Chattal area (Fig. 1).

In Azad Kashmir, the main areas lie between the Jhelum and Mahi rivers and around Rawala Kot with the latter being presently the most important growing area (Fig. 1). Potatoes are also grown in the Leepa valley (1500-2000 m).

6.2. ECOLOGY

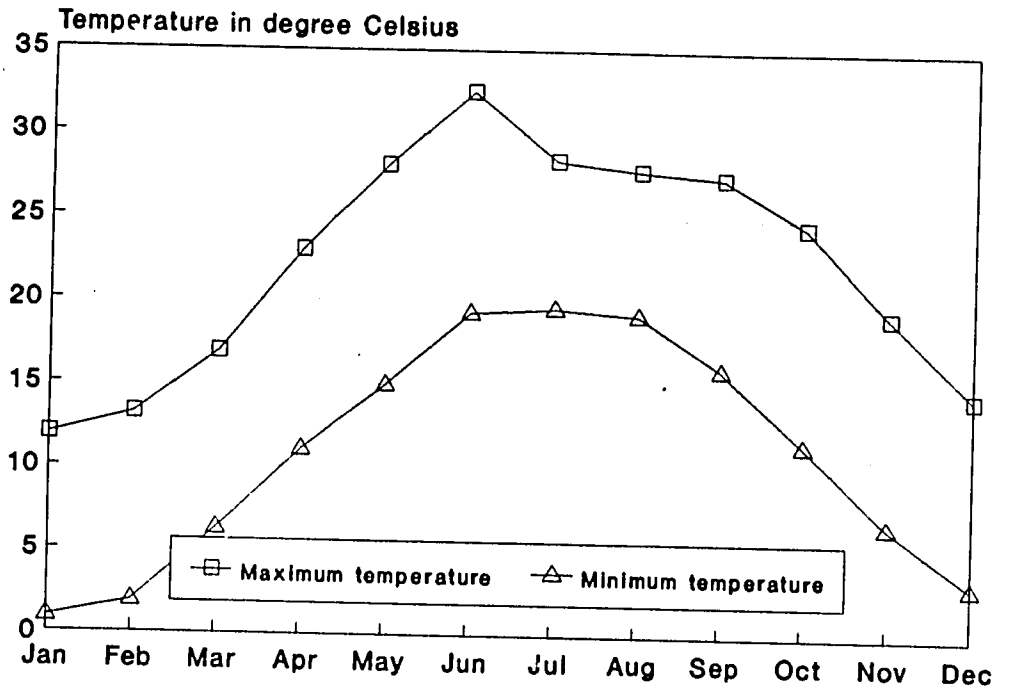
6.2.1. Temperature

The climate in this zone is cool temperate and humid with mild summers and winters. All locations display the same longtime seasonal pattern of temperatures independent of the altitude (Fig. 4 through 9). However, the mean temperature decreases by approximately 1°C per 100 m increase in altitude. Thus, at about 2100 m the maximum temperature stays below 25°C during the whole year (Fig. 6).

The highest temperatures occur in June and the lowest from December to February. Winter in this zone is mild with less frost risk than locations at similar height in zone 6. The frost risk is highest from December to February. Dir has a more continental climate with lower mean temperatures in summer and winter as compared to other stations at the same altitude farther east (Fig. 4 and 8).

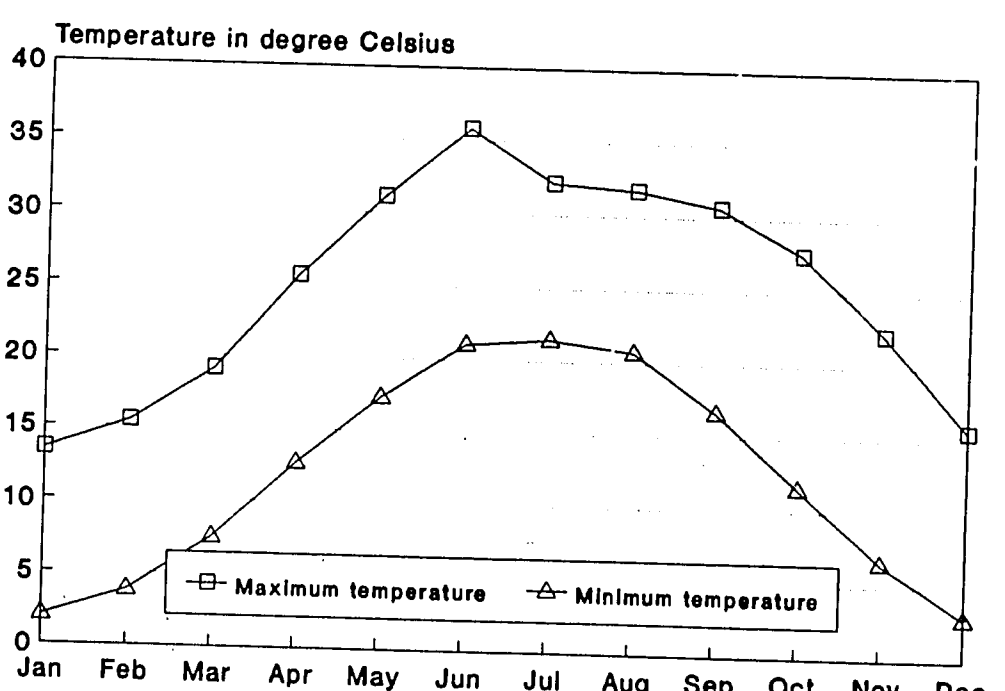
The maximum temperature decreases sharply in July with the onset of the heavy monsoon rains and reaches a plateau until September. The maximum temperature curve is distinctly different from that in zone 7 where the maximum temperature is reached in July and August, and from zone 6 where the temperature slowly decreases after the maximum temperature is reached in June. The minimum temperature stays constant from June to August. Maximum and minimum temperatures sharply decrease after September.

Fig. 4: **Mean monthly temperatures at Kakul (Abbottabad, zone 5)**



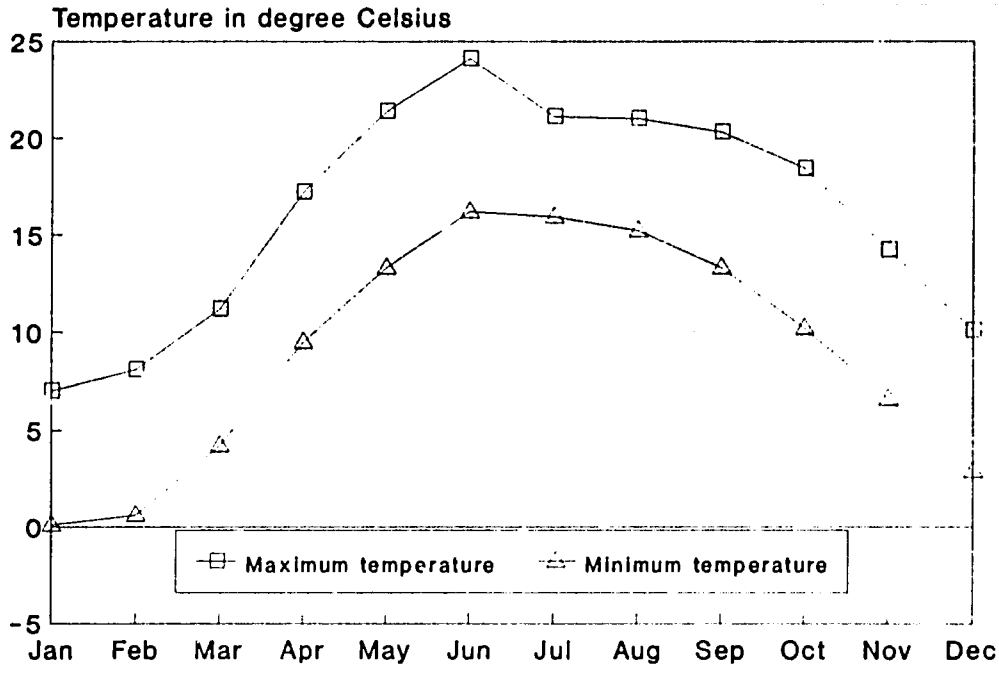
(Source: Meteorological Office, Lahore, 1977-86)

Fig. 5: **Mean monthly temperatures at Balakot (Kaghan Valley, zone 5)**



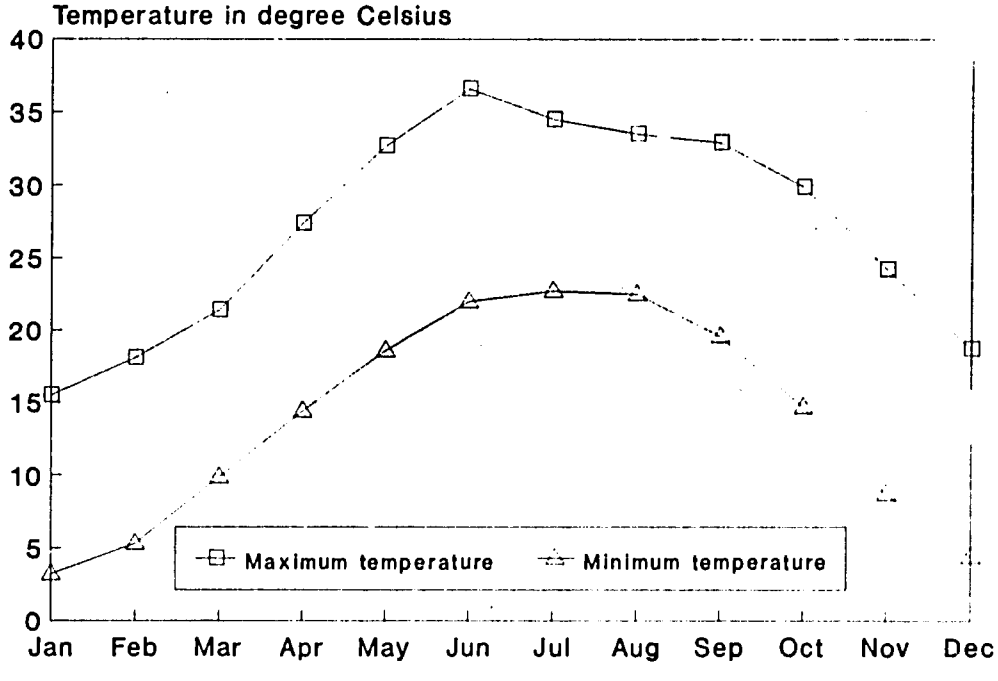
(Source: Meteorological Office, Lahore, 1977-86)

Fig. 6. Mean monthly temperatures at Murree (zone 5)



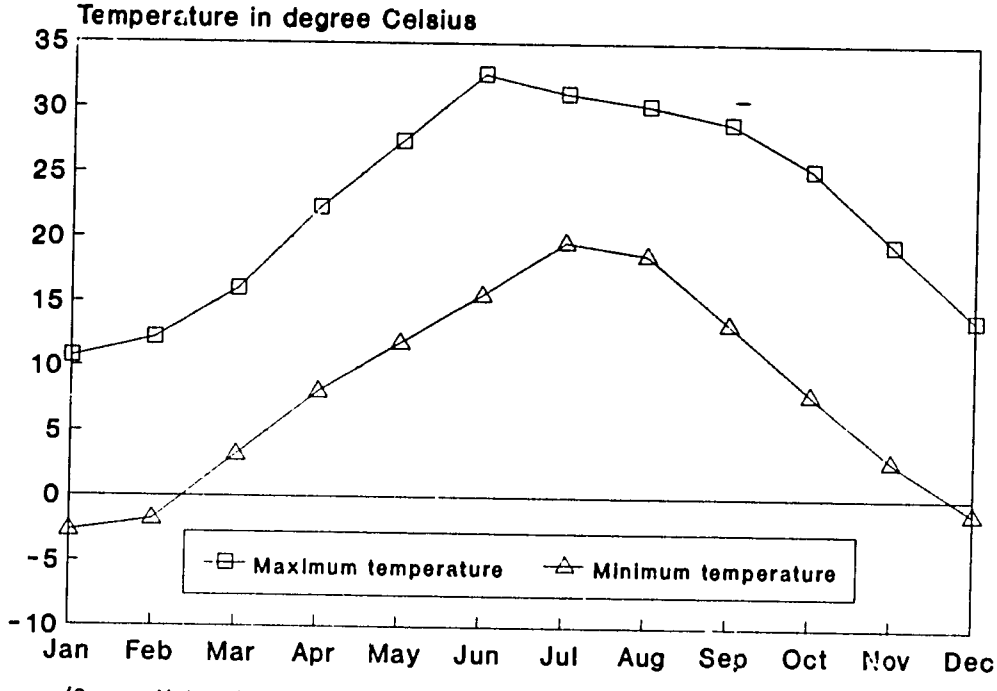
(Source: Mete. rological Office, Lahore, 1977-86)

Fig. 7: Mean monthly temperatures at Muzaffarabad (zone 5)



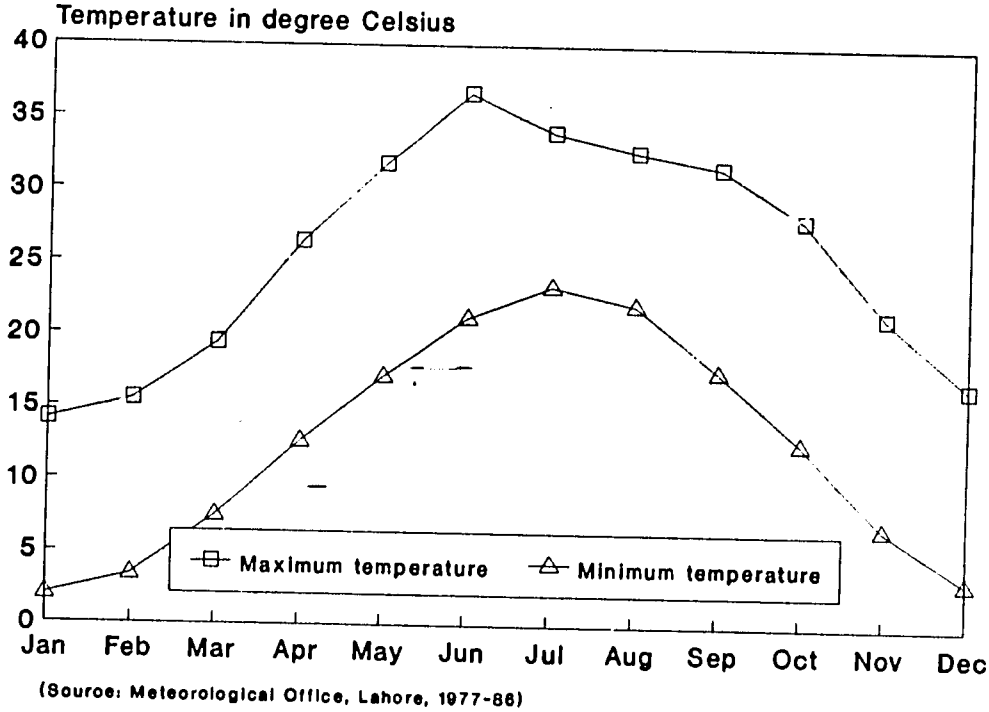
(Source: Meteorological Office, Lahore, 1977-88)

Fig. 8: Mean monthly temperatures at Dir (zone 5)



(Source: Meteorological Office, Lahore, 1977-86)

Fig. 9: Mean monthly temperatures at Saidu Sharif (zone 5)



(Source: Meteorological Office, Lahore, 1977-86)

6.2.2. Precipitation

Most areas of zone 5 receive abundant precipitation from the monsoon in summer and the westerly depression in winter. Snowfall mainly occurs between November and March at higher altitudes and between January and February at lower altitudes. The quantity of snow varies with altitude, longitude, and exposure. Thus, Shahi in the Barawal valley receives reportedly about 6000 mm as compared to Dandi in the Usherai valley and Murree which receive about 900 mm. Ganur and Shogran in the Kaghan valley receive about 1200 mm and 2000 mm, respectively.

Kakul, Balakot, Murree, and Muzaffarabad display the same seasonal pattern of rainfall even though the short term behavior within one year is more erratic (Fig. 10). In these locations most rainfall is in July and August, and least between October and December. Dir and Saidu Sharif receive relatively more rain in winter with a peak in March as compared to the monsoon in July and August (Fig. 11). The potato production areas at higher altitude are expected to receive even more rain. It was observed that the Barawal and Usherai valleys in Dir are less green and that rainfed maize grows less well than in the rainfed valleys of Swat, the Galis, and Kaghan. It is possible that the limit between irrigated and rainfed potato production, i.e. between zone 5 and 6, is at a higher altitude farther west. The total annual rainfall varies from 960 mm to 1900 mm (Table 2).

Table 2: Total annual rainfall for different stations in zone 5 from 1977-86 (Source: Meteorological Office, Lahore).

Station	Total annual rainfall (mm)
Murree	1911
Balakot (Kaghan)	1838
Dir	1560
Muzaffarabad	1511
Kakul (Abbottabad)	1389
Saidu Sharif	962

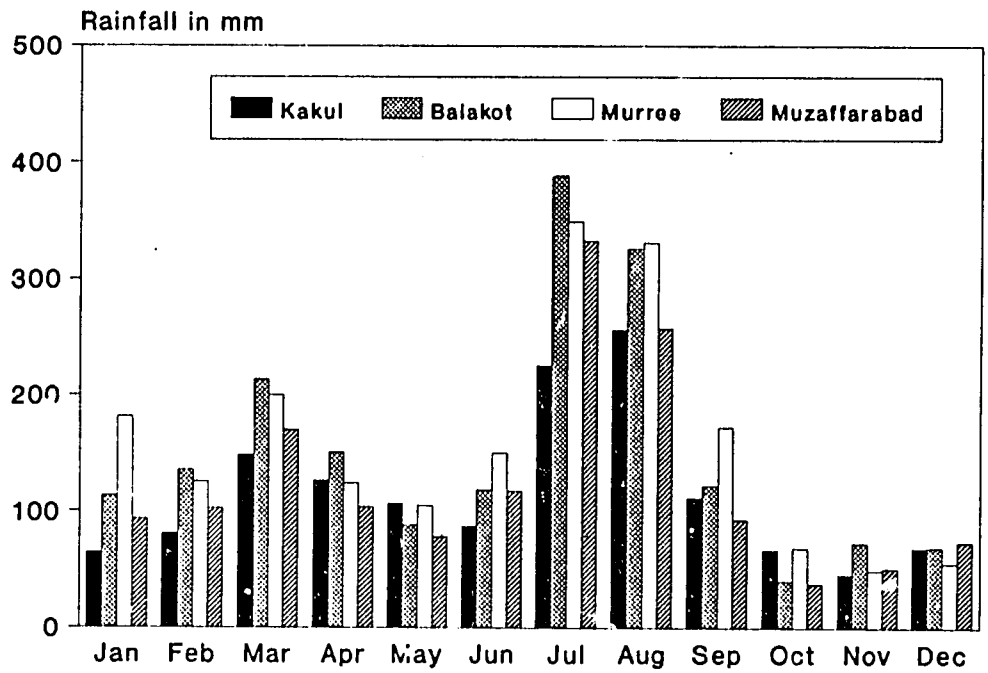
6.2.3. Irrigation infrastructure

Most potato fields in this zone are rainfed. Even though most valleys are fed by a river, the river beds are too low to allow irrigation in the fields on slopes and hilltops. The fields close to the rivers are usually planted with irrigated rice and vegetables. At lower altitudes and on flat fields, some supplementary irrigation may be possible, but not always necessary. In the Miandam valley for example, the limit between rainfed and irrigated production is not very clear. Some farmers seem to irrigate if water is available, and land which can be irrigated is more expensive to rent.

6.2.4. Soils

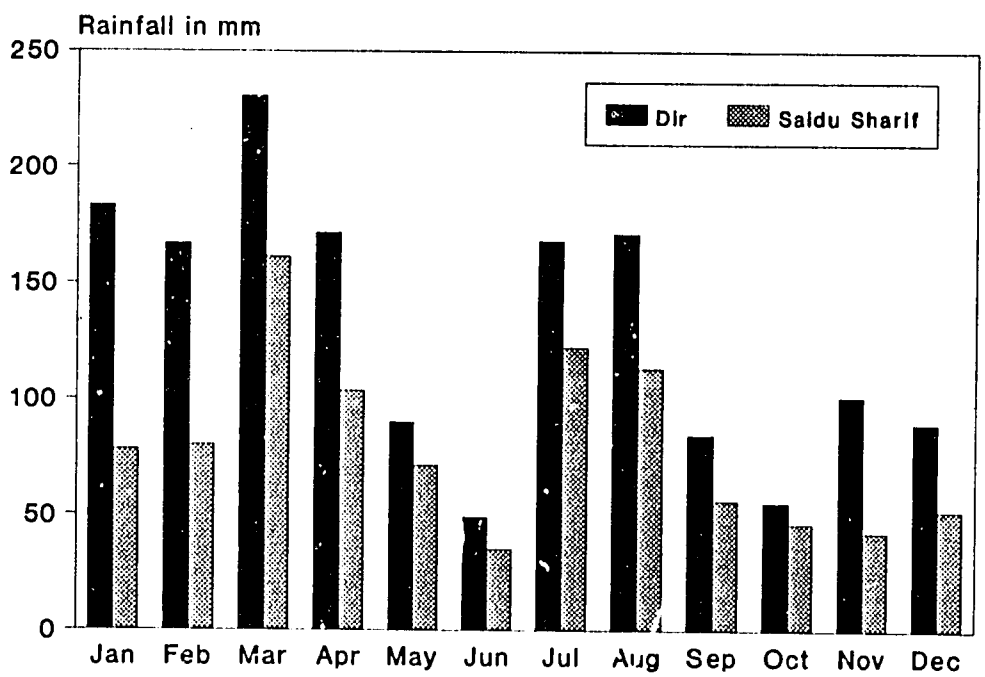
Soils in this zone are variable in texture, nutrient content, and depth. They vary from very heavy red clay soils at lower altitudes in Kaghan, Swat and the Galis to sandy-silty black, organic (swamps, forests) or brown soils (loams) at higher altitudes and on plateaus. Nine soil

Fig. 10: Mean monthly rainfall in zone 5



(Source: Meteorological Office, Lahore, 1977-86)

Fig. 11: Mean monthly rainfall in zone 5



(Source: Meteorological Office, Lahore, 1977-86)

samples from Malam Jabba have been analyzed to study the nutrient requirements and status of the soils. They showed that pH was below 7, P varied from low to very high and K from medium to very high. Chemical and physical erosion seem to play a major role in the soil formation due to the topography of the areas, the heavy rains and the lack of sufficient countermeasures.

6.2.5. Cropping season

The length of the cropping season and the planting and harvest dates in this zone are basically a function of the temperature, amount of snow, and the end of the winter rainfall. Temperature and snowfall vary with altitude and exposure.

There is only one cropping season for potatoes in the whole zone with planting generally in April/May and harvest in September/October. Planting might be delayed up to mid-June due to the high amount of snow as for example in Shogran (Kaghan) or Shahi (Barawal). One farmer in Din Kot (Roringar) reported to delay planting of the Ultimus crop until mid-June to get higher yields taking advantage of the longer bulking period. Harvesting might start as early as end of July/mid-August in Miandam, parts of the Galis, and lower villages of the Kaghan valley.

Up to about 1800 m, wheat might be grown as a winter crop from November/December to April/May. Below 1800 m, tomatoes are grown from mid-May to October. They are usually transplanted from the nursery into the field around mid-July. As high as Dunga Gali at 2250 m two successive crops of turnips are possible from March/April to June and July/August to October. Some farmers also plant turnips after an early harvest of potatoes in July/August. Onions are transplanted in April, and harvested in July/August. Maize is usually planted in May/June and harvested in October. Planting of maize depends very much on the onset of the monsoon rains.

6.3. PRODUCTION FACTORS

6.3.1. Farm size

The majority of the farms in this zone are very small even though in most areas there are no exact figures available about the average cultivated area (Table 3). In addition to the cultivated land, farmers might also own some uncultivated land.

Table 3: Farm size and land tenure in the different areas of zone 5.

Area	Farm size	Land tenure
Kaghan valley	1.5 ha	below Kawai mostly owners, above Kawai tenants and owners[1]
Murree	0.5 ha	mostly owners[2]
The Galis	0.5-1 ha	mostly owners
Malam Jabba	0.1-0.2 ha[3]	55% owners[4], 30% share-cropping, 15% leasing
Alpuri	0.5 ha	Pathans are mostly owners[5], Gujars are mostly tenants
Miandam	0.25 ha	mostly owners, leasing

Continued

Table 3 (Continued)

Area	Farm size	Land tenure
Roringar	0.5 ha	mostly owners
Barawal	0.5 ha	mostly owners
Usherai	1-2 ha	mostly owners
Azad Kashmir	0.5 ha	mostly owners

[1]See also zone 6 for more detail.
[2]Two big tribes: Raja, Abbasi.
[3]Source: Bajwa and Geddes (1988).
[4]Source: MFVDP (1990).
[5]Source: MFVDP (1988).

6.3.2. Land tenure

The majority of the households in this zone own their land (Table 3; MFVDP, 1988). Four systems of tenancy are common: (1) the tenant receives one third of the produce, providing labor and one third of the fertilizer; (2) the tenant receives one fourth of the produce, providing only labor; (3) inputs and produce are equally shared between tenant and owner except for labor which is fully provided by the tenants; (4) tenants rent land for cash ranging from Rs. 4000 to 40,000/ha or agricultural produce. In Miandam, farmers lease land from small landholders who cannot afford to buy expensive seed potatoes or who go with their cattle to higher pastures during summer.

6.3.3. Labor

Most of the work on the farms in this zone is done by the family itself. Some better-off farmers may hire additional labor which is usually paid in cash (reportedly, Rs. 30-60/day for adults, Rs. 15/day for children). Labor is more costly in Murree and Azad Kashmir (Rs. 60-100/day for adults), causing limitation to potato production. Most families depend on an additional income from off-farm employments. Important off-farm employments and income are: tourism around Murree and the Galis, coal mines in Hyderabad and marble mines in Chakesar for people in Alpuri, forest royalties for Alpuri and Miandam. In Azad Kashmir and Alpuri, the principal source of income is estimated to be from off-farm activities (see also MFVDP, 1988). People from Murree and Azad Kashmir work in the Middle East.

Some people in Murree, Malam Jabba, and Alpuri migrate to lower areas in winter. Sometimes only one member of the family migrates to earn some additional income.

Most farmers have many years of experience growing potatoes.

6.3.4. Credit

Many farmers rely on traders to get credit for their inputs. Most areas, except for the valleys in Dir, seem to be well served by traders.

6.4. FARMING PRACTICES

6.4.1. Cropping pattern

Potatoes, maize, wheat in areas below 1800 m depending on the amount of snow, rice and onions below 1400-1600 m, and some vegetables are the most important crops in this zone (Table 4). Scattered fruit trees and fruit orchards are also important sources of income in the whole zone.

In 1991, potato production in the whole zone 5 was much less than in previous years (Table 4). In 1990, an estimated 30% of the cultivated area in Sahkra, Miandam, Roringar, and Malam Jabba was under potatoes. In 1989, the percentage was even higher (>50%). The importance of potatoes seems to fluctuate from year to year and even decline in the long term in some areas due to the following reasons: (1) the entire zone is rainfed, thus production depends on natural conditions which cannot be controlled and crop failure due to too much or too little rain is possible, (2) farmers found easier sources of income such as tourism in Murree, (3) holdings are small and farmers are poor and cannot afford to buy seed potatoes at high prices, and (4) access to major markets with stable potato prices is difficult. In some areas, for example in Miandam, potato production will remain important because they are more profitable due to early planting and harvesting.

Maize is the most important crop to replace potatoes in the short and long term because it provides fodder and grain and is less expensive and labor intensive to produce. Thus, in years with high seed potato prices farmers plant less potatoes and more maize. Maize is easier to manage than potatoes when the farmer also works outside the farm. Maize is also increasingly important due to the growing population and better road access to consumer centers. Farmers close to these areas prefer to produce milk assuring a stable and regular income during the whole year. Some vegetables such as turnips, radish or tomatoes in lower areas are also grown.

The quantity of potatoes retained for own consumption varies depending on the area and the potato price. If the potato price is high and pit storage is difficult farmers tend to sell all their potatoes. In recent years, some farmers grow potatoes for home consumption only.

In the whole zone, potatoes are planted in pure stands or intercropped in variable degree with maize, beans, squashes or pumpkins. In Kaghan, a high percentage of maize or beans in the potatoes is more common than in other areas. Maize is almost always intercropped with some beans.

Most farmers do not follow any conscious crop rotation due to the overriding importance of potatoes as a cash crop. Unconscious rotation is often a result of too much rain or too high seed prices to plant potatoes.

Livestock are kept as draft-animals for ploughing and for subsistence purposes. The number of animals is limited because of the limited fodder resources. In Malam Jabba, farmers tend to own 2-3 cows and 10-20 goats.

Table 4: Importance of the potato crop, percent cultivated area under potatoes in 1991, and main competitive crops for potatoes in the different areas of zone 5.

Area	Importance of potatoes in general	Percent under potatoes in 1991	Main competitive crops
Kaghan valley	+[1]	<10%	maize,
Murree	+/-	< 5%	maize, turnips, radish, fruits
The Galis	+	<10%	maize, vegetables, fruits
Malam Jabba	+	< 5%	maize, tomatoes (below 1800 m)
Alpuri	+	< 5%	maize
Miandam	+ +	10%	maize, tomatoes, onions, turnips
Roringar	+	<10%	maize
Dir	+ +	< 5%	maize
Azad Kashmir	+	< 5%	maize

[1] + + very important, + important, +/- importance is changing rapidly.

6.4.2. Potato production

6.4.2.1. Varieties

The main potato varieties grown in this zone are Ultimus, Desiree, and Cardinal (Table 5). Ultimus seems to be very well adapted to the climatic and agronomic conditions prevailing in this zone; it was grown most often in 1991. Some white varieties mixed with red ones were found in: (1) the Kaghan valley where the German Seed Project in Battakundi has multiplied white potatoes and where white potatoes were originally introduced in the valley, (2) the Roringar valley, where the original variety introduced was Multa, and (3) Dir because the original variety had been white or some varieties have developed through spontaneous true potato seed.

Multa was reportedly introduced in the Roringar valley from Peshawar by Mr. Rahman Ali who is a farmer in Dim Kot. Then it had been multiplied for about 25 years using room storage. About 20 years ago, Ultimus was introduced in the valley. Potato production in the Kaghan and Swat valleys is probably less than 45 years old.

Table 5: Common potato varieties and seed sources in the different areas of zone 5.

Area	Varieties	Sources
Kaghan valley	Ultimus, others mixed in	Punjab, pits
Murree	Desiree	Punjab
The Galis	Desiree, Ultimus[1]	Punjab (Sialkot)
Malam Jabba	Ultimus, Desiree[2]	Punjab
Alpuri	Ultimus, Desiree	Punjab (Okara)
Miandam	Ultimus, Desiree, Cardinal	Punjab (Lahore, Okara, Sahiwal)
Roringar	Ultimus, Cardinal,	Punjab (Okara)
Dir	mixture of Ultimus, Cardinal, Desiree, white *desi*	Dir, Mingora, pits
Azad Kashmir	Desiree	Punjab, Sudhan Gali and Neelum valley seed farm

[1]Ultimus for early harvest.
[2]See also Bajwa and Geddes (1988). In 1991, mainly Ultimus.

6.4.2.2. Seed sources

Most seed potatoes used in this area come from the Punjab (Table 5, Fig. 12). However, most farmers do not know the exact seed source. In the Kaghan valley, most seed is bought from local traders in Balakot. Whether seed is stored in pits depends mainly on the market price of potatoes at harvest time. Seed is usually replaced by fresh seed after 2 to 3 multiplications. Transport costs from Battakundi to Balakot are higher than from Lahore to Balakot. For this reason, farmers in the lower Kaghan valley buy little seed from the Battakundi seed farm.

In the Murree hills and the Galis, seed is bought from the local dealers or directly from the markets in Rawalpindi or Abbottabad. Farmers used to store seed in pits or rooms but nowadays most seed is bought from the market every year.

In the Swat side valleys, seed is mainly bought from Mingora, Mardan, or directly from Lahore. The Mardan seed, which probably also comes from the Punjab, is said to be of lower quality but cheaper. One field in the Shahpur valley of Alpuri was observed where two different sources of seed (Mardan and Mingora) had been used. One part of the field was completely infested by PLRV. Little seed is stored in pits or rooms in these valleys. In 1991, some seed in Miandam came from the previous crop in Kalam which had been stored in Charbargh. In addition, some leftover seed from an Indian variety introduced in 1989 was observed.

In Dir, seed is bought from local dealers or the markets in Dir and Mingora. Little seed is stored in pits. In Shahi, pit storage is not possible because of wet soils. In Azad Kashmir, seed is bought from the local dealers in Rawala Kot or from the market in Rawalpindi and there is a significant supply of subsidized seed from the AJK Department of Agriculture's seed farm at Sudhan Gali and the Neelum valley. In the Leepa valley, farmers use their own seed.

6.4.2.3. Land preparation

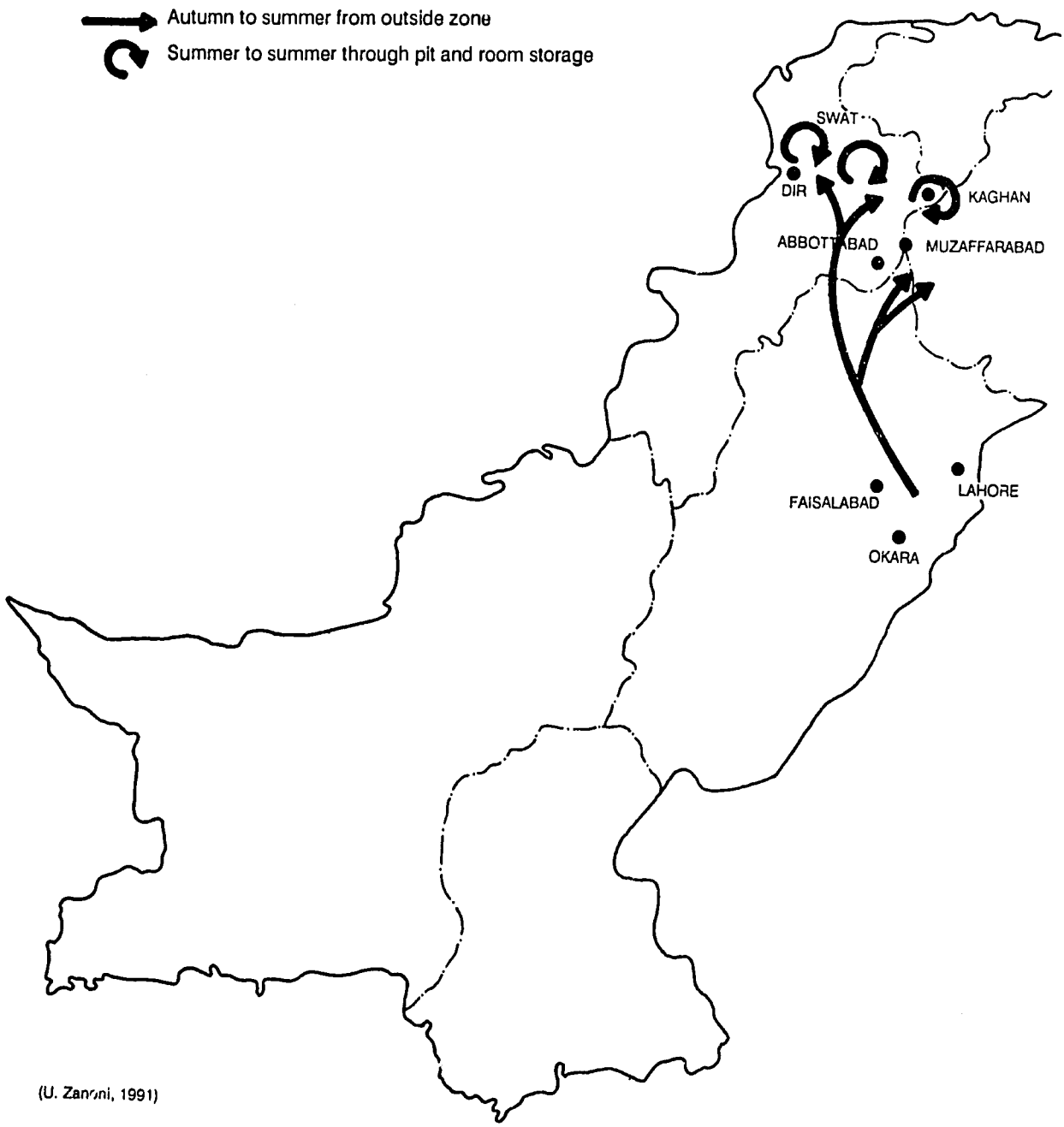
In fields which are close to the road and which are flat, and if a tractor is available and affordable, primary tillage is done with spring tine cultivators. In the Barawal and Miandam valley, tractors come from Swat. However, in many areas of this zone bullocks and wooden ploughs are still extensively used. Fields are usually ploughed two to four times.

6.4.2.4. Fertilizer

Farmers are using whichever fertilizer is available and affordable, i.e. urea, nitrophosphate, DAP, and ammonium sulfate. Fertilizers are usually more expensive because of higher transport costs to the remote villages. In the Shapur valley, farmers buy their fertilizer in Mingora because it is not always available in Besham. In general, farmers apply between 0 and 2 bags (50 kg each) of chemical fertilizer per 1 bag (100 kg) of potatoes planted independent of the nutrient content and type of fertilizer applied. At a seed rate of 1 bag per kanal, i.e. 2 t/ha. between 0-690 kg N/ha, 0-345 kg P/ha, and no potash were applied by the interviewed farmers. As farmers are very resource-poor they seem to apply on the average less chemical fertilizer than in other zones. Doses applied are very unbalanced in terms of N and P applied.

In addition to chemical fertilizer, FYM is applied by most farmers. Branches and leaves from the forests are also used as organic fertilizer. FYM and chemical fertilizer are usually

Fig. 12: Main seed sources for zone 5



(U. Zanoni, 1991)

applied before planting. FYM may exceptionally be applied in autumn before snowfall. Some farmers split the nitrogen fertilizer into two applications, the first one before planting and the second one at earthing-up.

6.4.2.5. Planting

The furrows are marked with the wooden plough and the seed potatoes are placed in the furrow by one person following the plough or on pre-made ridges. In tractor-ploughed fields if no bullocks are available the furrows are marked with a hoe or shovel (*belcha* or *kudal*). Planting is generally shallow. Small single hills instead of ridges are formed over the rows in Kaghan, Murree and the Galis. In all the other areas, ridges are made either parallel to the slope with some tie-ridges in very steep fields or more or less vertical to the slope in the other cases (Rawala Kot, Sudhan Gali). In steep fields, ridges follow the slope because otherwise they get washed away or water logging becomes a problem. Big tubers are cut into 2-3 pieces and small tubers are planted as a whole. In Alpuri, some farmers still cut the tubers in pieces with 1-2 eyes resulting in 1-2 stems per hill. Most farmers use a seed rate of 2 t/ha (1 bag/kanal) for pure stands and 0.7-1 t/ha for intercropped potatoes depending on whether beans or maize are used as the second crop. At 1-2 eyes/piece, the seed rate is probably less than 2 t/ha. Intercropping with a high percentage of maize or beans is most common in the Kaghan valley.

Row-to-row and plant-to-plant distance vary in Kaghan, Murree, and the Galis. In the other areas, where ridges and tie-ridges are used, the row-to-row distance is between 60 to 75 cm and the plant-to-plant distance varies between 20-30 cm. Thus, at plant-to-plant distance of 25 cm the plant density varies from 53,000 to 67,000 plants per ha. One farmer in the Shahpur valley used planting distances of 45x25 cm to suppress weeds. In Dir, the distances were variable, sometimes up to 100x30 cm.

6.4.2.6. Weeding and earthing-up

Weeding and earthing-up is done about one and a half months after planting using hand-hoes (*kudals*) to form single hills in Kaghan, Murree, and the Galis or using spades to form ridges in the other areas. No other weeding is done and no herbicides are used. One farmer in the Shahpur valley used high plant density to suppress weeds.

6.4.2.7. Water management

Some farmers in the transition zone between zone 5 and 6 apply supplemental irrigation to their rainfed potato crop if required. Thus, they can get more stable yields independent of the amount of rainfall. As in most rainfed areas, the rainfall is not evenly distributed over the cropping period and from year to year.

6.4.2.8. Diseases, pests, and their control

Since many farmers use fresh seed every year, viruses are mostly a result of poor seed quality. In 1991, various fields in this zone were observed with different levels of PLRV and mechanically transmitted viruses.

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Late blight (*Phytophthora infestans*) is the main disease in this zone (Khan et al., 1985; Turkensteen, 1986). Its intensity varies considerably from year to year depending on the weather, and in some years losses may be small. Late blight is a danger in cool cloudy weather with frequent rains. A severe attack can be expected when leaves are wet from dew or rain for more than eight hours per day for several days, with temperature between 10 and 24°C. In this zone the danger period starts early July/early August depending on the onset of rain. In on-farm trials in 1990, Dithane M-45 was sprayed starting from mid-June to beginning of July.

Early blight (*Alternaria solani*) was found in most fields in Sudhan Gali in 1985, but it did not reach epidemic proportions (Turkensteen, 1986).

Wilts caused by *Verticillium* spp., and *Fusarium solani* were widely spread in 1985 but the incidence level could not be estimated due to the attack of late blight.

Common scab (*Streptomyces scabies*) and powdery scab (*Spongospora subterranea*) were identified in the Galis area in 1991.

The most widespread pest seems to be cutworm (*Agrotis* spp.). It causes more damage when the weather is dry after planting.

Most farmers do not control late blight. However, a trader in the Miandam valley mentioned that more farmers are using Dithane M-45 as a consequence of the trials conducted by PSPDP in this area. Trials with spraying of Ridomil and Dithane M-45 have been conducted in Azad Kashmir. But frequency of rains is too high in summer to allow Mancozeb treatments to be effective. Turkensteen (1986) mentioned that Dithane M-45 had not been successful because of the long interval between sprays, the low doses used, and the insufficient spraying technique.

6.4.2.9. Harvest

Potatoes are harvested by hand using hoes or spades. Vines are cut off prior to harvest and sometimes used for fodder. Farmers usually do not grade the potatoes except for seed storage in pits. One farmer in Miandam reported that he separated smaller tubers from the large ones which then were sold at a 50% lower price.

6.4.2.10. Yield

Since potato production depends on rainfall and farmers usually do not take any plant protection measures, yield is expected to fluctuate from year to year and to be on the average rather low. Farmers reported multiplications rates varying from 1:4 up to 1:18, and one farmer in Roringar whose fields of Ultimus were looking good and who is using high rates of fertilizer and fresh seed from the Punjab even reported 1:25. The lower ratio would be obtained in years with severe late blight attacks or drought. Assuming that one bag of potatoes is planted per kanal, the yield would be 8 to 36 t/ha on the average and 50 t/ha for the farmer in Roringar. Lower yields per ha are expected for potatoes intercropped with beans or maize. The AJK Department of Agriculture assesses yields at abut 10 t per ha in Rawala Kot. Bajwa and Geddes (1988) reported multiplication rates between 1:5 and 1:25 in Malam Jabba, and between 1:2 and 1:16 in Miandam.

6.4.2.11. Post harvest handling

The nearest cold store for the Kaghan valley is located in Mansehra. But it is not operative because of low demand. There is also an inoperative cold store in Mingora. For longterm storage up to 6 month (November through April) in Kaghan, potatoes are placed into pits covered with straw and soil. Few farmers in the other areas use pit storage. Pits seem to be poorly managed as farmers reported high percentage of rotten or diseased seed.

6.4.2.12. Marketing

Potatoes are transported from the field to the roadside by donkey, horse, or human back. In the Kaghan valley, most potatoes are sold to the local dealers who also come to the farmer's field. In Murree and the Galis, potatoes are sold to local dealers, or directly to the markets in Rawalpindi or Abbottabad. Early harvested Ultimus is sold to Abbottabad where it might be sold for making chips or for use in the army. The Murree hills and the Galis used to produce seed for the plains 10 to 15 years ago. Whether potatoes from this area are still used for this purpose is not known. But anyhow production was very low in 1991. The main markets for the Swat side valleys are Mingora, Rawalpindi, Peshawar, and Lahore. Some farmers organize their own transport to the Lahore market. Farmers in Miandam take advantage of the high prices in August to start early harvest of not fully mature potatoes. Thus, even in years with low prices they can get reasonable profits (in 1990, potatoes were sold for Rs. 300-400/bag). In addition, early harvest allows a second crop of turnips. In Dir, local traders used to come and buy potatoes directly from the farmers. The local market in Dir played probably also some role in the marketing of potatoes from the area. In Azad Kashmir, potatoes are sold to the local market in Rawala Kot or in Rawalpindi. Farmers in Rawala Kot suffer in years of low market prices because they have less access to markets in Punjab and because no traders come to the area to buy.

6.5. PRODUCTION SUPPORT PROGRAMS

PSPDP: In 1987 the Pakistan-Swiss Potato Development Project (PSPDP) collaborated with the district agricultural extension services in on-farm trials in Malam Jabba, Usherai and Lawari. In 1988 late blight control demonstration plots were organized in collaboration with the district agricultural extension service in Malam Jabba and Miandam and with the ADBP's credit scheme in Alpuri. These activities of PSPDP were expanded in 1989 to include demonstrating two crop systems (Miandam/Malam Jabba) and fertilizer trials (Bazar Kot, Alpuri). The project is also supporting the AJK Department of Agriculture with on-farm trials and demonstrations in Rawala Kot.

Dir District Development Project: This project is interested in potato development in Dir district in both zone 5 and zone 6.

Azad Kashmir: The agricultural department has a farm at Sudhan Gali, where some seed multiplication and variety trials have been carried out. There is a World Bank supported "Integrated Hill Farming Project" in the zone but it is not thought to include potatoes in its scope.

6.6. CONCLUSIONS

Farmers and researchers perceive climatic conditions, accessibility, lack of credit, and agronomic practices as the major constraints to potato production in this zone.

Potato production in this zone is dependent on sufficient rainfall. Even though the average annual rainfall is high low rainfall in May and June can cause poor emergence and growth. The humid and mild conditions in July and August can cause severe late blight attacks reducing yield by more than 50%.

Roads to the remote villages in this zone are constantly being improved thus allowing easier access to larger markets in the plains. Farmers are frequently not aware of opportunities in more distant markets such as Lahore through lack of trader contacts. Access is most difficult for the Shogran and Sharan valleys, some valleys in Alpuri, Roringar, Dir, and Azad Kashmir. Potatoes have to be transported to the roadside by donkey, horse, or human back. Seed, fertilizer, and other inputs become more expensive due to the higher transport costs.

The most serious constraint in this zone is the lack of money to buy inputs. This was the single most important factor for less potato production in 1991 when seed prices were high. Thus, potato area might decrease from over 50% of the cultivated area to below 10% in only two years. When seed prices are low many farmers will grow potatoes contributing to the glut. Most farmers sell all the potatoes at the end of the season to pay back their debts for inputs and consumer items. Thus, little seed storage in pits or cold stores is practiced even though it would be technically feasible in some higher locations. It was observed that those farmers with access to informal credits, lack of alternative crops to grow, or who occupy a market niche still plant a high percentage of the cultivated area under potatoes. At higher altitudes, maize usually does not mature or farmers are not used to grow other cash crops such as peas, turnips, or cabbage. Thus, the risk to grow potatoes is taken even if seed prices are high. Farmers often receive credits for seed, but less often for fertilizer, pesticides and equipment. Farmers in Miandam are a good example for occupying a market niche and thus getting good profits even in years with low market prices. Some farmers also take advantage of direct marketing and buying good quality seed from known sources.

Late blight is causing heavy losses in the whole zone. In areas, such as Malam Jabba, Miandam, Alpuri where PSPDP has been working, some farmers are aware of late blight and its control, but lack of sprayers, pesticides and training prevent them from adopting the recommendations completely. Smaller and poorer farmers are especially hard hit. Fertilizers are usually applied in variable quantity, type and timing. Few farmers are aware of the different nutrient content of different fertilizers and of the benefits of balanced rates. Proper erosion control receives little attention.

The potential for the development of production lies in the better access to credits and/or savings to buy inputs and the concomitant adoption of improved agronomic practices through proper extension. Improved linkages with the major Punjab markets are also required.

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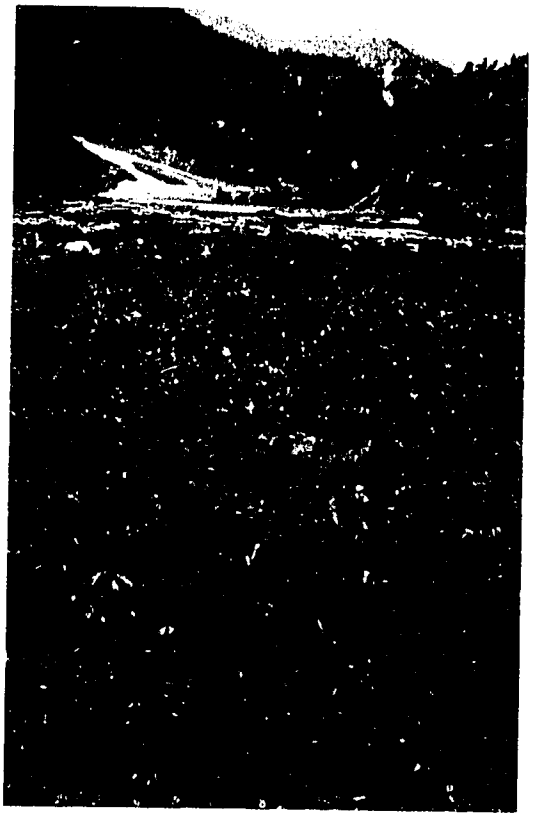

Potatoes are sometimes intercropped with maize (or maize and beans) in varying degrees and patterns, upper Kaghan valley, NWFP

Spraying potatoes against late blight disease on fields near Utror, NWFP.

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The author and PSPDP staff member interviewing farmer groups in Kalam, NWFP.

View of Shilibella on the right side of the Kunhar river, and Bas on the left. Shilibella is one of the last and highest (2700 m.a.s.l.) potato growing village in the upper Kaghan valley.

7. ZONE 6: IRRIGATED HIGH VALLEYS OF NWFP, NORTHERN AREAS AROUND CHILAS, AND AZAD KASHMIR.

7.1. GEOGRAPHICAL COVERAGE

7.1.1. Altitude

Zone 6 covers the high valleys of NWFP which range in altitude from about 1700 to 3000 m (Table 1).

Table 1: Approximate altitudes[1] (m a.s.l.) of important cities and villages in zone 6.

City/village	Valley	Altitude (m a.s.l.)
Kaghan	Kaghan	1900
Naran	Kaghan	2350
Battakundi	Kaghan	2500
Lalazar (hotel)	Kaghan	2850
Burawai	Kaghan	2900 (Karasch, 1987)
Saif-ul-Muluk	Kaghan	3200
Kedam	Swat	1500
Kolalai	Swat	1700
Mankyal	Swat	1700
Peshmal	Swat	1950
Kalam	Swat	2100
Bayun	Swat	2350
Gorkin	Ushu	2150
Ushu	Ushu	2150
Matiltan	Ushu	2300
Chorat	Ushu	2300
Dorga	Ushu	2300
Paloga	Ushu	2450
Eshgol	Ushu	2550
Shandur	Ushu	2550
Bhan	Utror	2050
Ushuran	Utror	2100
Utror	Utror	2200
Utror Gabral	Gabral	2300
Barra Jabba	Gabral	2550
Gulabad	Gabral	2700
Anakar	Anakar	2200
Dir	Dir	1400
Thal	Kumrat	2100 (Bajwa et al. 1988)
Miana	Lawari	2100
Lawari village	Lawari	2600
Lawari top	Lawari	3200
Gayal	Darel	1400
Gumari	Darel	1800
Tabor	Darel	1900

Continued

Table 1 (Continued)

City/village	Valley	Altitude (m a.s.l)
Manical	Darel	2000
Biari	Darel	2150
Astore	Astore	2150 (Whiteman, 1985)
Babusar	Babusar	3000 (Whiteman, 1985)
Naltar	Naltar	2900
Chitral	Chitral	1500 (Whiteman, 1985)
Neelum valley	Azad Kashmir	1700-3000

[1]Measured with altimeter if not stated otherwise.

7.1.2. Latitude and longitude

Zone 6 spans one degree of latitude (34° 30' to 35° 30') and two degrees of longitude (72° to 74°).

7.1.3. Topography

The potato growing areas in this zone are valley bottoms, plateaus, and slopes enclosed by high mountains on one side and the rivers rushing below on the other side. South facing villages receive more sunlight than north facing villages, thus warming up earlier in spring. In addition, some parts of the valleys are more open, allowing more sunshine to enter. The irrigated potato fields lie on terraces supported by stonewalls, on high plateaus, or just along steep slopes secured with only one tie-wall on the lower part.

The mountains and valley walls are precipitous, especially where vegetation has been destroyed due to overgrazing, thus changing the topography. Chemical and physical erosion are major problems in these areas (Schreiber and Schütz, 1986). There is more natural vegetation, especially pine, spruce and deodar forests in this zone than in the Northern Areas (zone 7).

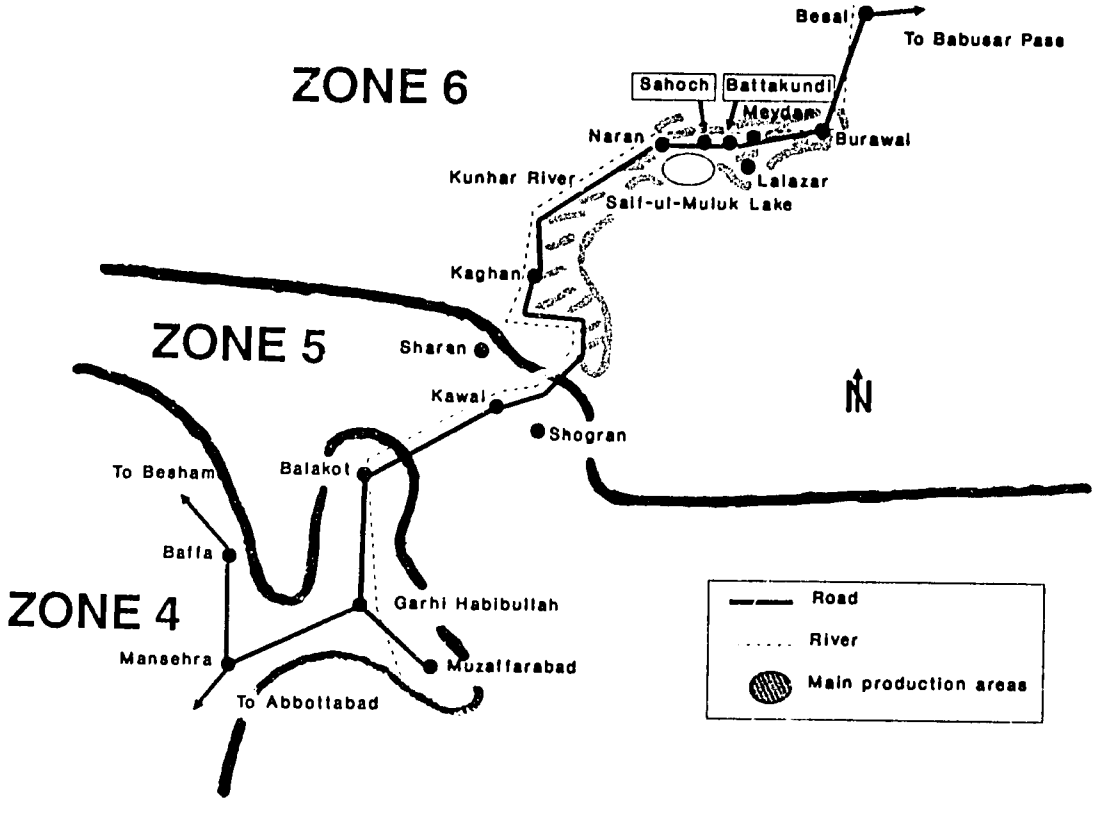
7.1.4. Potato production areas

In this zone, potatoes are grown in the Kaghan valley, the Kalam area (Ushu, Utror, Gabral, and Anakar valley, and south of Kalam), Dir-Kohistan, in side valleys of the Indus river near Chilas (e.g. Darel, Thor, Babusar, Ginny, Astore, and others), southern parts of Chitral, and Neelum valley in Azad Kashmir. The limits between zone 5 (rainfed) and zone 6 (irrigated) is not always very clear cut, since this distinction mainly depends on the availability of irrigation water (springs, streams, surface water) and the amount and distribution of rainfall.

In the Kaghan valley, irrigated potato production starts around Kaghan at 1900 m and continues up the valley to Burawai at 2900 m following the Kunhar river and main access road (Fig. 1). Potatoes have also been found towards the Saif-ul-Muluk lake up to an altitude of about 2900 m. Potato fields below Kaghan are mainly rainfed and therefore belong to zone 5.

In the Kalam area, irrigated potato production starts around Kolalai at 1700 m and continues up the valley to Kalam at 2100 m (Fig. 2). Potatoes are also grown in the villages

Fig. 1: Main potato growing areas in the Kaghan valley



Maskoon, Jabba, and Serai in one eastern side valley and in the village Goshai in one western side valley starting from Mankyal. Another side valley bifurcates at Kedam and potato growing starts at the village Gurnai. Many potato fields were also found in Bayun, a high altitude plateau east of Kalam village. This village was used by Jaffer Brothers Ltd., as a seed production area in 1985 but was abandoned because of difficult access and limited water supply. There are probably more side valleys below Kalam where potatoes are grown, but which have not been visited yet. In the Ushu valley above Kalam, irrigated potato production starts around Gorkin at 2150 m and continues on both sides of the river up the valley to Shandur at 2550 m. In the Utror-Gabral valley, irrigated potato production starts around Ushuran at 2100 m and continues on both sides of the river up the valley to Gulabad at 2700 m. Potatoes are also grown in Anakar.

In Dir-Kohistan, irrigated potatc production starts around Kalkot at 1800 m and continues up the Kumrat valley to Thal and farther up to about 2300 m (Fig. 3; Bajwa et al., 1988). There is also some potato production in :ne Lamutai, Jandri, Choti Jungi, and Barri Jungi, Dankar, side

Fig. 2: **Main potato growing areas around Kalam (Swat)**

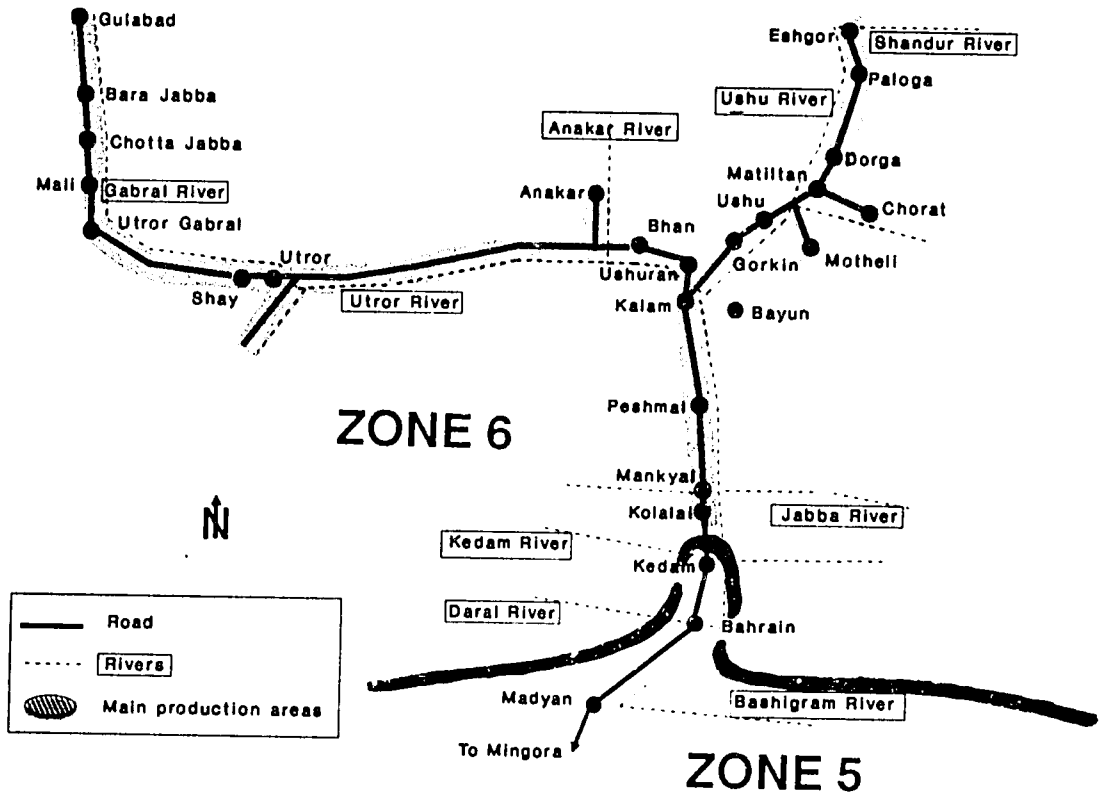
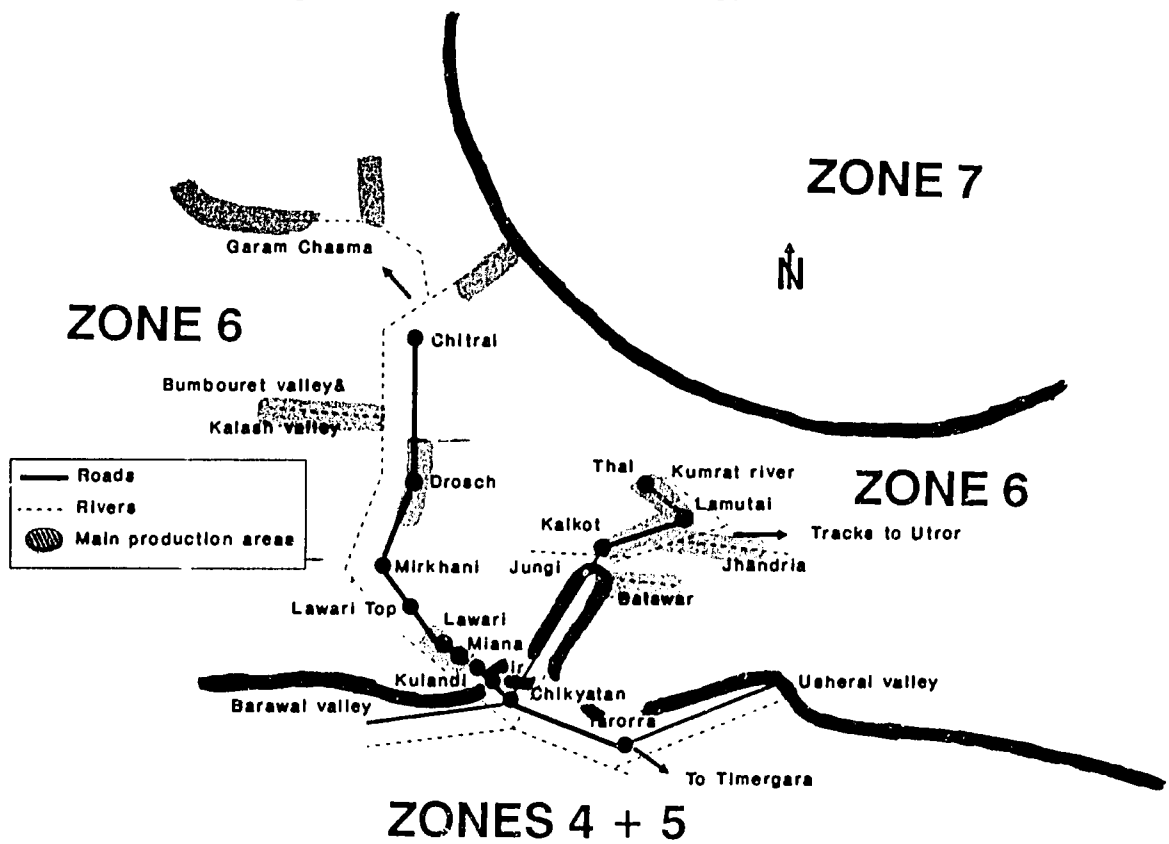


Fig. 3: **Main potato growing areas in Dir-Kohistan & Chitral**

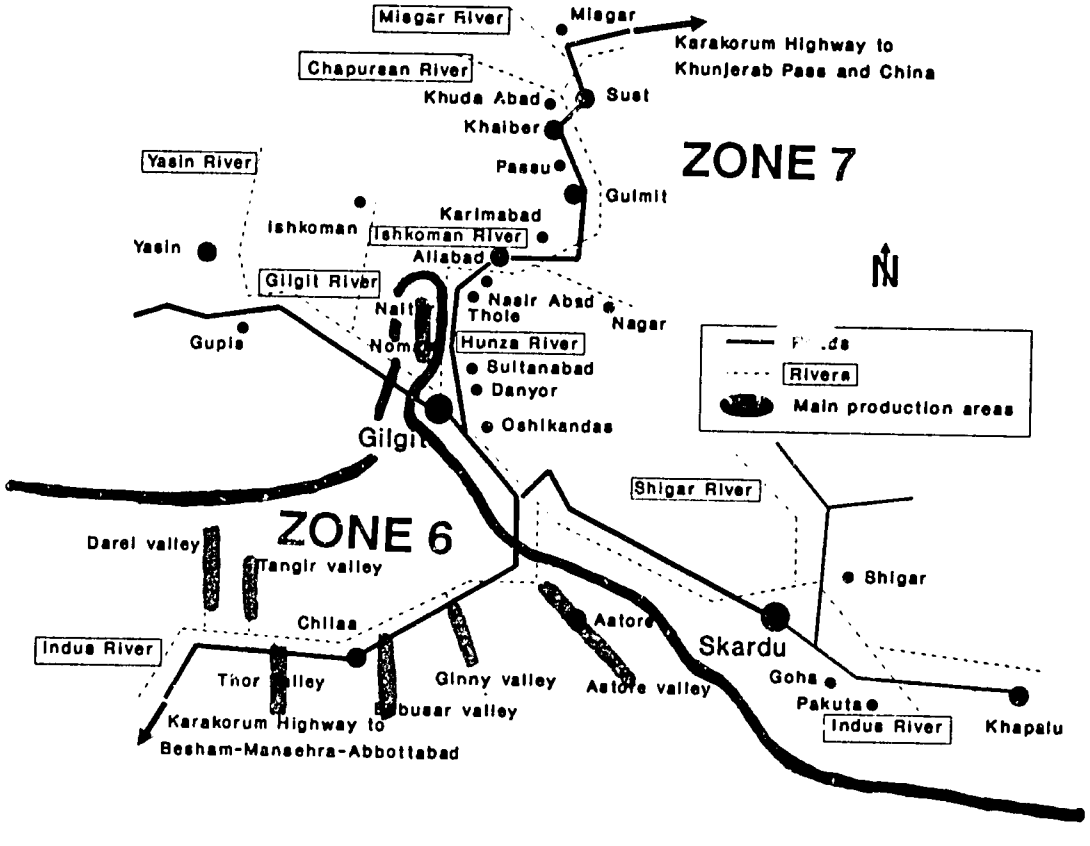


valleys. Potatoes are also grown under mostly irrigated conditions in the Lawari valley starting around Miana at 2100 m and continuing up to Lawari village at 2600 m.

In Chitral, the main potato growing areas belonging to zone 6 are around Drosch, Chitral, and Garam Chasma (Fig. 3). In Garam Chashma and around Drosch, potatoes are grown on a commercial scale.

In the Darel valley, *desi* potato production starts at about Tabor (1900 m) and continues up the valley. Other side valleys near Chilas such as Tangir, Thor, Babusar, Ginny, Astore and others are similar to Darel (Fig. 4). The Naltar valley also belongs to this zone. In 1991, Jaffar Brothers Ltd. had planted some potatoes for seed in Biari (Darel), Thor (Thor), and Ginny (Ginny).

Fig. 4: Main potato growing areas around Chilas

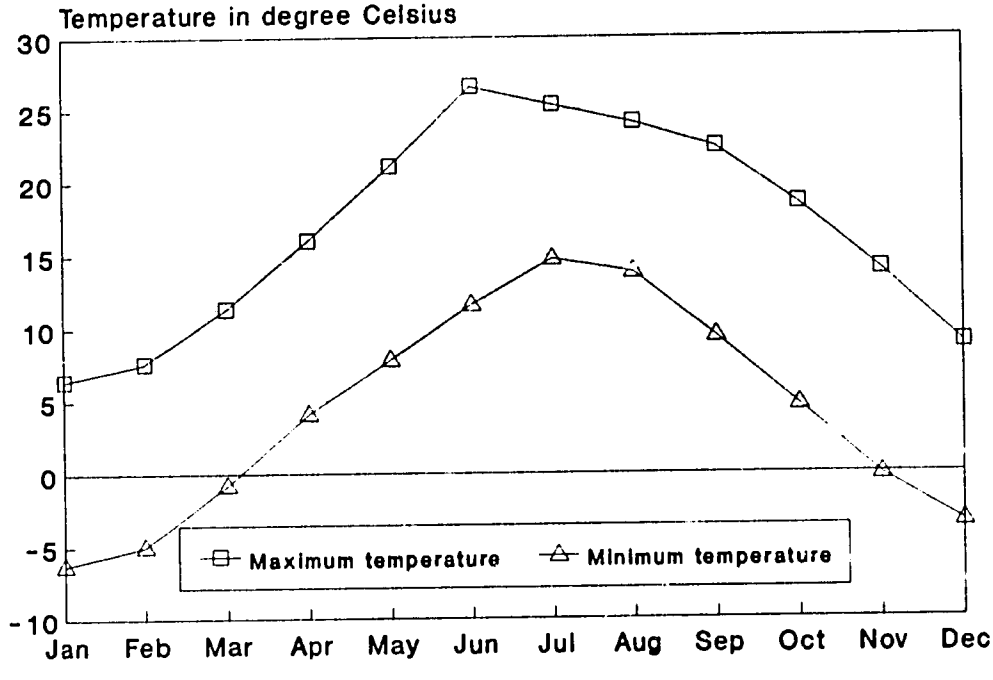


7.2. ECOLOGY

7.2.1. Temperature

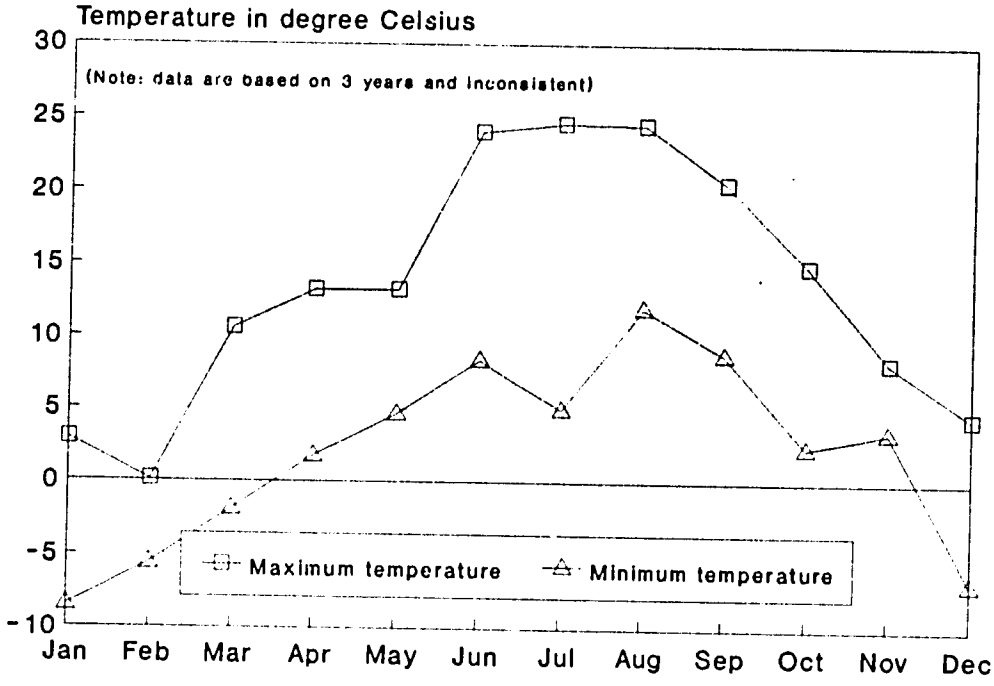
The climate in this zone is cold temperate with mild summers and cold winters (see also Parsons, 1989). The highest temperatures occur in June, July, and August, and usually stay below 30°C (Fig. 5, 6, 7, 8 and 9). Chitral at 1500 m and Dir at 1400 m display the same seasonal pattern as the higher altitude stations but with 5-10°C higher mean temperatures (Fig. 8 and 9). The lowest temperatures occur in December, January, and February, and the frost risk is highest from November to April. At 1500 m the frost risk period is reduced to December and January.

Fig. 5: Mean monthly temperatures at Kalam (zone 6)



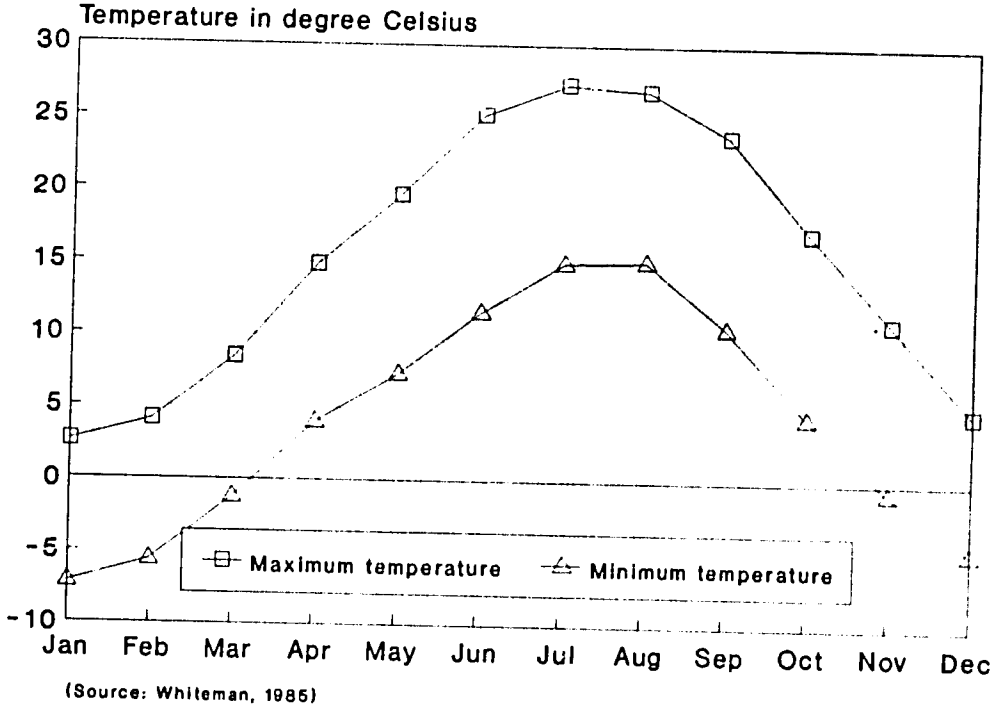
(Source: Geiser, 1988)

Fig. 6: Mean monthly temperatures at Battakundi (zone 6)



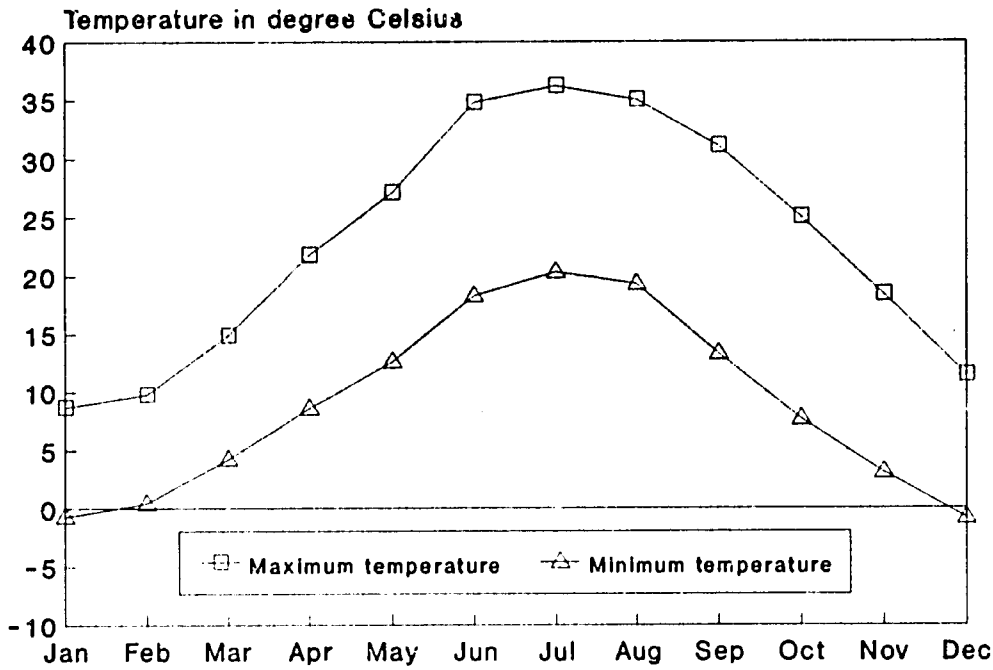
(Source: Karasch, 1987)

Fig. 7: Mean monthly temperatures at Astore (zone 6)



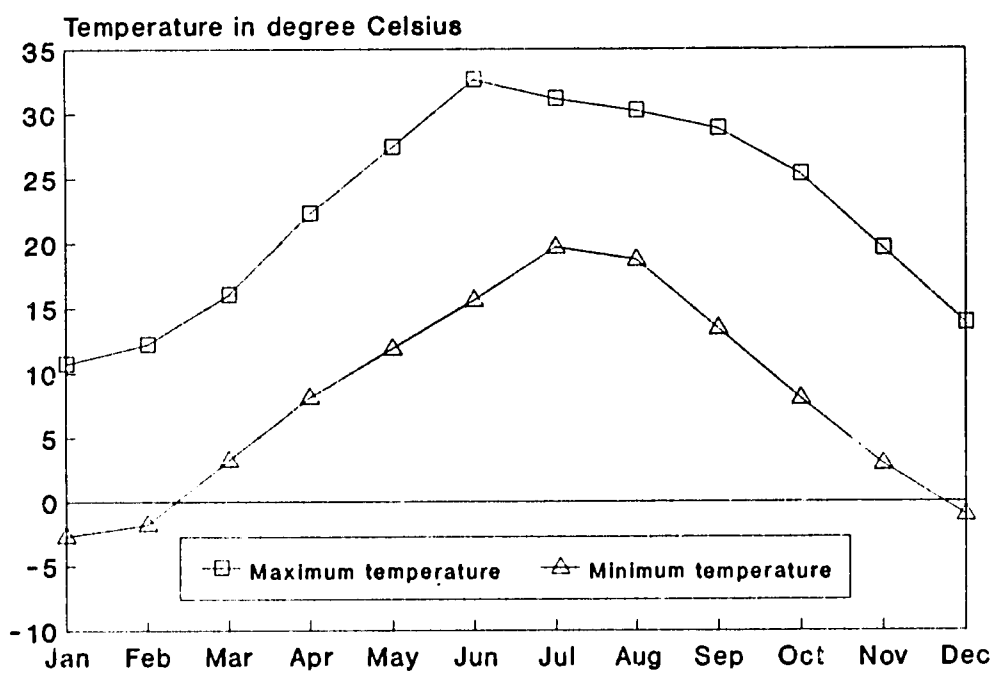
(Source: Whiteman, 1985)

Fig. 8: Mean monthly temperatures at Chitral (zone 6)



(Source: Whiteman, 1985)

Fig. 9: Mean monthly temperatures at Dir (zone 6)



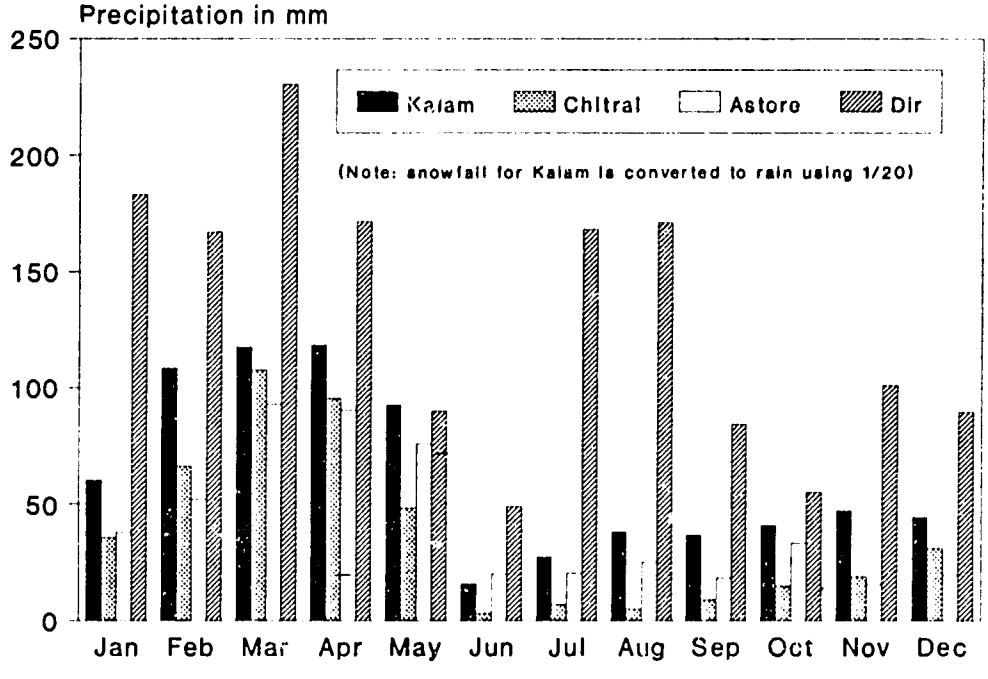
(Source: Meteorological Office, Lahore, 1977-86)

7.2.2. Precipitation

In Battakundi at 2500 m, snowfall is possible as early as mid-October and as late as end of May (Karasch, 1987). In Kalam at 2100 m, the first snow may fall in mid-October and the last snow in April (Geiser, 1988). The annual average snowfall in Kalam averaged over 20 years was 3700 mm, and the average snowfall in Battakundi averaged over three years was 7050 mm (Karasch, 1987). Kulandi at 1900 m receives about 900 mm of snow while Lawari village at 2100 m gets about 7500 mm annually. At Kalam and Battakundi, the highest snowfall was reported in February. Thus, snowfall in winter is contributing to replenish the soil moisture content.

Rainfall is irregular and insufficient in summer which makes irrigation necessary. The total amount and distribution of rainfall varies from valley to valley depending on the exposure and altitude, thus contributing to different microclimates. The total precipitation (snow and rainfall) in Kalam averaged over 20 years was 749 mm, and the total precipitation in Battakundi averaged over 3 years was 954 mm (Karasch, 1987; Geiser, 1988). In the Kaghan valley, Naran receives more rainfall than Sahoch or Battakundi. However, Battakundi receives more snow than the other two villages. In Chitral, Astore, and Naltar the total annual precipitation was 440 mm, 500 mm, 411 mm averaged over 20, 24, and 2 years, respectively (Whiteman, 1985). Kalam, Chitral, and Astore received most precipitation in February, March, April, and May (Fig. 10). The driest month was June.

Fig. 10: Mean monthly precipitation in zone 6



(Source: Whiteman, 1985; Geiser, 1988; Meteorological Office, Lahore, 1977-86)

7.2.3. Irrigation infrastructure

All potato fields in this zone are irrigated through gravity-fed channels, which collect melt water from glaciers, snowfields, springs, and rivers. In the Kalam tehsil, about half of the farmers use spring water and half use river water (Habib, 1989). The amount of water available is adequate in Utror valley and Dir-Kohistan, but somewhat insufficient in Kalam, parts of the Ushu valley, parts of the Kaghan valley, and parts of Garam Chasma. Generally, the higher the altitude, the more water of melting snow and glaciers becomes available. When water is scare, farmers take turns irrigating. In fact, at many locations maintenance of water supply channels is difficult because of frequent snow avalanches and lack of funds to set up sophisticated irrigation infrastructure.

In Battakundi, a channel from the Kunhar river carries water to Meydan. Farmers using this channel constitute a water user group which decides about maintenance and water distribution (Meyer, 1988). For the first cleaning and repairs in spring, each family has to contribute labor. All further maintenance during the season is executed by a small holder who is compensated with payment in kind (maize) for his time spent.

In the Kalam area, on the initiative of elders, each family has to contribute labor or cash to build and maintain water channels.

7.2.4.Soils

Soils in this zone are variable in texture, nutrient content, and depth probably due to erosion and the history of soil formation. Soils are generally light in texture varying from silty/sandy loams to clay loams (Devaux et al., 1985; Khan, 1990). They are dark in color in low lying fields, indicating their higher organic matter content and their origin from forests and swamps. Upper parts of slopes are lighter in color, indicating chemical erosion (Schreiber and Schütz, 1986). Chemical erosion is due to a drop in the pH of the soil because of leaching which consequently leads to unstable soil structure and erosion of the light organic matter particles.

The organic matter content of soils in Kalam is usually below 1%, except for those soils which were formerly swamps (e.g. in Matiltan). The pH is usually between 7 and 8 except for black soils which are acid (Devaux et al., 1985). They respond well to N, P, and K applications.

No soil samples have been analyzed by PSPDP to study the nutrient requirements and status of the soils in Kaghan, and Chitral. Soil samples from Thal in Dir-Kohistan have been analyzed. Soils are acidic with pH below 6, contain very high amounts of K, and low to high amounts of P. Zn was found at medium to high levels.

7.2.5.Cropping season

The length of the cropping season and the planting and harvest dates in this zone are basically a function of the temperature and amount of snow. Temperature and snowfall vary with altitude and exposure. In Sahoch for example, north facing fields receive less sunshine than south facing fields and therefore are snow-covered two weeks longer.

There is only one cropping season for potatoes in the whole zone with planting generally between the last week of May at about 2300 m and the fourth week of June at about 2700 m, and harvesting generally in September/October. Thus, the cropping season varies from about 90 days at higher altitudes to 120 days at lower altitudes. In Manical (Darel) at 2000 m, early planting in April is possible. In Mankyal (Swat) at 1700 m, potatoes can be planted as late as mid-July after the first crop of turnips and are harvested in November. Planting of the crops can be delayed due to high snowfall in winter or high rainfall or low temperatures in spring. Time of harvest is fixed by frost and snowfall. In 1991 for example, most fields in the upper Kaghan valley were planted late due to late snowmelt.

7.3. PRODUCTION FACTORS

7.3.1. Farm size

The majority of the farms in this zone are smaller than 5 ha (Table 2). The mean holding of arable land is about 1.5 ha in Kaghan, 0.5 ha around Kalam, 1 ha in the Lawari valley, 2 ha around Drosch and Chitral, 1.3 ha around Garam Chasma, and 0.5 ha in Darel (Geiser, 1988; Meyer, 1988; Habib, 1989). About 60% of the farms in Thal (Dir-Kohistan) are below 2.5 ha (Bajwa et al., 1988). Holdings in Kaghan and Kalam generally consist of many small fields scattered over different locations due to the fragmentary process of inheritance. Leasing of land becomes increasingly popular, especially in the Utror and Ushu valleys, thus increasing the mean holding.

Table 2: Farm size and land tenure in the different areas of zone 6.

Area	Farm size	Land tenure
Kaghan valley	1.5 ha	35% owners, 53% royalty, 5% lease, 7% share-cropping[1]
Kalam	0.5 ha	mostly owners, leasing is becoming more important
Thal	1.5 ha	mostly owners
Lawari	1.0 ha	mostly owners
Darel	0.5 ha	mostly owners
Drosch and Chitral	2.0 ha[2]	mostly owners[2]
Garam Chasma	1.3 ha[2]	mostly owners[2]

[1]Source: Meyer (1988).
[2]Based on small farmer survey of Habib (1989).

7.3.2. Land tenure

Almost all households in this zone, except for parts of the Kaghan valley, own their land (Table 2).

In the Kaghan valley, land tenure varies from village to village. In Naran and Sahoch for example, most farmers seem to own their land while most farmers in Kaghan and the Battakundi area are tenants (see also Meyer, 1988). Ownership of the so-called community land (*sharnilat*) is still disputed (Karasch, 1987; Meyer, 1988). For this land, no land titles exist. Whoever occupies and works the land, retains the produce and sells it, but pays royalties on each bag of potatoes produced. The occupier keeps this right a long as he uses it. Most of this

land is estimated to be marginal land which is used as pasture by the community and nomads (*gujars*).

More than one hundred years ago, the first farmers settled in the upper Kaghan valley. Under British law, the farmers became legal owners of the developed land after 12 years of cultivation and payment of taxes. The Sayed clan, which was given the responsibility to collect taxes, claimed the community land for themselves and collected dues on it. In 1947, after independence, a compromise was reached between 144 families living in the upper Kaghan valley and the Sayeds; only newly developed land would be taxed in form of a royalty. In 1964, one member of the Sayed family became Minister of Regional Affairs in charge of registration of landownership and wanted to reclaim ownership on all the land and collect royalties. This royalty is product-specific and until now is only based on bags of potatoes produced. In 1974, the quarrel between the farmers and the Sayed family over this royalty tax resulted in violent clashes. The Government intervened and introduced a tax collection station in Kaghan. Farmers who pass through the tax post to sell their produce have to pay the tax. If a farmer sells his potatoes to a local dealer above the tax station, the dealer will deduct the tax from the sale price. Taxes paid on each bag of potato vary according to the price of potatoes in the market (In 1991, Rs. 25/bag).

Not all landownership is disputed in the Kaghan valley. Some land (called *malkiat*) is registered with ownership titles, can be sold or rented out freely, and is located mostly close to the main access road. The disputed community land (*shamilat*) is to be found mainly in higher altitudes where access is difficult and therefore it is difficult to excise taxes from the farmers. In the Battakundi area, royalties have to be paid on about 50% of the cultivated land (Meyer, 1988). In the undisputed land, different forms of tenancy exist: (1) the landowner manages the holding, but may rent out a part of it, (2) the tenant receives between one fifth and one third of the produce, providing only labor, (3) inputs and produce are equally shared between tenant and owner except labor which is fully provided by the tenants and (4) tenants rent land for cash ranging from Rs. 300-1000/ha depending on the quality of land (Meyer, 1988; own observations).

The majority of farmers in the Kalam area own their land (Geiser, 1988). Three systems of tenancy are common: (1) the tenant receives one third or one fourth of the produce, providing only labor, (2) inputs and produce are equally shared between tenant and owner except labor which is fully provided by the tenants, and (3) tenants reportedly rent land for cash ranging from Rs. 12,000 to 40,000/ha depending on the quality of land. However, Rs. 40,000/ha seems to be very high. Leasing land seems to be increasingly popular. Land where maize is grown is usually not leased. The alpine forests and pastures are common property of tribes. The *gujars* in the Gujar Gabral valley represent a special case of tenancy as they pay no rent to the Kohistani landowners. About 5% of the households are landless.

In Dir-Kohistan, most farmers own their land, but in the Lawari valley some share-cropping on a 50/50 basis is possible (Bajwa et al., 1988).

In the Darel valley, most farmers own their land, but some share-cropping with the tenant receiving one third of the produce occurs.

In Chitral, most farmers own their land (Habib, 1989).

7.3.3. Labor

Most of the work on the farms in Kaghan is done by the own family itself. Contrary to zone 7, women seldom work in the fields for reasons of *purdah*, except for harvesting and if the family is very poor, but the children have to help. Some better-off farmers may hire additional labor which is usually paid in cash (reportedly, Rs. 30-40/day for planting and weeding, Rs. 50/day for harvesting). In the Battakundi area, small and medium farmers are underemployed as compared to larger farmers (Meyer, 1988). Therefore, small farmers work as temporary laborers to supplement their income. Important off-farm employments are: shopkeeper, government employee, transporter and tourist guide. During the season, farmers travel several times to their lower lying winter residences to make hay and cultivate maize.

Many farmers and *gujars* in the upper Kaghan valley retreat to lower areas (e.g. Kaghan, Balakot, Garhi Habibullah) at the end of October/early November and come back mid-May. Only about 10% of the farmers in the Battakundi area stay behind because they cannot afford to migrate or because they produce sufficient fodder (maize straw) on sun exposed southern slopes to stay behind with some animals (Meyer, 1988). Moving the household by jeep to the lower areas costs between Rs. 700-1200 depending on the road conditions. For this reason, many households are moved on the back of animals during the migration. During winter time, at least one family member looks for a temporary job sometimes as far away as Karachi.

The main source of income in the Kalam area is agriculture (Geiser, 1988). People work collectively (*ashar*) during peak times, especially for planting and harvesting potatoes. Only resourceful farmers hire labor and pay cash. Generally, men do the farm work but sometimes women have to help, especially for weeding, applying fertilizer, or occasionally for cutting seed before planting (Zanolli-Davenport, 1989).

About 50% of the population in the Kalam area migrates to the Peshawar valley between mid-October and mid-November and comes back between mid-April and mid-May (Geiser, 1988). The rate of migration is dependent on the income gained through the sale of potatoes to purchase food and fodder for the long winter and on the limited fodder supply for the animals. Some farmers leave their cattle with neighbors, other farmers migrate with the whole household. Fodder for the animals is then provided from the sugarcane harvest in the Mardan area. The upper Gabral valley is settled by a nomadic tribe of herdsmen (*gujars*) whose entire community migrates.

In Dir-Kohistan, few people migrate (Bajwa et al., 1988).

In Chitral, whole families do not migrate to the plains during winter (Khan et al., 1989). However, male family members work outside the area in winter and on a temporal basis when jobs can be found.

Farmers in the Kaghan valley and Kalam area have about 20 to 30 years of experience growing potatoes. In Chitral, potatoes are said to have been there for more than 50 years.

7.3.4. Credit

Many farmers rely on traders and shopkeepers to get credit on their inputs (seed, fertilizer) and consumer goods (see also Bajwa et al., 1988; Zanolli-Davenport, 1989). The

farther the distance to main villages and the poorer the family the more important the shopkeeper becomes as a creditor. In the Battakundi area, 70% of the 100 households surveyed, depended on credit for buying food which is much more expensive locally than in the plains (Meyer, 1988). In 1991, one bag (70 kg) of wheat flour, for example cost Rs. 450 in Battakundi as compared to Rs. 290 in Abbottabad. The higher price covers the transport costs from Balakot to Battakundi. Transport costs for bringing potatoes to the market have also to be paid in cash. In some years prices are so low in the market that selling the produce does not cover the credits. In Kalam, 26% of the creditors were friends and 55% were shopkeepers (Geiser, 1988). Thus, most of the respondents in Swat used informal credit sources. Credits are usually paid back in cash at the end of the season after selling the potatoes.

Seed bought on credit is generally more expensive than that paid in cash (between 30 to 60% in Kalam in 1991, between 30 to 50% in Thal in 1987). The traders have a vital function in providing seed to remote areas and resource-poor farmers on loan, especially in years such as 1991 with high seed prices. Where no traders are present to provide seed on loan, as for example in the Lawari valley (Dir), farmers grow less potatoes when seed prices are high. Habib (1989) reported that only 4% of the small farmers surveyed in Dir used credits as compared to 12% in Chitral and 41% in Swat.

PSPDP has carried out an extension/credit scheme in conjunction with the Agricultural Development Bank of Pakistan (ADBP) in Matiltan. This was extended to Ushu (Kalam area) and Thal (Dir-Kohistan) in 1988. In 1989, Motali, Dorga, and Paloga villages in Kalam participated for the first time but both schemes were discontinued in 1990 because of credit repayment problems after a year of very low potato prices.

In Chitral, the Aga Khan Rural Support Program (AKRSP) provides loans and grants for physical infrastructure projects and agricultural inputs such as seed and fertilizers (Conway et al., 1987). These grants and loans are provided through village organizations i.e. broad-based NGOs.

7.4. FARMING PRACTICES

7.4.1. Cropping pattern

Potatoes, maize, and some vegetables (for example local spinach called *sumchal* (*Malva verticillata*), beans, pumpkins) are the most important crops in this zone (Table 3). Fruit trees and forests are other important sources of income.

In the Kaghan valley, potatoes have been introduced about 20 to 30 years ago, gradually replacing the traditional barley cropping system to become a potato monocropping area. Dependence on potatoes as a source of income is strong, providing about one third of the farm income (Meyer, 1988). The area under potatoes increases at higher altitudes. Above about 2300 m (Sahoch), between 50 and 95% of the arable land is under potatoes. In the Battakundi area, encouraged by the Pak-German Seed Potato Program and supported by good marketing links and input credits from traders, farmers have switched from the potato monoculture to crop rotation with peas and cabbage which may cover up to 30% of the cultivated land. Another incentive for crop diversification was the fact that royalties are only levied on potatoes. In 1987, only about 1% of the arable land in this area had been planted with peas and cabbage (Meyer, 1988). Maize is grown on about 5 to 10% of the arable land, preferably on fields which cannot

be irrigated properly, preferably on southern slopes, and on less accessible fields, or on bunds between potato fields. Below 2300 m the importance of maize is increasing and the area under potatoes is decreasing.

Farmers in the Kaghan valley keep about 1 to 2 bags (100 kg) of potatoes for own consumption stored in pits during 6 months. At an average household size of 12 persons as reported by Meyer (1988), between 8 and 16 kg of potatoes per person per six months period are consumed. The home consumption is limited by the space available on the jeeps to transport household items to the winter residence.

In the Kalam area, potatoes have been introduced about 30 years ago, gradually replacing maize grown on fertile land, buckwheat on less fertile land, and by transforming valley-bottom pastures into arable land (Geiser, 1988). In 1982, potatoes covered 90-95% of the arable land. In 1991, potatoes were grown on about 25% of the cultivated area in Ushu, less than 50% in Gorkin, more than 50% in Matiltan and Bayun, and almost 100% in Paloga. Potato cultivation is increasing with higher altitude because the available maize varieties do not mature properly. Thus, where maize can be grown, the area under potatoes reduces in years with high seed prices. In Ushu, for example the area under potatoes was reduced by 50% in 1991 as compared to 1990. In the Gabral valley, much less maize is grown compared to similar altitudes in the Ushu or Utror valleys. This could be because more people migrate during winter. In the nematode infested area between Utror and Utror Gabral, potatoes are still grown on about 50% of the cultivated area, the other 50% being grown under turnips. In the Gabral valley above Mali, potatoes cover the whole cultivated area. Gulabad is the most recently developed potato growing village of the valley after improved accessibility and the construction of water channels made potato production feasible. Potatoes have been grown there for the last 9 years. In Anakar, less than 50% of the cultivated area was under potatoes in 1991. Maize was the most important crop in this valley. Below Kalam towards Mingora, the percentage of maize and tomatoes increases at lower altitudes. Maize and tomatoes are dominant in the farming system of Mankyal at 1700 m. Whether maize or potatoes are grown might also be a question of accessibility to the main road. Scattered apple and walnut trees are kept by many farmers (Habib, 1989). In some areas, where no maize is grown, maize and rice straw are purchased from the lower areas. Grass grown on uncropped irrigated slopes or on swampy meadows is cut for hay.

Most potatoes in Matiltan, Dorga, and Ushu are sold; one bag is sometimes kept for own consumption and stored in pits during 6 months (Zanolli-Davenport, 1989). Thus, at a family size of 10 persons, the average potato consumption per person would be about 10 kg per six months period.

In Thal (Dir-Kohistan), maize and potatoes are the main crops grown (Bajwa et al., 1988). In 1987, about 25% of the cultivated area south and north of Thal was under potatoes. Few scattered fields of potatoes were also found further south down to Kalkot at 1800 m. In the lower parts of the Lawari valley, potatoes were more important a few years ago. A lot of volunteer potatoes can still be found in the maize crop. At present they are only grown for home consumption. About 25-50% of the cultivated area in proper Lawari at 2650 m is under potatoes, the rest being grown under an early maturing maize variety. At this altitude, 3 to 8 bags of potatoes per family are kept during winter time because the area is often not accessible due to heavy snow.

In the Darel valley, potatoes are mainly grown for own consumption with each family keeping about 2 to 3 bags (100 kg). Only recently, JBL has introduced some seed production into the valley.

In Chitral, potatoes have probably been grown for more than 50 years. Potatoes are produced for local and home consumption. At lower altitude (<1750 m), potatoes are mixed with other vegetables in garden plots or planted on the bunds of rice and other cereal plots. At higher altitudes (>2000 m), potatoes are grown in pure stands or still intercropped with other crops. One to 4 bags are kept per family. According to a survey among small farmers in Chitral, 52% of the farmers around Drosch, 19% around Chitral, and 85% around Garam Chasma were growing potatoes (Habib, 1989). Maize is the most important summer crop.

In the whole zone, potatoes are planted in pure stands or intercropped in variable degree with maize, beans squashes, or pumpkins. Maize is almost always intercropped with beans.

Until recently no conscious crop rotation was followed by most farmers due to the overriding importance of potatoes as a cash crop. This also explains the high percentage of cultivated area under potatoes, especially in the Kaghan valley, Kalam area, Lawari, and Thal. At higher altitudes under the potato monoculture, scab in Kaghan and nematodes in Kalam became a problem. The Pak-German Seed Potato Program encouraged and supported the introduction of peas and cabbage as alternative crops in the Battakundi area. This was accomplished by successfully establishing market links between traders and farmers. But many farmers still have to be convinced of the benefit of planting potatoes in different fields every year. The farther away from Battakundi the less impact of the introduction of peas and cabbage can be observed. In Kalam, the Kalam Integrated Development Program (KIDP) promoted crop rotation with maize and vegetables. In Thal, farmers are reportedly using crop rotation (Bajwa et al., 1988). In Lawari, farmers do not understand the concept of crop rotation.

Table 3: Importance of the potato crop, percent cultivated area under potatoes, and main competitive crops for potatoes in the different areas of zone 6.

Area	Importance of potatoes	Percent under potatoes	Main competitive crops
Kaghan valley	+ + [1]	>50% above 2300 m <50% below 2300 m	maize[2], peas[3]
Kalam	+ +	25-100%[4]	maize, turnips[5], tomatoes[6]
Dir-Kohistan	+	25-50%[7]	maize
Darel	+/-	<5%	maize
Chitral	+/-	<5%	maize

[1] + + very important, + important, +/- mainly for home consumption.
[2] Above 2300 m, maize is preferred on less accessible fields where potatoes cannot be grown. Below 2300 m, maize is the main alternative crop to potatoes.
[3] Mainly in the Battakundi area.
[4] Percentage is increasing with altitude.
[5] Mainly in the nematode infested areas.
[6] At lower altitude below Kalam.
[7] At lower altitude, mainly for home consumption.

Livestock are kept as draft-animals for ploughing and for subsistence purposes. Their number is limited due to limited fodder resources. In the Kalam area, farmers own on average 3 cows, 5 goats, 3 sheep, and 7 chicken (Geiser, 1988). Livestock are kept in the valley bottoms in spring, thus a second cash crop cannot be grown in unfenced fields. In Battakundi, farmers own on average 1 bullock, 2 cows, 1 heifer, 1 calf, 1 buffalo, 1 sheep, 2 goats, and 3 chicken (Meyer, 1988). Hay has to be stored on the farm as fodder for the first months in spring. Most families migrating in winter take their animals with them.

7.4.2. Potato production

7.4.2.1. Varieties

The main potato varieties grown in this zone are summarized in table 4.

Potatoes were first introduced to the Kaghan valley about 20 to 30 years ago. According to one farmer in Battakundi this first introduction was called *calci*. Then Ultimus was introduced and is still the prevailing variety. In 1984, the Pak-German Seed Program introduced Desiree and Cardinal to farmers in Battakundi (Schreiber and Schütz, 1986). Receiving little assistance by the project, farmers paid little attention to storing varieties separately so that in the 1985 season mixed seed was planted. Desiree was not accepted by farmers due to its poorer storage quality, transport quality, and adaptation as compared to Ultimus but Cardinal is spreading, especially in the Battakundi area and villages close to it. Maturity of the variety is important because of the limited cropping season. Ultimus is well adapted to Kaghan. Since also some seed of the white varieties Multa and Diamant have been produced on the Battakundi farm, a few plants of these varieties could be found in farmers' fields in 1991.

Potatoes were introduced into the Kalam area about 30 years ago. In 1982, Ultimus was the most commonly planted variety (70%), followed by Desiree (28%), and Cardinal (2%). In 1991, most potato fields displayed a mixture of all three varieties with Desiree at the highest percentage. Many groundkeepers from previous crops survive in the soil contributing to a mixture of varieties in the field. In rotated fields, the number of groundkeepers decreases.

In Thal, the most common variety was Ultimus in 1987 (Bajwa et al., 1988). In the Lawari valley, most fields were a mixture of Ultimus, Cardinal, and Desiree. Red and white *desi* (traditional local) varieties were also found. The red variety had as many as 25 tubers per plant and the white variety long stems and late tuber setting. The white varieties were reportedly introduced by their forefathers and multiplied for many years. Potato tubers in this area seem to survive quite well under the snow cover in winter and tend to regrow at high percentage in the succeeding maize crop. Some of the local potato varieties could also have evolved through spontaneous true potato seed, since volunteer potatoes growing in maize or other crops could have shed their seed.

Potatoes were introduced into the Darel valley about 50 years ago. *Desi* varieties still dominate the area. In one farmer's garden in Manical 3 different *desi* varieties were observed: (1) purple-red variety, rectangular, somewhat russet skinned tubers with shallow eyes, plants look like Desiree or Ultimus but with thin, slender and branched stems, without virus symptoms, foliage resembles Desiree but with smaller leaves, (2) white variety, similar to some varieties in Chitral and Dir, with some *andigena* growth characters, without virus symptoms, and (3)

cobbler shaped variety, with virus riddled foliage and pink eyes, probably identical to the local variety from Gojal and Skardu, reported to be a recent introduction in the area. The yield of the two first varieties is excellent. Up to 650 kg are reportedly harvested from about 100 m^2 of home garden (65 t/ha). JBL provided some Desiree for seed multiplication but emergence was poor due to rotting of cut seed pieces.

In Chitral, red and white *desi* varieties are presently grown (Khan and Hussain 1989). In the Neelum valley (Azad Kashmir), local varieties are grown.

Table 4: Common potato varieties and seed sources in the different areas of zone 6.

Area	Varieties	Sources
Kaghan valley	Ultimus, Cardinal[1]	pits, Punjab, Battakundi seed farm
Kalam	variable mixtures of Desiree, Ultimus, Cardinal[2]	Punjab, few pits
Thal	Ultimus	Peshawar, Dir, Mardan
Lawari	mixtures of Desiree, Ultimus, Cardinal, red and white *desi*	Peshawar, Dir, Mardan
Darel	different *desi*	pits
Chitral	red and white *desi*	pits

[1]Mainly in the Battakundi area.
[2]Desiree with highest percentage in 1991.

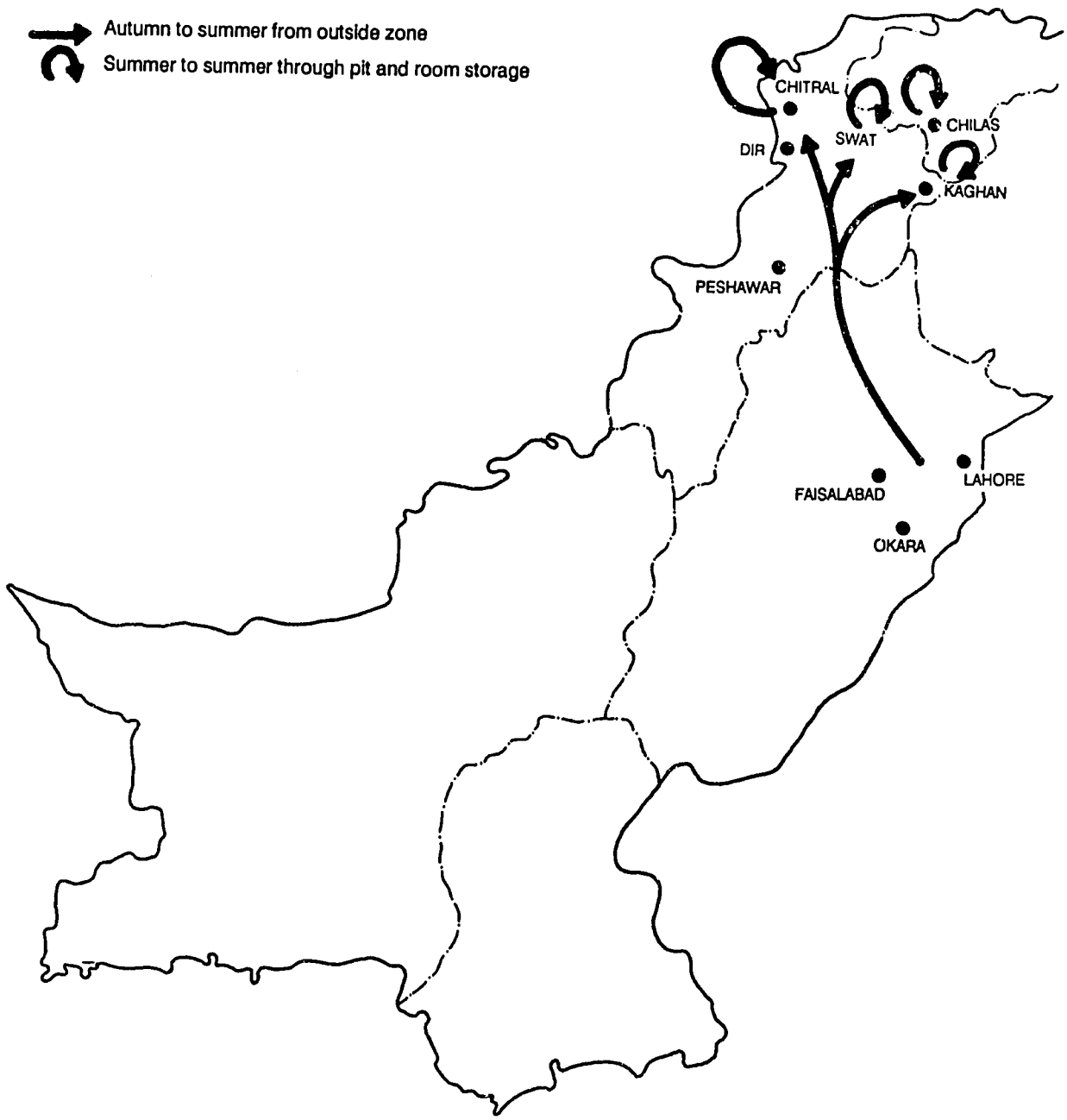
7.4.2.2. Seed sources

The common seed sources used in this zone are summarized in table 4 and figure 11.

Ultimus has been multiplied for the last twenty years in the Kaghan valley and is still looking quite healthy. Farmers store the seed in pits over the winter. Every two or three years fresh seed is bought, usually from Punjab in lower lying villages close to Balakot, and from Battakundi in higher lying villages. Transport costs from Battakundi to Balakot are higher than from Lahore to Balakot, thus farmers close to Balakot buy their fresh seed preferably from Lahore.

Most farmers in Kalam buy new seed every year, usually from the autumn crop in Punjab (Geiser, 1988). The seed is stored in cold stores in the plains and transported to Kalam in May/June. Traders seem to know very well whether the seed comes from Sahiwal or Okara because of the way the caps are put on the bags and because the name of the cold store is written on the bag. However, farmers do not know the exact source unless they go themselves to buy the seed in the Punjab. Due to low prices in 1990, some potatoes from Kalam were stored by traders in Charbargh and resold to the Kalam area in 1991. Only a few potatoes are stored in pits because: (1) farmers sell all the potatoes after harvest to pay back their debts, (2) potato prices are often higher in autumn than in spring, so that farmers can buy new seed at lower prices, and (3) farmers prefer new seed from the plains because of better quality and therefore higher yielding. Pit-storage seems to be practiced more commonly in Gabral because of the poor accessibility of the Gabral valley.

Fig. 11: Main seed sources for zone 6



Farmers in Thal and Lawari buy their seed in Peshawar, Dir or Mardan for cash or locally on credit (Bajwa et al., 1988; Hangarter, 1989). No potatoes are stored in Thal because of the risk of rotting. Some farmers in Lawari use pit storage.

In Darel, pits are used for storing potatoes and JBL provides the seed for the seed production scheme.

The road to Chitral remains blocked during winter (Khan and Hussain 1989). Thus, farmers store seed from the previous year in pits and *desi* varieties have not yet been replaced by new seed sources.

7.4.2.3. Land preparation

In fields close to the road and if a tractor is available and affordable, primary tillage is done with spring tine cultivators (in 1991, Rs. 140/hour). Tractors used in Kalam are mostly rented from Mingora (Geiser, 1988). In the Ushu valley above Matiltan and in Lawari (Dir-Kohistan) only bullocks are used. Bullocks and wooden ploughs are still extensively used in the Kaghan valley. In Chitral (Kalash), ploughs are pulled by men or bullocks. The tractor-drawn preparation has the advantages of being more efficient (about 1 hour for 0.25 ha as compared to 2-4 days with bullocks), allowing deeper preparation, and resulting in a fine-structured seed bed. With the tine cultivator, the fields are usually prepared in 4-5 passages as compared to two passages with the wooden plough. If required a planking equipment can be attached to the cultivator. Since the planting time is very short, efficient land preparation is highly desirable. In some fields along very steep slopes, simple hand-hoes have to be used. Fertilizer and big-size seeds (for example beans, maize) are broadcast before the first passage while small-size seeds (for example turnips) are broadcast after the final passage.

7.4.2.4. Fertilizer

Farmers are using whichever fertilizer is available and affordable, i.e. urea, nitrophosphate, DAP, ammonium sulfate, and potash. in the potato growing areas of Swat, farmers get fertilizer locally (e.g. in Kalam) or from Mingora (e.g. in Matiltan). Urea, DAP, ammonium nitrate, and ammonium sulfate (AS) were the best selling fertilizers in 1989 (Hangarter, 1989). Since AS is usually the cheapest nitrogen fertilizer, it is very often used by resource-poor farmers. Potato growing farmers in the Thal area have difficulties in getting fertilizers or they have to pay higher prices due to transport costs (increasing with altitude) and monopoly of a few traders. In Chitral, the Agriculture Development Authority is the only organization supplying fertilizers. Fertilizers are sold at official rates at their sales points in Drosch, Chitral, and Garam Chasma. Only DAP and urea are available. In Chitral, farmers tend to organize their transport through the village organizations of Aga Khan Rural Support Program (AKRSP). For fertilizer bought on credit an additional Rs. 10-20/bag are charged by the shopkeepers in Kaghan and Rs. 50/bag of ammonium sulfate in Dir (Hangarter, 1989).

In general, farmers apply 1 to 2 bags (50 kg) of fertilizer per 1 bag (100 kg) of potatoes planted in Kaghan and Thal, and one half to 2 bags in Kalam independent of the nutrient content and type of fertilizer applied. One farmer reported that AS was less effective and shorter lasting than urea. At a seed rate of 1 bag per kanal, i.e. 2 t/ha, between 180-690 kg N/ha, 65-258 kg P/ha, and 65-166 kg K/ha were applied by the interviewed farmers in Kaghan. If the

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seed rate is 1 bag per 3 kanals, i.e. 0.7 t/ha, as might be the case in intercropping with maize or beans, the doses per ha are reduced to one third.

A survey of 10 farmers in Kalam in 1987 showed that they applied between 50-400 kg N/ha, 0-285 kg P/ha, and no potash (Devaux and Farooq, 1988). In on-farm trials, potatoes seemed to respond well to N and P application by giving more tubers per plant and higher tuber weight. In 1991, at a seed rate of 1 bag per kanal, between 105-960 kg N/ha, 0-263 kg P/ha, and no potash were applied by the interviewed farmers in the Utror, Gabral and Ushu valleys.

In Thal, farmers use chemical fertilizer but doses are not known. In Lawari, farmers use little fertilizer and are not clear about the quantity applied. Only farm yard manure (FYM) is applied in *desi* potato production for home use.

In Chitral, chemical fertilizer is seldom used.

In addition to chemical fertilizer, FYM is applied by most farmers. Farmers use their own FYM or it is provided by the landowner in case of leased land. No exact measure of the amount applied is available, but it is estimated to be low because of the limited number of cattle kept in stalls. FYM is generally applied to the fields close to the cattle-sheds In Kalam and Kaghan, branches and leaves are collected from forests and used as stable straw. This contributes to increase the amount of FYM produced.

In general, FYM and chemical fertilizer are usually applied before planting. FYM may exceptionally be applied in autumn before snowfall. Some farmers split the nitrogen fertilizer into two applications, the first one before planting and the second one at earthing-up which generally corresponds to the first irrigation. Some farmers had applied the second dose of urea too close to the potato plants causing burnt and rotten plants. Some farmers claimed that some chemical fertilizer applied at planting caused rotten tubers. Other did not apply the second dose of fertilizer because it was too expensive.

7.4.2.5. Planting

The furrows are marked with the wooden plough and the seed potatoes are placed in the furrow by one person following the plough. In tractor-ploughed fields if no bullocks are available the furrows are marked with a hoe or shovel (*belcha* or *kudal*). Planting is generally shallow. Small single hills instead of ridges are formed over the rows in Kaghan and Lawari. Big tubers are cut into 2-3 pieces and small tubers are planted as a whole. In Kalam, many farmers still cut the tubers in pieces with 1-2 eyes resulting in 1-2 stems per hill. Most farmers use a seed rate of 2 t/ha (1 bag/kanal) for pure stands and 0.7-1 t/ha for intercropped potatoes depending on whether beans or maize are used as the second crop (see also Devaux and Farooq, 1988). At 1-2 eyes/piece, the seed rate is probably also less than 2 t/ha. Intercropping is more common in Kaghan than Kalam.

Row-to-row and plant-to-plant distance vary in Kaghan and Lawari but result usually in approximately square plant-to-plant distances. In one field in Kaghan intercropped with beans the distances observed were 60x60 cm, and in one pure stand in Meydan, the distances were 30x30 cm. Thus, the plant densities vary from 28,000 plants per ha in the intercropped field to 111,000 plants per ha in the monocropped field. In the monocropped field, the stem density was 3-4 stems per hill. In Kalam and Chitral, where ridges and tie-ridges are used, the row-to-

row distance is between 60 to 75 cm and the plant-to-plant distance varies between 20-30 cm. Thus, at a plant-to-plant distance of 25 cm the plant density varies from 53,000 to 67,000 plants per ha.

In the Darel valley, ridges are flat, with row-to-row distance varying between 50 and 100 cm.

7.4.2.6. Weeding and earthing-up

Depending on soil moisture content, fields are irrigated once before weeding and earthing-up. Weeding and earthing-up is done about one and a half month after planting using hand-hoes (*kudals*) to form single hills in Kaghan or ridges in Kalam. No other weeding is done and no herbicides are used. In Lawari, no earthing-up is practiced and weeds are pulled by hand.

7.4.2.7. Water management

Water is usually applied as often as necessary to supplement rainfall. On the average two to four irrigations are required usually starting before earthing-up. The most critical period for supplementary irrigation seems to be after monsoon. In most areas water is abundant. Since no ridges are formed in Kaghan and Lawari, because of too much labor required, fields are flooded causing erosion. Erosion due to poor water and ridge management in Kalam has also been observed. This erosion usually leads to soil compaction and poor growth. Since most farmers in Kaghan migrate several times to their winter residences, potatoes might not always be irrigated in time. For the same reasons, many farmers do not plant cabbage which requires a lot of attention after transplanting. In Kalam, many farmers reported to delay the first irrigation to about 40 days after planting to avoid germination of weeds and compacted ridges. In many areas, too much water is applied too late.

7.4.2.8. Diseases, pests, and their control

In the Kaghan valley above Naran, the incidence of aphids is low. In Kalam, the concentration of *Myzus persicae* and especially *Macrosiphum euphorbiae* coming from wild roses is still high enough at 2300 m for insecticide spraying to be needed if seed production were to be contemplated; other aphids are also present but little is known about their virus transmission capabilities. Aphids have not been monitored in Thal but the situation is likely to be similar to that in Kalam. Thus, aphid transmitted viruses are of minor importance. Since Ultimus has been multiplied for the last twenty years in this zone without introducing new seed, yield reductions due to mechanically transmitted viruses are expected and observed. High incidence of PLRV in Desiree fields in the Ushu valley was observed in 1991, probably due to poor seed quality. Other pure stands of Desiree, where seed had reportedly come from Okara or Sahiwal, looked much healthier.

Bacterial wilt (*Pseudomonas solanacearum*) and black leg (*Erwinia carotovora* var. *atroseptica*) were commonly found but with low incidence in 1985 (Turkensteen, 1986). Bacterial wilt was more common at lower altitudes while the incidence of black leg increased with increasing altitude. It is possible that bacterial wilt was introduced with seed from the plains.

In the Kaghan valley above Naran, scab has recently become a problem. The scab incidence has also increased dramatically in Kalam valley. Common scab (*Streptomyces scabies*) and powdery scab (*Spongospora subterranea*) were identified in the Kaghan valley around Battakundi, Kaghan, and in Babusar in 1991.

The main disease is late blight (*Phytophthora infestans*) which may reduce yield by up to 50%. Its intensity varies considerably from year to year depending on the weather, and in some years losses may be small. Late blight is a danger in cool cloudy weather with frequent rains. A severe attack can be expected when leaves are wet from dew or rain for more than eight hours per day for several days, with temperature between 10 and 24°C. In the Kalam area the danger period starts late July/early August depending on the onset of rain. A severe disease attack was observed in the whole Kalam area during a survey in 1984 starting mid-August (Khan et al., 1985). In more humid areas close to rivers, in the shades of mountains, and at lower altitudes higher disease attack is to be expected (Turkensteen, 1986). In the upper Kaghan valley above Naran the disease comes too late in the season to have much effect on yield.

Early blight (*Alternaria solani*) was found in most fields in 1985, but it is expected to start too late in the season to affect yield (Turkensteen, 1986). However, early varieties in a germplasm trial at the PARC experimental station at Kaghan were severely affected by early blight which may have been at least partly due to the observed high incidence of *Verticillium* wilt. Non pathogenic secondary *Alternaria* infections often affect wilting plants.

Wilts caused by *Verticillium dahliae, Verticillium albo-atrum*, and *Fusarium solani* were widely spread in 1985. *Verticillium albo-atrum* was more common at lower altitudes in Kalam than in Kaghan. Decreasing yield of potatoes reported by farmers may have been caused by these diseases and soil depletion due to unbalanced fertilizer applications and lack of crop rotation.

The most widespread pest is cutworm. *Autographa nigrisigna* was the most common species observed in Kalam in 1989. *Agrotis* spp. were also observed in Ushu, Utror, and Gabral. Cutworms do also attack beans, maize, cucurbits, radish, and turnips which are commonly grown in the area. *Autographa* feeds on foliage while *Agrotis* spp. damage tubers.

Potato cyst nematode (PCN) is the most potentially serious pest causing yield reductions. It has only been confirmed in a 5 km stretch of the main valley upstream from Utror in Upper Swat (Khan et al., 1985). However, pest symptoms (stunted growth) and cysts have been visually observed as far as Chotta Jabba in 1991, indicating that the pest is spreading further north. It is possible that the pest is spreading with the cultivators used for preparing the fields. In the same field, the farmer reported a yield reduction of 50%. *Globodera rostochiensis* Ro1 is the main species found, but *Globodera pallida* is also present at a low concentration. In the Utror infested area potato yields have been seriously reduced and farmers are increasingly growing vegetables and maize instead. However, it was observed that farmers are reluctant to abandon the potato crop entirely. In Shay, one part of a field had been planted after three years of turnips and the other part for the first time (a house was torn down). Symptoms were clearly visible (Table 5). Part of the difference could have been the effect of better soil fertility after so many years of fallow. Desiree is more susceptible than Cardinal, but Cardinal is only resistant to Ro1 and hypersensitive to high nematode populations (Devaux and Farooq, 1988). Unconfirmed reports suggest that PCN may also be present in Battakundi. A team of CDRI (PARC) scientists has recently surveyed the area.

Table 5: Plant height and soil coverage of a mixture of Cardinal and Desiree (2:1) grown after 3 years of turnips and after at least twenty years of fallow.

Rotation	Plant height cm	Soil coverage %
20 years	75	100
3 years	60	60-70

In Kalam, especially in the Ushu valley, control of late blight by spraying Dithane M-45 is widespread after introduction by PSPDP and its production by KIDP. Weekly spraying, starting about 24 July, is recommended. Maintenance of the sprayers seems to be a problem since the credit scheme is no longer applied in the area. In the Gabral valley, Thal area and Lawari, farmers do not spray against the disease because they lack the knowledge about the disease and its control or they do not have cash to purchase fungicides.

Farmers in the nematode infested area are aware of the importance of crop rotation and of the fact that Cardinal is better suited for this area than Ultimus or Desiree. However, potatoes are so important as a cash crop that farmers still tend to grow a large percentage of their cultivated area under potatoes. They might also face difficulties in getting seed of Cardinal.

Most of the diseases and pest problems can be controlled through proper crop management (irrigation, rotation, plant protection) and use of healthy seed. Some spraying of insecticide in seed potato fields in Kaghan may be required.

7.4.2.9. Harvest

Potatoes are harvested by hand using hoes. At higher altitudes, the potatoes may not always be fully mature. Groundkeepers are also harvested. Many of the small tubers especially of the local varieties, stay in the ground.

Farmers do not grade the potatoes (Kokab, 1989). They usually fill the smaller tubers at the bottom of the bags. Bags are not weighed at the farm level.

7.4.2.10. Yield

Potato yields of 20 to 40 t/ha can be obtained by farmers using good seed, modern varieties, fertilizer, and good agronomic practices (see also Bajwa et al., 1988). However, most farmers in upper Kaghan report lower yields ranging from 5 to 20 t/ha with a mean yield of about 10 t/ha (see also Meyer, 1988). Some of the lower yields are probably due to the low plant density in Kaghan, nematode problems in Utror or insufficient plant protection against late blight in Kalam, insufficient agronomic practices in Lawari and Thal. Germplasm screening trials in small plots in Kalam showed that potential yields of up to 60 t/ha are possible (Devaux and Farooq, 1988).

Multiplication rates between 1:5 and 1:20 were reported in the Kaghan valley, Kalam tehsil, and Thal area. Ratios of 1:20 in 1989 and 1:10 in 1990 were observed for the seed produced in Darel valley. Higher multiplication rates are possible where cut seed of only 1-2 eyes/piece is used.

7.4.2.11. Post harvest handling

The nearest cold store for the Kaghan valley is located in Mansehra. But it is not operative because of low demand. There is also an inoperative cold store in Mingora. For long term storage up to 8 month (November through June) in Kaghan, potatoes are placed into pits covered with straw and soil. Few farmers in the Kalam tehsil use pit storage because of the better accessibility as compared to Kaghan (see also section 7.4.2.2.).

7.4.2.12. Marketing

Potatoes are transported from the field to the roadside by donkey, horse, human back or (in the case of Kalam) by camel. The owners of the camels come to Kalam from Sakhakot (north of Mardan) and Mardan areas (Kokab, 1989). Potatoes may be sold to traders at the roadside or taken by the farmers to the market. If trucks are not readily available potatoes are stored in rooms along the road for a few days. From the roadside the bags are collected by trucks in Upper Swat and Dir-Kohistan. In the Kaghan valley jeeps are used above Naran, and trucks at lower altitude where the road is better. In 1991, transportation charges were the highest from the upper Kaghan valley to Naran with Rs. 55/bag as compared to Rs. 18/bag from Naran to Balakot and Rs. 27/bag from Balakot to Faisalabad. The transportation costs from the different valleys in Kalam tehsil varied according to the distance but were around Rs. 1100/truck in 1989 (Kokab, 1989). Kokab (1989) found that farmers only pay transport up to Mingora because they do not directly sell to the Punjab.

In the upper Kaghan valley, about 90% of the potatoes are sold to the local shopkeeper who provides the gunny bags, organizes the transport and storage, and sells the produce to the wholesale market or directly to the farmers in the Punjab (Karasch, 1987). An estimated 75% of potatoes go directly as table potatoes to the Punjab in December and January. The remaining potatoes are stored by traders inside houses in Balakot from where they are sold as seed to traders and farmers coming from the plains in January and February. "Balakot potatoes" are mostly used as seed for spring planting. They are used by farmers who cannot afford imported seed or certified seed from the Northern Areas schemes. However, their reputation has suffered lately in the Punjab as seed of mixed varieties has been sold as Balakot seed. Around Faisalabad, there are farmers using Ultimus from Balakot, which has been multiplied once in spring, to produce an early autumn crop harvested in mid-November. Mixed seed is not suitable for such practice.

The main markets for Kalam are Mingora, Rawalpindi/Islamabad, Lahore and the other important Punjab wholesale markets. Mingora, although in the region, only accounts for about 5-10% of produce sales. Dealers from nearby places such as Peshawar, Mardan, and Sakhakot also buy at the Mingora market. Traders from Punjab buy potatoes from Kalam at the roadside outside the Mingora market by dealing without the intervention of commission agents directly with the farmers (Kokab, 1989). Potatoes are transferred to other trucks. The transfer is paid by the farmers. The transport costs from Mingora to the Punjab are paid by the traders. Farmers are usually paid in cash after the auction or after selling to the Punjabi traders.

For Thal and Lawari the main markets are Peshawar, Dir, and Mardan.

In Chitral, potatoes were not allowed to be marketed to external markets because of

possible shortage for the local population when the area is not accessible (Khan N.U. and Hussain 1989). However, this prohibition was reportedly lifted in 1990. The bulk of potatoes produced is for home consumption. However, traders buy potatoes from the valleys around Drosch and Garam Chashma.

The crop from zone 6 reaches the market during the period of least supply when most of the main cold stored autumn production in the plains is already consumed. Prices are therefore at their highest level in the year.

7.5. PRODUCTION SUPPORT PROGRAMS

PSPDP: Since 1984 the Pakistan-Swiss Potato Development Project (PSPDP) has operated in Kalam and during 1987 and 1988 in Dir-Kohistan. It has encouraged and supported an input supply/credit scheme in conjunction with the Agricultural Development Bank of Pakistan (ADBP) in Matiltan. This was extended to Ushu (Kalam area) and Thal (Dir-Kohistan) in 1988. In 1989, Motali, Dorga, and Paloga villages in Kalam participated for the first time but both schemes were discontinued because of credit repayment problems in autumn 1989. PSPDP also carried out an extensive series of research trials (fertilizer, disease control, true potato seed, germplasm screening etc.) between 1984 and 1990.

In collaboration with the district agricultural extension service and the Dir District Development Project, on-farm trials were started in Thal in 1987 and in 1988 late blight control demonstrations were started in some of the other villages of Dir-Kohistan. However, these activities were also discontinued.

KIDP: The Kalam Integrated Development Project (KIDP) started operating in the Kalam area in 1982. It has concentrated on the introduction of alternative crops which are now used widely in the area, particularly maize and turnips. In potatoes it has promoted pit storage and also the spread of late blight control by selling sprayers and encouraging local shopkeepers to stock fungicide.

Earlier the project initiated a seed production scheme in upper Gabral and produced seed of very high quality. This was abandoned due to the unwillingness of farmers to grow alternative crops and the difficulty of managing such a scheme in the face of high table potato prices. The main residual of the scheme has been the successful promotion of pit storage in the upper Gabral area.

Dir District Development Project (DDDP): This project started collaboration with PSPDP in Dir-Kohistan in 1987. It is carrying out fertilizer trials and is interested in continuing potato development in Dir-Kohistan (and in Zone 5).

Azad Kashmir: The agricultural department has a farm at Nigdar (Neelum valley) where some seed multiplication and varietal trials are carried out.

Pak-German Seed Potato Program: This project has operated in the Kaghan valley from about 1981 to 1990 with its headquarter in Abbottabad and a field station in Battakundi, Upper Kaghan.

Agricultural Research Institute (North), Mingora: This has a potato section which has conducted trials on a plot it owns in Kalam. Most of the trials have been variety evaluation. In 1989-90, research was done on the following topics (Khan, 1990): cytomorphological studies of colchicine induced mutants; effect of various levels of zinc and boron; inhibition of phellogen activities by haulm destruction; variety screening; effect of seed age; evaluation of insecticides.

7.6. CONCLUSIONS

Farmers and researchers perceive accessibility, lack of credit, and agronomic practices as the major constraints to potato production in this zone.

Roads to the remote villages in this zone are constantly being improved, thus allowing easier access to larger markets in the plains. Access is most difficult for the upper Kaghan, Ushu, Gabral valley, and Chitral. Potatoes have to be transported to the roadside by donkey, horse, human back or camel. Transport costs to the market increase because only jeeps with a low loading capacity are used in the upper Kaghan valley. Seed, fertilizer, and other inputs become more expensive due to the higher transport costs.

The most serious constraint in this zone is the lack of cash to buy inputs. This was the single most important factor for less potato production in 1991 when seed prices were high. Most farmers sell all the potatoes at the end of the season to pay back their debts for inputs and consumer items. Thus, little seed storage in pits or cold stores is practiced even though it would be technically feasible at higher altitudes. It was observed that those farmers still plant a high percentage of the cultivated area under potatoes who have access to informal credits or lack alternative crops to grow. In Kalam, traders come to the area to sell seed from the plains. At higher altitudes, maize usually does not mature or farmers are not used to grow other cash crops such as peas, turnips, or cabbage. Thus, they take the risk to grow potatoes even if seed prices are high. Farmers often receive credits for seed, but less often for fertilizer, pesticides and equipment.

In most areas, potatoes have been grown for at least twenty years gradually replacing other crops such as barley in Kaghan, and maize and buckwheat in Kalam leading to monocropping of potatoes and consequently to an accumulation of soil-borne diseases and pests. Late blight is causing heavy losses in the whole zone. In areas, where KIDP and PSPDP have being working, farmers are aware of late blight and nematodes and their control, but economic constraints and lack of adequate marketing connections for suitable alternative crops have prevented them from adopting the recommendations completely. Fertilizers are usually applied in variable quantity, type and timing. Few farmers are aware of the different nutrient content of different fertilizers and of the benefits of balanced rates. Water management in many areas could be improved by applying less water more often and using properly managed ridges.

The potential for the development of production lies in the better access to credits and/or savings to buy inputs and the concomitant adoption of improved agronomic practices through proper extension.

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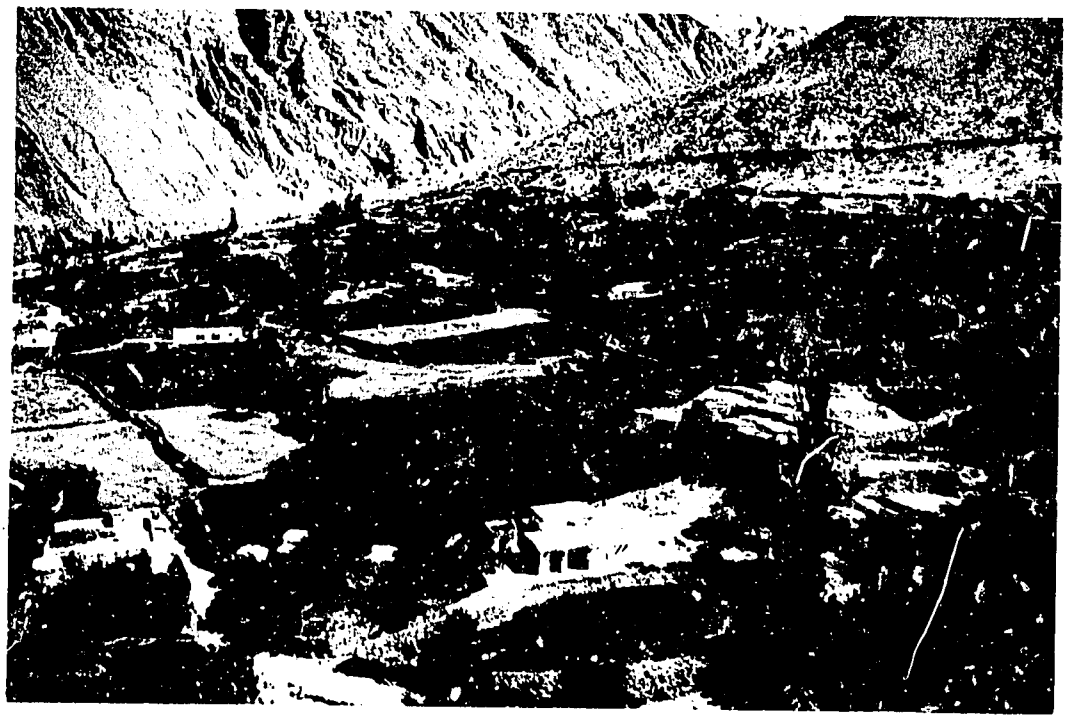
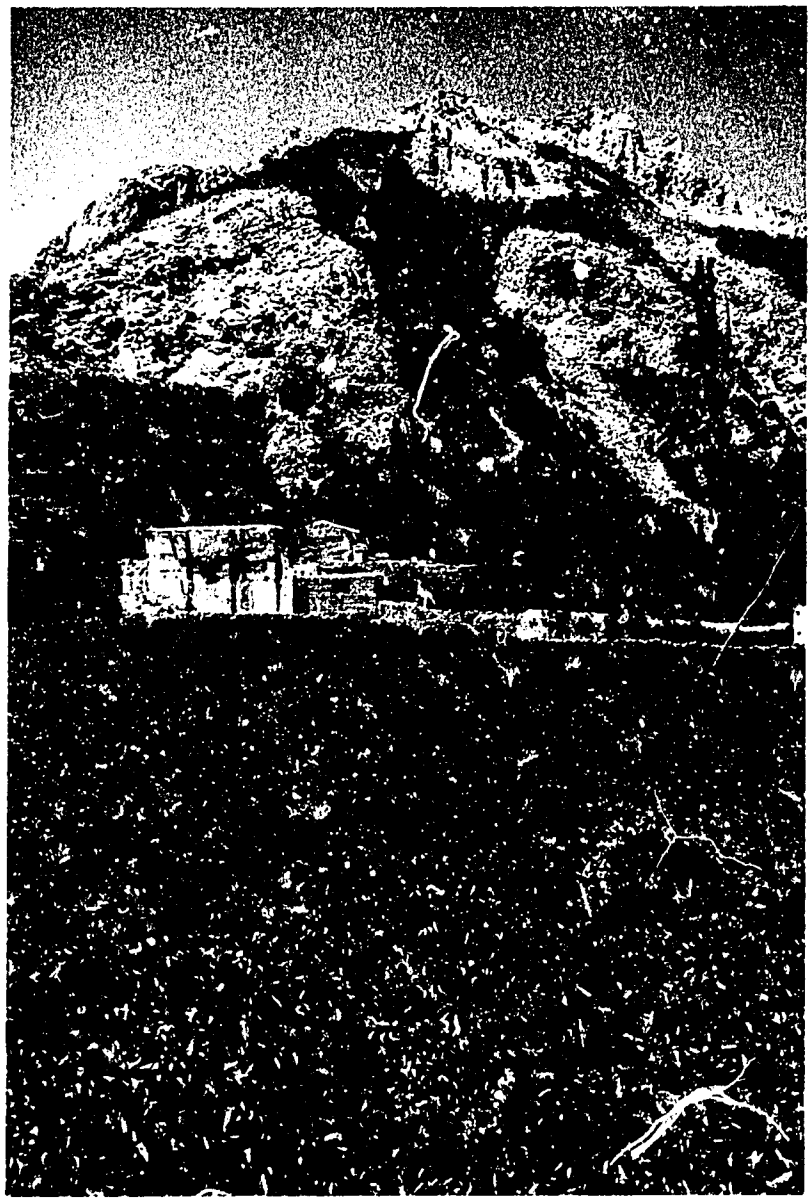
Irrigated alluvial fan, Hunza valley, Northern Areas.



Irrigated terraces with potatoes and barley, Hunza valley, Northern Areas.



Potatoes in mid-season near Khyber, Gilgit, Northern Areas.

8. ZONE 7: IRRIGATED HIGH VALLEYS OF NORTHERN AREAS AND NWFP AROUND MASTUJ

8.1. GEOGRAPHICAL COVERAGE

8.1.1. Altitude

Zone 7 covers the valleys of the Northern Areas and Chitral which range in altitude from 1500 to 3100 m (Table 1).

Table 1: Approximate altitudes (m a.s.l.) of important cities and villages in zone 7 (Saunders, 1983; Whiteman, 1985).

City/village	Altitude (m a.s.l.)
Gilgit	1500
Chitral	1500
Gupis	2150
Skardu	2200
Shigar	2250
Karimabad	2400
Yasin	2450
Passu	2500
Gulmit	2500
Ishkoman	2500
Khapalu	2600
Sust	2750
Khuda Abad	2800
Naltar	2900
Misgar	3100

8.1.2. Latitude and longitude

Zone 7 spans two degrees of latitude (35° to 37°) and three degrees of longitude (72° to 75°).

8.1.3. Topography

The potato growing areas in this zone are bowls, plateaus, and slopes enclosed by sheer walls running up to high mountains and down to the rivers below. Four main land forms exist: screes, glacial moraines, alluvial fans, and terraces (Conway et al., 1987b). The tiny irrigated potato fields lie on terraces supported by stonewalls.

The mountains and valley walls are very precipitous, thus changing the topography. Sometimes new villages are founded and old ones disappear, depending on the changing glaciers which provide the essential irrigation water.

8.1.4. Potato production areas

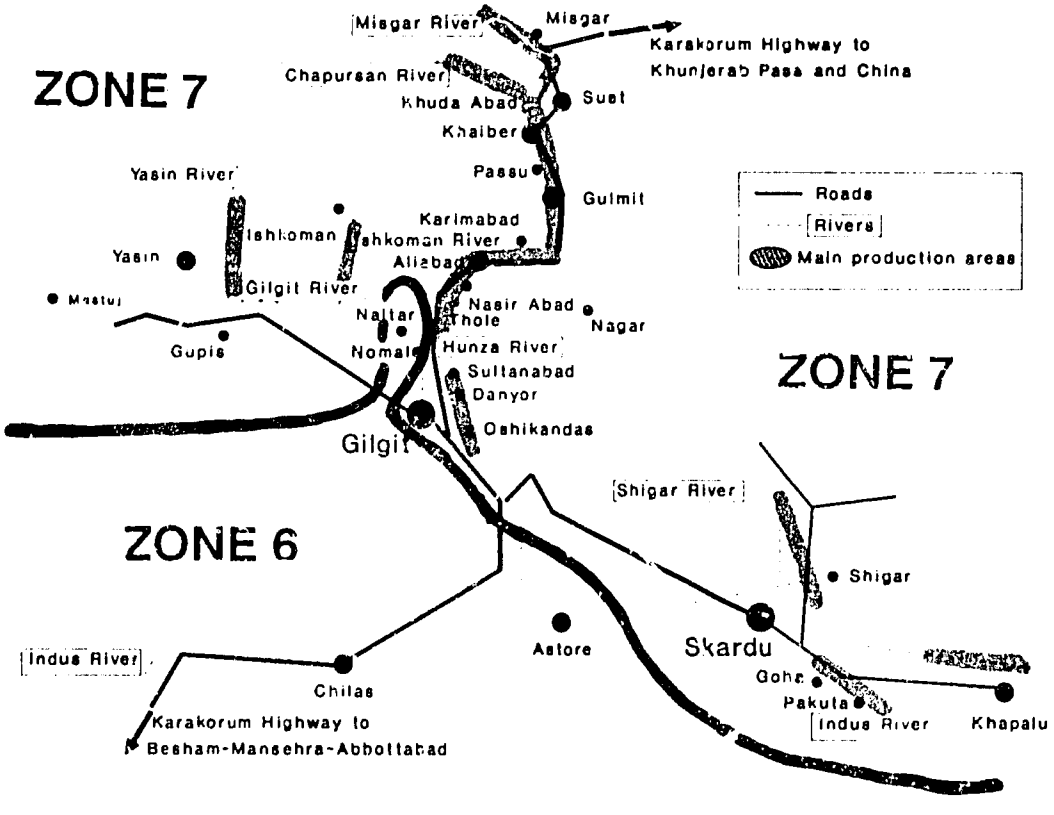
In this zone, potatoes are probably grown on the majority of farms. Until recently, nearly all potatoes were produced for subsistence consumption and for sale to local markets within Northern Areas and Chitral, using local (*desi*) varieties. Since 1984, seed schemes producing certified seed of modern varieties for sale to the plains have become important.

The major potato growing areas in the Chitral district belonging to zone 7 are around Mastuj. No seed potatoes are produced in this district, and mainly local varieties are grown.

Potatoes for sale to the local market in Gilgit are mainly produced in Danyor, Sultanabad, and Oshikandas (Fig. 1). In 1991, Jaffar Brothers Ltd. (JBL) used the Hunza villages along the Karakoram highway from Nasir Abad to Khuda Abad for seed production. The following side valleys of the Hunza and Gilgit rivers were also used for seed production: Yasin, Naltar, Nagar, Misgar, and Chapursan.

In Baltistan, some potatoes for the local market in Skardu are produced in the surrounding villages lying within a distance of approximately 50 km. In 1991, Abdul Ghafoor Bhatti Corporation (AGBC) produced seed potatoes near Shigar, Khapalu, and between Goha and Pakuta in the upper Indus valley.

Fig. 1: Main potato growing areas in Northern Areas



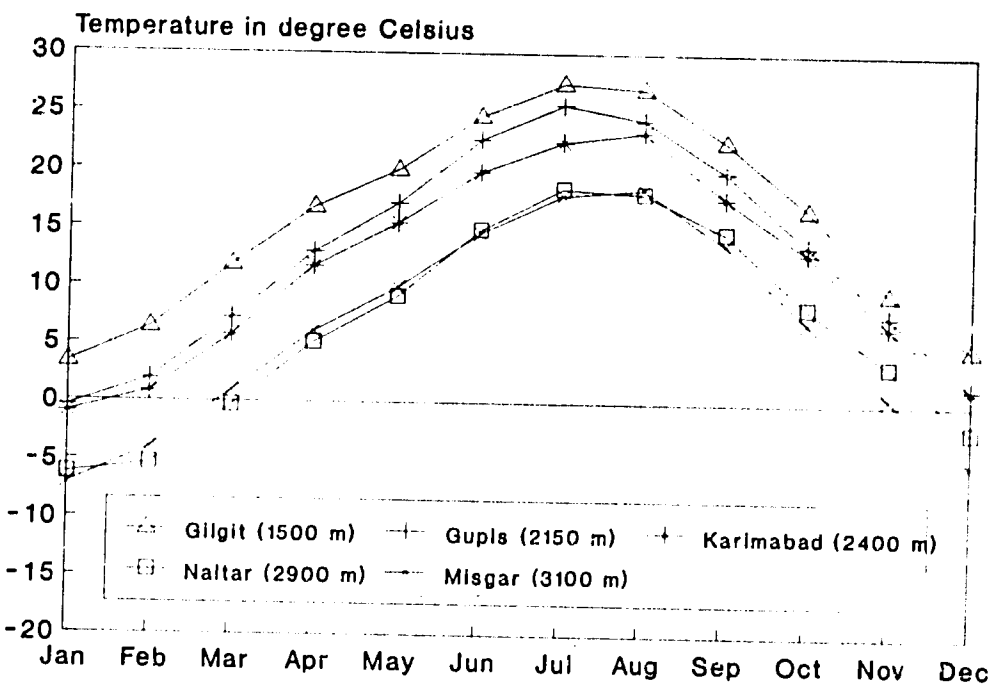
8.2. ECOLOGY

8.2.1.Temperature

The climate in this zone is a dry continental, mediterranean climate (Whiteman, 1985). However, the temperature varies locally as a function of altitude and topography. The higher the altitude the lower is the mean daily temperature (Fig. 2). The south facing villages, receive more sunshine than the north facing villages, resulting in higher temperatures.

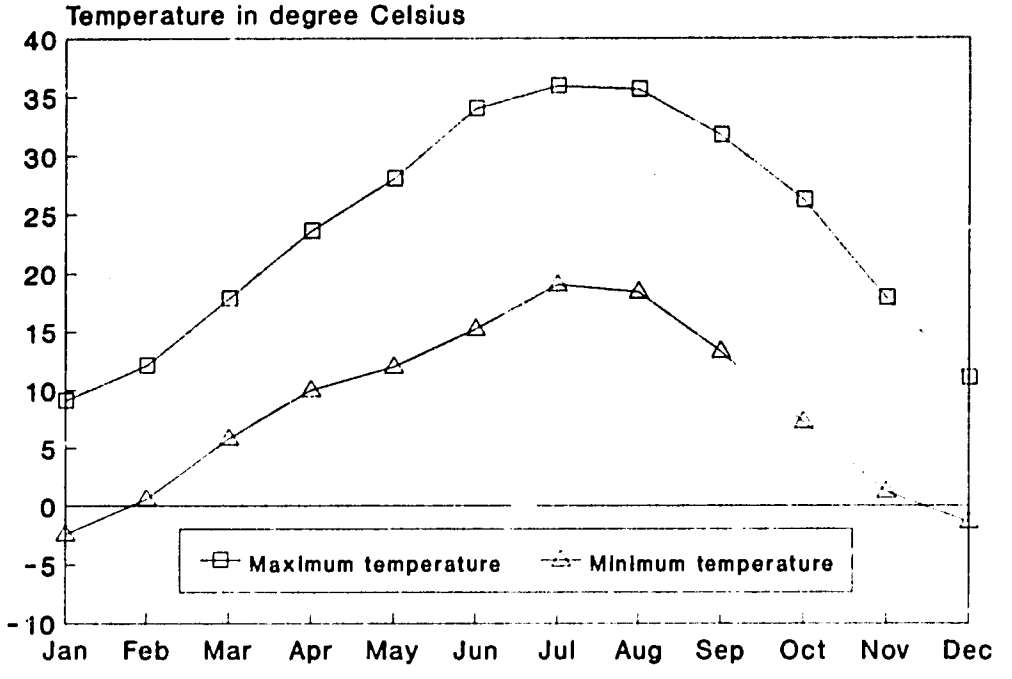
All locations in this zone display the same long time seasonal pattern of temperatures which is a function of the latitude (Fig. 2). There is a large seasonal range between the coldest and hottest month. Temperatures steeply increase in spring and even more steeply decrease in autumn. The diurnal range as expressed in the difference between minimum and maximum

Fig. 2: Monthly mean of average (max. + min.)/2 daily temperature



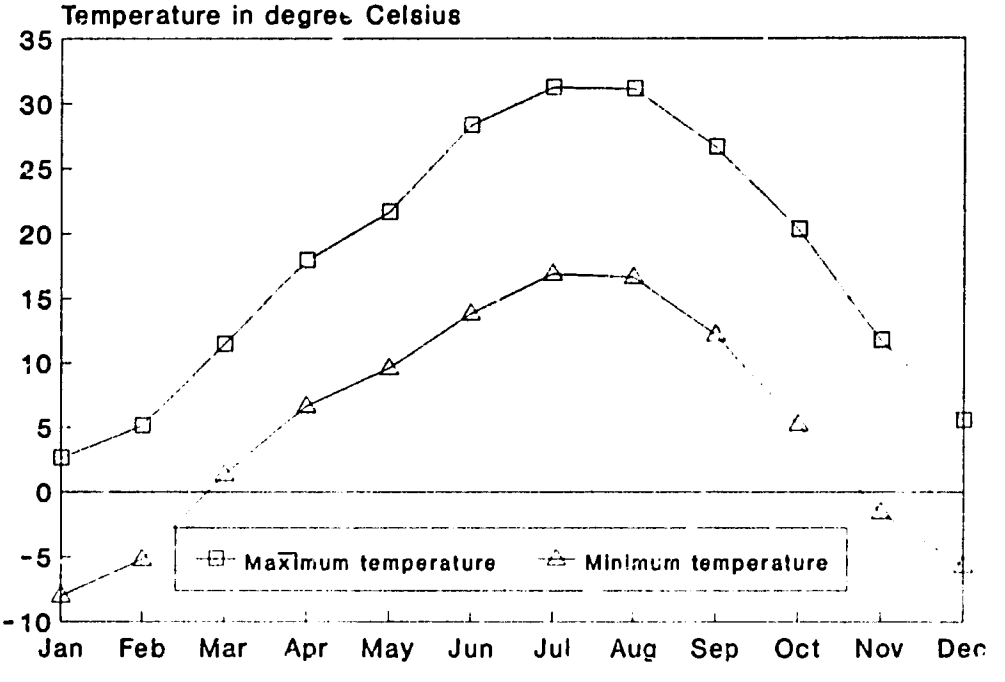
(Source: Whiteman, 1985)

Fig. 3: Mean monthly temperatures at Gilgit (zone 7)



(Source: Whiteman, 1985)

Fig. 4: Mean monthly temperatures at Skardu (zone 7)

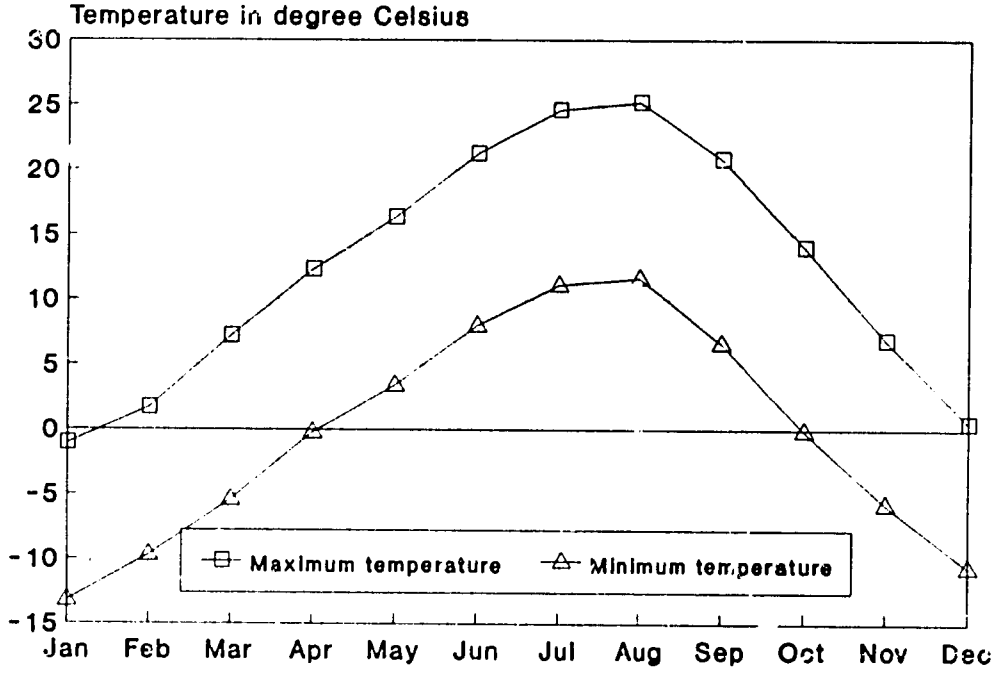


(Source: Whiteman, 1985)

temperature is large (Fig. 3, 4, and 5). Skardu has the most continental climate, i.e. hotter in summer and cooler in winter than other villages at the same altitude because of the wide, open Indus valley (Fig. 4).

The frost risk is highest from November to February in Gilgit (1500 m) and from October to April in Misgar (3100 m).

Fig. 5: Mean monthly temperatures at Misgar (zone 7)



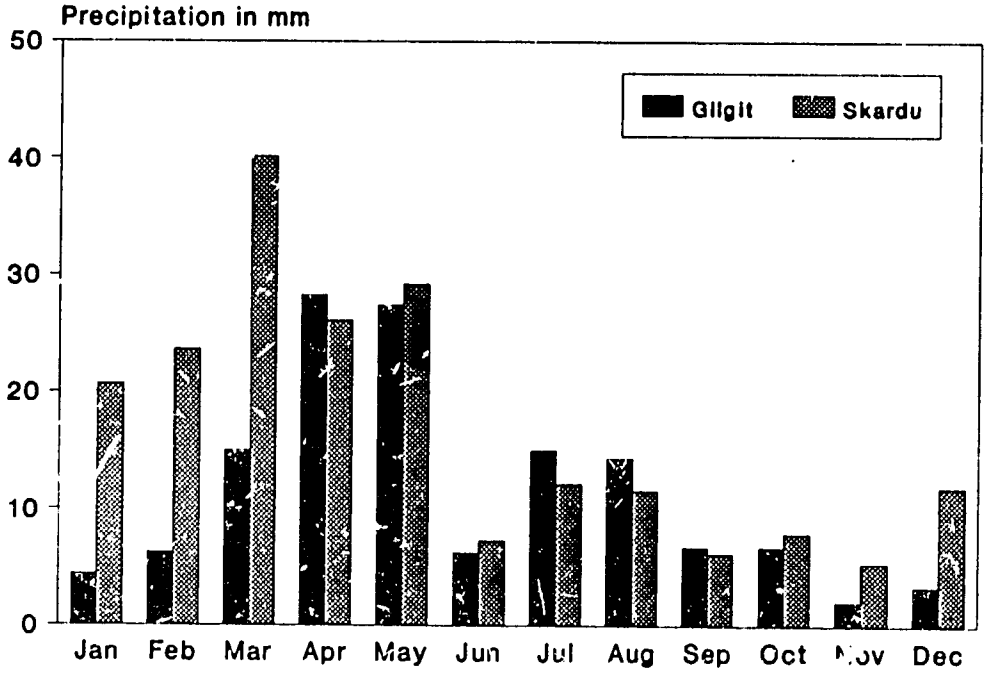
(Source: Whiteman, 1985)

8.2.2. Precipitation

The areas of zone 7 lie in the rain-shadow of the monsoon in summer and the westerly depressions in winter. Snow and rainfall are abundant at the top of the mountains but steadily decreasing towards the bottom of the valleys. There the total annual precipitation is insignificant for recharging the soil moisture reserves. At altitudes above 6000 m, the total annual precipitation (snow and rainfall) is estimated to be at least 2000 mm (Whiteman, 1985). In Gulmit at 2500 m, about 20-30 mm of snow is reported in December and about 150 mm in January and February.

All locations in this zone display the same long time seasonal pattern of rainfall even though the short term behavior may be more erratic (Fig. 6). Therefore, precipitation distribution for only a representative sample of stations in Northern Areas are presented. However, total rainfall and snowfall vary according to altitude and topography (Table 2). In general, March, April, and May are the wettest months while June, October, and November are the driest months. The winter/spring rains are far more universal compared with the more localized and erratic summer rains (Whiteman, 1985). However, any month in the year may receive less than 2 mm of rainfall.

Fig. 6: Mean monthly precipitation in zone 7



(Source: Whiteman, 1985)

Table 2: Total precipitation for different stations in Northern Areas.

Station	Number of years recorded	Altitude m a.s.l.	Total annual precipitation[1] mm
Gilgit	30	1500	132
Gupis	26	2150	133
Skardu	29	2200	202
Karimabad	9	2400	145
Yasin	3	2450	126
Misgar	17	3100	129

[1]Average of number of years recorded.

8.2.3. Irrigation infrastructure

All potato fields in this zone are irrigated through gravity-fed channels, which collect melt water from glaciers, snowfields, and springs (*nallahs*). Water availability varies depending on glacier or snowmelt, the amount and timing of snowfall, the height of the village (temperature and warming-up), and the aspect of the source, i.e. whether it is facing south or north (Whiteman, 1985). Water availability in spring is a determinant factor for the beginning of the cropping season. Some villages around Gilgit (Danyor, Sultanabad, Oshikandas) and in Central Hunza (Aliabad, Karimabad etc.) may face shortage of water in the early part of the growing season while others such as Gulmit and Khaiber have sufficient water at any month of the year.

All families have to delegate one member for construction and maintenance of the water supply channels irrespective of their holding size. Some water supply channels were built with the financial help of the Aga Khan Rural Support Program (AKRSP). Bigger villages hire one or several laborers to survey the water channels and regulate the water flow during the whole season. Each family has to contribute to the payment of this person. In 1991, the contribution ranged between Rs. 60-80/day.

Irrigation water is generally low in salts but is loaded with silt (Whiteman, 1985). Salinity is a problem in a few villages of upper Gojal and Shigar.

8.2.4. Soils

Soils in the Gilgit district are diverse due to the diversity of the mother rocks and the land form, i.e. whether they are located on screes, alluvial fans, glacial moraines, or terraces (Whiteman, 1985). They are classified as regosols (entisols). They vary in texture from loam to silty/sandy loams to loamy sands and sands and their clay content is generally below 15%. In general, the loams predominate on the lower fans and older terraces which also contain the deepest soils (Conway et al., 1987b). Gravel and stones are common in these soils.

They have organic matter below 1%, but except for nitrogen no obvious macronutrient deficiencies are reported. Turkensteen (1986) observed some zinc deficiency symptoms on apricots in Hunza. Their pH is between 7 and 8. Due to the low clay and organic matter content their cation exchange capacity (CEC) and water-holding capacity is moderate and P, and K contents are vulnerable to depletion. Their conductivity is moderately high indicating some danger for the build-up of alkaline salts.

Irrigation water carries silt thus contributing to soil formation but also to soil compaction in pre-irrigated tractor-ploughed fields.

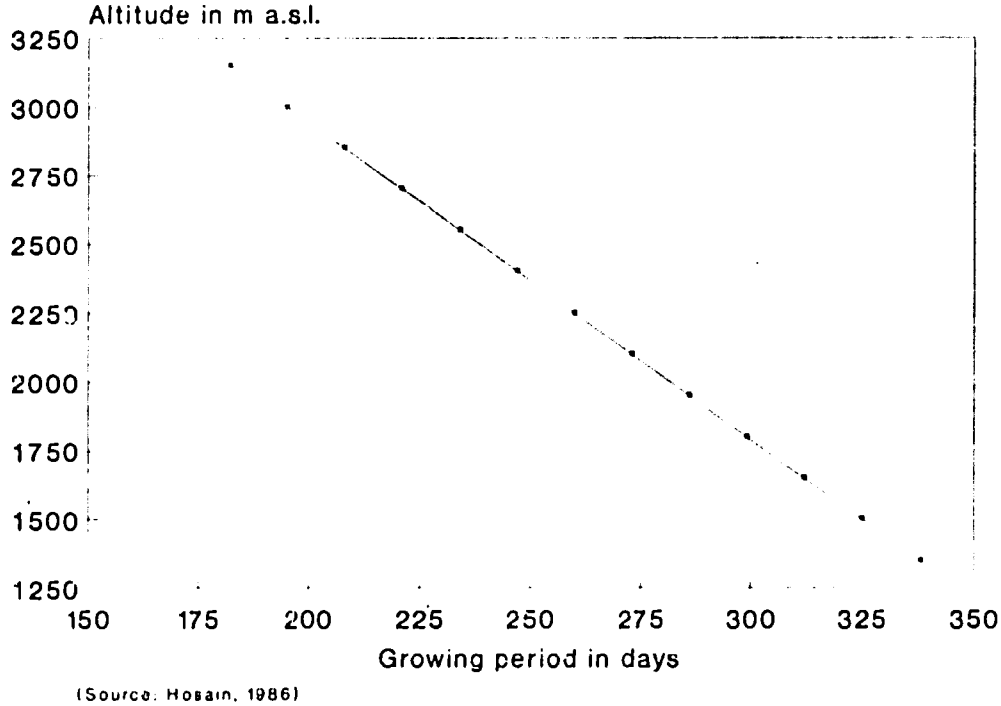
No information is available about the soils in Chitral. The soils in Skardu are similar to Hunza, but in the wide open valleys of Skardu and Shigar, salt accumulation is sometimes higher.

8.2.5. Cropping season

The length of the cropping season and the planting and harvest dates in this zone are basically a function of the temperature and thus of the altitude because all the land is irrigated

(Fig. 7). In areas below 1800 m, two subsequent crops are possible (Whiteman, 1985). Between 1800 and 2300 m, two crops may be grown depending on the year and the growing period of the crops (transitional zone). Above 2300 m only one crop is grown. The limits between one and two cropping seasons vary locally depending on the topography. The habit of free grazing may also limit the cropping season. Planting and harvest dates for potatoes vary as a function of altitude (Fig. 8). Around Gilgit (1500 m), two growing periods from February to end of June and from July to October are theoretically possible, but no farmer have been found to actually grow a second crop because they prefer other vegetables.

Fig. 7: Growing period (mean temperature above 5 degree C) as a function of altitude in Gilgit district (zone 7)



(Source: Hosain, 1986)

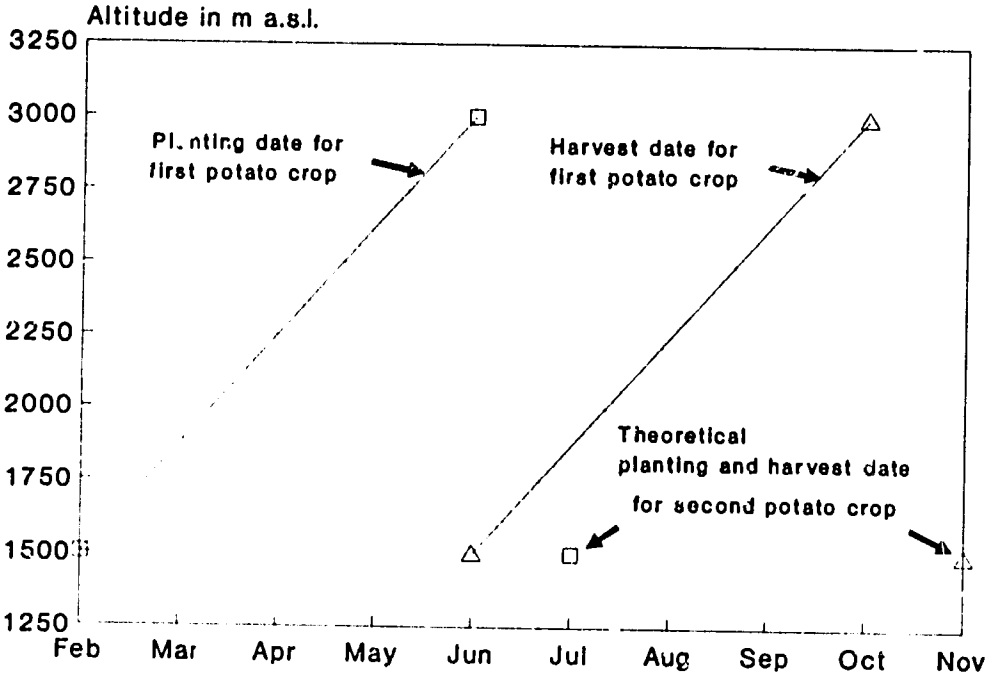
Planting of the crops can be delayed due to low temperatures and non availability of water and the harvest is fixed by frost. Timing of cultivation, planting and irrigation become critical because of the steep increase of the temperature in spring.

8.3. PRODUCTION FACTORS

8.3.1. Farm size

The majority of the farms in this zone are smaller than 5 ha. Saunders (1983) concluded that the average irrigated area per household in Gilgit district varies between 0.75 and 1 ha in double crop areas and between 1.5 and 2 ha in single crop areas. The author explained the larger farm size in single crop areas by the need for growing more hectares of staple food to meet the self-sufficiency requirements. He further concluded that land distribution was quite equitable with only a few families owning large holdings.

Fig. 8: Planting and harvest dates as a function of altitude



The average farm size in Baltistan seems to be about the same. Habib (1989) reported an average farm size of 1.3 ha in Mastuj.

In addition to the irrigated land, the villages own mountain pastures above the *nallahs*, at 3000-5000 m altitude for summer feeding of the cattle. Some pastures are the property of individuals, others belong to tribes, but most are the common property of all the villagers (Saunders, 1983). However, each farmer has only as many animals as he can feed through the winter, i.e. according to his irrigated landholding and access to pastures at the valley bottoms below the *nallahs*.

The average farm size decreases over time. The farm is equally divided among the sons. In some villages, additional land can be reclaimed after the construction of new water channels, but this is not sufficient to keep pace with the growing population. In this case, each family receives an equal share of the new land independent of the family and farm size.

8.3.2. Land tenure

Almost all households in the Northern Areas and Chitral own their land (Saunders, 1983). After the dissolution of the local "kingdoms", property reverted to the occupants. Farms are generally too small to allow development of tenancy systems. Some farmers may rent land for cash as indicated by one farmer in Yasin. Those farmers who are engaged in off-farm activities such as teaching, shop-keeping, tourist guidance, may rent out their land to other family members.

8.3.3. Labor

Most of the work on the farms is done by the family itself. Neighbors and relatives may help in peak times. Some better-off farmers may hire additional labor which usually is paid in cash (Rs. 40-50/day) but which is not easily available in these areas. Laborers for controlling the water channels are also hired by the bigger villages. In smaller villages, this job is done by farmers who take turns.

Women bear a major burden of the farm work (Artech-Elsayed, 1987). Ploughing is done by men. Planting and harvesting are done together. Weeding is done only by women. Women are responsible for the vegetable production for home use. Most men and some women have some off-farm employment (soldiers, tourist guides, teachers, government employees hotel staff, small transporters). The level of education is high in Hunza.

Most farmers and their wives have many years of experience growing the local (*desi*) potatoes. Potato seed production was introduced into Hunza in 1984 and into Skardu in 1988. Thus, experience in growing seed potatoes is limited.

8.3.4. Credit

The seed companies (JBL and AGBC) provide farmers with potato seed, fertilizer, and pesticides at no initial cost. In this case, the farmer has to pay for the inputs once he delivers the seed to the company.

AKRSP provides loans and grants for physical infrastructure projects and agricultural inputs such as seed and fertilizers (Conway et al., 1987a). These grants and loans are provided through village organizations i.e. broad-based non-governmental organization (NGO's).

8.4. FARMING PRACTICES

8.4.1. Cropping pattern

In general, the cropping pattern vary little between villages of similar altitude and within villages, reflecting the overriding consideration of producing staple cereals and fodder on limited land.

A wide range of crops could be grown by choosing the correct altitude (Whiteman, 1985). The major cereal crops are wheat, barley and maize. In the double crop areas maize usually follows wheat as a second crop. At higher altitudes, wheat is sometimes planted in November or barley replaces wheat as the first crop to allow a second crop of maize, buckwheat, or short season vegetables. The wheat planted in November usually does not emerge until spring, thus problems with free grazing are avoided, but can be harvested 10 to 15 days earlier than spring sown wheat. Above 1800 m, for example in Yasin valley, maize becomes an important single crop after winter/spring fallow. In Nomal, rice is planted as a single crop.

In the single crop areas, wheat is preferably grown at lower altitudes and barley or maize at higher altitudes. In Skardu, for example, 30% of wheat and 70% of barley is grown in villages at an altitude of 2200 m while only barley is grown at altitudes above 2600 m. In Chitral, maize is more important than barley while in Upper Hunza maize is grown only as fodder after barley.

Broad beans (*Vicia faba*) are grown as a single crop or mixed with wheat in Upper Hunza (for example Passu) and the Yasin valley. Fodder crops such as alfalfa and clover are important for making hay for winter feeding. In general, alfalfa is planted into maize, cut for the first time in November/December, and lasts for 5 to 10 years. Alfalfa is also planted on steep slopes or on newly reclaimed land where no other crops can grow. Clover is planted into wheat, cut for the first time in April and lasts only one year. In some areas, for example Nomal, maize is planted as a second crop after clover (Saunders, 1983).

Fruit trees are particularly important and also trees grown for timber and fodder. Vegetables are widely grown for home consumption in villages distant to the markets of Gilgit, Skardu, and Chitral. In villages close to those markets, vegetables are also grown on a commercial basis.

Potato is the most important vegetable. In the double crop area, a short season crop may be grown before but most often after the potatoes. Farmers in this zone keep between 50 to 100 kg of potatoes per person per eight months for home consumption. If 10 persons live in a household, 1 kanal (0.05 ha) of potatoes has to be grown at an expected yield of 20 t/ha. People in Hunza eat more potatoes than in other regions of the Northern Areas. Since its introduction in 1900, potato never became an important crop until the introduction of the seed schemes, because cereal straw is needed for fodder. In seed scheme villages, potatoes occupy up to 25% of the cropped area. Potatoes grown for seed are often concentrated near the access roads. In villages where some fields are without road access, more potatoes are grown in the ones with access, thus increasing the percentage of cropped area under potatoes.

In the lower areas of Chitral, potatoes are grown as vegetables in small mixed plots or more commonly on the bunds between irrigated plots of rice or other cereals. At higher altitude, large plots of potatoes become apparent.

In newly reclaimed land, poplar trees are planted first, followed by alfalfa, wheat, barley, and finally potatoes. On flat land where the soil is more fertile, cultivation can start at once.

In the double cropping area, wheat and maize are grown every year except in villages where vegetables are produced on a commercial basis, thus enriching the crop rotation. In single crop areas, particularly where seed potatoes are produced, 2 to 4 year rotations are practiced. Seed companies put emphasis on crop rotation to avoid accumulation of soil-borne diseases. In vegetable gardens, potatoes are usually intercropped with other vegetables.

Goats, sheep and cattle (small cows, yak) are kept as livestock and graze the high pastures in summer. Fodder production for winter is an important function of the farming system. In winter, livestock are stall fed at night and their farm yard manure (FYM) is essential to the maintenance of soil fertility and structure. One or two cows per household are also kept in stall during the summer to supply milk.

8.4.2. Potato production

8.4.2.1. Varieties

Local (*desi*) potatoes are derived from varieties introduced many years ago and from more recent introductions (Ultimus for example). The first introductions to Northern Areas were made about 1900 (Whiteman, 1985). They display different tuber colors (rose color in Hunza, white color in Chitral), are generally riddled with virus of the contact transmitted type such as virus X, are said to taste well, and have exceptional storage properties. However, farmers have become used to the taste of new varieties and to their higher yields, so that the importance of the local varieties is steadily decreasing, especially in the seed multiplication areas or in villages with good road access (Central Hunza) growing potatoes as a cash crop (Bajwa, 1989). In 1990, few fields of local varieties were found in Hunza. In Yasin, at least four local varieties different from those grown in Hunza and Chitral have been observed in 1990. One of the local varieties seems to be a degenerate form of Ultimus (Whiteman, 1985).

Modern red and white varieties (mainly Desiree, Cardinal, Ultimus, Diamant) have been introduced to the Northern Areas through the FAO/UNDP project and private seed companies.

Red varieties are preferred in the local market in Gilgit, but white varieties are also sold.

8.4.2.2. Seed sources

Desi varieties are stored in pits over the winter (Fig. 9). Stored seed is used for planting the next crop. Farmers in lower villages replenish their seed from higher villages. In this way, local varieties have been multiplied for decades.

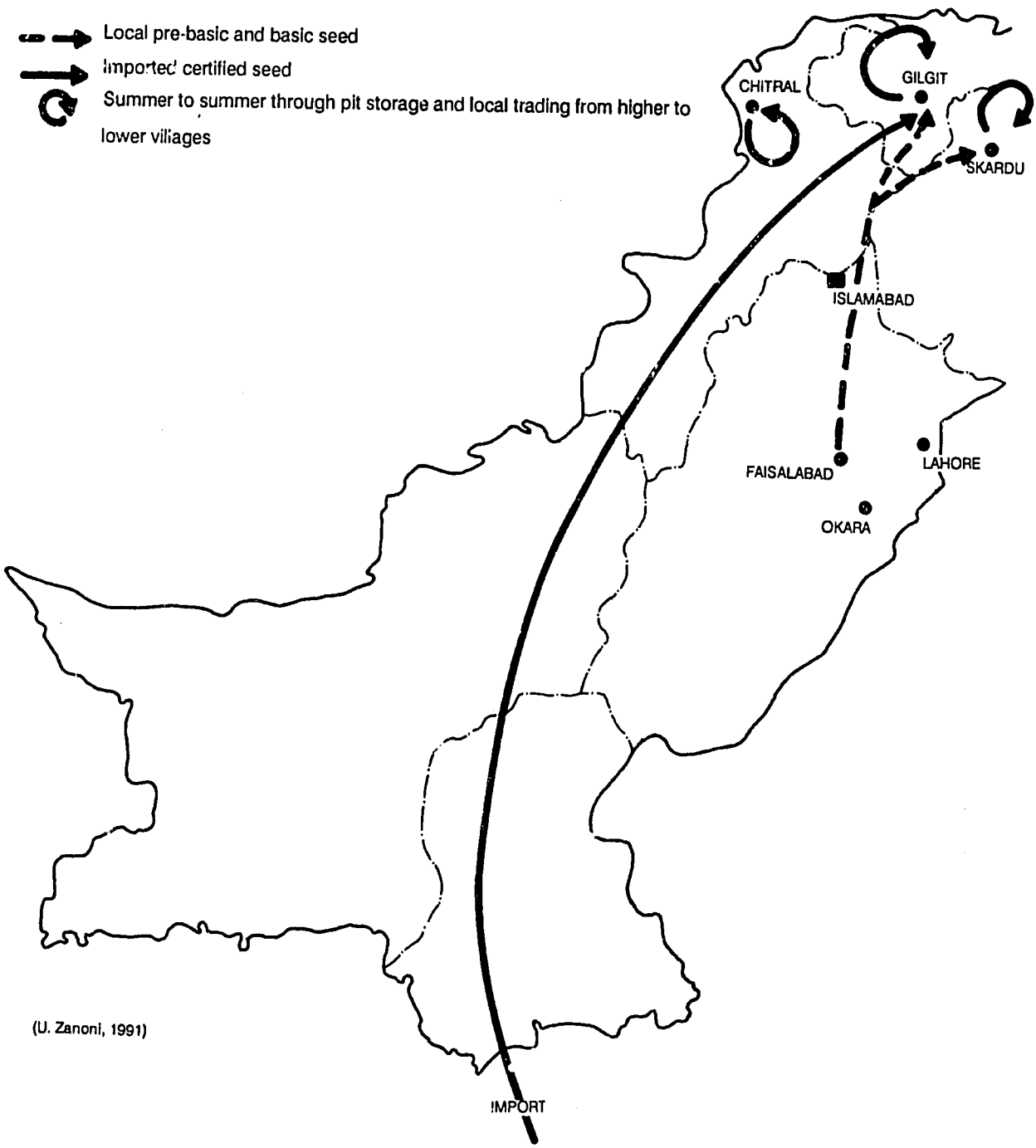
Seed of improved varieties for seed production have been brought until now to the Northern Areas every year. Seed is only exceptionally stored in the area. However, FAO and PSPDP have undertaken efforts to construct adapted seed stores in the Northern Areas so that basic and pre-basic seed could be stored locally. Initial seed stock is from imports of basic seed or plantlets or tuberlets from tissue culture. This is multiplied two to three times with the produce of the third multiplication sold as certified seed to farmers in the Punjab plains. Due to insufficient seed from the earlier multiplications, this system had to be supplemented in 1988 and 1989 by one of direct production of certified seed from imported certified seed.

Many farmers use seed from improved varieties for the production of table potatoes. In that case, seed is bought from farmers in the seed producing villages or from the vegetable markets. Sometimes seed is bought in autumn and stored in pits. In Chitral, own retained seed is used.

8.4.2.3. Land preparation

In fields close to the road and if a tractor is available and affordable, primary tillage is done with spring tine cultivators. Bullocks and a wooden plough are still extensively used. One pair of bullocks needs about 10 days to plough one hectare (Whiteman, 1985). In general, fields are ploughed only twice, once before applying the FYM and once after. No wooden beam

Fig. 9: Main seed sources for zone 7



(U. Zanoni, 1991)

(*sohaga*) is required for planking. Some farmers pull a bundle of wooden branches or thorns over the field after tillage to preserve soil moisture.

8.4.2.4. Fertilizer

In general, farmers apply 1 to 2 bags (20-25 kg) of nitrophosphate (N:P=23:23) per 1 bag (50 kg) of potatoes planted as recommended by the seed company. No chemical fertilizer is used for the traditional production. At a seed rate of 2 bags of seed per kanal, i.e. 2 t/ha, between 230 and 460 kg of nitrogen and phosphorous would be applied per hectare. Farmers in Yasin planted 4 to 6 bags of potato seed per kanal, i.e. 4-6 t/ha. Thus, the dose of fertilizer applied would be 2 to three times higher than the recommended dose. No potassium and no micronutrients are applied.

Some farmers also use urea instead of nitrophosphate. In Gojal, ridges are partially broken down before earthing-up and the second dose of fertilizer is sidedressed. As a consequence, severe burning of the potato plants has been observed when using urea. In other areas, urea is mixed with the soil in the furrows and the field is irrigated shortly afterwards to avoid burning.

In addition, FYM is applied by all farmers. Farmers use their own FYM, and no exact measure of the amount applied is available. It is estimated that about 40 t/ha are applied.

In general, FYM is applied before planting and the chemical fertilizer before earthing-up. In the traditional *desi* cultivation system, FYM is also applied before earthing-up. Whenever chemical fertilizer is difficult to obtain or when the farmer cannot afford to buy it, FYM is applied the same way as in the *desi* cultivation system.

8.4.2.5. Planting

The furrows are marked with a shovel and the seed potatoes are placed on preformed ridges. Big tubers are cut and small tubers are planted as a whole. In the old *desi* cultivation system, farmers used to plant only the eyes to eat the leftover tubers. Most farmers use a seed rate of about 2 t/ha. Some seed potato fields in the Yasin valley have been planted at a rate of 6 to 7 t/ha in 1991, because farmers seem to overestimate the area under potatoes. As a result, densities of 42 stems per m^2 were counted. One farmer reportedly had planted 3 kanals (0.15 ha) of Ultimus, but measuring the field resulted in about 1 kanal (0.05 ha).

Row-to-row distance varies from 60 to 110 cm. The narrow row spacing was observed in seed potato fields in Yasin and the wider spacing in Skardu. Plant-to-plant spacing varies from 10 to 30 cm, the narrow spacing being used in seed production. Thus, at a plant-to-plant intra-row distance of 15 cm the plant density varies from 61,000 to 111,000 plants per ha. Some farmers, for example in Skardu and Yasin, plant their potatoes quite shallow. In the *desi* cultivation system, row-to-row and plant-to-plant spacing was very variable. However, farmers are now adopting the seed production techniques for producing table potatoes.

The FAO/UNDP project is promoting some different methods for planting. Potatoes are placed on the flat ground and ridges are made longer without tie-ridges. Even distribution of irrigation water becomes more difficult and potatoes are buried 18 to 20 cm deep after earthing-up.

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8.4.2.6. Weeding and earthing-up

Earthing-up is done about one and a half months after planting, using shovels or hand-hoes. In Hunza, potatoes are weeded twice before earthing-up and the weeds are used for fodder. At the second weeding, ridges are partially broken down to weed as much of the furrows as possible. Some of the stolons and tubers may be cut. If required, the potatoes are weeded a third and a fourth time. In other areas, potatoes are weeded only once. No herbicides are used.

8.4.2.7. Water management

Water is usually applied as often as necessary in villages where no water shortage occurs. Since there is not much rainfall in the area and the water holding capacity of the soils is limited, frequent irrigation is required (4 to 5 days interval). If water supply is limited, the interval has to be extended. The interval of water allocation may be as long as 20 days, as for example in Hindi (Saunders, 1983). Farmers reported starting irrigating 10 to 15 days after planting and stop irrigating 10 days after haulm killing. In Yasin, farmers start irrigating 2 days after planting.

8.4.2.8. Diseases, pests, and their control

The Upper Hunza district is a region with relatively few disease problems due to the low humidity, low precipitation, and high altitude (Turkensteen, 1986).

Old *desi* varieties are generally riddled with mechanically transmitted viruses. They are transmitted through the widespread practice of seed cutting, by cultural practices and by plant-to-plant contacts. PVX, PVS, mild PVY and PLRV are the most common virus diseases in the area. The rate of degeneration is generally low.

Late blight (*Phytophthora infestans*) and early blight (*Alternaria solani*) were not present in a survey in 1985 (Turkensteen, 1986), and have not been observed so far. This constitutes one major difference between zones 6 and 7.

The most common diseases were *Verticillium* wilts (*Verticillium dahliae* and *Verticillium albo-atrum*). Expression and severity of symptoms depended on plant age, soil type, and field management practices. Excessive or irregular irrigation, also due to low ridges or improperly levelled fields, and irrigation with cold water in full sun light could have been the main reasons for the occurrence of the diseases. One sample infected with bacterial wilt was observed in 1985 at altitudes below 2300 m, suggesting that the risk to infect seed lots with this disease increases at lower altitudes.

Common scab (*Streptomyces scabies*) and powdery scab (*Spongospora subterranea*) were identified in the Hunza area in 1991.

Aphids have difficulties to survive the winter in the parthenogenetic cycle at altitudes below 2000 m. Free grazing by large flocks of goats and sheep leaves the land barren of green vegetation. However, aphids do survive in the egg stage on their woody primary hosts in the higher valleys. They attack the vegetable crops in mid-July. The most common species

observed in the potato crop are:

- *Myzus persicae* coming from *Prunus* spp.
- *Brachycaudus helichrysi* from *Prunus* spp.
- *Macrosiphum euphorbiae* from *Rosa* spp.

The transmission of virus diseases to the seed potato crop can be reduced if crop is sprayed at least once in July and if haulms are destroyed in early August. The virus-riddled local varieties have now almost disappeared from the seed producing areas, which has contributed to the elimination of the most important virus source from the area.

Leafhopper damage (hopperburn) was important in fields below 2300 m in 1985. Leafhoppers were also seen in Thole (Lower Hunza) in 1991.

In 1991, cutworms (*Agrotis* spp.) were a big problem in late planted seed production fields in Upper Hunza. Cutworms are also a problem in Chitral.

One pest mainly posing problems to the seed schemes is the European vegetable lygus bug (*Exolygus rugulipennis*) causing extensive brittling and crinkling of leaves in sun exposed fields. This reduces the efficiency of field workers when virus infected plants are to be rogued out. The first damages become apparent by the end of June. The pest can be easily controlled by spraying insecticides. The local seed multiplication companies are assisting the farmers with the supply of Sevin WP.

In 1987, up to 5% of tubers in some seed potato fields were damaged by wireworms (*Elateridae* spp.) and white grubs (*Melolontha fuscipennis*). The farmers are aware of the large grubs of *Melolontha* and destroy them during land preparation and earthing-up.

Considerable loss due to sunburn of tubers was observed in 1987 because of shallow ridges and improper storage after harvest. Cut and bruised tubers were also common because of the use of shovels for harvesting.

Most of the disease and pest problems can be controlled through proper crop management and use of healthy seed. Some spraying of insecticide in seed potato fields may be required for the control of bugs and aphids.

8.4.2.9. Harvest

In the seed potato fields, the haulms are cut near the soil level about 15 days before harvest. The vines are dried and fed to animals. Potatoes are harvested by hand, using shovels.

Seed size tubers are separated from small and oversized tubers and delivered to the seed company. Some farmers also sell the under and oversized potatoes to the seed company.

Early harvested seed potatoes can be directly transferred to the Punjab to start autumn-to-autumn seed multiplication (Devaux, 1988).

8.4.2.10. Yield

Potato yields of over 40 t/ha can be obtained by farmers using good seed, commercial varieties, fertilizer, and good agronomic practices. Whiteman (1985) reported high yields of 85 t/ha in field trials in Yasin and bulking rates of 1 t/ha/day. Tuber initiation starts after one and a half to two months depending on the planting date. One farmer in Danyor (near Gilgit) harvested 35 t/ha of Desiree in 1991 even though the crop could not be irrigated until the end of May. High radiation and moderate temperatures may be determining factors for the high yield potential of potatoes.

Desi varieties are usually less productive owing to the high infestation of viruses and the less intensive cultivation.

Multiplication rates of 1:30 in modern varieties and 1:7 in *desi* varieties are reported.

8.4.2.11. Post harvest handling

Except for one small insulated store in Khaiber no cold storage is available. For long term storage up to 8 month (November through June) potatoes are placed into pits and covered with straw and soil (Artech-Elsayed, 1987). At 2400 m tubers must be buried at least 60 cm deep to avoid frost damage. For short term storage, potatoes are placed into wooden boxes, in bags or on heaps inside the house. Below 2200 m, potatoes cannot be stored in pits because of high temperatures.

8.4.2.12. Marketing

Before the Karakoram Highway was built and before the onset of seed production, most villages produced potatoes only for their own consumption and for trading within short distances. Areas close to the markets in Gilgit, Skardu, and Chitral still produce most of the table potatoes for these markets. Nowadays, Hunza is better accessible and traders from Lahore, Peshawar, Rawalpindi, Hazro and other places come to buy potatoes from the farmers or the farmers go themselves to the distant markets. In years of glut such as in 1989 however, potatoes are difficult to sell in the distant markets because of the higher transport costs (Deomampo, 1989). In that case, farmers feed potatoes to their animals, and more potatoes are used for own consumption. There is only a limited market potential in Gilgit. One farmer in Danyor who was growing plenty of vegetables reported that he had no problems selling his potatoes at a good price because he marketed his potatoes along with other vegetables.

In Chitral, potatoes were not allowed to be marketed to external markets because of possible shortage for the local population when the area was not accessible (Khan and Hussain 1989). However, this prohibition was lifted in 1990. The access to areas such as Yasin and Ishkoman is still very difficult, increasing transport costs to the market in Gilgit.

Seed produced in Hunza and Skardu is directly handed over to the seed companies which transport, store and market it. Growing seed potatoes in the Northern Areas is highly profitable (Deomampo, 1989). Profitability is affected by the price of seeds used, sales price of seed potatoes and table potatoes, and yield.

8.5. PRODUCTION SUPPORT PROGRAMS

Aga Khan Rural Support Program (AKRSP): This has been operating in Gilgit and Hunza since approximately 1983. In about 1987 it was extended to Baltistan and Chitral. It therefore covers the whole of zone 7. It is at heart a community development project which fosters village committees and supports projects chosen by the villages. It has had some minor involvement in the organization of growers in the JBL seed scheme in Hunza. AKRSP has been actively involved in the distribution of trial seed of modern varieties into the *desi* growing areas over the last 5 years. In 1989, PSPDP supplied a small quantity of improved seed to AKRSP Chitral for trial purposes.

Northern Areas Seed Potato Project: This Northern Areas Agricultural Department Project is supported by FAO and is the follow-on to the earlier Northern Areas Integrated Rural Development Project. It became operational in 1987/88. It gives technical support on the production side to the JBL seed scheme and has constructed a store in Khaiber.

Pakistan-Swiss Potato Development Project (PSPDP): This project has been working in Gilgit and Hunza since 1985, helping to fill the gap between the end of the FAO supported Integrated Rural Development Project, which started the seed scheme, and the effective start of the FAO supported Northern Areas Seed Potato Project. From 1989 onwards PSPDP's direct involvement has diminished and is now concerned primarily with the relation of the seed projects to the rest of the potato sector. However, it has continued to support the private seed companies' efforts, particularly with technical and marketing back-up and with operational planning. PSPDP will also in future assist AKRSP in Chitral to upgrade potato quality in the area and will provide technical advice.

Jaffar Brother (Private) Ltd., (JBL): This company started the Hunza seed scheme in 1984 in conjunction with the earlier FAO project. The scheme is becoming more established, producing around 700 tons annually in the early 1990s.

Abdul Ghafoor Bhatti Corporation (AGBC): Dr. G. Bhatti is the former consultant who managed JBL's scheme until 1987. In 1988 he started his own seed schemes in the Astore valley and Skardu. He is now concentrating on developing his activities in Skardu.

8.6. CONCLUSIONS

Farmers and researchers perceive climatic conditions, accessibility, and agronomic practices as the major constraints to potato production in this zone.

The dry continental climate causes the potato production to be dependent on sufficient irrigation water. Some villages face water shortages in spring, thus causing delayed planting. Steep increases and decreases of the temperature at the beginning and the end of the season require good timing of planting, cultivation, irrigation, and harvest.

Very few production areas have an easy access to major markets for potatoes. Local markets in Chitral, Gilgit, and Skardu have only limited demand for potatoes which can be satisfied by a couple of farmers in their surroundings. Access to the Northern Areas and Chitral

is hampered by poor infrastructure, land slides and long distances. Chitral is especially difficult to access in winter. Seed, fertilizer, and other inputs may not arrive in time, thus delaying necessary farming operations.

Most farmers and their wives have a long tradition in growing local potatoes on a small scale in their vegetable plots, usually intercropped with other vegetables. Through the introduction of seed schemes to the Hunza and Skardu area, new agronomic practices have been transferred to the farmers. Most farmers still lack the experience and training using these practices to obtain acceptable yields. However, they are willing and open-minded to accept advice and training from the seed industry since potatoes have caused a substantial increase of their income. In fact in some villages, the advent of seed potato production has had a major positive impact on their welfare.

The potential for the development of production lies in the improved availability of irrigation water through the construction of additional channels, in the better i.e. timely organization of input supplies and marketing, and in the adoption of improved agronomic practices through better training of the seed producers.

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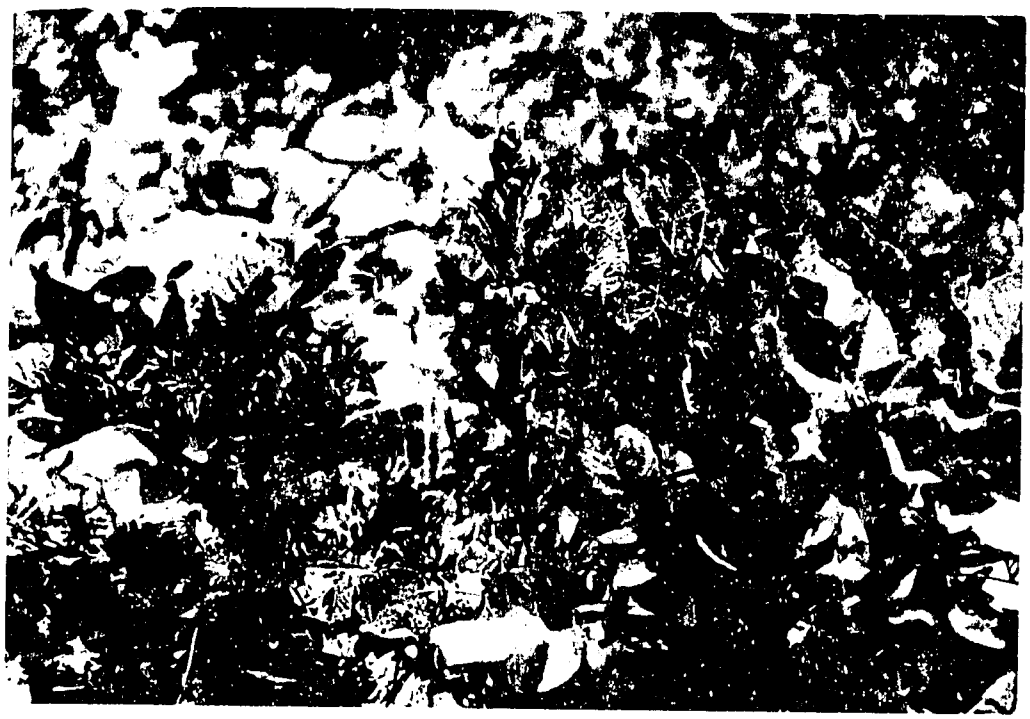

Orobanchae is a important parasitic weed in some areas of Balochistan.

Potatoes are often intercropped in young fruit orchards, and serve as a intermediate cash earner before the orchards bear fruits.

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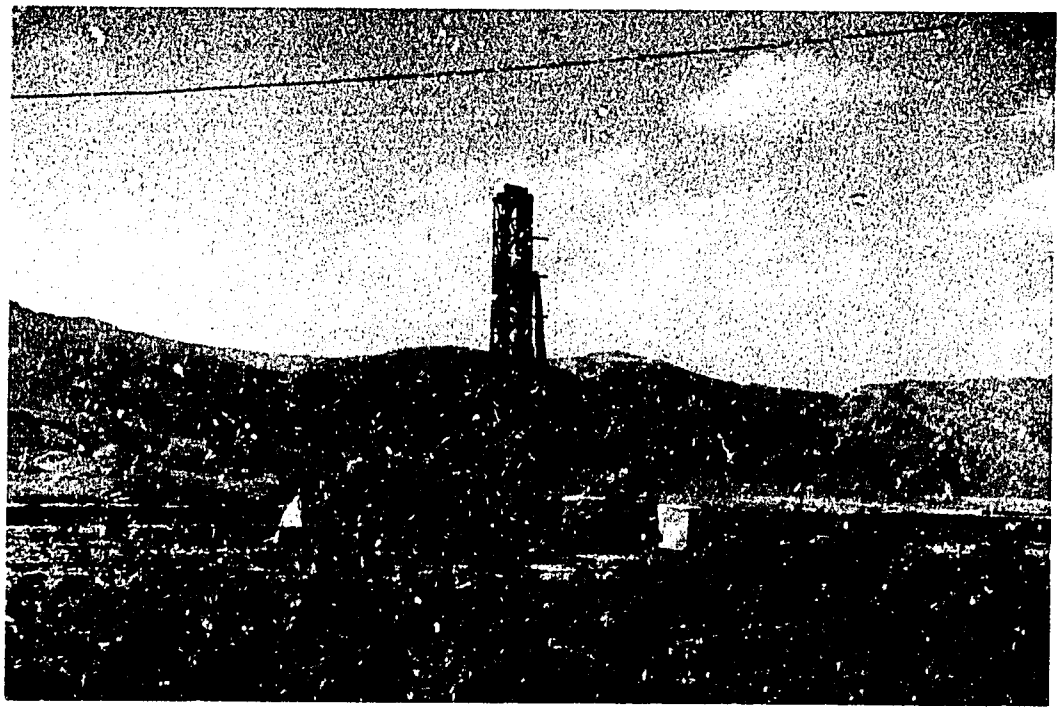
First irrigation of recently planted potatoes in a orchard near Kalat, Balochistan



Water is the most limiting factor for agriculture, and specially for potato growing, in Balochistan. The drilling of a tubewell can cost up to 5 lakh rupees (500,000.) or more.

9. ZONE 8: IRRIGATED HIGH VALLEYS OF BALOCHISTAN, SOUTH AND NORTH WAZIRISTAN

9.1. GEOGRAPHICAL COVERAGE

9.1.1. Altitude

Zone 8 covers the irrigated high valleys of Balochistan, South and North Waziristan which range in altitude from about 1500 to 2500 m (Table 1).

Table 1: Approximate altitudes[1] (m a.s.l.) of important cities and villages in zone 8.

City/village	Area	Altitude (m a.s.l.)
Zhob	Zhob	1380 (Bajwa et al., 1986)
Wana	S. Waziristan	1400 (Khan and Hussain, 1990)
Loralai	Loralai	1446 (Syed, 1985)
Pishin	Pishin	1570 (Bajwa et al., 1986)
Mastung	Kalat	1687 (Syed, 1985)
Kanak	Kanak	1690 (Bajwa et al., 1986)
Quetta	Quetta	1702 (Syed, 1985)
Mangochar	Kalat	1720 (Bajwa et al., 1986)
Khanozai	Pishin	1800
Shakai	S. Waziristan	1800 (Khan and Hussain, 1990)
Killi Goam	Kalat	1950
Kan Mehtarzai	Zhob	2150

[1]Measured with altimeter if not stated otherwise.

9.1.2. Latitude and longitude

Zone 8 spans six degrees of latitude (28° to 34°) and five degrees of longitude (66° to 71°).

9.1.3. Topography

The potato growing areas in this zone are wide open valleys, plateaus, foothills, and slopes (alluvial fans) surrounded by steep and arid mountains covered with sparse vegetation. In slopes exposed to the south east, humid air coming from the plains allows some native forests composed of junipers, pines, ashes and wild pistachios to grow.

The mountains and valley walls are precipitous, especially where the sparse vegetation has been destroyed due to overgrazing and cutting firewood. Erosion is a major problem in this zone, but also contributes to land reclamation. Fields are brought into production by trapping the silt-laden water with dams and allowing the water to drain and the silt to settle. Some farmers also truck in soil. The use of heavy machinery for land reclamation has increased considerably over the last 10 years.

9.1.4. Potato production areas

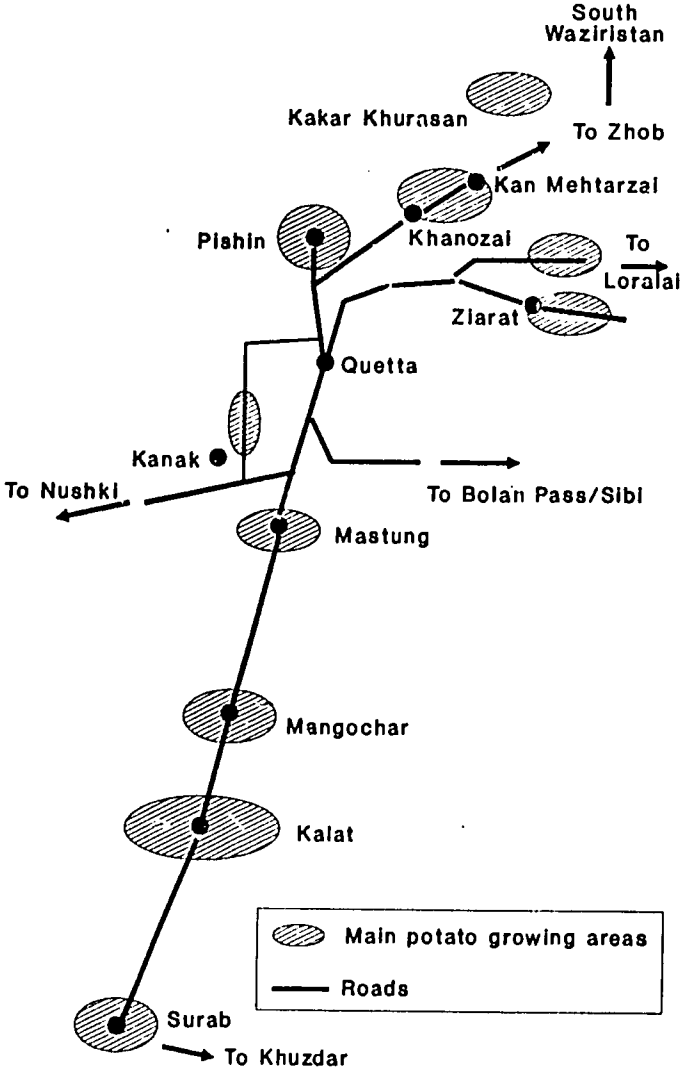
In this zone, potatoes are mainly grown in the districts of Kalat, Pishin, Loralai, Zhob, Quetta, and in South and North Waziristan (Bajwa et al., 1986; ADB, 1990; Khan and Hussain, 1990).

Most potatoes in terms of area and production are produced in the Kalat district (Fig. 1). Potatoes are grown around Kalat, Mangochar, Surab, Mastung, in the Kirdgap tehsil, and in the Kanak valley (see also Ahmed et al., 1990).

In South Waziristan, potatoes are grown around Shakai, Tiarza, Birmal, Kaniguram, and in North Waziristan around Razmak (Khan and Hussain, 1990). Some areas at lower altitudes such as Wana may belong to zone 4.

This agro-ecological zone can be further subdivided into three subzones: (a) higher altitudes, main planting of potatoes in April/May, (b) lower altitudes, early planting in March is possible, and (c) tribal areas of S. and N. Waziristan.

Fig. 1: Main potato growing areas of zone 8

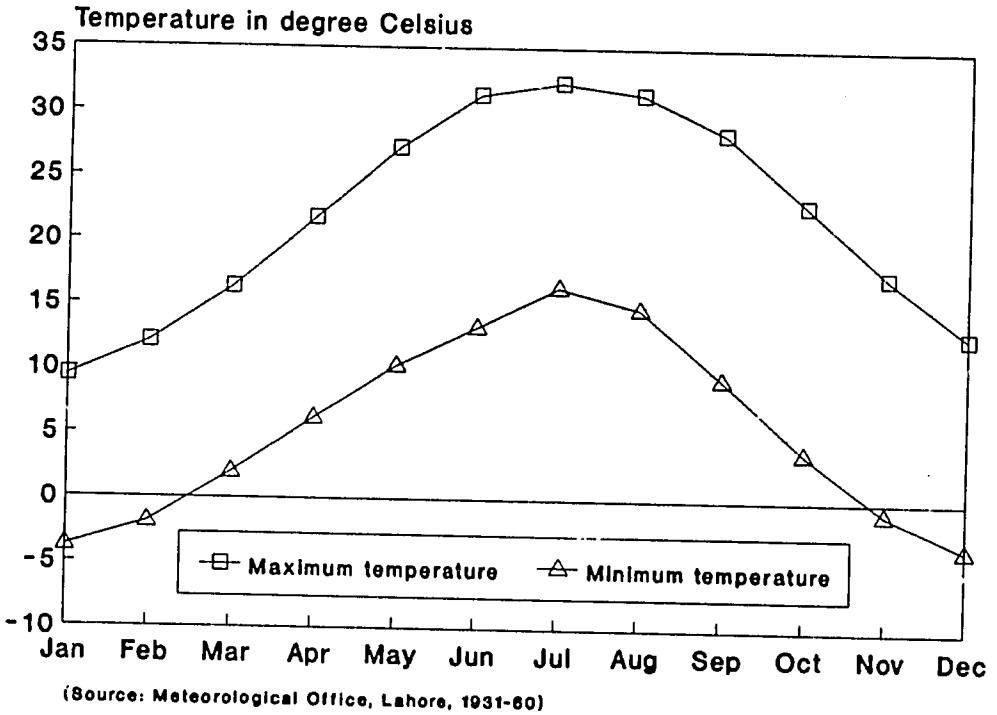


9.2. ECOLOGY

9.2.1. Temperature

The climate in this zone is an arid to semi-arid, continental climate with large differences between the lowest temperatures in December and January and the highest temperature in July (Fig. 2). The climate in this zone is similar to the one in zone 7 in aridity, but with higher daily temperature fluctuations in zone 8. It is more continental than the climate in zone 6. The frost risk is highest from October to March at higher altitudes such as Kan Mehtarzai, and from November to February at lower altitudes such as Kanak valley.

Fig. 2: Mean monthly temperatures at Kalat (zone 8)



(Source: Meteorological Office, Lahore, 1931-60)

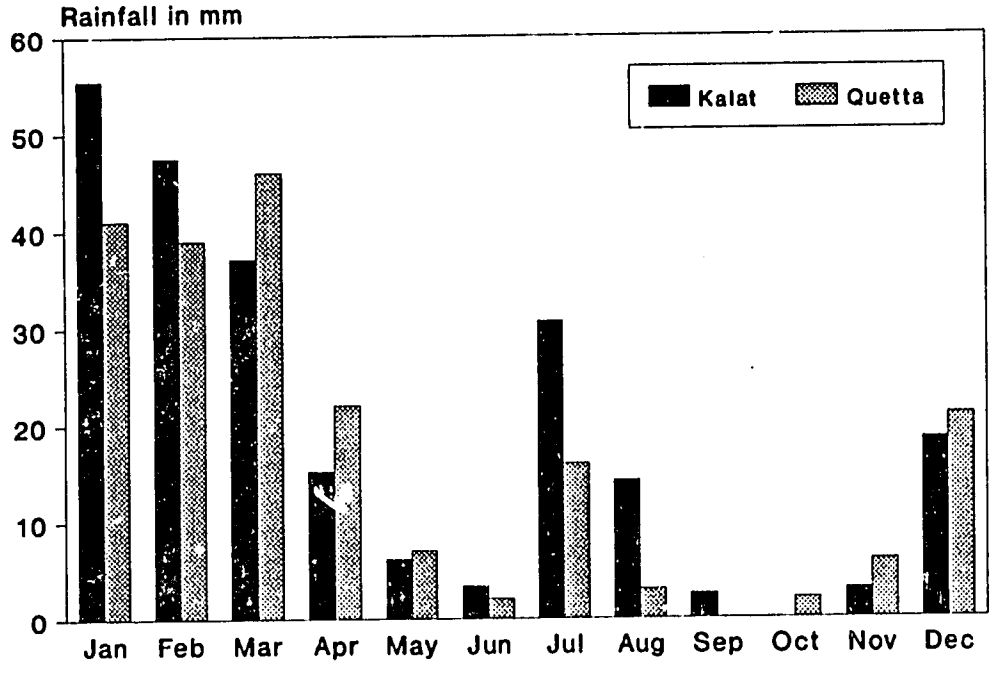
9.2.2. Precipitation

The low total annual precipitation, varying from about 50 to 400 mm, makes irrigation necessary, and is insufficient to keep the groundwater table at a constant level. The winter precipitation in form of snow and rain is more important (about 90% of the total annual precipitation) than the rainfall in summer (Fig. 3). However, the average monthly evapo-transpiration is higher than the average monthly rainfall during the whole year (Anonymous, undated).

9.2.3. Irrigation infrastructure

Water is the major limiting factor for increasing intensive, irrigated cultivation. All potato fields in this zone are irrigated through tubewells, open-surface wells, streams, or *karezes*.

Fig. 3: Mean monthly rainfall in zone 8



(Source: Meteorological Office, Lahore, 1931-60; Anonymous, undated)

Karezes are ancient tunnels dug from the valley sides bringing water to the cropped area near the center of the valley at lower altitudes. Not many are still operating as the increasing number of wells and pumps has seriously lowered the water table. Irrigation interval with *karezes* is usually longer and varies according to family rights determined by the original contribution of ancestors to digging the tunnels.

The water table is said to be at about 30 to 60 m, but some farmers have tubewells as deep as 150 m. Open-surface wells are usually less deep. From the wells the water is pumped into reservoirs, and from there, it flows in open canals as far as 1 km to the fields, causing a lot of evaporation and other losses. New tubewells are not allowed within about 400 m distance of each other. Nonetheless, the water table has been decreasing during the last years by about 1.5 to 3 m per year (Anonymous, undated). Therefore, wells have to be dug deeper and deeper. The construction of reservoirs is subsidized. Most pumps are electrical. Electricity charges were reportedly between Rs. 2500 and 5000 per month in 1991. A 120 m deep well cost about Rs. 500,000 in 1988. Maintenance and deepening of the wells costs about Rs. 25,000 per year at current prices.

Balochistan's connection to the national electric grid is comparatively recent and a great expansion of cultivated area has taken place as a result of cheaper irrigation as compared to diesel pumps. This expansion is still continuing.

9.2.4. Soils

In the Kalat district, about 7.9% of the area has a very high potential under irrigation with no soil limitations, 0.6% of the area has a high potential under irrigation with minor workability

and permeability problems of the soils, and 1.8% of the area has a low potential under rainfed farming with water being the main limitation (Anonymous, undated). 39.7% of the area has a low potential for grazing or is unproductive.

Soils in this zone are variable in texture, nutrient content, and depth. Soils on mountain slopes are usually shallow and highly calcareous (>30% $CaCO_3$), have low organic matter content (<0.5%), and pH >8 (Anonymous, undated). They are classified as lithosols (Sabir et al., undated). Soils in the valley bottoms are deep, highly calcareous (10-30% $CaCO_3$), have low organic matter content (<1%) and pH >7.5. They are classified as yermosols. Soils are generally heavy in texture varying from sandy loams to loamy clays.

The soils contain low to medium amounts of P, and medium to high amounts of K (Sabir et al., undated; Khan and Devaux, 1988). Soil analysis has shown that some soils are deficient in Zn, but sufficient in Cu, Fe, and Mn (Khan and Devaux, 1988). It is possible that some soils have high levels of Cl (Turkensteen, 1988). The high content of lime and the high pH might cause fixation of P and micronutrients.

Wind erosion due to low rainfall, sparse vegetation, and dry winds might be a problem. The high silt content (20-30%) and low organic matter content (<1%) causes crust formation, water run-off, poor emergence of crops, and erosion.

9.2.5. Cropping season

The length of the cropping season and the planting and harvest dates in this zone are basically a function of the temperature which varies with altitude.

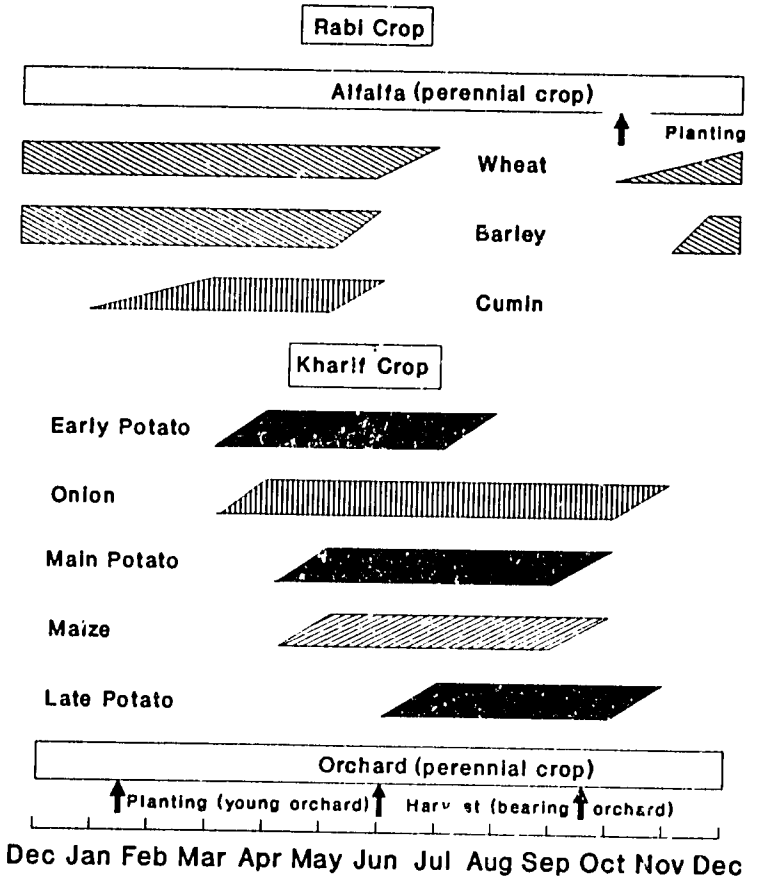
There are two main seasons: the *rabi* season from October to April and the *kharif* season from April to October. The main crops and their planting and harvest dates are summarized in table 2 and figure 4. Potato is a *kharif* crop with planting between March and June and harvest between July and November. The early crop is planted in March (for example Bostan in Pishin district), the main crop in April/May, and the late crop in June. In the Kalat district, more than 90% of the farmers finish planting before the end of May (Ahmed et al., 1990). In the Kanak valley, many farmers plant in June after harvesting the wheat (Sabir et al., undated). Early harvest is in July (for example in Bostan), the main harvest in September/October, and late harvest in November. Most farmers in Kalat finish their harvest by the end of October (Ahmed et al., 1990). Early planted and late harvested potatoes might suffer frost damage.

Table 2: Common planting and harvesting dates for main crops in zone 8.

Crop	Planting date	Harvesting date	Crop	Planting date	Harvesting date
rabi crop			*kharif* crop		
alfalfa	Oct.	several times	fruit trees (young orchards)	Jan./Feb.	June-Sept.
wheat	Oct.-Dec.	June/July			
barley	Nov./Dec.	May/June	early potato	Feb./Mar.	July/Aug.
cumin	Jan-mid-Mar.	May/June	onion[1]	Mar./Apr.	Oct./Nov.
			main potato	Apr./May	Sept./Oct.
			maize[2]	Apr.	Oct.
			late potato	June	Oct./Nov.

[1]Onions can be planted in autumn (winter hardy).
[2]Mainly grown in South and North Waziristan.

Fig. 4: Common planting and harvesting dates for main crops



9.3. PRODUCTION FACTORS

9.3.1. Farm size

There is a strong joint family system in this zone (50 persons per family), and it is not clear whether the existing information on farm size refers to farms held by joint families or nuclear families. It is also not clear whether the total landholding reported includes the uncultivated or grazing land (land which can be reclaimed), the rented land, and the land operated by sharecroppers. Moreover, some farmers do not know the exact size of their holdings.

Sabir et al. (undated) found that most holdings in the Kanak valley were between 2 and 20 ha. Ahmed et al. (1990) found an average farm size of 14 ha among 100 surveyed farmers in the Kalat district. Fourteen percent of the farmers owned less than 5 ha, 57% between 5 and 15 ha, and 29% more than 15 ha. Mahmood et al. (1989) found an average farm size (cultivated area) of 11 ha among 60 farmers surveyed in Mangochar (Kalat), Kanak, and Kan Mehtarzai. Farms in Mangochar were on the average larger than those in Kanak or Kan Mehtarzai. Geddes and Bajwa (1986) found an average farm size of 15 ha among 92 farmers surveyed in Kalat district, Pishin district, and Kan Mehtarzai. They observed larger farms in Pishin than Kalat and Kan Mehtarzai.

9.3.2. Land tenure

In general, the landowners hire sharecroppers at will which provide the labor for most crops except for orchards which are given to contractors after fruit setting. The tenants are hired for one year, but the contract can be extended if both sides agree. They receive one fourth or one third of the final produce. All inputs are generally provided by the landowner. He seems to be the primary decision maker although he might discuss management practises with his tenants. Thus, he might not be around when important decisions have to be taken. Sometimes the tenants keep their part of the produce and sell it themselves, in other cases the landlord sells all the produce and pays the tenant in cash.

In some cases, the land is rented from a big landlord (for example the Khan of Kalat who owns 350,000 ha) or another farmer who has not enough water. Then the landowner receives one seventh of the produce, the operator receives 6/7, and gives 1/4 of his share to the laborer (6/28). If the landowner provides the water, he receives 1/7 of the total produce as water charges. It is also possible that one farmer provides the water and the other one the land, and they share the produce equally, or the land is counted as 1/7 of the share. In areas recently connected to the electric grid belonging to semi-nomadic tribes, land is rented by agro-investors for 10-15 years depending on their investment into new tubewells. They cultivate mainly vegetables and annual fodder crops and employ members of the owner family as share-croppers. At the end of the rent period, the installations revert to the land owner. It will then be divided in small individual units and most probably planted with orchards. In some cases, a hereditary type tenancy might still exist (Anonymous, undated). In that case, every input is provided by the tenant who pays one fourth of the grain and 1/6 of the straw to the landlord and arranges a big feast for the landlord.

Ahmed et al. (1990) reported that 90% of the sampled farms in Kalat were owner-operated but they did not specify who provides the labor in that case.

9.3.3. Labor

Most of the work on the farms in this zone is done by the tenant and his family or relatives including women and children. Labor seems to be in short supply so that the area cultivated by one tenant is limited to the area he can handle with his own family which is about 1-1.5 ha of land. Farmers also provide mutual help during planting and harvesting (Sabir et al. undated). Women and children of nomad families and Afghan refugees are also hired especially for weeding the potatoes and onions. They are paid Rs. 10, five kilogram of the produce, and the grass collected per day and labor. Other arrangements are Rs. 30-50 per day including food and lodging (Anonymous, undated). There seems to be one peak in labor requirements in June and July during the wheat and cumin harvests, weeding and earthing-up of potatoes, and a second peak in October and November during the wheat planting, onion, potato, and fruit harvests (Sabir et al., undated).

The orchard crop is usually sold to contractors after fruit setting who then hire their own labor for spraying and harvest. Thus, the landowner does not have to worry about hiring tenants which could be one reason of the expansion of orchards. Sometimes land owners sell their orchard crop in advance to contractors for 5 to 10 years to finance major investments such as new wells. During that time they will make their living with the other field crops.

Farmers in S. Waziristan may have additional sources of income besides farming (Khan and Hussain, 1990).

Farmers in this zone seem to have a long tradition of growing potatoes (50-100 years).

9.3.4. Credit

Most farmers rely on commission agents and friends or relatives to purchase seed, fertilizer, and pesticides (Table 3). Farmers from Mastung and Mangochar rely on commission agents in Sukkur, while farmers in Pishin rely more on agents in Quetta. Inputs are readily available in Quetta and Wana. Medium and large farmers (>5 ha) also use loans from commercial banks for buying tractors and tubewells. Commission agents advance credits for about 5 to 6 months, i.e. until harvest, on the condition that the farmer sells the potatoes through him. They charge a higher price for seed bought on credit. The additional charge was Rs. 20 to 50/bag of 100 kg in 1985 (Bajwa et al., 1986), Rs. 20/bag in Balochistan in 1989, and about Rs. 100/bag in S. Waziristan in 1989 (Khan and Hussain, 1990), which corresponds to about 5-25% of the cash price, but probably varies with the seed price in the market. These charges are less than in other zones such as zone 6 (30 to 60% of the cash price in 1991), however the commission agents in Balochistan charged about 9% commission when selling the produce in 1988 as compared to 4% in the Punjab markets (Mahmood et al., 1989). The main risk that commission agents take is that farmers do not repay their loan in time if the crop fails.

Table 3: Sources of credits for farmers in upland Balochistan in 1988 (Mahmood et al., 1989).

	Source of credit		
Farm size	Commission agents	Friends and relatives	Commercial banks
		%	
< 5 ha	40	25	35
5-10 ha	50	29	21
> 10 ha	73	23	4
Average over all farms	56.7	25	18.3

9.4. FARMING PRACTICES

9.4.1. Cropping pattern

Wheat, barley, and cumin are the most important *rabi* crops, and vegetables such as potatoes, onions, tomatoes, melons, and turnips and fruits are the most important *kharif* crops in this zone (Bajwa et al., 1986; ADB, 1990).

Potatoes are an important cash crop in this zone covering up to 30% of the landholding (Table 4).

Table 4: Percent of total holding under potatoes in different areas of zone 8.

Year	Area	Percent under potatoes	Reference
1985	Kalat	35	(Geddes and Bajwa, 1986)
	Pishin/Kan Mehtarzai	8	ditto
	Kanak	10	ditto
1988	Kalat	37	(Ahmed et al., 1990)
1988	Mangochar	32	(Mahmood et al., 1989)
	Kan Mehtarzai	30	ditto
	Kanak	16	ditto

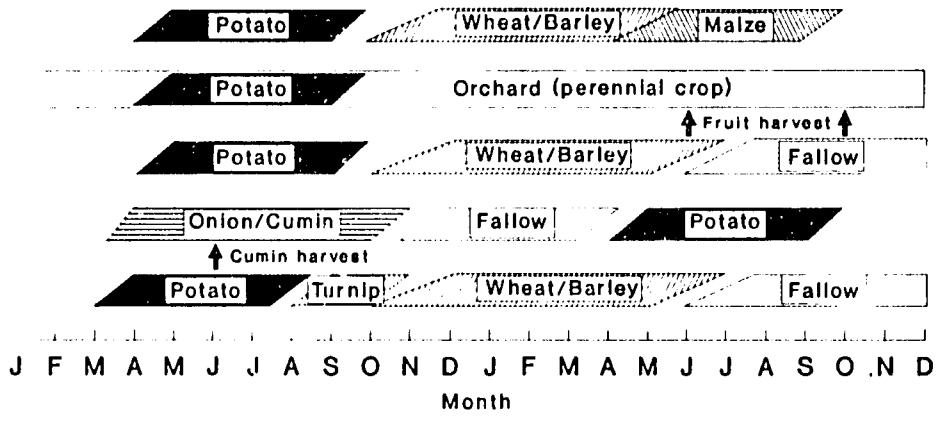
Fruit trees are the main competitor of potatoes in the area. Potatoes compete with onions and cumin in the Kalat district, with tomatoes, other vegetables, and fodder in the Pishin district, and maize in South and North Waziristan (Bajwa et al., 1986; Khan and Hussain, 1990). Fallow up to two years is also common because of lack of water to irrigate the whole arable land. Fruit trees seem to result in a higher net income than potatoes. Tomatoes are marketed during about three months, thus spreading the risk for price fluctuations. Onions can be stored more easily or left in the field for seed production, and are often intercropped with cumin.

Potatoes and alfalfa are very often intercropped in orchards in the first three years after planting. Onions and cumin are usually intercropped. Cumin is harvested earlier. Maize is sometimes grown on the bunds surrounding potato fields.

Maize, millet, alfalfa, haulms from potatoes, onion leaves, weeds, wheat and barley straw are used as fodder for the livestock in winter. Local wheat is often cut or grazed once in Jan./Feb. for fodder. 44 farmers surveyed in Mangochar in 1988 owned on the average 1 cattle (bull, cow), 85 sheep, and 25 goats (Anonymous, undated). FYM produced in winter is used as fuel.

In general, potatoes do not follow potatoes on the same piece of land from year to year. Some common rotations are summarized in figure 5.

Fig. 5: Common crop rotations with potatoes in zone 8



Farmers in upland Balochistan keep about 250 kg (1% of total produce) potatoes for own consumption (Mahmood et al., 1989). Assuming that the average family size is about 12 persons (Anonymous, undated), the average consumption of potatoes would be about 21 kg per person per year.

9.4.2. Potato production

9.4.2.1. Varieties

White varieties are more commonly grown than red varieties (Table 5). At higher altitudes red potatoes are more common than white ones (Monninkhof, 1985). In S. Waziristan, Ultimus is also grown (Khan and Hussain, 1990). More than 60% of the farmers surveyed by Ahmed et al. (1990) planted two or more different varieties, mainly to spread the risk.

Table 5: Distribution of common potato varieties in zone 8.

Variety	%	Year	Area	Reference
Diamant	42	1988	Kalat	(Ahmed et al., 1990)
Patrones	33			
Desiree	23			
Cardinal	1			
others	1			
Patrones	60	1985	Kalat,	(Geddes and Bajwa, 1986)
Desiree	29		Pishin,	
Cardinal	11		Kan Mehtarzai	

9.4.2.2. Seed sources

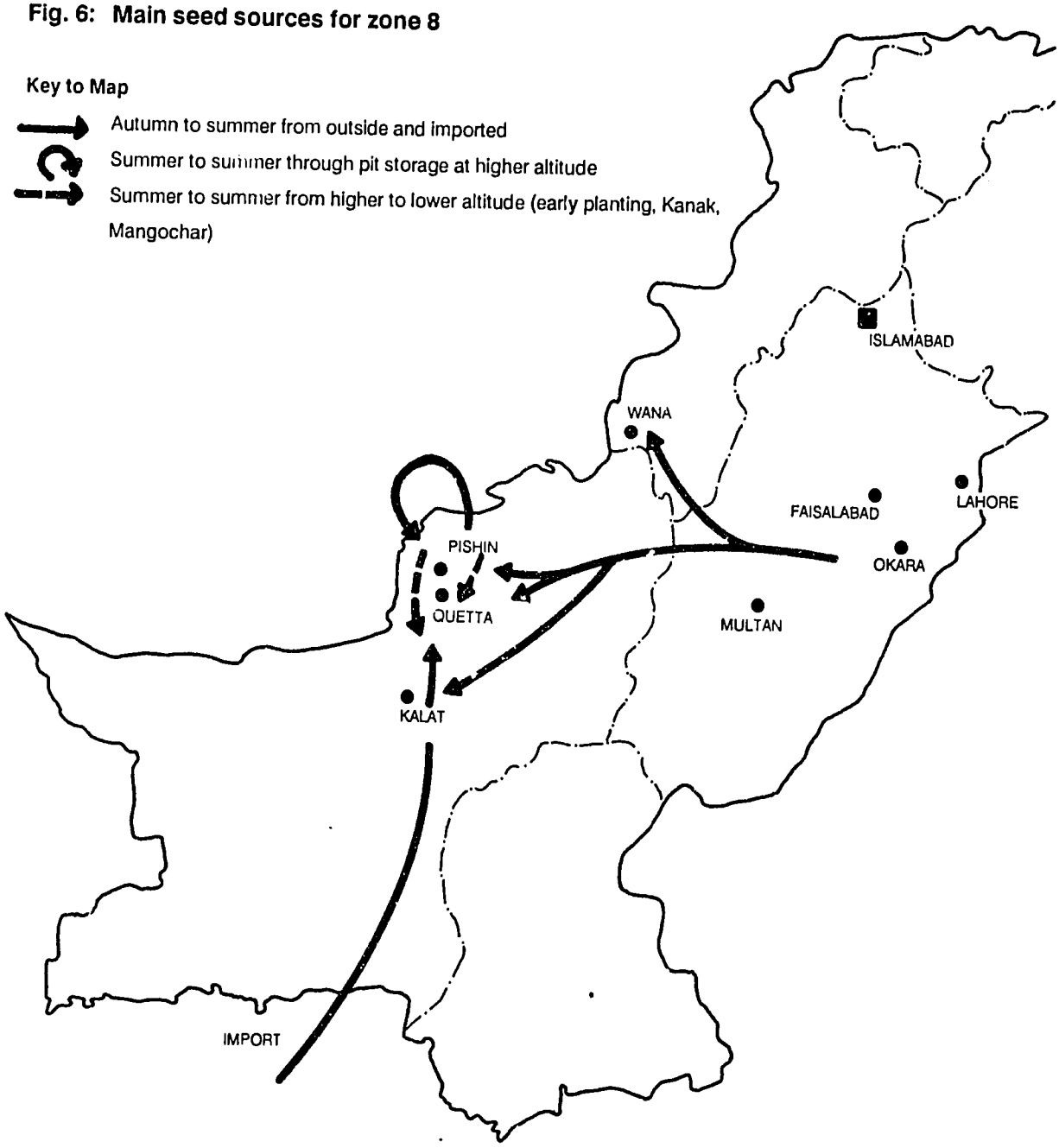
Most of the seed used in this zone comes from the Punjab autumn crop. Seed is bought from commission agents in Quetta, Okara, Sukkur, Multan, or Wana (Table 6; Fig. 6)

Table 6: Common seed sources in zone 8.

Source	%	Year	Area	Reference
Okara	44	1988	Kalat	(Ahmed et al., 1990)
Quetta	39			
Sukkur	6			
Karachi	9			
Lahore	1			
Quetta	51	1985	Kalat,	(Geddes and Bajwa, 1986)
Okara	41		Pishin,	
Sukkur	8		Kan Mehtarzai	

Some farmers, usually traders or community leaders, approach potato growers in Punjab directly to get seed for themselves and often also for other members of the community. Forty to

Fig. 6: Main seed sources for zone 8



50% of the seed in Balochistan is sold by the local commission agents, but it is not clear in which markets they buy the seed, whether all is from the same source, and whether all the seed is from the previous autumn crop. Farmers make constant complaints about the quality of Punjab seed. Some farmers at higher altitude such as Pishin and Kan Mehtarzai in Balochistan and Shakai in S. Waziristan might store their potatoes in pits or rooms to sell them to farmers at lower altitudes such as Kanak and Wana, but its importance as a seed source is not known (Sabir et al., undated; Khan and Hussain, 1990). Potatoes are brought to Quetta at the beginning of February and kept in warehouses until planting.

9.4.2.3. Land preparation

Most primary cultivation in the irrigated areas is done by tractor using a spring tine cultivator (Anonymous, undated; Bajwa et al., 1986). Only a few farmers seem to use ploughs for deep ploughing. Rent for a tractor amounted to Rs. 60-80/hour in 1988 (Anonymous, undated; Sabir et al., undated). Bajwa et al. (1986) reported that 5-7 hours were required for ploughing one hectare and that on the average 3-4 ploughings followed by one planking were practised. It is possible that ploughing within orchards slows down the operation.

9.4.2.4. Fertilizer

Farmers are mostly using urea and DAP fertilizer (Sabir et al., undated; Bajwa et al., 1986). Some farmers use nitrophos instead of DAP. The amount of N and P applied, and the N/P ratio vary with farmer, area, and farm size (Table 7). Few farmers apply potash. Larger farmers seem to apply more fertilizer (Ahmed et al., 1990). DAP and half of the urea are usually applied at planting. The second split of urea is applied at earthing-up.

FYM is not very common in Balochistan even though the number of cattle, sheep, and goats are very high because it is used as fuel. It is more common in S. Waziristan. Some farmer use to apply silt to their fields.

Table 7: Amount of N and K applied, N/P ratio in different areas of zone 8.

Area	N	P	N/P	Reference
	---kg/ha---			
Zone 8	160	115	1.4	(Bajwa et al., 1986)
Kalat	166	71	2.3	(Ahmed et al., 1990)
Kalat	60-115	46-69	1.3-1.7	(Anonymous, undated)
Kanak	160	115	1.4	(Sabir et al., undated)
Mangochar	76	40	1.9	(Khan and Devaux, 1988)

9.4.2.5. Planting

Potatoes are mostly planted by hand on the flat ground (Ahmed et al., 1990). Oversized tubers are used and cut into several pieces. Most farmers use a seed rate of 2 to 2.5 t/ha with a row-to-row distance of 90-100 cm and a plant to plant distance of 10-15 cm, and a planting depth of 15 cm (Khan and Devaux, 1988). This seed rate is similar to other areas in the hills. However, the row-to-row distance is larger and the plant to plant distance shorter than usual. At a row-to-row distance of 95 cm and an plant-to-plant distance of 10 cm the initial plant density would be 105,000 plants per hectare. Since water is limited, the irrigation interval long, and the

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initial plant density high, using narrower row spacing would not have a significant effect on the yield (Khan and Devaux, 1988). Ridges and tie-ridges are made using a broad toothed wide spade (*dhaull*). Ridges of 30-40 cm height were observed. In S. Waziristan single hills are more common (Khan and Hussain, 1990).

9.4.2.6. Earthing-up and weeding

Broom rape (*Orobanchae aegyptica*) and dodder (*Cuscuta reflexa*) are parasitic weeds severely affecting potato production in this zone (Ahmed et al., 1990). Broom rape can be controlled through early planting since it attacks in June/July. Most farmers do not use any herbicide, probably because the laborers who are hired for weeding receive the weeds as winter fodder for their goats and sheep (Sabir et al., undated).

9.4.2.7. Water management

Water is the single most important input hindering an increase in production in this zone. Many farmers do not have sufficient water to cultivate all their arable land, thus leaving fields fallow which might cause wind erosion. Considering the scarcity of water and the decreasing water table due to installation of more wells, water management becomes an important factor to increase production.

The average irrigation interval for potatoes is about 10 days in Balochistan and 15 days in S. Waziristan, however it depends not so much on the need of the crop but on the priority set by the farmer on which crop to irrigate first (Anonymous, undated; Bajwa et al., 1986). Water shortage increases the dormancy period of wheat, thus prolonging its growth period. Water requirements of the *rabi* and *kharif* crops can therefore coincide. Khan and Devaux (1988) have shown that under the current agronomic practices yield can be increased by decreasing the irrigation interval from 12 to 4 days.

9.4.2.8. Diseases, pests, and their control

Turkensteen (1988) found few pathogens in his survey in 1987. However, the disease symptoms were amplified by severe drought, high temperatures, and possibly insect attack and low soil fertility.

Virus diseases, especially PVY and PLRV, are a severe problem in this zone. Many farmers reported poor seed quality due to viruses, especially in the seed kept locally. Seed degenerates fast if multiplied locally. Potatoes coming from South Waziristan to the Tank market were sampled and checked for virus infection. 30% of the tubers were infected.

Wilts caused by *Verticillium dahliae, Verticillium albo-atrum, Fusarium solani, and Fusarium oxysporum* were the pathogens most often isolated. *Verticillium dahliae* was the most prevalent pathogen and 140, 578, and 683 infectious particles were isolated in three soil samples of Mangochar, Kan Mehtarzai, and Khanozai (Pishin).

Late blight (*Phytophthora infestans*) and early blight (*Alternaria solani*) were not isolated. They are not important diseases in Balochistan due to low relative humidity and lack of rain in summer. In the high areas of S. Waziristan, late blight attacks in July-August.

Powdery scab (*Spongospora subterranea*) has been isolated in samples taken from Mangochar and Kanak in 1987 (Turkensteen, 1988). Its incidence might be correlated with deep planting, shallow ridges, high water levels at irrigation, or water-logging in badly levelled fields. The incidence of powdery scab is increasing, menacing profitability of the potato crop in the zone.

The main pests in this zone are: cutworms (*Agrotis* spp.), potato tuber moth, leafhoppers, white flies, aphids, and mites. Leafhopper burn seems to be the most important damage observed in potatoes in June/July at areas below 2000 m altitude. However, no comprehensive study of the relative importance of these pests has been undertaken.

Ahmed et al. (1990) found that 45% of the interviewed farmers in Kalat used insecticides and 22% used fungicides. Larger farmers tended to use pesticides more frequently. However, it is not clear whether the pesticides are mainly used in orchards. It is not known whether farmers are aware of the main disease and pest problems or not.

9.4.2.9. Harvest

Potatoes are harvested by hand using spades. Some farmers reportedly graded small and large tubers.

9.4.2.10. Yield

The mean yield of 92 farmers in Balochistan surveyed during the main harvest period in 1985 under the current management practices was 24 t/ha (Geddes and Bajwa, 1986). The lowest yield was found in the Kanak valley probably due to the late planting. Intercropped fields tended to yield less. In the fields sampled, Desiree was higher yielding than Patrones or Cardinal. For early harvest lower yields are expected.

Many farmers reported decreasing yields as compared to the past.

9.4.2.11. Post harvest handling

There is one cold store in Quetta but most potatoes are sold before winter to pay back loans and because of lower price expectations later in the season.

9.4.2.12. Marketing

More than half of the producer sell their potatoes directly to markets outside Balochistan such as Sukkur, Karachi, Lahore, D.G. Khan, Multan, and Faisalabad (Mahmood et al., 1989). Sukkur is the trading center for the southern parts of the Kalat district (Monninkhof, 1985). The rest is sold through local commission agents in Quetta. Half of it is consumed in the local market in Quetta and the other half is sold by the local commission agents to outside markets. Some traders go to the farmers' field to buy potatoes especially when prices are high. It is not clear whether there is any difference in marketing red or white potatoes. It is assumed that most of the white potatoes end up in the Karachi market. More small than large farmers tended to sell their produce in the local market. Reasons for selling in the local market reported by the farmers interviewed were: (1) shorter distance, (2) credit arrangements with local commission agent, and (3) price expectations.

The main market for S. Waziristan is Wana (Khan and Hussain, 1990). From there most potatoes go to Lahore or through Tank as seed to Peshawar. The commission in this market was 6.25% in 1989.

Marketing costs in 1989 for selling the produce at the local market were Rs. 542/t which was lower than the Rs. 560/t for selling directly to outside markets, or the Rs. 610/t for selling to outside markets through local commission agents (Mahmood et al., 1989). Farmers considered low price expectations, high commission, transport problems, and unfair dealings in the market as the major constraints in marketing the produce.

9.5. PRODUCTION SUPPORT PROGRAMS

Sariab Agricultural Research Institute: This is the provincial institute near Quetta. It has carried out potato research for many years, mostly at the institute. Since 1987 the program has been planned jointly with PSPDP. The Agr. Economics Research Unit (PARC) and Sariab run a FSR project in Kanak with funds of USAID through the Management of Agr. Research and Technology Project/Arid Zone Research (MART/AZR). They have conducted some potato research trials since 1989.

Balochistan Seed Potato and Vegetable Seed Program: This program has a potato seed farm at Gidar, South West of Surab and another at Kila Ibrahim (Surtal), north east of Quetta near the Afghan border. Some seed is also produced at its headquarters farm near Quetta. Gidar and Quetta are at an altitude of about 1700 m and Kila Ibrahim at 2300 m. In 1989, they produced about 31 tons of seed (Idris, 1989).

Besides seed production, project staff are active in on-farm research, variety evaluation, and true potato seed (TPS) research.

Pakistan-Swiss Potato Development Project (PSPDP): This project has been cooperating with provincial institutions for several years. In 1985 PSPDP carried out farming systems and yield surveys of Balochistan jointly with provincial staff and in 1986 started cooperation in TPS research. From 1987 onwards it has helped both ARI Sariab and the Seed Project plan their research programs and has also financed them. It is envisaged that a direct provincial program of PSPDP with the Department of Agriculture will be started in 1991. A reconnaissance survey of S. Waziristan was carried out jointly by the Department of Agriculture and PSPDP in 1989.

9.6. CONCLUSIONS

Farmers and researchers perceive availability of irrigation water, seed quality, pests, diseases, and weeds, competition of potatoes with other crops, and the tenure system as the major constraints to potato production in this zone.

The most serious constraint is the lack of water. Evapo-transpiration is higher than the monthly rainfall at any month of the year. The water table has been decreasing steadily during the last 20 years due to the increasing number of new wells installed. Most of the traditional irrigation channels (*karezes*) have gone dry. Sometimes water runs in open canals as far as 1 km to the fields, resulting in extensive losses. Most farmers cannot cultivate the whole arable land, leaving part of it fallow up to two years. Irrigation intervals are usually too long.

Most of the seed for Balochistan comes from the open markets in Punjab. Pit and room storage has been practised formerly at higher altitudes, but nowadays does not seem to play a major role in supplying seed to lower altitudes. Thus, farmers have to buy fresh seed every year, independent of the price. Since the seed potatoes supplied from the Punjab are basically table potatoes, there is no guarantee of good quality. Local seed traders play an important role in providing seed on credit to the farmers. Charges for seed bought on credit are not as high as in other hill areas of Pakistan, but farmers have to sell their produce to the trader who provided the credit.

Broom rape and dodder are parasitic weeds affecting yield. Wilts and leafhoppers seem to be the major diseases and pests in this zone. Powdery scab has been identified in the area and is spreading. Few farmers use pesticides because they lack the knowledge to identify and control diseases and pests. Weeds are traditionally used as fodder for the animals. Control of Broom rape and dodder is difficult.

Seed of potatoes is more expensive than tomatoes or onions. Fruit orchards can be sold to a contractor after fruit setting, thus no tenants are required to look after the crop. Therefore, the area grown under potatoes seems to be decreasing. On the other hand, new areas are reclaimed and planted with potatoes and onions.

Tenants and their family provide only labor for which they are paid one fourth or one third of the produce. The contract is renewable every year. Since the landowner provides all the inputs, and usually also controls the water, he also is the main decision-maker. Any teaching of improved agronomic practices would have to address the landowner as the primary decision-maker and the tenants as the ones who execute.

The potential for the development of production lies in improved water management, better access to quality seed, control of diseases, pests and weeds through proper extension involving landowners and tenants.

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ANNEX 1: Performance of various potato varieties in Pakistan.

AJAX

Year of approval	1976
Maturity	Medium early, bulking best during the spring and summer crops.
Tubers	Large, oval, shallow eyes, 8-9 eyes per tuber, yellow skin and pale yellow flesh, conical sprout.
Yield	High, grades well.
Plant & Growth	Rapid growth, broad smooth leaves, medium haulms, green, erect crop, little spreading, white flowers.
Diseases	Highly susceptible to late blight, Verticillium wilt and virus Y. Highly tolerant to PLRV. Highly susceptible to early autumn frost.
Consumer's Quality	Low dry matter content, poor chipping. Texture remains fairly firm on cooking.
Storability	Good.
General remarks	Very popular variety in district Attock. Good for marketing in Sindh province. This variety produces well in areas with a prolonged spring crop especially in the Potohar plateau. Future: good in limited area.

BARTINA

Year of approval	Not approved; has been tried on large scale experimental basis by a few growers of the Okara Cooperative Society and in Chiniot area.
Maturity	Medium early, bulking best during the autumn crop.
Tubers	Few very large, round, red skin, flesh yellow, fairly shallow eyes, with high tendency to develop cracks and hollow heart.
Yield	Very high, grades well.
Plant & growth	Rapid growth, medium broad hairy leaves, dark green color, few thick stems.
Diseases	Susceptible to late blight, Rhizoctonia, Fusarium, highly tolerant to PLRV, virus Y and to some extent to common and powdery scab.
Consumer's Quality	Low dry matter content, very poor chipping, fairly firm on cooking.
Storability	Very poor, highly susceptible to Fusarium dry rot. Big tubers rot after storage.
General Remarks	Only advisable to sell the fresh potato in the market after harvesting, and large size ware potatoes should never be stored. Crop should be planted deep, on broader ridges, but at a higher density or seed rate. Crop should not be allowed to bulk to the end.

CARDINAL

Year of approval	1975.
Maturity	Medium late.
Tubers	Large, long oval, red skin, yellow flesh, shallow eyes, 8-10 eyes per tuber, barrel sprout.
Yield	High, grades well.
Plant & growth	Rapid growth, covers the rows well, strong haulm, few main stems, leaflets are large rough and hairy, hairs being stiff, dark green color, semi spreading, dark purple flowers.
Diseases	Susceptible to late blight, fairly tolerant to PLRV, medium susceptible to PVY, fairly resistant to common and powdery scab, Verticillium wilt, Rhizoctonia, and Fusarium dry rot.
Consumer's Quality	High dry matter content, firm on cooking, good for chipping.
Storability	Good.
General Remarks	This variety is suitable for growing in all three growing seasons i.e. autumn spring and summer in Pakistan. If quality seed of this variety is introduced directly in the autumn season, the seed can be carried from one autumn to another autumn for about 4 years without any serious degeneration. If seed is introduced through the spring season then the degeneration rate is very quick. Successfully proved for direct introduction of seed from Hunza summer crop to Punjab autumn crop. Can be planted deep on broader ridges. Tolerates well late planting in Punjab autumn crop, given normal crop protection.

CLEOPATRA

Year of approval	Not approved, has been tried on experimental basis.
Maturity	Medium early.
Tubers	Large, long oval, red skin.
Yield	Very high.
Plant & growth	Rapid top growth, broad smooth leaves, dark green, few thick stems.
Diseases	The most susceptible variety to late blight in Pakistan, highly tolerant to PLRV and PVY.
Consumer's Quality	Low dry matter contents, texture remains firm on cooking.
Storability	Good.
General Remarks	The seed has been introduced on large scale by some of the seed importers and it has very badly failed due to susceptibility to late blight. The variety may have a future as a local crop in the dry mountain valleys were late blight is not an issue. The variety should not be planted in the Punjab or in the monsoon exposed mountains.

DESIREE

Year of approval	1969
Maturity	Medium early.
Tubers	Large, long oval, shallow eyes, 9-10 eyes per tuber, red skin, yellow flesh, elongated sprout.
Yield	Good, grades well.
Plant & growth	Quick top growth, covers the rows well, by spreading early, medium number of main stems, long, fairly thick, deep brown red in color, small leaflets, smooth and curling under stress, purple flowers
Diseases and environmental reaction	Susceptible to PLRV, tolerant to PVY, comparatively tolerant to late blight, highly susceptible to common and powdery scab, susceptible to Verticillium wilt. Highly susceptible to cold weather and early frost
Consumer's Quality	Medium dry matter content, fair for chipping, firm on cooking. Comparatively less sugar content after storage under low temperature.
Storability	In general good but cold-stored seed must be handled with care and does not tolerate cutting very well.
General Remarks	Suitable for growing in all three growing seasons i.e. spring, autumn and summer in Pakistan. Very popular for marketing in the Punjab and NWFP. If quality seed of the variety is introduced directly in the autumn season, then it can be taken from one autumn to another autumn crop for 4 years without any serious degeneration. Proved successful for direct introduction of seed from Hunza summer crop to Punjab autumn crop, even if, this requires some skill if intended on a commercial scale.

DIAMANT

Year of approval	1986
Maturity	Medium late
Tubers	Large, long oval, yellow skin and flesh, shallow eyes.
Yield	High, grades sell.
Plant & growth	Rapid top growth, covers the rows well after spreading, few main stems and strong leaves fairly large grayish dark green, covered with stiff hairs.
Diseases & environmental reaction.	Susceptible to late blight, fairly resistant to PLRV, weakly susceptible to PVY, Verticillium wilt, Fusarium, Rhizoctonia, powdery and common scab.
Consumer's Quality	High dry matter content, fairly good for chipping, firm on cooking.
Storability	Good
General Remarks	This variety is good for marketing in Sindh and Balochistan province, as well as for export purposes. It is so far the best variety from all points of view. Its degeneration rate is very slow. If the quality seed is introduced directly in the autumn season, the seed can be carried from one autumn to another autumn for more number of years than any other variety presently being cultivated in Pakistan. Has been proved successful for direct introduction of seed from Hunza summer crop to Punjab autumn crop. Tolerant to early winter frosts if planted late. Responds well if left bulking into the spring in the Punjab.

KONDOR

Year of approval	Not approved, tried on experimental basis.
Maturity	Medium early.
Tubers	High
Yield	Large, oval, red skin, yellow flesh, medium deep eyes.
Plant & growth	Rapid top growth, medium broad smooth leaflets, few stems.
Diseases	Susceptible to late blight, PVY and mosaic, tolerant to PLRV.
Consumer's Quality	Very low dry matter content, fairly firm on cooking.
Storability	Fairly good.
General Remarks	This variety has been tried on large scale by some of the progressive growers. It has a quick seed degeneration rate when passed through spring, and therefore cannot be carried from autumn to autumn more than one year without a major decrease in yield.

MULTA

Year of approval	1969
Maturity	Medium early.
Tubers	Large, oval, fairly shallow eyes, 6-10 eyes per tuber, yellow skin and flesh, elongated sprout.
Yield	High, very high in Potohar spring crop.
Plant & growth	Rapid top growth, covers the rows well. Numerous main stems, leaves light green leaflets small, medium to dense hair cover, reddish flowers.
Diseases	Most tolerant variety to late blight in Pakistan, fairly resistant to PLRV and PVY. Most susceptible to Fusarium.
Consumer's Quality	Fair to high dry matter content, remains firm on cooking.
Storability	Good
General Remarks	This variety has shown good performance during autumn season in the plains of Pakistan. If quality seed is introduced directly in the autumn season, it seed can be carried from one autumn to another autumn for 5-6 years without any serious degeneration. This variety has created some time problems if the seed was received from Quetta/Murree hills due to susceptibility to Fusarium wilt.

MURILLO

Year of approval	Not approved, has been tried on experimental basis.
Maturity	Medium early.
Tubers	Medium large, oval, red skin, yellow flesh, shallow eyes.
Yield	High
Plant & growth	Fairly rapid development, good soil coverage. Few main stems, leaves medium broad, dark green color.
Diseases	Susceptible to late blight and Verticillium wilt. Fairly tolerant to Rhizoctonia, most susceptible variety to powdery scab out of the varieties presently cultivated in Pakistan.
Consumer's Quality	Firm on cooking.
Storability	Good
General Remarks	Has been tried on large scale by some of the progressive potato growers, especially in Kasur and Chiniot areas. Its yield is good but it has been proved most susceptible to powdery scab, which has become a serious problem in the plains of the Punjab and in the Mangochar area in Balochistan.

PATRONES

Year of approval	1969
Maturity	Medium early to medium late.
Tubers	Medium to large, oval, shallow eyes, 6-9 eyes per tuber, skin and flesh yellow, oval sprout.
Yield	Good.
Plant & growth	Rapid top growth, covers the rows well. High number of main stems, leaves broad light green, smooth and few hairs, semi erect, purplish flowers.
Diseases	Highly susceptible to late blight, Verticillium wilt and Rhizoctonia, fairly resistant to common and powdery scab, PLRV and PVY.
Consumer's Quality	Fair to high dry matter content, but firm on cooking. Yield good in chipping but chips do not hold color if stored.
Storability	Good, but danger of rotting if crop has been affected by late blight.
General Remarks	This variety has been very popular with the growers of the whole country. This variety is successful in all three growing seasons i.e. spring, autumn in the plains as well as summer in the hills. This variety has been especially successful in Balochistan. Good marketing in Sindh and Balochistan. If quality seed is introduced directly in the autumn season then it can be carried for at least 4 autumn-to-autumn seed cycles, except if the crop has been subjected to late blight or too much irrigation.

SPUNTA

Year of approval	1975
Maturity	Medium early.
Tubers	Very large, long, slightly kidney shaped, shallow eyes, yellow flesh and skin.
Yield	High.
Plant & growth	Quick top growth, numerous main stems, medium broad leaves, light green in color.
Diseases	Fairly tolerant to PVY and PLRV, susceptible to late blight, Fusarium tuber rot.
Consumer's Quality	Low dry matter content, poor for chipping, fair for cooking.
Storability	Poor
General Remarks	This variety should be grown only as ware potato for the fresh market, long storage is not advisable for this variety, quick degeneration rate. The variety is therefore not suitable for the Punjab autumn crop.

ULTIMUS

Year of approval	1961
Maturity	Medium early.
Tubers	Medium to large, long, deep eyes, red skin, yellow flesh.
Yield	High
Plant & growth	Numerous main stems, fairly rapid top growth, leaves are narrow and purplish dark green, good soil coverage. Upright growth.
Diseases	Comparatively less susceptible to late blight. Susceptible to Verticillium wilt, fairly tolerant to Rhizoctonia, powdery and common scab, PLRV and PVY.
Consumer's Quality	High dry matter content, very good for chipping. Firm on cooking, less conversion of starch into sugars after cold storage.
Storability	Very good.
General Remarks	This variety has been proved as heat tolerant, is being planted for capturing early market during winter season in the plains of the Punjab, especially in the district of Faisalabad and Jhang. The crop for early marketing is planted three weeks earlier than the normal planting season i.e. from 1st of September when the maximum atmospheric temperature is generally 36°C which is very harmful for potato cultivation in case of most of the presently cultivated varieties in Pakistan.

ANNEX 2: District and zone wise area of potato in Pakistan

Zone	District/Agency	Area (ha):[a]	[b]	[c]
1	Bahawalpur	199		
	Shikarpur	161		
	Khairpur	147		
	Nawabshah	138		
	Hyderabad	80		
	Sibi	72		
	Sukkur	55		
	Karachi	53		
	Larkana	31		
	Dadu	17		
	Rahimyar Khan	11		
	Rajanpur	5		
	Sanghar	5		
	Jacobabad	0		
	Tharparkar	0		
	Badin	0		
	Thatta	0		
	Lasbela	0		
	Gwadar	0		
	Kachhi	0		
1	Total	971	2000	1370
2	Okara	10129		
	Sahiwal	8919		
	Sialkot	4956		
	Jhang	3961		
	Sheikhupura	3102		
	Kasur	3006		
	Lahore	2990		
	Gujranwala	2646		
	Faisalabad	2642		
	Toba Tek Singh	1757		
	Khanewal	1455		
	Multan	1046		
	Gujrat	910		
	Vehari	480		
	Sargodha	335		
	Dera Ghazi Khan	254		
	Leiah	56		
	Bahawalnagar	45		
	Muzaffargarh	19		
	Bhakkar	4		
	Mianwali	3		
	Jhelum	207		
	Chakwal	2		
	Khushab	2		
2	Total	48925	43800	43000

Zone	District/Agency	Area (ha):[a]	[b]	[c]
3	Peshawar	1795		
	Mardan	1163		
	Swabi [d]	125		
	Charsadda [d]	66		
	Kohat	0		
	Karak	0		
	Attock (Hazro)	204		
	Rawalpindi (Taxila) [e]	316		
	Bannu	0		
3	Total	3526	5000	4500
4	Abbottabad (Rush plain) [e]	53		
	Malakand	30		
	Mansehra (Pakhal plain) [f]	20		
	Buner [c]	20		
4	Total	123	300	200
5	Swat (Side valleys) [f]	443		
	Mansehra (Below Kaghan) [f]	262		
	Abbottabad (The Galis)	247		
	Azad Kashmir [c]	500		
5	Total	1452	2000	2500
6	Dir (Thal, Lawari)	1524		
	Swat (upper Swat) [e]	1413		
	Mansehra (Above Kaghan) [e]	622		
	Chitral	332		
6	Total	3891	2500	1950
7	Northern Areas		2000	
7	Total		2000	

Zone	District/Agency	Area (ha):[a]	[b]	[c]
8	Kalat	3603		
	Pishin	1199		
	Loralai	372		
	Zhob	356		
	South Waziristan	281		
	Chagai	247		
	Kurram	213		
	North Waziristan	179		
	Ziarat	85		
	Quetta	51		
	Bajour agency	49		
	Khuzdar	28		
	Jafarabad	12		
	Kohlu	9		
	Tamboo	8		
	Derabhugti	0		
	Kharan	0		
	Turbat	0		
	Panjgoor	0		
	Khyber agency	0		
	Mohmand agency	0		
	Orakzai agency	0		
8	Total	6653	5000	5000
Pakistan	Grand total	65541	62600	58520

[a]; Source: Crop area, production by districts, average of 1986-90, Government of Pakistan, Ministry of Food, Agriculture and Cooperatives, Food and Agriculture Division, Islamabad.
[b]; Source: Naumann-Etienne, K. 1990. Current situation and future strategy in seed production for Pakistan: a discussion paper. Report B1990/1.
[c]; Source: Geddes et al., 1989. Potato atlas of Pakistan: information on potato production by agro-ecological zones. Report S1989/1, PSPDP/PARC, Islamabad.
[d]; New district.
[e]; Irrigated area.
[f]; Rainfed area.
[g]; Based on 3 years data only.

ANNEX 3: Estimated area, average yield, potential yield, and production of potatoes in each zone.

Zone	Area[1] (ha)	Average Yield[2] (t/ha)	Potential Yield[3] (t/ha)	Production[4] (t)
1	1,500	18	40	27,000
2	45,000	20	45	900,000
3	4,300	15	40	64,500
4	200	20	30	4,000
5	2,000	17	40	34,000
6	2,800	25	45	70,000
7	2,000	30	65	60,000
8	5,600	24	40	134,400
Total	63,400	20	40	1,293,900

[1]Estimated from annex 2.
[2]Estimated from yield surveys and on-farm trial results. Official yields tend to be lower (10t/ha) since the estimation procedures are different.
[3]Estimated from maximum yields obtained in each zone.
[4]Area multiplied by average yield.

11. GEOGRAPHICAL -, AUTHORS - INDEX AND ABBREVIATIONS:

Note: Page numbers in **bold letters** behind geographical names indicate a map;
Authors are in *italic letters*;
Only abbrevations are mentioned which are not commonly used, not explained in the text or relevant for the understanding;

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AARI -> Ayub Agricultural Research Institute
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ADBP -> Agricultural Development Bank Pakistan
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AKRSP -> Aga Khan Rural Support Program
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ARI Sariab -> Agricultural Research Institute Sariab
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FSR -> Farming Systems Research

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