GUIDELINE FOR SEED POTATO PRODUCTION IN PAKISTAN - PLAINS

PAKISTAN-SWISS POTATO DEVELOPMENT PROJECT
PAKISTAN AGRICULTURAL RESEARCH COUNCIL
ISLAMABAD

MAY 1992

Cover photograph: *A good looking crop during mid-season (autumn) near the Chenab river, Chiniot, Punjab*

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FOREWORD

The potato production of Pakistan has now reached a volume of more than 1 million tonnes annually on an area of above 70,000 ha. This means that potato, the fourth largest food crop, is no longer a minor crop in this country. With a consumption of around 10 kg per capita it comes to the table of nearly every family at least once per week.

Given the increasing demand for food in Pakistan, the potato crop has a preponderant role to play. With an average production above 20 tonnes per ha, it is relatively easy to increase production without affecting the areas planted with the other main food crops. Even so, the annual increase of the area under potato crop in Pakistan has averaged around 8%, which is far above the growth rate of the population. For planting the current area, about 190,000 tonnes of healthy potato tubers are required every year. The quality of the seed stock was mainly maintained by importing up to 4000 tonnes of certified seed potatoes from abroad every year. For some time Pakistan has been making increased efforts to reduce the dependency on these imports and to increase the health standard of the existing stock. For this purpose, several projects, institutions and private companies are gaining experience and being successful in the domestic seed multiplication. During 1991 far more certified seed potatoes were produced locally than imported.

This guideline has been produced by PARC in order to promote and strengthen the local seed potato production in the main growing area of the country.

This document was an urgent need, as Pakistan has now accumulated about 20 years of not always successful experience in this field. This document may therefore help avoiding past errors repetition and promote sharing gained experiences. There is the special hope that the information contained herein may encourage the private sector to increase their efforts and produce the 10,000 to 20,000 tonnes of certified seed potatoes required by the farming community of Pakistan in the near future. For economic reasons, over 80 % of this production has to come from the plains of Punjab and NWFP. I hope that this guideline will also aid increasing the level of coordination and integration of the existing efforts. Last but not least, the document may help the innovative potato growers in the plains to improve the health standard of their own seed stock kept for further multiplication.

Dr. Zafar Altaf
Chairman, PARC

Islamabad, May 1992

RESPONSIBILITY OF WORK

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HOW TO USE THIS GUIDELINE

This guideline is particularly aimed at:

- **technical staff** of **commercial seed companies** (key reader),
- skilled and literate **potato growers**, especially those producing their own or commercial seed,
- potato **extensionists** and **subject matter specialists**,
- **university, development** and **research** staff,

It is a summary of seed potato multiplication recommendations developed by the PSPDP, incorporating farmers' own knowledge and experience gained in Pakistan and in countries with similar conditions. The basic recommendations on how to use this guideline are:

- farmers interested in seed production should evaluate the recommendations by applying the methodology first on small trial plots managed under their own conditions. If this is successful, or the farmer is satisfied with the results, it can be introduced on a large scale. If and when required, the practices may be adapted or modified. Care should be taken that the quality of the seed produced is not reduced by the modifications.
- this guideline can be followed as a whole or partially, especially when some of the recommended inputs and equipment are not available. When recommendations are followed in part, the main factors limiting crop productivity will have to be changed first. Otherwise the desired results may not be achieved. These limiting factors are highlighted in the following chapters.
- the technical terminology has been limited as much as possible but, considering the large readership this guideline is aimed at, many terms currently used in technical seed multiplication had to be included. All these terms can be found in a glossary presented as annex II. Most of the terms are also explained in the text when they are used for the first time. Abbreviations sometimes have had to be used, especially in the tables. They are explained on page VII.
- there is the firm intention of PSPDP, AARI and PARC to update this guideline after every 3 years, in order to incorporate the latest knowledge and introduce changes, where better recommendations have been worked out. For this purpose, a suggestion's slip has been inserted in this document. Readers are invited to use this slip to communicate to the authors any suggestion at any time. These suggestions will be considered and quoted in the next edition.
- Suggestions from farmers giving their experience with some of the techniques described hereunder are especially requested and will be acknowledged.

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FIGURES

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ABBREVIATIONS

AARI	:Ayub Agricultural Research Institute, Faisalabad
act	:actual
ADBP	:Agricultural Development Bank of Pakistan
AMV	:alfalfa mosaic virus
aph	:aphids
appl	:application
AS	:ammonium sulphate (fertilizer)
chem	:chemical
cm	:centimeter
cutw	:cutworms
DAP	:diammonium phosphate (fertilizer)
dd	:direct damage
eg.	:for example
etc	:*et cetera* (and others)
formul	:formulation
FSCD	:Federal Seed Certification Department
FYM	:farmyard manure
ha	:hectare
harv	:harvest
i e	:in example
incl	.including
ingr	:ingredient
irrig	:irrigation
K	:Potash
kg	:kilogrammes
LB	:late blight, a fungal potato disease (chapter 5.3.1)
Mg	:Magnesium
MINFA	:Ministry of Food & Agriculture
mm	:millimeter
N	:Nitrogen
N_2	:molecular Nitrogen
NA	:(Federally Administrated) Northern Areas of Pakistan
NARC	:National Agricultural Research Centre, Islamabad
np	:virus transmission does not persist in the vector
NWFP	:North West Frontier Province
OP	:operation
P	:Phosphorus
PARC	:Pakistan Agricultural Research Council
pH	:grade of acid-alkaline soil reaction
plant	:planting
PLRV	:potato leaf roll virus (viral potato disease)
prep	:preparation
PSPDP	:Pak-Swiss Potato Development Project
PVA	:potato virus A (viral potato disease)

PVM :potato virus M (viral potato disease)
PVS :potato virus S (viral potato disease)
PVX :potato virus X (viral potato disease)
PVY :potato virus Y (viral potato disease)
TSP :triple superphosphate (fertilizer)
Zn :Zinc

1. INTRODUCTION

This guideline will provide principles, background and technical know-how to start and improve seed potato production in the plains of the Punjab and adjacent areas.

In Pakistan, potatoes are grown on over 70,000 hectares annually (21). On average this figure is increasing by 8 to 12 % every year. This increase is above the population increase of Pakistan, thus suggesting that per capita potato consumption is slowly growing. Currently, about 190,000 tonnes of seed potatoes are required for planting this area averaging about 2.67 tonnes per hectare (31). Out of the entire quantity of seed required, about 4000 tonnes of certified or otherwise quality controlled seed is purchased, both from local and foreign sources. The certified seed available constitutes only 3 % of the total quantity of potato tubers planted (31). The rest of the so-called seed-potatoes are exchanged informally between traders/commission agents and growers and amongst growers themselves. As only 3% of the seed available every year to replace the old stock is certified, most of the crop is planted with seed of unknown quality, which may have already degenerated during several multiplications. This degeneration results in a decrease of the yield which very often dramatically decreases the profit margin left to the grower or even results in net losses. In particular, the seed grown once during spring for rapid multiplication purposes may degenerate very fast. Seed potato multiplication in spring may cause:

- physiologically weak seed due to the high temperatures at harvest in May,

- virus degeneration triggered by several seed-borne virus diseases, passed on to the next potato crop through the tubers used for planting.

The farmers' seed stock has to be renewed with healthy stock after every 2-4 years to maintain a normal level of productivity (22,24). Special care of this seed replacement has to be taken in Punjab where many growers tend to re-plant small tubers from their own potato fields year after year.

Seed of good quality is an essential prerequisite for a high yielding potato crop. A healthy seed stock should have the following essential characteristics:

- be of the desired variety without mixture of other varieties,

- be free from viral, fungal and bacterial diseases or at least with disease levels not exceeding the current minimum standards of seed certification presented in annex I,

- physiologically mature, i.e. ready to give vigorous sprouts at the time of planting.

Extreme care nas to be taken during the growing period and also during the post-harvest handling, packing, storage and transport in order to achieve the established seed health standards.

In order to reduce seed costs, farmers are advised to multiply new seed in separate plots at least for one season, using seed multiplication techniques as outlined in the following pages. Some of the practices recommended herein may increase the cost of production per unit of

land, but these costs will be more than recovered through increased productivity from the commercial plots produced from the seed.

The potato growers in Pakistan are generally skilled, specialized, and have many years of experience in handling this crop. Therefore, the production of a healthy stock of seed potatoes large enough to supply the local demand is a realistic and achievable target. Most of the resourceful farmers have already started their own multiplication cycles of 2 to 3 years starting with seed from reasonably reliable sources. Some years ago, imported seed from Europe (mainly Holland) was the only quality source available (1). However, during the last 5 years, local sources of certified seed have been developed. During 1990-1991 there was for the first time more local than imported seed available in the market of Pakistan. One big advantage for the farmers is that local seed can be made available for autumn planting, thus avoiding the risky spring crop (5,9). This is very difficult with the imported seed. Another big advantage is that the local seed costs less than imported and in the long run, it will be of better quality since the risky long distance transport is avoided.

In order to maintain high yield levels, farmers own seed multiplication cycles of not more than 3 years in autumn-to-autumn potato production in Punjab are desirable (3). Multiplying seed stocks beyond 3 years may result in economic yields, but there are risks involved such as:

- build up of mechanically transmitted virus diseases,
- build up of other tuber-borne potato diseases,
- loss of flexibility to the market situation,

which cannot be controlled when crops are handled by potato growers not specifically trained for seed multiplication.

2. AGRONOMIC GUIDE I. Land selection, planting

In this section, all the essential operations to be undertaken before and during planting of the seed potato crop are described.

2.1 Land selection

The following factors have to be considered while selecting the land for seed potato multiplication:

- soil quality,
- previous crops or crop rotation,
- irrigation infrastructure.

SOIL QUALITY: ideally, seed potatoes should be grown in **well levelled, well drained,** predominantly light soils. Soils with a history of **water logging / salinity** must be avoided. Soils with a pH value over 7.5 should also be avoided.

CROPPING HISTORY: land for the multiplication of certified seed potatoes should not have been planted with potatoes or other crops of the potato (Solanaceae) family such as tomatoes and egg plants (brinjal) for two years (FSCD minimum standards, Annex I) or at least for three different crops.

IRRIGATION INFRASTRUCTURE: farms irrigated by canal water can potentially give better results than those irrigated from tube-wells because canal water is in average of higher quality and contributes less to soil salinity.
Tube-well irrigation is however useful for the following reasons:

- at planting as water is required permanently during this operation and canal water comes only once per week,
- in December, when canals are usually shut down during 4 weeks for maintenance,
- for frost protection, irrigation in December-January, applied at shorter intervals,
- during spring, as temperatures rise and the potato crop has to be irrigated every 4-5 days especially for cooling the ridges.

In the Punjab, potatoes are extremely sensitive to irrigation errors immediately after planting and during bulking. Therefore, farmers without tube-wells are usually not able to achieve optimum yields as they can not respond flexibly to the water demands of the crop.

2.2 Crop rotation

Crop rotation is one of the most essential and probably the cheapest technique to ensure the

health standard of the potato crop.

Crop rotation serves three main purposes of seed potato production:

- it reduces the level of soilborne diseases and pests,
- it minimizes incidence of potato weeds,
- it maintains or even improves the level of soil fertility.

Among the above three considerations. the first one is by far the most important for the seed grower.

2.2.1 Autumn crop

In the farmer's own seed plot, not subjected to FSCD rules, at least a "**3 crops**" **rotation** should be considered. The best results so far have been achieved with spring maize followed by green manure (*Sesbania sesban* (*dhancha*) or *Crotalaria juncea* (sun hemp). The rotation sequence and timings should be as follows:

February/March	spring maize or sunflower
June	green manure or sorghum/maize for fodder
September	fallow, tilling
October 5 to 10	potatoes sown
January/February	potatoes harvested

After potato, the next crop can be spring maize, sunflower, cotton, watermelon, musk melon, mung beans or some other deep rooting crop which will make use of the residual fertilizer left in the soil.

The **fallow in September** is **essential** for land preparation and **preventive weed control.** One or two irrigations with canal water should be applied if there is no rain during this period. To control weeds preventively, the soil preparation for the potatoes should be performed in two steps with an interval of 15 days in which weeds may emerge and will be destroyed by the second tillage before flowering.

This will help to reduce the population of annual and perennial weeds during the early stage of the potato crop and therefore reduce the herbicide costs. Many farmers in the Punjab leave their potato plots fallow over most of the summer months and control annual weeds with broad spectrum pre-emergence herbicides. This has favored the development of high populations of perennial weeds such as *Cyperus rotundus* (Deela), *Cynodon dactylon* (Khabal ghas), *Imperata cylindrica* and *Sorghum halepense* (*Baru*). In particular during the autumn crop, *Cyperus rotundus* is causing grave concern in the southern half of the Central Punjab (Lahore-Multan, see weed control below). Therefore, a long fallow in summer is very detrimental and should be discontinued.

The rotation practice indicated above is quite widespread. Experience has shown that the **three crop rotation** will not prevent the build up of certain soil-borne diseases such as powdery scab (see 5.3.2 below). To avoid this problem, the farmers should keep at least a two year rotation without any potato crop or any other solanaceous crop such as egg plant, tobacco or tomato.

When **certified seed** is to be produced, potatoes have to be **replaced for two years** by **other autumn crops**. Preference should be given to the planting of seed crops such as seed cotton, seed sorghum, seed sunflower, etc. These rotation crops are likely to give higher returns than ordinary crops and will help to improve the general seed multiplication skills of the seed grower.

2.2.2 Spring planting

Due to the **high population of virus vectors,** especially *Myzus persicae* (3,10), during February and March, **the spring production of seed potatoes in the plains of central and southern Punjab is not recommended.** In the extreme north of the Punjab (Attock-Rawalpindi) and the plains of NWFP (Mardan-Peshawar) the spring crop is the main potato crop and seed for the **autumn** and sometimes also for **spring planting** is usually produced during the **spring season.** This practice is not recommended here, especially because of the risk of worsening the late blight situation already existing in these areas. However, in case it is practiced, the rotation should be as follows:

January / May	:	potatoes
June	:	maize/sorghum as fodder
September/November	:	fodder/vegetables
December	:	fallow/land preparation wheat

If a longer rotation is required for the production of certified seed, potatoes should be replaced by wheat for two years. If late planted, the summer fodder crop can also be ploughed in as green manure.

2.3 Land preparation

In Punjab, most of the seed potato producers plough 8 to 10 times (25), mainly with a spring tine tiller, alternating with four to five plankings.
When remains of a previous crop have to be destroyed, disc ploughs are often also used. The result is usually a fine textured seed bed with a **depth of only 10 to 15 cm.**
For the **plains areas of Pakistan** we recommend the breaking of slightly **pre-irrigated soil** with a **chisel or a mouldboard plough** (depending on the **existence or not of a hard pan** from previous tillages) up to a **depth of at least 25 cm.** After this, about **three spring tine harrowings and up to four plankings** may be applied. This should result in a **well levelled and fine textured seed bed of a depth of 20 to 25 cm.** Clod crumbling equipment should also be considered where hard clods are prevalent. This can be achieved with implements of the horizontal or vertical rotating type (**Figs 1 and 2**).
If and when powerful tractors are available, the number of operations can be further reduced by using tandem equipment.

2.4 Seed selection and preparation

Seed for planting a seed crop has to follow some essential criteria:

be of the desired variety without mixture,

- if there is an intention to produce certified seed, the disease levels should not exceed the current minimum standards of seed certification (see annex I) for the category below the one to be produced. This must be proven by a lot number provided by the FSCD (see also chapter 6),

- be physiologically mature, i.e. ready to give vigorous sprouts at the time of planting,

- be of the size (grade) prescribed by seed certification or adequate to the conditions at planting.

2.4.1 Seed size and time of planting

For the main autumn planting (25th September to 10th October) (23) the farmers in the Punjab use medium size seed, usually around 30 to 45 mm. Small tubers ("goolies" of 20 to 30 mm) do have a high degree of sprouting failure under hot weather. Small tubers from the previous autumn crop or cut, freshly harvested hill seed can also be used for multiplication if special precautions are taken. In this case, planting should be done between 8th and 20th October.
There are less limitations in the size of the seed tubers used for planting the spring crop as the climate in January does not hinder cutting the seed and this is a common practice of the farmers. **Tubers larger than 60 mm should not be used for seed.** They are more susceptible to rotting of seed pieces as they may have a hollow or soft heart.

2.4.2 Variety selection

Commercial seed growers or contract seed growers will usually multiply varieties under instruction of a seed multiplication institution or company.

If the seed multiplication is carried out to cover the farmer's own needs, he will carefully select the varieties considering past experience.
The farmer will decide whether white or red skinned varieties or both (6,23,27) types are required, depending on the access and linkage to markets where these types of potatoes are in demand. Furthermore the choice of the variety will depend on the time of planting and also on the type of farm management. Farmers very often decide the varieties to be planted purely on tradition. They are wise to do so, because their experience of handling their traditional varieties is the best and the risks of failure initially will increase when a new variety is tried. To avoid this, large farmers in the plains keep permanent small plots with varieties on trial, including some traditional and some new ones. These varieties are currently kept for three years. After this period, the farmer will decide to keep or discard a particular variety. If the variety is kept, the farmer has already gained 3 years experience about its particular handling requirements, before taking the risk of planting the new variety on a larger scale.

Some general recommendations concerning the varieties with the widest use in the plains are given:

for early autumn crop (early harvest):
Ultimus
Desiree (but is sensitive to stress and delicate to handle)

Patrones (heat stress sensitive but early bulking)

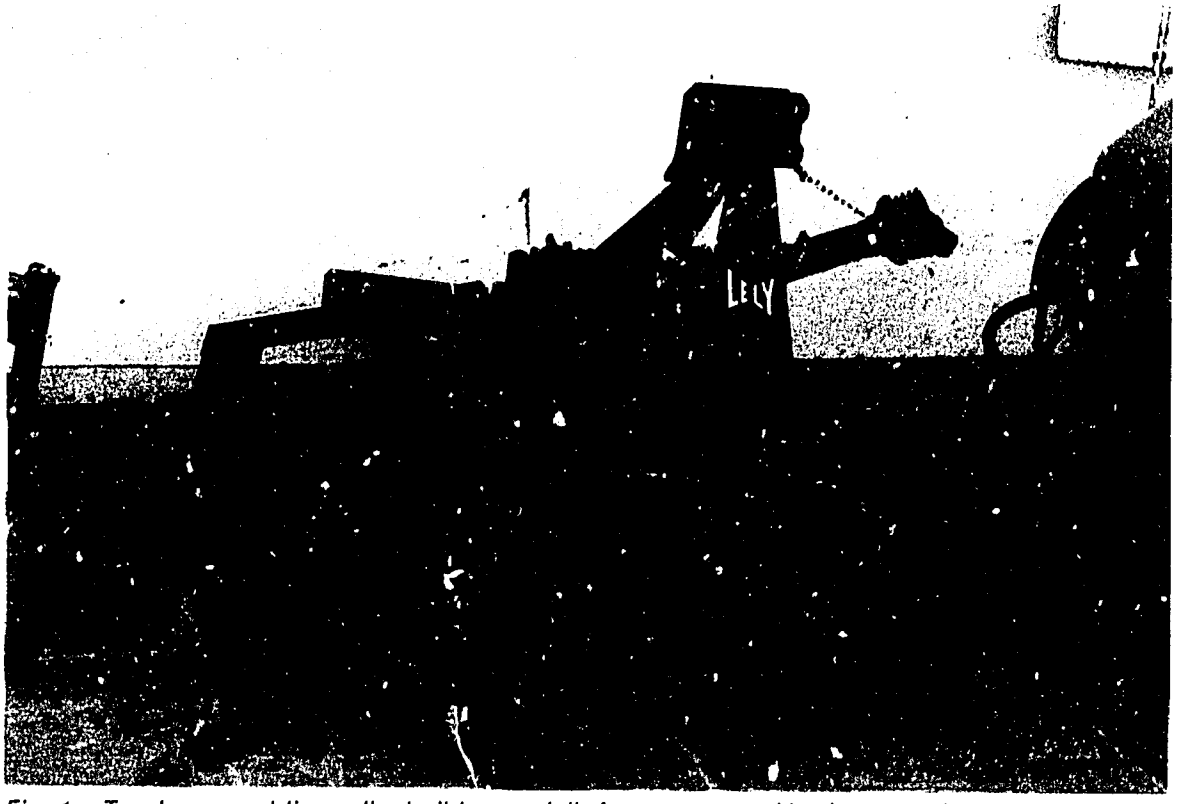


Fig. 1. Tandem crumbling roller build especially for potato seed bed preparation

Fig. 2 Vertical clumbling tiller adapted to heavy potato soils.

- for the main autumn crop:
  any modern variety registered in Pakistan

- for late autumn planting:
  Cardinal
  Diamant

- for spring planting in the northern plains
  Cardinal
  Desiree
  Ultimus
  Diamant
  Patrones
  Ajax (high yielding, LB susceptible)
  Multa

- for low input small growers:
  Ultimus
  Diamant
  Lal e Faisal

(the **varieties** shown **in bold** letters are **red skinned)**

2.4.3 Seed preparation

At planting, seed potatoes should be dry, kept at ambient temperature and should have started sprouting. Pre-sprouted seed tubers are better but not essential for the autumn crop planting. In the Punjab, sprouted tubers may not gain any advantage under the prevailing pre-planting handling practice. The main limitations are the poor soil preparation, poor coldstore management, and ridging with soil compacting equipment. It is, therefore, recommended to take the seed out of the cold-chambers of the store 5 to 10 days before planting. During this time, the seed should be placed in a **pre-cooling chamber of the store or under permanent shade** of any kind. If the seed is kept in stacked bags in the open, air should be blown through the stacks in order to accelerate drying. If sufficient shaded space is available, the seed should be laid out to dry. This also allows for a thorough sorting out of cracked, diseased, rotted or unsprouted tubers prior to planting. Extreme care must be taken with shock sensitive varieties like Patrones or Desiree. These varieties are prone to rot if kept at ambient temperature for more than 10 days after having been subjected to shock. Shocks at handling may be caused by:

- too fast cooling,
- cooling below 2°C,
- overstoring at changing temperatures,
- overheating,
- too fast heating up,
- long transportation under very hot or very cold temperatures (see also chapter 7),
- rough loading, unloading or poor stacking practices.

In summary, **the adaption of the cold stored seed tubers to outside temperatures should**

be gradual over several days (up to 10) and, if the tubers become wet when exposed to hot temperatures, they must be dried in less than 2 days.

After warming up, drying and sorting, the seed should be transported to the planting site in **crates or baskets**, to minimize damage through crushing. Re-bagging of sprouting seed should be avoided if possible. If bagging is unavoidable, smaller bags (30 to 50 kg) than the usual ones of 100 kg should be used. **Long transportation from the store to the field is detrimental to cold-stored seed potatoes, especially if the seed is transported in bags.**

2.5 Planting techniques

Four types of planting techniques are being used in the Punjab (25):

- hand planting and ridging by spade,
- manual or hand planting with drawn ridger,
- semi-automatic planting,
- fully automatic planting.

2.5.1 Manual planting and ridging by spade

Some small growers in the northern plains plant by hand and have no access to a tractor-drawn ridger. Precise levelling in this case is difficult. Wider but shorter ridges connected with tie-ridges are the correct practice of skilled farmers.
Lines for ridges and tie-ridges are marked in the field with the help of a thin rope. One unskilled field worker then places the seed on these lines and another trained appropriately, corrects the spacing of the seed. The two person broad spade (bailcha or chari) is in general use for manual ridging of potatoes (see fig 3).

2.5.2 Manual planting with tractor drawn ridger

About 5-10 cm deep furrows are produced with the potato ridger and the seed potatoes are then placed in these small furrows by hand at the desired distance. The potatoes are then covered by the same ridger. The method is labour intensive but not too expensive. Sufficient labour should be available to carry out planting in a short of time. With trained labour, very precise planting can be carried out with this method.

Currently the main problems observed are:

- **too narrow and/or too small ridges are made in shallow plant beds,**
- **no provision for drainage of excess water is made.**

Fields planted by hand **yield far better if the ridges are at least 80 to 95 cm apart and 35 cm high**. Seed bed preparation should be deep enough to allow for this (see 2.3, above).

2.5.3 *Semi-automatic planting*

Two men sit on a ridger equipped with a simple hopper and two tubes. Potatoes dropping

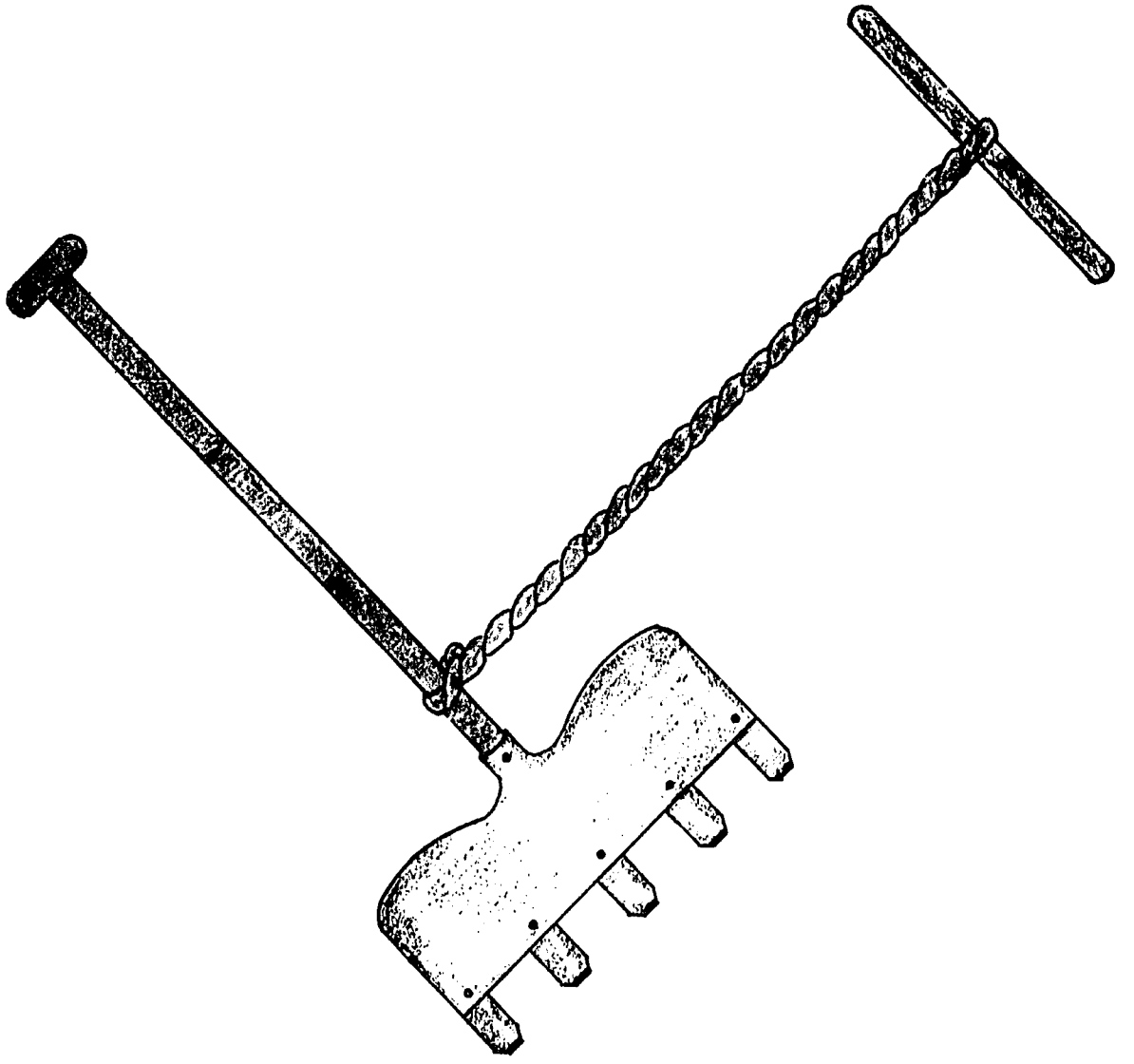


Fig. 3. "Bailcha" or "Chari" the ideal hand tool for potato planting as used in the Northern Punjab and NWFP

Fig. 4. Semi automatic potato planter suited for regular placing of the seed tubers.

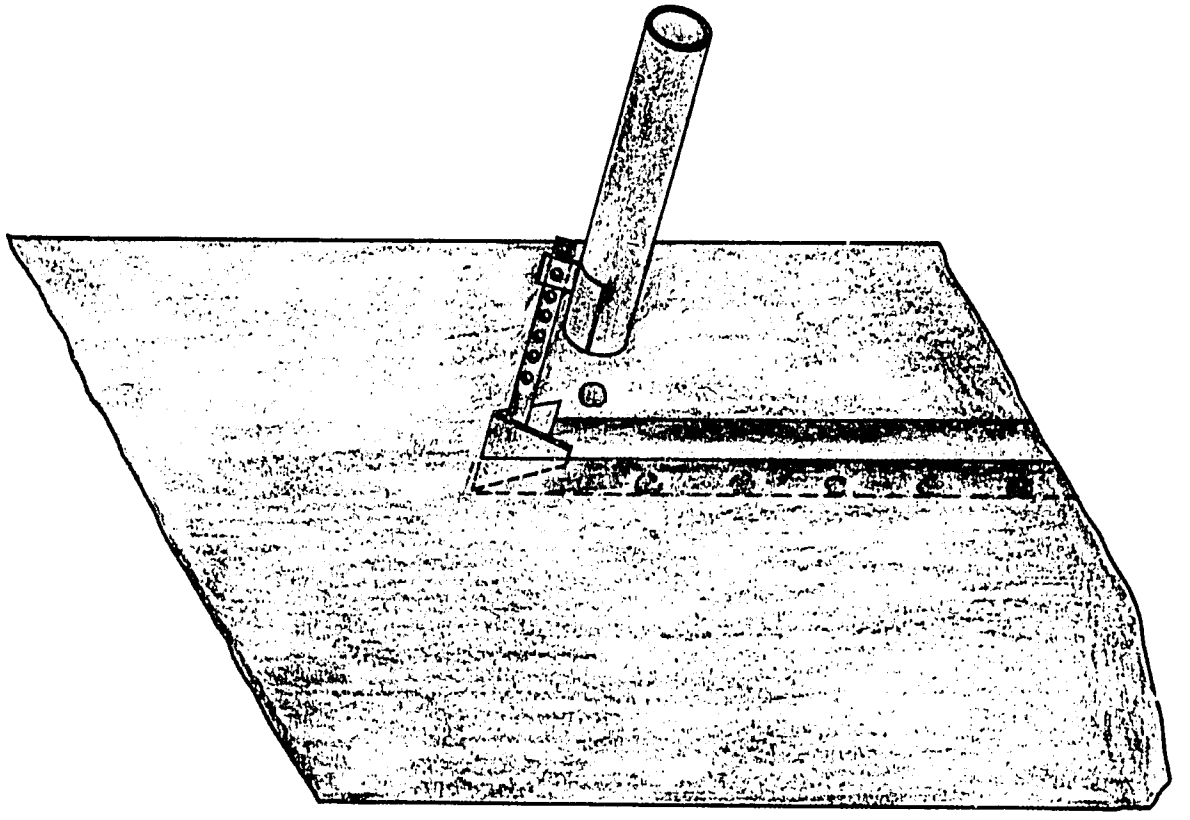


Fig. 5. Correct (Semi automatic) planting

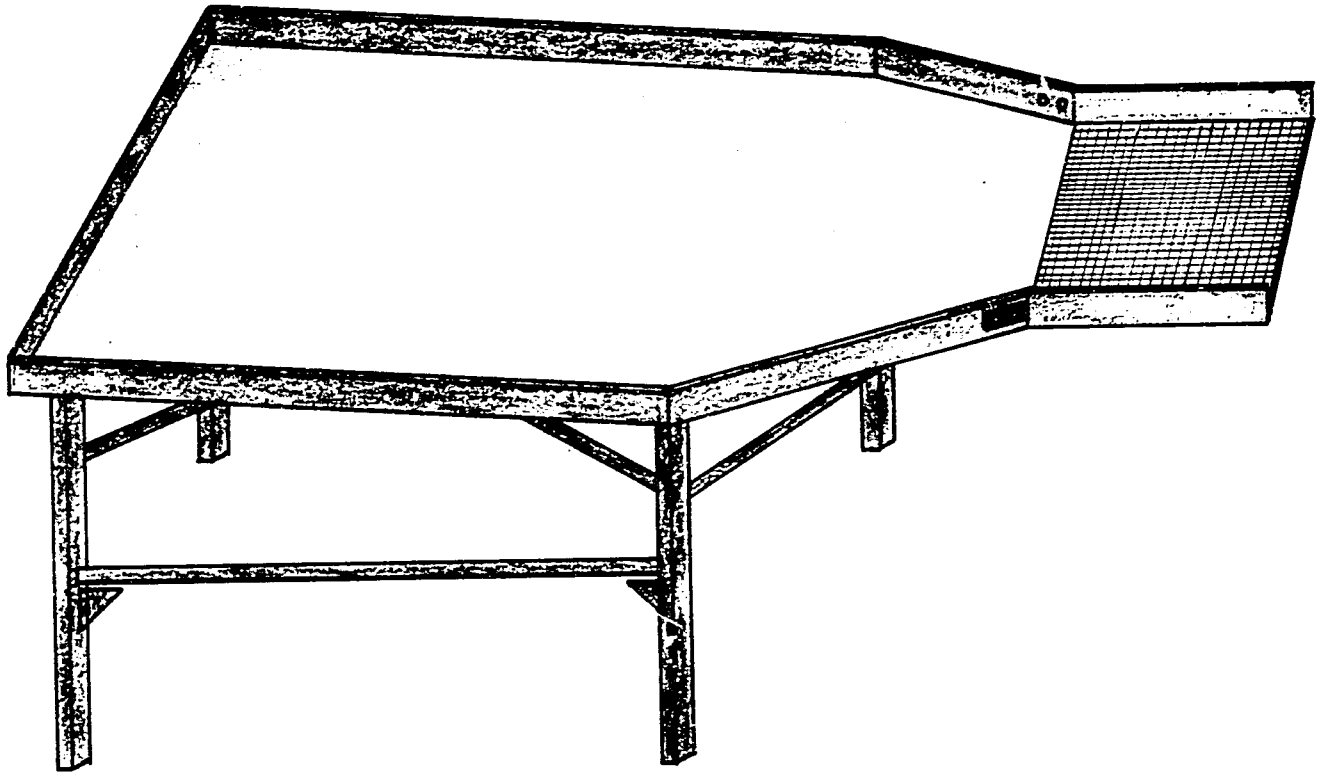


Fig. 6. Manual Grader Based on the inclined table principle

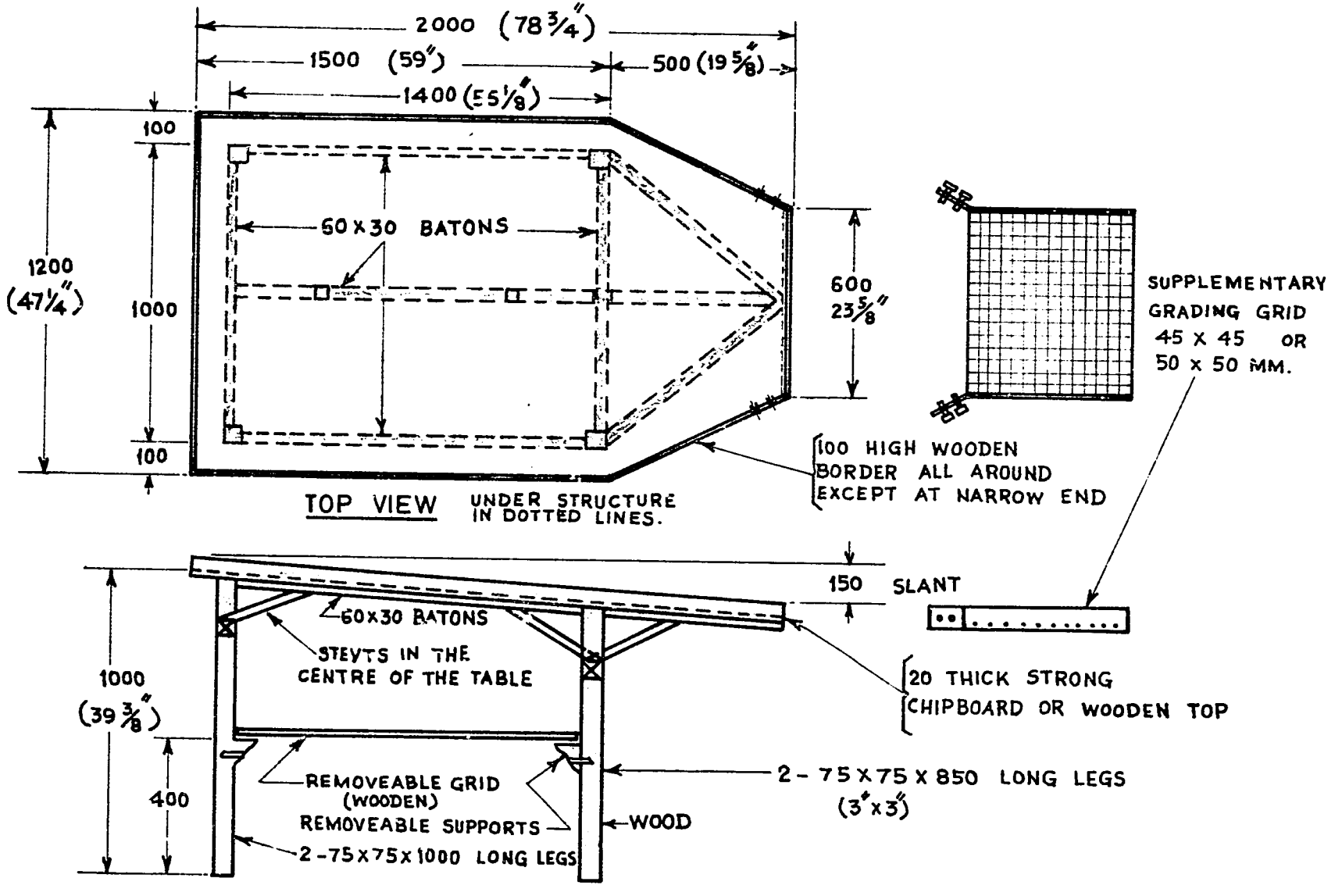


Fig. 6(a) Manual Grader Based on the Inclined table principle

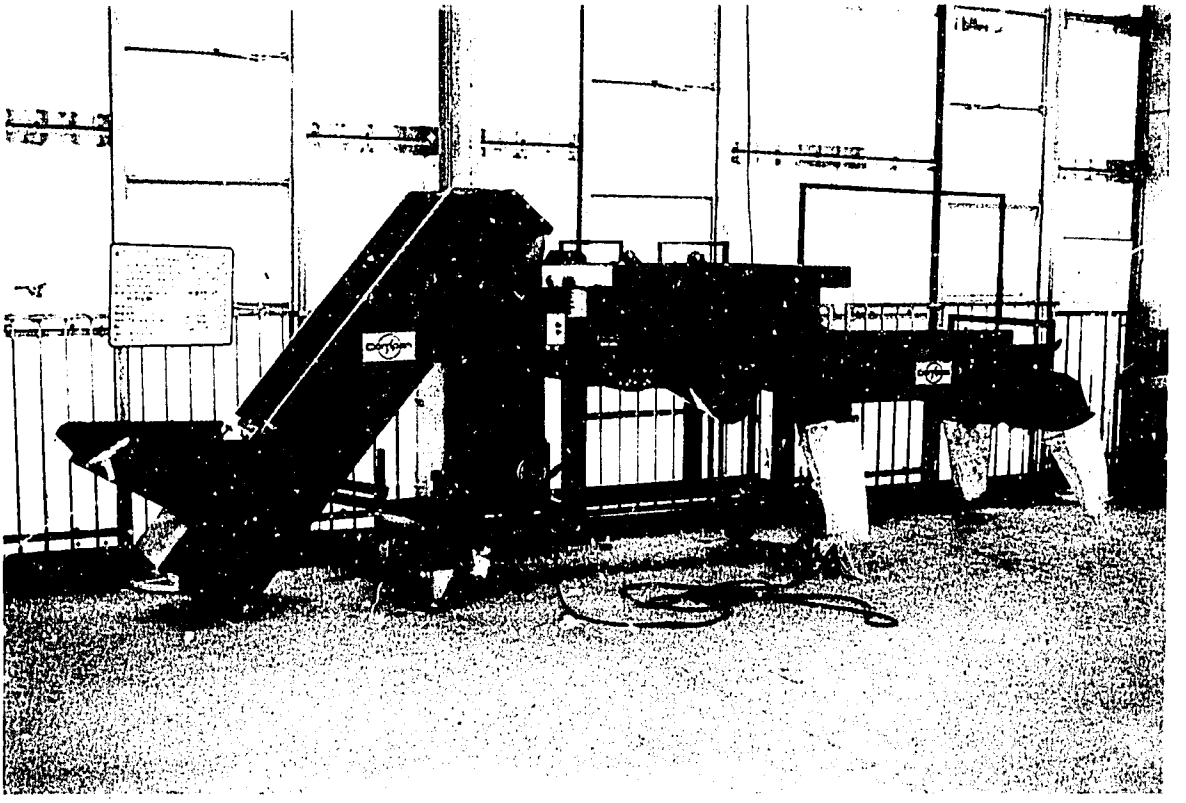


Fig. 7. Mechanical grader

through a slit in the base of the hopper are manually placed in the tubes. The labour working on this locally manufactured planter has to be extremely skillful. The use of unskilled labour results in a very irregular plant-to-plant distance, which is not acceptable in seed production. Semi-automatic planters provided with a pacing or regular placing device (see fig. 4) would work satisfactorily but are not yet used in Pakistan.

The main problems are:

- if the planting tubes are set too high, the seed tubers will roll out of the planting lines, resulting in irregular planting,

- planting into badly levelled soil causes rolling of seed, resulting in irregular planting and irrigation problems,

- planting with a convex ridger causes compacted ridges, which may result in poor tuberization and poor plant development,

- irregular spacing of seed causes gaps, resulting in poor seed multiplication rates and poor yield.

A small marker, placed below the planting tube, should enter at least 5 cm deep into the soil and make a small furrow preventing the seed from rolling around before the ridge has been formed (see fig 4).

2.5.4 Automatic planting

The equipment so far available in Pakistan is only suitable for planting whole, perfectly graded potato tubers. Some farmers in the Punjab are using this equipment. The gaps in the seed flow caused by bad grading are usually filled by two labourers uncomfortably sitting on the machine and placing missing seed tubers in the chain cups. The locally manufactured equipment is rather simplified but unfortunately some essential parts, such as exchangeable cups and planting depth adaptor, are missing. Good grading is difficult for most farmers because they rely on hand grading and the seed size is kept smaller or bigger in accordance with the seed quantity required. Big growers aiming for fully automatic planting due to labour shortage problems, should be aware that they need to use at least some sort of accurate manual grader (see fig. 6). Larger lots of commercial seed can also be graded mechanically (see fig 7).

For **all types of mechanized or semi-mechanized planting, the ridger should be of the concave mouldboard or disc type**. Convex, soil compacting ridgers as currently in use in Pakistan are inadequate for seed potato multiplication. They press the ridges into shape, causing ridge compaction. This results in large clods hampering the harvest operation. Furthermore, in the case of heavy rains or irrigation errors, compacted ridges are prone to waterlogging which results in very poor seed production.

2.6 Planting density

If planting and ridging is performed mechanically, the **row to row distance** should be adjusted

to the universally accepted standard type for potatoes. As most modern potato varieties are selected for optimum performance at row to row distances of 75 cm, this width should also be used for seed multiplication in Pakistan. Where ridging is carried out manually, larger and wider ridges (up to 90 cm) are practiced by farmers in some areas. They will probably give better results under these farmers' crop production systems. Nowadays, ridges as close as 65 to 70 cm prevail amongst the semi-mechanized potato growers in Pakistan (see fig. 8). Close row to row spacing can result in the following problems:

- a reduction of the number of tubers per hill by pruning stolons during weeding and earthing-up,

- ridge compaction in order to avoid the collapse of the narrow and steep ridges during first irrigations thus reducing the number of tubers per hill,

- a higher proportion of clods and lumps in the ridge, hampering a clean harvest operation (see fig. 11),

- a tendency of shallow land preparation as small narrow ridges need less loose soil to be formed,

- a lower overall production due to flooding of the crop during irrigation and water stress between irrigations as it is difficult to practice correct irrigation and to avoid waterlogging under these conditions (13,14).

The **plant-to-plant distance** for seed potatoes should always be less than for ware potato production. This is to aim at a larger number of small tubers. It is difficult to recommend a general plant-to-plant distance for all seed potato crops:

- For the main autumn crop planted with normally graded uncut seed, 6 tubers should be placed per running meter, with a final population of about 80,000 plants (hills) /ha.

- When cut seed or "goolies" (20-30 mm) are planted, a plant population of up to 100,000 hills/ha should be aimed at.

- In case of planting uncut bigger tubers (up to 60 mm), a current practice when valuable pre-basic seed is multiplied into basic seed, the plant density should not exceed 65,000/ha. In this case a higher number of tubers per hill is the target and a wider spacing will also facilitate thorough roguing and prevent the spread of mechanically transmitted virus diseases (30).

The main aim of a narrow plant-to-plant distance in the seed crop is to control bulking of the seed tubers, thus increasing the proportion of seed size tubers and therefore increasing the multiplication rate for clean seed. Some adjustment in the plant-to-plant distance will also have to be made according to the development pattern of the varieties:

- varieties with a large amount of smaller tubers per plant (Patrones, Multa), and varieties with a large amount of strong growing stems can be planted at wider spacing,

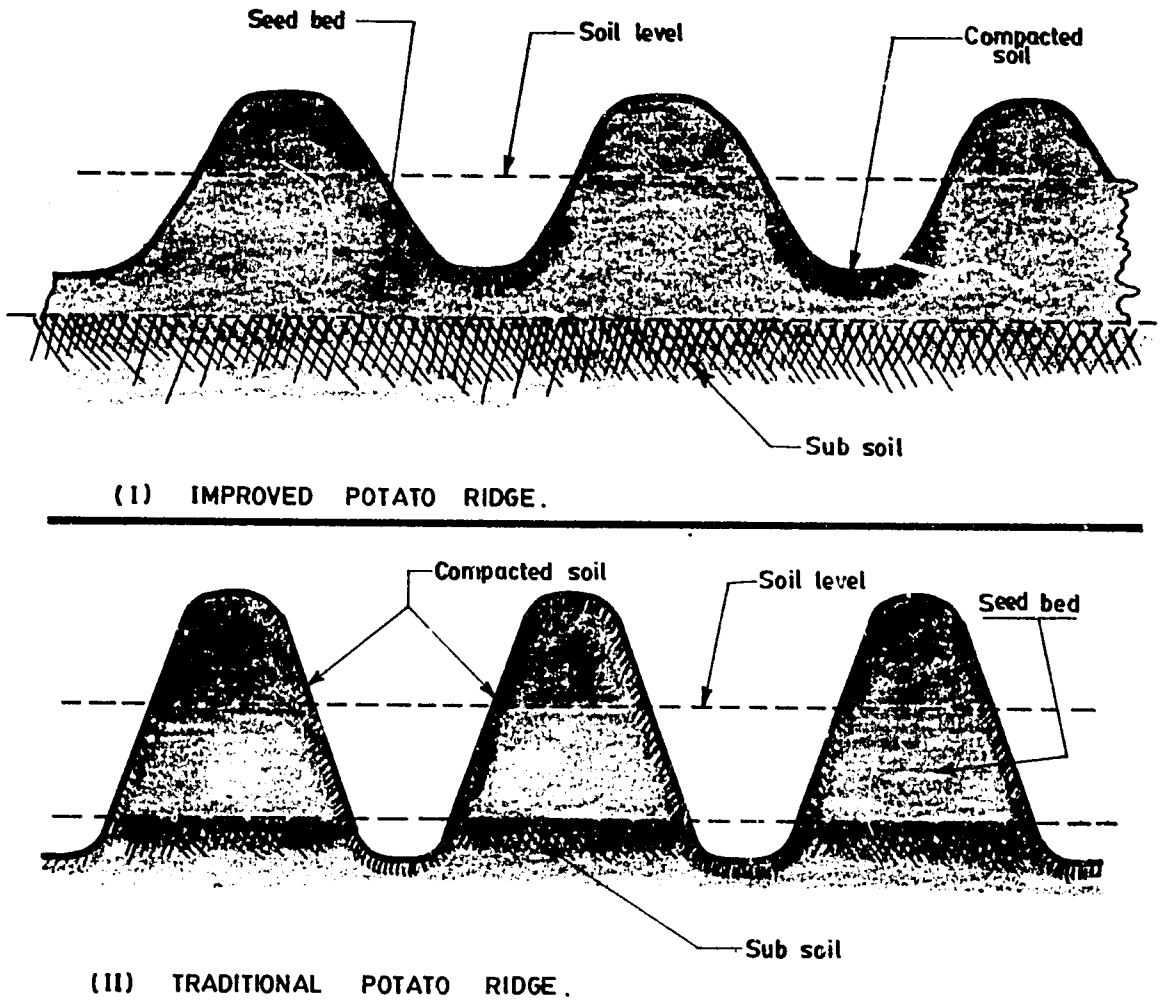


Fig. 8. Improved and traditional potato ridges

varieties with small aerial growth, small number of stems, or naturally small number of large tubers must be planted at a closer spacing (Desiree, Diamant, Cardinal).

2.7 Planting Time

The **autumn seed crop** should be planted immediately after the main autumn ware crop planting, generally around 5th to 10th October (6,23). Planting of the seed crop should be carried out as fast as possible. Heat tolerant but frost susceptible varieties such as Patrones, Lal-e-Faisal and Desiree can be planted earlier (3rd to 8th October).
The day on which to start planting depends primarily on two factors:

- soil humidity may be too high due to late rains,

- temperature may be still too high in dry years.

The planting dates should therefore be kept flexible.
In the northern plains (Peshawar, Attock), planting can start much earlier if the weather and soil conditions are favourable.

The **spring seed crop** is usually planted around 15th January. Planting as late as 15th February has been recorded but planting after 1st February should be avoided. Late planting is usually due to heavy rains in January and early February. The effect of rains on the planting dates can be reduced by preparing the fields in December, including marking of the lines. Planting can then be carried out in January, even under rainy conditions, if ridging is done by hand operated tools. Temperatures in January are usually low. Under such conditions tubers are less affected by excess soil humidity at planting. Heavy losses due to rotting of seed tubers after rains have been observed in the late planted spring crop in the Punjab in 1989. That means that the risk of losing the crop due to waterlogging is increased by delayed planting.

3. AGRONOMIC GUIDE II, Cultural Techniques

The potato crop, and very especially the seed potato crop, only gives good results when a number of cultural techniques are carefully carried out.

3.1 Fertilizer Application

The potato crop takes a very high quantity of nutrients from the soil. Potatoes have this in common with other high yielding root crops. It is essential to replace at least the quantity of nutrients extracted. Some additional quantity of fertilizer has to be applied containing those elements expected to become blocked in the soil or to be leached out.

3.1.1 Nutrient requirements of the potato seed crop

The recommended quantities to be used when no special recommendation based on experimental data are available are presented in table I hereunder. Table I shows the quantities of active ingredients per hectare and the kg/ha recommendations for the most potato-compatible formulations commercially available in Pakistan.

TABLE I: The PSPDP general recommendations for the application of fertilizer to the seed potato crop in the plains of Pakistan

Nutrient	Fertilizer	Active Ingredient %	Fertiliser Rate kg/ha	No. of Application
N	Ammonium sulphate	90	appr. 860*	2 (50% at planting 50% at earthing up)
P	Single super phosphate	18	appr. 610	1
K	Sulphate of potash	50	240	1
Zn	Zinc sulphate	-	10	1

* For every tonne of farmyard manure applied the application at Ammonium sulphate can be reduced by 25 kg/ha

The reason for the recommendations given in Table I above is as follows:

1) **Ammonium sulphate (AS)** is a formulation enhancing the acid reaction of the soil. This is of advantage as most of the soils in the plains have a pH above 7. This formulation is also far better tolerated by the potato root system and yields are usually higher when farmers apply AS, as compared to applications of Urea, DAP or CAN (see **abbreviations**, page vii).
Up to **20 tonnes of FYM**, to be applied at least 45 days before planting will encourage **balanced soil microorganism development** and improve soil structure. This is especially important when planting in the poorly structured heavy soils prevailing in the plains of Pakistan.

2) **Single Superphosphate** is a formulation based on **Gypsum.** Gypsum has the property to **improve the soil structure** in the Punjab, and the farmers using this formulation tend to get higher yields as compared to TSP, Nitrophos and DAP. The farmer has to apply more fertilizer but this formulation is also comparatively less expensive.

3) **Sulphate of Potash** is the **only formulation** of potash well **tolerated** by the potato crop. The residual reaction is acid, reducing the pH values of the soil.

4) **Zinc Sulphate** is the cheapest effective Zn formulation available in Pakistan.

If there is any difficulty in getting the formulations of N and P recommended above, alternative formulations available in the market can be used at the quantities recommended below.

NITROGEN: The exact N requirement of the seed potato crop is difficult to calculate since it depends on the yield expectations. A lower dosage of nitrogen results in an earlier start of bulking and less vegetative growth. Final bulking may be lower or higher depending on the earliness, yield potential and the response to N of the variety. A lower dosage of Nitrogen also contributes to reducing the final size of the tubers and will accelerate the maturity of the crop. The seed potato producing farmer should destroy the haulms before periods of intense virus vector flights or as soon as 80% of the tubers have reached seed size. Therefore, maximum bulking is not a target, rather maximum percentage of seed size tubers.
Sufficient nitrogen has to be applied to supplement the quantity of N extracted from the soil by the developing potato crop (33) and make good the losses caused by leaching, denitrification as N_2 and ammonia and for the N fixation caused by microorganisms which decompose fresh organic matter in the soil.

In the Punjab autumn crop, the leaching is low but in October (hot weather) losses due to denitrification are high. The crop uptake of N is moderate and yield expectations in the 90 days crop are also moderate.

The farmers who are already using the seed plot technique in the Central Punjab have the tendency to reduce the application of N by about 30% as compared to the quantities applied to the ware potato crop. Increased N application of about 10 to 15 % above the indicated level for seed potatoes may be required, when undecomposed organic matter has recently been ploughed under. High amounts of undecomposed organic matter are detrimental to seed potato production. FYM applications induce higher yields but it should be applied to the previous crop about 2 months before planting the potatoes.

As a rule of thumb, the quantity of N applied per hectare to the Punjab autumn seed crop should be about 150 - 200 kg active ingredient. This is contained in :

700	to	950	kg of AS
834	to	1110	kg of DAP
652	to	870	kg of Nitrophos
360	to	435	kg of Urea
30000	to	40000	kg of FYM

PHOSPHORUS: P is essential in order to obtain a high number of tubers (16) and for tuber health and disease resistance. P must be increased in soils of higher pH but these soils are less suited for potato production. As a general rule, the requirements of the seed potato crop are about 10 % less than of the ware potato crop, especially for maintaining the P-N balance. A full dose of P should be applied for those varieties with late maturity. Full skin maturity is reached earlier under a higher dosage of P which is very desirable in seed potato multiplication.

In the Punjab autumn crop, as a rule of thumb, about 110 to 120 kg. active ingredient of P should be applied per hectare. This is contained in:

610	**to**	**670**	**kg of Single Superphosphate**
240	**to**	**260**	**kg of DAP**
480	**to**	**520**	**kg. of Nitrophos**

POTASH: K is in average well supplied in the plains of Punjab. Potato is nevertheless the annual crop with the highest uptake of this element, which is stored in the tubers. It is therefore recommended to at least replace the potash removed with the harvested tubers, increased by a factor for leaching. This is estimated at about 60 kg per 10 tonnes of potatoes. Since yield expectations in the Punjab seed potato crop are about 20 tonnes per hectare, the recommended dose would be:

120 kg. active ingredient perhectare

This is contained in:

240 kg. of Sulphate of Potash

MAGNESIUM: This is a **macro-element** in the nutrient requirements of potato. Mg is usually in sufficient supply in the Punjab soils. Its application should be recommended only in the case where experimental data suggest a deficiency.

ZINC: Zn is a **micro-element**, essential for high yields of solanaceous crops (13, 15) and generally in short supply or not accessible to the plants in the Punjab soils. Potatoes require balanced provision of Zn and Mg. The demand of the potato crop for Zn is relatively high and foliar applications of organic chelates or Zinc Sulphate are well tolerated by the potato crop. If sprayed on the crop, care should be taken that the spray does not touch a neighboring cotton crop. Zn compounds have a herbicidal or defoliant effect on cotton and some other susceptible crops.

Soil applications of Zinc Sulphate as a side dressing before earthing up also resulted in better yields and may be more practicable.

Zinc compounds are relatively cheap and first results of trials made in Faisalabad indicate that yields can be increased up to 20 % with Zn applications to the crop, as a side dressing after earthing up.

There is no harm in applying 10 to 15 kg of Zinc Sulphate per ha to the potato crop, as a side dressing after earthing up.

3.1.2 Time of application

NITROGEN: In most countries a single application of N is recommended for seed potato crops. This is undertaken to avoid the setting of tubers in two phases. In the Punjab autumn crop this cannot be generally recommended because too high N applications at planting time will increase denitrification during hot weather, intensive enough to cause ammonia poisoning (scorching) of the plants. If seed crops are planted after 15th October, danger of ammonia scorching is lessened but such late plantings are not recommended north of Lahore and risky all over the Central Punjab.

The N should be applied to the seed crop in two equal doses. The second application should be done just before earthing up when 70% of the crop has reached 10 cm (4" or 2-4 developed leaves), and not later than 5th November. This is at least 1 week earlier than in the ware potato crop. Through this early application, the second set of tubers produced after earthing up should get sufficient time to reach seed size 90 days after planting.
If at least 50% of the required N has been applied as FYM two months before planting or through the summer green manure crop ploughed under at least 6 weeks before planting, only one application of up to 100 kg N at planting is sufficient and preferable.

PHOSPHORUS: P is introduced in the soil during the last steps of land preparation before planting and ridging. In soils with higher pH value or affected by some salinity, 5 % of the requirements can be applied by spraying the crop with soluble fertilizer before the start of bulking (two sprays before and just after earthing up).
The concentration to be applied should follow the recommendation given on the label of the brand to be used.

POTASH: If potash is applied just before planting, jointly with N and P, it is recommended applying only Sulphate of Potash. Some farmers prefer to apply the cheaper Muriate of Potash and sometimes Sulphate is not available. In these cases the Potash will have to be applied to the soil 2-3 weeks before planting and before the "rouni" irrigation, to avoid the **toxic effect of active Chlorine** on the potato roots and sprouts.

MAGNESIUM: If it is to be applied, deficiencies in the soil should be corrected well before planting by applying Sulphate of Magnesium.

ZINC: Trials in the Punjab have shown reasonable results when Zinc Sulphate is applied as a side dressing to the plants before earthing up. Zn can also be applied as a spray if the crop is to be sprayed with micronutrients anyway. The application can be delayed till shortly after earthing up but should start well before tuber setting. Two applications with one week interval are recommended in this case.

3.2 Hoeing and earthing up

There is much controversy concerning this operation amongst the potato growers in the Punjab. More and more farmers tend to abandon it, because it decreases yield.
The cause of this decrease in yield may be found in the narrow and pressed ridges and in the very shallow land preparation (25).

In the seed potato crop, the benefits of earthing up are as follows:

- incorporation of the second N application into the soil,
- destruction of perennial weeds before closure of the crop canopy,
- loosening of the ridge, so increasing the oxygen available to the potato roots,
- covering additional stem nodes with soil before the main stolon development, thus increasing the number of tubers per hill.

Possible disadvantages are:

- destruction of potato roots if the ridges are too narrow,
- delay in crop development, and destruction of stolons if the operation is carried out too late.

It is therefore recommended to :

- keep row-to-row distance at least at 75 cm,
- carry out earthing up as soon as the crop is on average 10 to 12 cm high,
- before earthing up, loosen the soil between the ridges by hoeing with three pronged spring tines,
- use only concave double-mouldboard ridgers or concave disc ridgers for the earthing up operation,
- hoe and earth up with tandem equipment,
- apply regular irrigation immediately after earthing up.

3.3 Roguing

This is the technique used to eliminate all diseased, off-type or otherwise abnormal plants in a standing seed potato crop. The precondition for a successful roguing operation is a very homogeneous crop where:

- at least 80% of the plants have emerged from the ground (8),
- not more than 5% of the plants are diseased or off-types (8),
- the top foliage is undisturbed from frost, herbicide burn, fertilizer burn, caterpillar damage, sucking insect damage, mites, etc.,
- fertilizer has been applied in time and spread evenly,

- germination is regular and has not been affected by field levelling errors.

The following diseases can be reduced considerably by the roguing technique:

- secondary virus infestation by PLRV, PVY and severe mosaic,
- severe rhizoctonia,
- severe wilting caused by diseases,
- blackleg caused by bacterial infestation.

Roguing will also help to reduce the number of off-types caused by:

- mixing of tubers from other varieties,
- somatic mutations like giant hill symptom or changes in the plant colour pattern.

Roguing is carried out by a crew of about 5 field workers accompanied by a trained supervisor walking through the seed plot. They have to walk along the lines with the sun at their back or to their sides. Each field worker covers two lines. The supervisor indicates the plants to be rogued out with a stick. The field workers remove the plants from the field. Affected tubers must be removed along with the vines and placed outside the field. Field workers will be more motivated if they are allowed to take rogued tubers home for consumption.

Ideally, roguing must be done twice:

- **about 40 to 45 days after planting, when earthing up has been completed, but also at least 15 days after earthing up, so that any disturbance of the crop caused by this operation may be healed. The first roguing is made to remove all the off-types, severe PVY, part of PLRV (most of it is not visible at this stage) and Fusarium tuber rot.**
- **about 25 days after the first roguing and at least 10 days before haulm destruction; to eliminate all plants affected by blackleg, wilting, PLRV, visible mosaic, severe rhizoctonia and remaining off-types.**

Symptom descriptions can be found in several publications (20, 34, 35, 36).

Some additional information is presented in chapter 5.

Ideally the roguing supervisors should be trained by experienced scientists.
Roguing costs are about one field worker per acre per day for each operation. Normally roguing does not have measurable effects on the yield. In particular the loss of plants removed during early roguing, before main bulking, will be compensated by the additional bulking of neighbouring plants. Roguing of fields with more than 5% of affected plants is to be discouraged mainly on economic grounds.

3.4 Haulm destruction

This is carried out to control seed size and prevent disease infection.

In the Central Punjab, if the autumn seed crop has been planted before 10th October, it should be ready for haulm destruction around 10th January (9).

There are slight differences amongst the varieties and some delays due to physiologically young seed:

- **Patrones, Ultimus, Desiree and Lal-e-Faisal** may be ready some 5-8 days earlier than other varieties,

- **Cardinal and Diamant** may be delayed by 2-5 days,

- crops **raised from seed tubers directly** transferred from the **hills to the plains** may be delayed by 5-10 days.

The decision to destroy the haulms must be taken after an assessment of the field condition. This can be carried out during the first two weeks of January:

- uproot one running meter of crop per plot planted on the same date and with the same seed lot; if more than 75% of the tubers are bigger than 35 mm, the haulm destruction can be done on 10th January,

- count the living aphids settled on 100 leaves taken at random from each seed plot; if more than 4 aphids are found per 100 leaves and the tubers are still too small for harvesting, the crop must be treated against aphids (see chapter 5.4, following); haulm destruction can then be delayed till 20th January.

No matter what may be the size of the tubers, in the Central Punjab the haulms must definitely be destroyed by 20th January.

In the Attock district, the Peshawar plains, and the Sialkot-Gujranwala-Lahore area, particularly in rainy winters, intense aphid flights are sometimes delayed until February. In this situation, haulm destruction can be delayed by another 8 to 10 days but, for plots to be certified, relaxation must be obtained from FSCD before taking the decision.

Irrigation should stop at least 4 days before haulm destruction.

The haulms are usually destroyed by cutting them and taking them out of the field. In the central Punjab they are currently in demand as animal fodder. Often the local people will remove the haulms free of cost but a supervisor is essential for a clean operation.

If rains or accidental flooding trigger regrowth from the cut haulms, a spray with specific caustic herbicides such as Diquat (reglone) or Paraquat (grammoxone) has to be applied to the stubbles. Before the spray, exposed tubers should be removed from the field.

3.5 Harvest

3.5.1 Harvest time:

The harvest has to be carried out at least 15 days and not later than 30 days after haulm destruction (9,11).

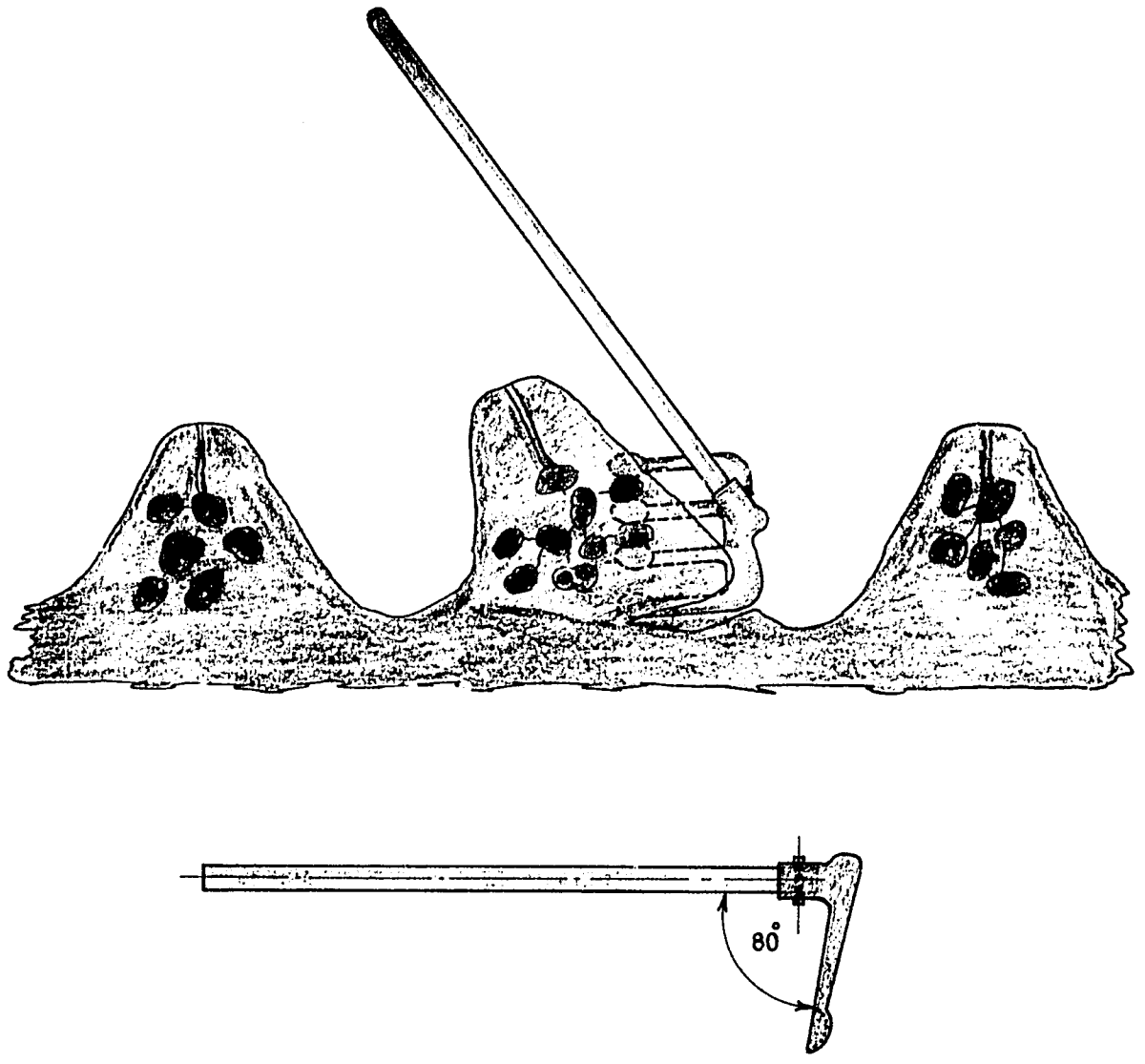


Fig. 9. Pronged potato harvesting hoe

Fig. 10. Hand picked potatoes thrown on the heap. This treatment is not adequate for seed potatoes

Harvesting time depends on the following factors:

Skin maturity

The skin on the whole potato tuber must be hardened. The skin at the rose end of the tuber should not peel off when pressured with the thumb.

Temperature

The soil temperature in the ridge should be well above 10°C to avoid tuber cracking. If harvesting takes place during frosty periods, digging up the tubers must be restricted to the warmest hours of the day. Otherwise the tubers tend to crack at the slightest blow or bruise.

Soil moisture

The mature seed plot should receive a light irrigation before the start of the harvest operation in order to minimize clod formation and tuber damage. The harvest can be carried out 2-4 days after this irrigation. If by chance there is a heavy winter rain, the harvest must be delayed till the soil moisture is satisfactory. At harvest, the soil in the ridges should be humid and crumbly and should not stick to the hand when pressed. In case of mechanical harvesting, the field should be dry enough to support the tractor.

3.5.2 Harvest technique

Spinner

The currently dominant technique for the harvest of the autumn potato crop in the Punjab is the spinning harvester or "spinner".
Due to the fact that potatoes are separated from the surrounding soil by a hitting device, this technique should not be used for harvesting seed plots (25).

Manual harvest

This is the second most popular method and provides by far the best results if adequate tools are available. The tools currently used in Pakistan (flat hoe, sand shovel and local style hand trowel) are inadequate but readily available. A more appropriate tool is shown in fig. 9. It has to be made of steel.
Harvested tubers are then put on small heaps or directly in baskets. Baskets are later emptied on large rectangular heaps (fig. 10).

Potato digger

This equipment lifts the ridge, shakes the soil from the tubers and deposits the tubers on a neat swath or row.
The equipment available in Pakistan is all of the single row type. Farmers do not favour them as they are quite slow. Two types of single row diggers are available internationally:

- **straight digger with chain belt,**

- **90° diggers with shaking grid or "potato mole".**

In trials made recently by PSPDP/ADBP in the Central Punjab, the 90° digger performed better (Fig. 12). It is also easier to maintain or copy.

A better solution would be a **straight double row chain digger.** Such equipment is available in the international market but it will have to be adapted to the local soil conditions.

Toolmakers in Pakistan are quick in **copying this** type of rather simple **equipment.** The locally produced straight single row diggers are copies of outdated models from China and elsewhere. The chains are totally inadequate. As the chain is the most sensitive part of this equipment we suggest using imported ones. The ridge lifting and ridge uptake provisions are also inadequate (25).

After digging, the tubers are usually left for a few hours to dry and warm up on the swath. Then they are collected in the same way as for the manual harvest.

Mechanical digging can only be recommended in case of scarcity of labour. Sufficient labour for hand digging must be available to complete the harvest in the available time-span. In areas of high density of labour intensive crops or sufficient offer of alternative industrial jobs, labour may be scarse during peak requirements. In larger seed multiplication operations labour management may also be a problem.

Automatic potato harvester

Taking into consideration the relatively cheap labour available in Pakistan, this equipment cannot be generally recommended for the harvest of seed potatoes. It is slower than the double row digger and the risk of internal and external bruising is higher with this equipment. Exceptionally, in very large seed operations, when the time for the harvest operation is short and transport, drying and grading have been mechanized, the use of single or double row automatic potato harvesters may be preferred. Adaptation changes in the equipment, to fit the local soil and working conditions, would have to be extensive.

Fig. 11. Potato digging mole in action

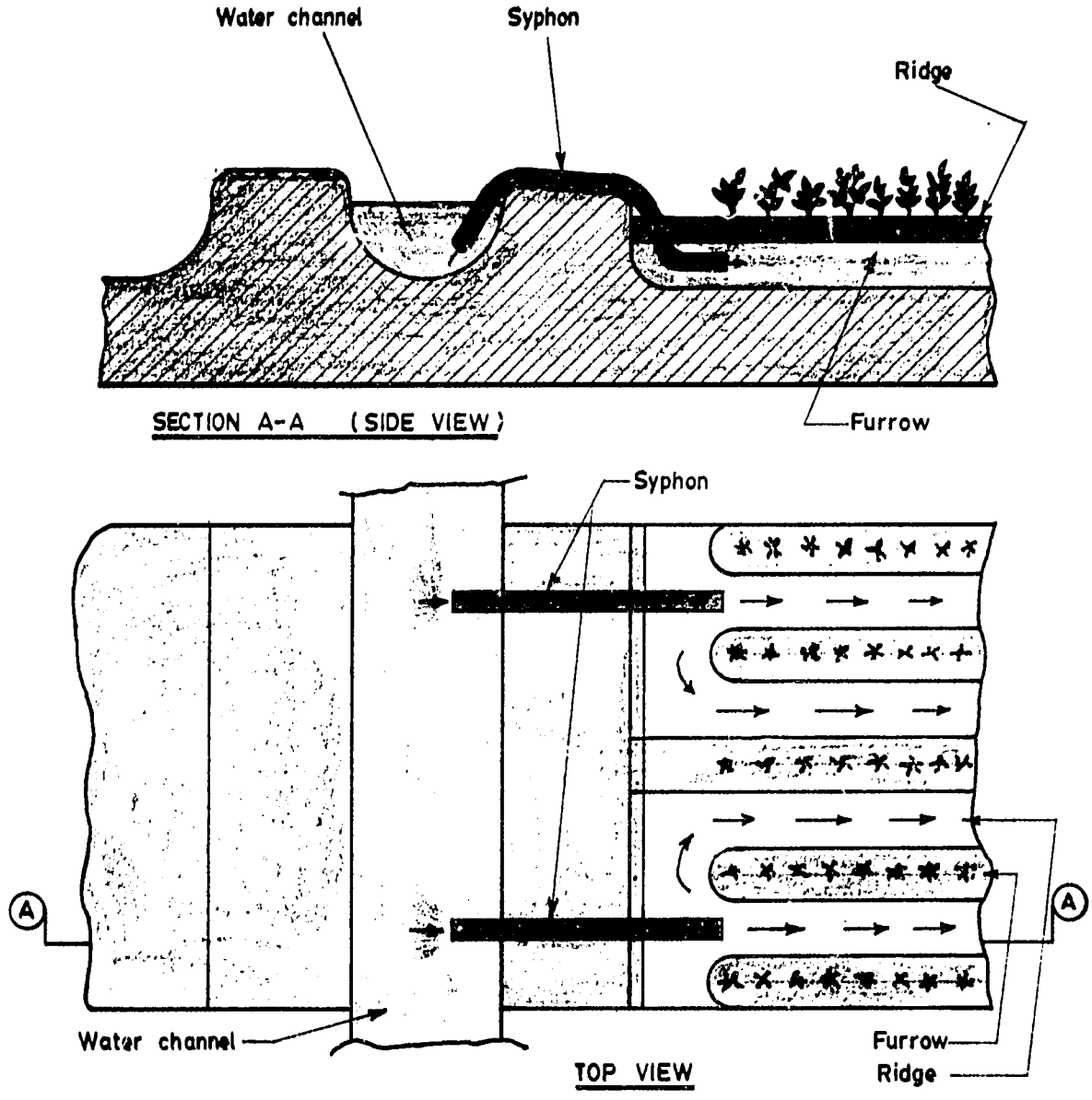


Fig. 12. Syphon controlling the water flow to the furrows

4 IRRIGATION GUIDE

There are only a few areas of Pakistan where potatoes are grown without artificial water supply. In the plains, all the potato crops are irrigated. As there are no serious water limitations so far and the labour is relatively cheap, most of the plain areas are irrigated by gravity. Only in the southern Punjab around Bahawalpur an automatic center pivot irrigation system is being used on one farm.

4.1 Pre-irrigations

Before planting the Punjab autumn crop, two "rouni" pre-irrigations may be required.
The first one is required about 15 to 20 days before planting. It will allow to judge the quality of levelling of the field (pools and dry islands will show up in badly levelled fields) and encourage annual weeds to germinate. Soil preparation should resume some 7-10 days after the first pre-irrigation. If there have been rains in this period and the soil is humid, this irrigation may not be required. The break in soil preparation (see chapters 2.3 and 5.2) is still essential (14).

The second pre-irrigation should be applied about 3 days before planting. Again this is only required if there are no rains during this time. It will help the germination of the tubers and reduce the risk of rotting, especially under hot weather conditions. Pre-irrigated soils help to achieve homogeneous germination. If the soil is bone-dry at planting and there are slight levelling errors in the field, some of the seed tubers will not get sufficient moisture until several days (up to 10) after planting. The resulting delay in germination, concurrently accompanied by seed rotting, will be responsible for a very irregular seed crop emergence.

4.2 Irrigation intervals

With or without pre-irrigation, the seed potato crop, especially during the Punjab autumn, must be irrigated immediately after planting. Then, depending on the weather conditions, irrigations should be applied every 5 to 8 days. The decision to irrigate (if water is available) should be made by inspecting the crop every day around 10 am. If at this time there are slight signs of moisture deficiency (hanging lower leaves), irrigation is due immediately.

Towards the first week of November, the irrigation intervals can be extended by 1-3 days. As the weather becomes mild and the crop canopy is closing, evapotranspiration loss is reduced. From the first week of December onwards, the irrigation intervals should again be reduced. The ridges should then be kept in a constantly humid condition to provide some frost protection to the crop.

4.3 Irrigation technique

4.3.1 Control of water quantity

As a result of the need to adapt the irrigation intervals to the climatic conditions, the quantity of irrigation water applied to the crop should be strictly controlled. The most feasible way to achieve this is by the use of syphons (fig. 12). The farmer should know the time required to

apply 30-35 mm of water to 1, 2, 3 or 4 rows with a syphon of a certain diameter. If syphons cannot be used, a constant water flow check should be installed at the water entry point of the seed plot. He must then calculate the time required for applying the appropriate amount of water. 30-35 mm means filling the furrows to a little less than half. Any higher amount will have a detrimental effect on the seed potato crop and encourage the development of diseases which may result in the rejection of the whole seed lot.

4.3.2 Drainage

Sometimes there are heavy rains immediately after planting the potatoes. Sometimes excess water has been applied by mistake. Sometimes there are rains during the time frost is expected. Sometimes salts accumulated from tube-well water have to be washed out when canal water is again available. For these and many other reasons it is occasionally necessary to drain the seed potato plot. This is only possible if provision for drainage has been made. If potatoes have been planted near a tube-well in a low lying field, a suction hose can be attached to the pump and the excess water drained mechanically. In most of the potato soils of the Punjab, infiltration is so slow that drainage may become essential. In most cases this is only possible if a deep drainage channel is available or if the potato field has some lower areas nearby. Fields without the possibility to drain excess water should not be planted with potatoes.

4.4 Frost protection irrigation

Many farmers in the Punjab fill the furrows to 2/3 of their depth with water and irrigation intervals are further decreased whenever frost is to be expected (25). This is effective but may be very detrimental if applied to the seed potato plot. A compromise will have to be sought between perfect frost protection, seed health and seed tuber quality. If the furrows are only filled up to 1/3 but this is done more often, the damage to the tubers will be less. A slight frost damage can be tolerated in the seed potato crop, as the maximum bulking rate is generally not aimed at.

4.5 Pre-harvest irrigation

As pointed out under 3.5.1, a slight irrigation, filling the furrows to about 1/3 of their depth is required some 2 to 4 days before harvesting if there are no rains at the time of harvest.

5. WEED, PEST AND DISEASE MANAGEMENT

Weeds affect the potato crop mainly by competing for light and nutrients and therefore reduce yields.

Pests cause direct damage to tubers, stems and leaves, sometimes transmit diseases and often interfere with the roguing operation.

Potato diseases are often transmitted through the seed tubers to the next crop. Their control in seed potato multiplications is therefore essential.

5.1 Weed control

Weed control in the seed potato crop should follow an approach of integrated management:

- decrease the population of perennial weeds by following an adequate crop rotation (see 2.2, above),

- encourage germination of annual weeds by pre-irrigating after the first set of soil preparation operations (see 2.3, 4.1, above),

- control annual weeds by applying a post planting/pre-emergence herbicide (currently **Stomp** is the most widely used product (25) in Pakistan, but some other products are being registered/used, such as Trilate and Topogard). For these herbicides, a knowledge of the cost of these products and their effect on following crops is essential. Some of them have strong and lasting residual effects and may damage the crop planted after potatoes. The residual effect can be reduced by strictly following the application procedures recommended by the manufacturer, but this is difficult with badly maintained equipment.

- control annual but especially perennial weeds by early hoeing plus earthing up of the crop.

The common weeds affecting the Punjab autumn crop and the best way to control them are presented in Table II below.

Table II: Common weeds affecting the potato crop in the plains of Pakistan and recommended control measures (bold print denotes perrenial or sometimes perrenial)

Botanical name	Common Name (Local Name)	Family	Control
Most common harmful weeds affecting the spring potato crop in the plains			
1. *Cyperus rotundus*	**Purple nutsedge** (Deela)	Cyperaceae	mech, rot, pos
2. *Cynodon dactylon*	**Bermuda grass** (Khabbal)	Gramineae	mech, rot, pos
3. *Sorghum halepense*	**Johnson grass** (Baru)	"	mech, pos
4. *Trianthema portrula castrum*	Hog weed (Itsit)	Aizoaceae	pre, mech
5. *Amaranthus viridis*	Wild blite (Chaulai)	Amaranthaceae	pre, mech
8. *Digera muricata*	Digera	Amaranthaceae	pre, mech
6. *Convolvulus arvensis*	**Bind weed** (Lehli)	Convolvulaceae	pre, pos, mech
7. *Portulaca oleracea*	Purslane (Kulfa, Tandla)	Portulacaceae	pre, mech
Most common weeds of plains autumn potato crop			
1. *Avena fatua*	Wild oat (Jangli jai)	Gramineae	pre, pos, mech
2. *Phalaris minor*	Bird seedgrain (Dumbi booti)	"	pre, pos, mech
3. *Poa annua*	- - (Choti ghass)	"	pre, mech
4. *Chenopodium album*	Goosefoot (Bathu)	Chenopodiaceae	pre, mech
5. *Chenopodium murale*	Nettle leave (Krand)	"	pre, mech
6. *Convolvoulus arvensis*	**Goose foot** (Lehli)	Convolvulacea	pre, pos, mech
7. *Coronopus didymus*	Suine cress (Janghi Halon)	Cruciferae	pre, mech
8. *Euphorbia helioscopia*	Milkweed (Chatri Dodak)	Euphorbiaceae	pre, mech
10.*Medicago polymorpha*	Annual lucerne (Maina)	Papilionaceae	pre, mech
11.*Melilotus indica*	Sweet clover (Senji)	"	pre, mech
12.*Rumex dentatus*	**Sorrel** (Jangli palok)	Polygonaceae	pre, rot, pos
14.*Vicia sp.*	Vetch (Rewari)	Papilionaceae	mech

mech: mechanical control; **pos**: post-emergence herbicide; **pre**: pre-emergence herbicide **rot**: control by rotation

5.2 Pest control

Crop damage caused by pests can be prevented by growing the crop in times of low pest populations. Pests should only be controlled when they are likely to cause economic losses. Chemical pest control should always be the last option.

5.2.1 Mite control

Several species of mites can be found affecting the potato crop in the Punjab plains. The only mites known to cause severe damage to potatoes are hot weather mites from the Tarsonemidae family. The symptoms are bronzing of leaves and stems. The stems remain slim, with long internodes. Young leaves become narrow and distorted. Heavy attack causes an interruption of apical and lateral growth and the affected potato plants become brittle and remain relatively small. These syptoms may vary according to the variety. Tuber production is also affected. Hot weather mites attack the potato crop especially in early autumn. **It is extremely difficult to rogue seed potato plots affected by mites.** The best way to avoid mite damage to the seed potato crop, is to delay planting until 8th October. Crops emerging in November are usually safe. In exceptionally dry years, or in the southern Punjab, mites sometimes are still affecting potatoes in November. In this case, seed plots should be treated preventively at the 3-5 leaves stage **with a known miticide** (e.g. Keltane, Hostathion). The mites can be seen with a hand magnifier of the type used in the cotton industry. **Once severe symptoms have developed, treatment of the crop has little impact.**

5.2.2 Leafhopper control

Leafhoppers of the Jassidae family attack and cause damage to the early planted potato crop in the Punjab. Severe damage can be observed in the southern part of the central Punjab, especially in cotton growing areas. The symptoms are leaf bending, leaf yellowing followed by browning and scorching, arrest of apical growth and brittle stems. Affected seed plots are extremely difficult to rogue as virus symptoms are masked by the leafhopper damage. The control should be preventative by delaying the planting of the seed crop till the end of the first week of October. If hoppers are observed during the 2-5 leaf stage, a preventative spray is required. Hoppers are easy to observe. They are green, about 3-4 mm long and fly very actively when the plant is shaken. If more than 5 hoppers are observed by shaking ten potato plants, spraying is required. Hopper attack during autumn is more severe in the proximity of large cotton fields. Leafhoppers should be controlled with residual insecticides in order to avoid re-infestation from surrounding areas. The cheapest product is Sevin. It will prevent hoppers from entering the fields for about 10 days. **Care has to be taken with the mites. If mite attack is already present, Sevin may encourage their development by controlling mite predators.** Therefore if both pests are observed, the treatment must be done with a broad spectrum product like Hostathion or Tamaron.

5.2.3 Cutworms, Armyworms

Cutworms are a common pest of the potato crop in the plains and foothills of Pakistan, especially during the first months after the rainy seasons. The times of more severe attacks are

March-April. In the Pabbi-Attock area cutworms often cause severe damage to the potato crop in spring.
In the cotton growing belt south of the Lahore-Faisalabad-Jhang line, armyworms often invade potatoes when the irrigation of the cotton crop is reduced to allow the start of the cotton harvest.

The more common species attacking potatoes are:

Heliothis armigera	bollworm
Autographa nigrisigna	green semi-looper
Spodoptera spp.	armyworms
Agrotis spp.	cutworms

All species except the *Agrotis* cutworms are relatively easy to control by spraying with broad spectrum pyrethroid insecticides against the early development stages of the caterpillars. It is much more difficult to control *Agrotis* as these caterpillars rest during the day deep in the soil and usually also feed underground once tuber formation has started. To control *Agrotis* it is recommended to:

- keep the potato crop free of weeds likely to attract egg laying and to nurture young larvae. *Amaranthus* weeds are especially attractive to *Agrotis*,
- surround the developing potato crop with cutworm bait whenever invasion from surrounding crops is to be expected (usually cereal bran mixed with chopped green fodder plants and a residual insecticide like *Trichlorphon* or *Lindane*),
- maintain the ridges humid if there is danger of tuber attack. Cutworms will in this case prefer to feed on the potato leaves where they can be controlled to some extent by specific insecticides (*Tamaron*, *Thiodane*, *Monocrotophos*).

Remember: If mite attack is noticed in the potato crop, miticide must be added to the mix whenever armyworm control with pyrethroids is intended. Pyrethroids control the mite predators and leave the mites free to multiply.

5.2.4 Aphid control

The aphids, likely to transmit virus diseases (19) or to cause direct damage (d.d.) to the seed potato crop in the plains and foothills, are presented in table III below.

Table III: Aphids affecting the Punjab potato crop

Aphid species	Example of Viruses transmitted	transmission type
Acyrtosyphon gossypii	PVY	non persistent
Aphis craccivora	(AMV)	(non persistent)
Aphis fabae	PVY, PLRV, AMV	non persist. and persist
Aphis gossypii	PVY,(PLRV)	non persistent (and p?)
Brachyunguis harmalae	(PVY)	(non persistent)
Macrosiphum euphorbiae	PVY (PLRV)	non persistent and d.d.
Myzus persicae	PVY, PLRV, PVA	n.p.. and persist.,d.d.
Rhopalosiphum rufiabdominalis	(PVY)	(n.p. and d.d.)

Only three species have been observed actively multiplying on the potato crop in the plains of Pakistan:

- *Myzus persicae* dominates during February-March (3); mainly attacks the spring crop and transmits plant virus diseases very effectively. Occasionally, high populations appear in some places in December-January. They can transmit virus diseases to the autumn seed crop,

- *Macrosiphum euphorbiae* is more common in the hills and foothill plains where it can occasionally cause severe damage and transmit virus diseases to potato,

- *Rhopalosiphum rufiabdominalis* is a known pest of the roots of grasses and Cyperaceae. During heavy infestations in December-March, the roots of Solanaceae and especially potatoes, are also attacked. Virus transmission by this species has so far not been recorded. Given the high populations in the Punjab, virus transmission is likely to occur.

All the other species are probably transmitting virus diseases to the potato crop during periods of intensive flight activity only. Except for *Aphis gossypii*, they are all more abundant during the spring season. *A. gossypii* can build up large populations on summer crops such as okra, cotton, watermelons and on many weeds, shrubs and trees. When the herbaceous hosts become less attractive, peaks of flight activity are observed, especially in October-November and less so in late spring.

Direct damage by aphids to the seed potato crop is best avoided by planting this crop in the autumn season, when it is less affected by *M. persicae* (11). Damage due to *R. rufiabdominalis* can be avoided by keeping the ridges humid in December by frequent, light irrigations. This technique is also required for frost protection (see 4.4, above).

5.3 Disease management

Potato diseases can be prevented to a large extent under the conditions prevailing during the autumn crop in the plains of Pakistan. Disease prevention is one of the principal tasks when multiplying seed potatoes. Diseases transmitted through the seed tubers to the next crop have

to be given special attention. For this reason, potato diseases affecting the potato crop in Pakistan are treated in some more detail hereunder.

5.3.1 *Early and late blight*

Early blight (caused by *Alternaria solani*) is a rather rare disease under the conditions prevailing in the Punjab plains and does therefore not call for any control measures. Most past reports of so-called early blight in this area have been triggered by the symptoms of other diseases, pests, physiological stress or by overzealous pesticide sales agents.

Late blight (caused by *Phytophthora infestans*) is a serious disease in the plains (35) but usually no symptoms appear before the month of December. As the haulms of the autumn seed crop are to be destroyed in early January, only a few preventive sprays with Mancozeb (**Dithane M 45 R**) in December/January are required. If exceptionally heavy attack occurs in January and the humid weather persists, the date of haulm destruction should be advanced by up to one week. **If symptoms of late blight are present in the crop, harvest should be carried out under dry conditions only.** Tuber brown rot due to this disease is not very common in the Punjab because most of the soils are too heavy to allow widespread tuber infection. **For the control of tuber brown rot, please see chapter 7.2.** If rains in spring are prolonged, the effect on the spring crop can be very severe. Therefore, if the spring crop is grown for seed, preventive treatment against late blight must be applied weekly, starting from the 50th day after planting. **The most important factor in the late blight control is to apply the recommended dose of fungicide at a low speed, at high pressure and mixed with at least 150 gallons (680 litres) of water/ha.**

5.3.2 Powdery scab

This is a potato-specific soil-borne disease surviving in the soil with the help of highly resistant spores which under favorable circumstances may remain viable up to 10 years (20). It can occasionally attack other species of *Solanum* (black nightshade, eggplant) but does usually not produce resistant spores on these plants. The fungus *Spongospora subterranea* is an obligatory intracellular parasite of nightshades, especially potato. Soils become infected by planting infected tubers, using dirty tools previously used in infected fields, or by dust blown from infected fields during dry weather. The potato crop becomes infected when the growing potato roots and stolons trigger the germination of dormant spores present in the soil. Infected root and tuber skin tissue proliferate into spongy nodules, releasing a dark mass of spore balls. The ultimate symptoms on the tubers are very much like those of common scab, caused by *Streptomyces scabies*. Control of this disease difficult once the soils are infected. Infection can be prevented by planting disease free seed. The build up of soil infestation can be avoided by a 3-4 year crop rotation. There is no tolerance for powdery scab in the current minimum standards for the certification of seed potatoes in Pakistan. Therefore, in the plots to be certified, the following has to be carried out:

- careful selection of (non-infected) soils,
- planting only non-infected basic seed,
- following crop rotation, leaving at least two years free of potatoes.

5.3.3 Rhizoctonia (Black scurf, stem pruning, white mould on stem base)

The pathogen *Rhizoctonia solani* is present in all soils of Pakistan and in most arable soils of the world (34,35,36). After uninterrupted potato growing, more aggressive strains, transmitted as scurf on potato tubers, become dominant in the soils. The main damage to the crop is sprout and stolon pruning under cold and wet conditions, resulting in a poor, delayed and irregular crop establishment (20). These symptoms may appear when hill crops are planted early, or when the plains spring crop is planted in January. Stolon pruning is not a serious problem of the main Punjab autumn crop planted in September-October under hot weather conditions. Tuber malformations and black scurf caused by this disease so far are not considered as major problems by the farming community or the consumers, but this may change if the potato trade becomes increasingly quality conscious. The disease can be controlled to a large extent by applying cultural practices such as moderate irrigations, and avoiding high quantities of fresh organic matter in the soil. It can probably be further reduced by the utilization of biological control agents already available in Pakistan. Rhizoctonia-free seed is not available anywhere in the world. Seed treatment with fungicides can also help. Pre-basic seed can be cleaned if treated with caustic products immediately after harvest. In the new national minimum standards for seed certification, potato tubers with less than 25% of their skin affected by black scurf are not considered a problem. Tubers with more than 25% of their skin covered with black scurf have to be sorted out during grading. The tolerance in the minimum standards for such tubers is only 1%. To avoid seed rejection due to black scurf, in areas or under conditions favouring its development, it is often sufficient to pull up the haulms instead of cutting them. Haulm pulling prevents up to 60% of black scurf, as the fungus structure is disrupted during this operation. Haulm pulling is more expensive because more and especially trained labour is required. Tubers accidentally uprooted during haulm pulling cannot be left in the field.
Under certain soil conditions, pulling up the haulms may cause skin bruising. Black scurf can also be reduced by anticipating the harvest as much as possible.

5.3.4 Fungal wilts

At least 3 species of *Verticillium* and 3 species of *Fusarium* are reported to cause extensive wilting symptoms in potato fields in different parts of Pakistan. There are important differences from region to region, depending on the climatic and management conditions to which the crop is subjected. The known pathogens primarily associated with early dying potato vines in Pakistan are presented in Table IV.

Table IV: Causal agents of potato wilt in Pakistan

Pathogen	Effect on yield (affected plants)
Fusarium avenaceum	little
Fusarium oxysporum	moderate
Fusarium solani	up to 30 %
Verticillium albo-atrum	over 30 %
Verticillium dahliae	around 30 %
Verticillium nigrescens	unknown but widespread in the Punjab

In general, the farming community is not aware of these diseases and does not regard them as important.

All these diseases can in principle be transmitted through the seed. They have devastating effects if physiologically old crops (from stressed or overstored tubers) are subject to additional stresses such as lack of fertility, waterlogging, irregular irrigation, weather stress, cutting of the seed, etc.

Wilts can best be avoided by planting healthy seed and by applying accurate cultural practices such as balanced fertilizer application, deep soil preparation in well drained fields, regular and moderate irrigation.

Verticillium albo-atrum and *Fusarium solani* can be reduced by roguing out the diseased plants. Usually tubers from wilt affected plants are systemically infected at their stolon end.
No effective chemical treatments can be recommended. Treatments of seed, especially cut tubers, with metallo-carbamate fungicides **(Mancozeb, Maneb, Zineb)** may reduce the risk of seed transmission of wilt diseases.
The new national standards for seed potato certification approved in January 1991 are quite tolerant for these diseases, except for the seed-borne severe *Verticillium albo-atrum*.
Early removal of vines (10,37) before the build up of innoculum on the senescent crop may additionally protect the seed from becoming infested (for pulling up of haulms, see 5.3.3, above).

5.3.5 Bacterial rotting diseases

Bacterial soft rot:

This is caused in Pakistan by three different pathogens:

(i) *Erwinia carotovora, var. atroseptica*
(ii) *Erwinia carotovora, var, carotovora*
(iii) *Erwinia chrysanthemi*

Plants are usually infected during very wet conditions from decaying tissues of the mother tuber or from other infective material in the soil. Infection usually starts in the lenticels, at the stolon end or at bruised tissues during handling of the crop. Once the skin of the tuber is fully mature, external smear infections result in a latent infection, only apparent if the tuber is used for seed. External smear infections of the tubers occur during the handling of wet or infected material, especially when using mechanical graders and conveyer belts. Hand sorting and grading of dry and well matured seed lots from clean and rogued fields are so far the only effective control methods which can help to eliminate black leg and soft rot from certified seed potato production.

Because potatoes are mostly handled by hand under dry conditions, bacterial soft rots are not common in Pakistan. They can occur in the hills, during the spring crop after water-logged conditions, or in badly drained fields. They may be found in some fields planted with imported seed lots. As the main autumn crop in the Punjab grows under cold weather conditions and the harvest is mainly handled by hand under dry weather, the incidence of eventually introduced black leg decreases in the successive autumn multiplications, especially when they are subject

to thorough roguing. If the post harvest handling of the Punjab autumn seed is indiscriminately mechanized, this favourable situation may soon deteriorate.
The national minimum standards for this disease permit a maximum incidence of 1%. If care is taken to plant only healthy and vigorous basic seed and the fields are thoroughly rogued before inspection, there should be no problem in meeting this standard.

Bacterial brown rot or bacterial blight:

This is caused by *Pseudomonas solanacearum*. The disease has been observed in the foothills of NWFP but is not favoured by the growing conditions in the high hills or in the main Punjab autumn crop. Therefore it is not very common in the main potato growing areas of Pakistan. Diseased seed lots must be discarded and no treatment can be recommended. Infected fields should not be used for seed potato multiplication for at least 10 years after the last potato crop. The minimum standards for seed certification for this disease in Pakistan are nil for crop and tubers. If seed potato production is started with basic seed, and the crop is planted on rotated land, this disease should pose no problem for the Punjab autumn crop. Some problems with this disease have been observed during the late spring in the foothill plains of Peshawar and Attock. This is one more reason for refraining from using the spring crop of those areas as seed source.

5.3.6 Common Scab

The causal agent of this common soil disease (the bacterium *Streptomyces scabies*) is widespread in Pakistan, but its presence is not detectable every year. Seed potato multiplication on fields with a known history of scab can and must be avoided, as powdery scab may also be present. Sudden outbreaks of this disease are still possible if the organic matter content of the soil is high and irrigation at the time of tuber formation is irregular. The disease became much more common in the Punjab in autumn 1990 after a long spell of humid weather. The **certification tolerances** for this disease are as for Rhizoctonia black scurf. Problems mainly occur in light sandy soils. Crop rotation is not effective.

5.3.7 Viral diseases

Viral diseases are prevented by planting virus-free basic seed (3,37). If a seed plot shows more than 5 % virus infection at the time of first roguing, it should be discarded. A lower percentage of severe virus diseases can be kept under control by early roguing of the crop. Late transmission of virus diseases is prevented by spraying against aphids from December onwards and by early haulm destruction in January. The spread of mechanically transmitted virus diseases such as **PVX** and **PVS** can be controlled by restricting the movement of persons and equipment through the seed plot to only those required for the cultural practices. In particular, neither ware potato growers nor potato equipment used in ware potato fields should enter the seed plots. Pre-basic and basic seed multiplication is best carried out using wider plant-to-plant distances, so as to reduce the spread of mechanically transmitted virus diseases.

6. SEED CERTIFICATION

In Pakistan, seed certification is the sole responsibility of the Federal Seed Certification Department (FSCD) with offices in all the provinces. The required interactions between this authority and the seed growers are discussed hereunder.

6.1 Seed growers registration

The Federal Seed Certification Department of Pakistan is responsible for certifying the locally-produced seed potatoes. In the plains, the Department has offices in Islamabad, Lahore and Sahiwal (1). Any grower intending to produce certified seed potatoes should approach their nearest office and fill up the required registration form. For this purpose, it is essential to have proof of the origin and grade of the seed to be further multiplied. At the time of registration, it is sufficient to have the lot numbers and quantities (bags or crates) of certified seed I, basic seed I or II or the pre-basic seed to be multiplied, mentioned in the registration form. If a lot number is not available because the pre-basic material has been produced by a recognized local breeder, the breeder's certificate of origin of the seed has to be attached to the registration form. If possible, this registration should be submitted before planting. Exceptionally, registration submission after planting is possible, but it must be done at least 30 days before the first field inspection. The registration can be undertaken by the grower himself or by the seed multiplication enterprise having a contract or some other seed multiplication agreement with the grower.

6.2 First field inspection

The first inspection is made about 45 days after planting or later (2) to observe the percentage of emergence and vigor of the crop. Crops with less than 70% emergence would only be accepted in exceptional cases. If external factors delay crop emergence, a proportional delay in the first inspection must be requested by the person or organization having registered the seed plot.
In addition, varietal purity and some severe virus diseases, especially PVY, can be observed at this stage. One roguing before this date is recommended but not essential (8). This will have to depend on the condition of the field, especially the purity situation. In some cases, fields not fully complying with the purity standards can be thoroughly rogued after the first inspection.

6.3 Second field inspection

Thorough roguing of the crop is essential before this most important inspection. The inspection date should be about 30 days after the first inspection or later if required by the condition of the crop. The inspection date should be agreed between FSCD and the grower about one week in advance. The grower is responsible for not irrigating the crop during the last 3 days previous to the inspection in order to permit unhindered walking and digging in the seed crop. During this inspection, such problems as wilts, black leg, virus diseases, off-types, Rhizoctonia early and late blight are checked for and their severity assessed. It is the responsibility of the grower that the crop at this stage is uniform, well-provided with moisture, and free of symptoms masking

the above mentioned diseases. Such symptoms can occur due to irregular fertilizer application, damage by hail, wind or insects. Fields not complying with the standards will be rejected. If the problem in question is minor and can be corrected by roguing, reinspection after 1 week can exceptionally be agreed upon between the FSCD and the seed grower. See for this purpose the "minimum standards" attached in annex I.

6.4 Third field inspection

It is essential to carry this out for the Punjab autumn crop, as by mid-January in most years aphids appear in large numbers and haulm destruction before that date has to be controlled. In the main potato growing areas, the haulms must be cut, burned or pulled between 10th and 20th January. In well-isolated places, a slightly later date can exceptionally be agreed upon. During this inspection, tuber infection with rot and wilt symptoms and the timely and correct haulm destruction will be checked. No irrigation should be made to the crop from 5 days before haulm destruction till 3 days before harvest. A light irrigation after confirmation of skin maturity and 3 to 4 days before harvesting is necessary for a smooth harvest operation and is therefore permitted.

6.5 Seed tuber inspection and bag sealing

The place for grading and seed tuber inspection should be agreed upon between the FSCD and the seed grower. The seed tubers should be inspected after harvesting and grading, and immediately before filling the bags. Once the bags are filled, the FSCD seal should be applied. During this inspection, random samples are taken and analyzed. The lot can be rejected even after sealing of the bags if the results from disease tests of the samples show that some of the standards have not been met (7). The minimum standards to be applied during this inspection are shown in annex I. If the standards are not met by a small margin of a less important factor (i.e. Rhizoctonia, Common Scab, dirt, size) regrading and inspection after a few days can be agreed upon. The FSCD tag only confirms the health condition of the seed at the time of inspection. In the Punjab autumn-to-autumn seed multiplication cycle, the seed tubers are stored up to 6 months in cold stores. If the seed grower has any doubt about the condition of the seed after the storing period, the FSCD can be requested to take representative samples.

7. POST HARVEST SEED TUBER MANAGEMENT

The correct harvest operation (chapter 3.5) only ensures the collection of undamaged seed tubers from the field (17). In Pakistan, between harvest and final sale of the seed, there is a time span from 2 to 7 months. Most of the seed is kept in cold stores. The alternatives for correct handling of the seed in this timespan are discussed hereunder.

7.1 Picking and heaping up

The operation will be carried out in different ways, depending on the time of harvest. The autumn seed crop, harvested in late January or early February during cold and usually dry weather conditions, is unearthed at rather low temperature (5° to 12°C). Potato tubers handled at such temperatures are turgid and brittle and tend to crack easily. It is therefore recommended leaving the tubers up to 5 hours on the swath or in small heaps on the field for drying. Only then can the tubers be either heaped up in the field or at some other dry and elevated storage place, preferably at the site at which grading will take place. Both operations should be undertaken with extreme care. Workers tend to collect the tubers in baskets, transport them on their heads and discharge them violently onto the in-field storage heap. This is inadequate as it causes bruising and cracking. A tractor- driven, adaptable elevator belt is recommended for a correct heaping operation. It can be used to make the heaps in the field or to fill the trailer if heaping and grading takes place at another site.
If spring seed is grown exceptionally, picking from the field should take place immediately after harvest as temperatures usually are too high for the in-field drying of the seed tubers. Picked tubers are best bagged in the field and taken for a few days to a shady place for drying and wound healing prior to grading and storing.

7.2 Wound healing and drying

7.2.1 Autumn seed crop

The traditional way in the Punjab is to leave the potato tubers for up to 2 months in large heaps in the field (see fig. 13). These heaps are covered with a thick layer of rice straw, sometimes fixed with a layer of 5-20 cm of soil. For seed potatoes, such a long in-field storage is detrimental, especially if it is followed by long cold-storage. The dormancy of most varieties may have ended before the tubers are finally loaded into the cold store. On the other hand, as the average outside temperatures are low in February, storing in the traditional heaps has a positive effect on wound healing, drying and skin maturity during this month. If seed potatoes are produced commercially, the following adaptations should be added to the traditional management:

- make the heaps on well-drained, elevated platforms of gravel or concrete, on a layer of rice straw,

- attach means of forced ventilation to the heap. This would decrease the formation of water condensates on the tubers and maintain the quality of the produce (see fig. 13).

This implies that the ungraded potatoes would have to be loaded on trailers in the field and mechanically heaped up at the grading place.

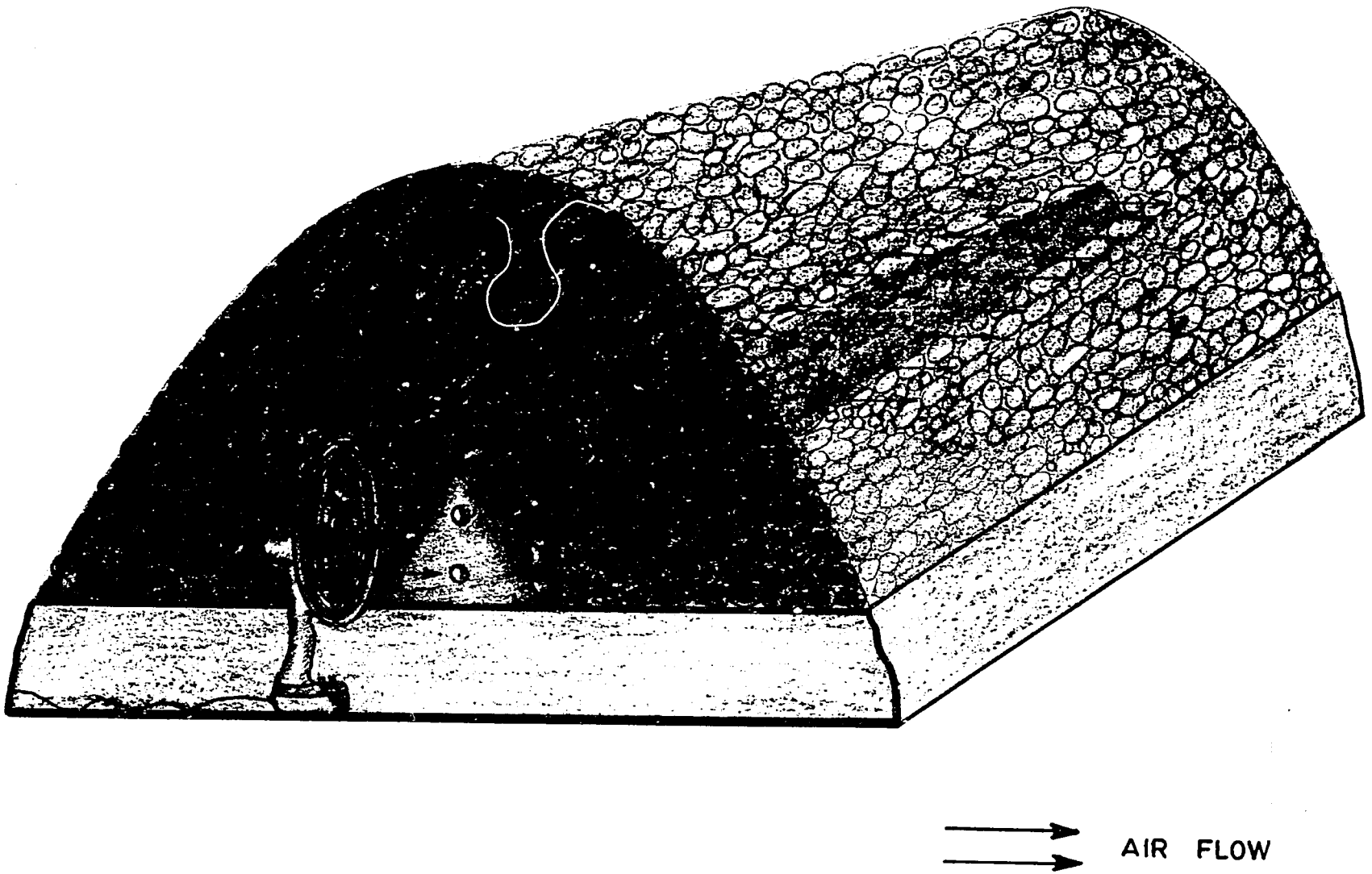


Fig. 13. Traditional potato heap modified with ventilation tunnel

7.2.2 Spring seed crop

Seed produced during the spring season in the plains, is currently harvested by the end of April and early May. At this time the temperatures are very high and the potato tubers must be placed in the cold store as soon as possible (25). Therefore, experienced farmers are grading and sorting the spring harvest at a shady place near the field during the ongoing harvest operation. The tubers selected for seed are then stored on the same day, without any delay.

7.3 Transport from the field

Pre-basic and basic seed should be collected by hand into wooden crates and transported in those crates directly to the store. Some sorting for quality is required but grading prior to storage is usually not required for seed that will be multiplied again and therefore not marketed.

Certified seed can be transported in bulk on trailers from the field to the grading place. Care has to be taken that the seed is not too cold nor wet during transport. Transport in bags, the usual method for ware potatoes, should be avoided. Bag transport of newly harvested material will increase bruising and the danger of disease infection.

7.4 Grading, seed treatment and packing

There are two ways to grade the usually large seed lots harvested in the plains:

- hand graders loaded with the traditional potato baskets, crates or with the help of an elevator belt,

- mechanical graders.

Hand grading requires a higher labour input but causes less bruising and cracking and requires much less capital investment. Provided sufficient labour is available, up to 10 hand graders will allow a flexible output of 1 to 10 tonnes per hour, depending on the number of workers put to use. (See figs. 6 and 7).

Mechanical grading is less labour intensive, has an increased bruising effect, requires a higher capital investment and is not flexible. If potatoes in excess of the equipment's capacity have to be graded in the available time, another grader will have to be acquired at high cost. If mechanical graders are chosen in order to ease management, some manual graders will still be required as stand-by equipment and for grading those lots with skin maturity problems.

7.4.1 Grading before storage

Basic seed should be **sorted** before storage. **Successful storage will depend on the quality of the material loaded in the store.** Therefore, all poor quality tubers must be graded out before storage.

Certified seed or other seed potato categories meant for sale, are **graded according to size and quality**, following the approved minimum standards as shown in annex I and considering the special requirements of the seed owner.

7.4.2 Sorting after storage

Bruised, cracked or otherwise damaged potato tubers tend to deteriorate faster during storage. If the seed potatoes are intended for marketing after a storage period of more than two months, it is strongly recommended to undertake re-sorting of the material prior to marketing.

The following should then be done:

- inform FSCD and request re-sealing of the seed potato bags after the sorting operation,
- warm up the seed potatoes slowly and allow two days for drying before sorting,
- sort preferably by hand on a wooden inclined table and dust with fungicide immediately after or during the sorting process,
- pack, re-seal and transport to the marketing outlets immediately after this operation.

7.5 Storage

For the storage of perishable goods such as potatoes the main basic rule is that: "**the result of the storage operation will only be as good as the quality of the produce loaded into the store**". Storing the goods is therefore only recommendable if a high standard of produce quality has been achieved by the operations described above (32). The correct in-store management is outlined hereunder.

7.5.1 Where to store

In the plains, seed potatoes are usually stored in cold stores specially designed for bag storage. These stores consist of several cooled chambers (30). The chamber used for seed potatoes should be specifically reserved for this purpose and should not be used for ware potatoes. The main reason for this is to prevent disease contamination and to keep a better check on temperature, humidity and the quality of the stored produce. Autumn or spring seed from the plains is currently kept in cold-stores. Seed potatoes harvested in June in the foothills for planting in September and seed potatoes harvested in February in the Punjab for planting in the high hills and Balochistan summer crops should not be put in the cold store, but preferrably be kept in boxes, standing bags or on racks in shady and ventilated places. The autumn seed for summer planting in the summer crops should be transported out of the Punjab before the end of March, when rising temperatures could adversely affect the produce in transit.

7.5.2 Loading and cooling down

The main aim of seed potato management is to keep the produce vigorous and to avoid any shock.
In the type of stores available in Pakistan, **seed potatoes are best stored on racks in crates or bags standing upright**. This will allow for natural ventilation. Access paths, stairs and at least 30 cm distance (12") to the walls should remain free for air circulation.
Autumn seed potatoes should be loaded between 15th February and 15th March at the latest, during the morning hours when they are as cool as possible. This will facilitate the cooling pro-

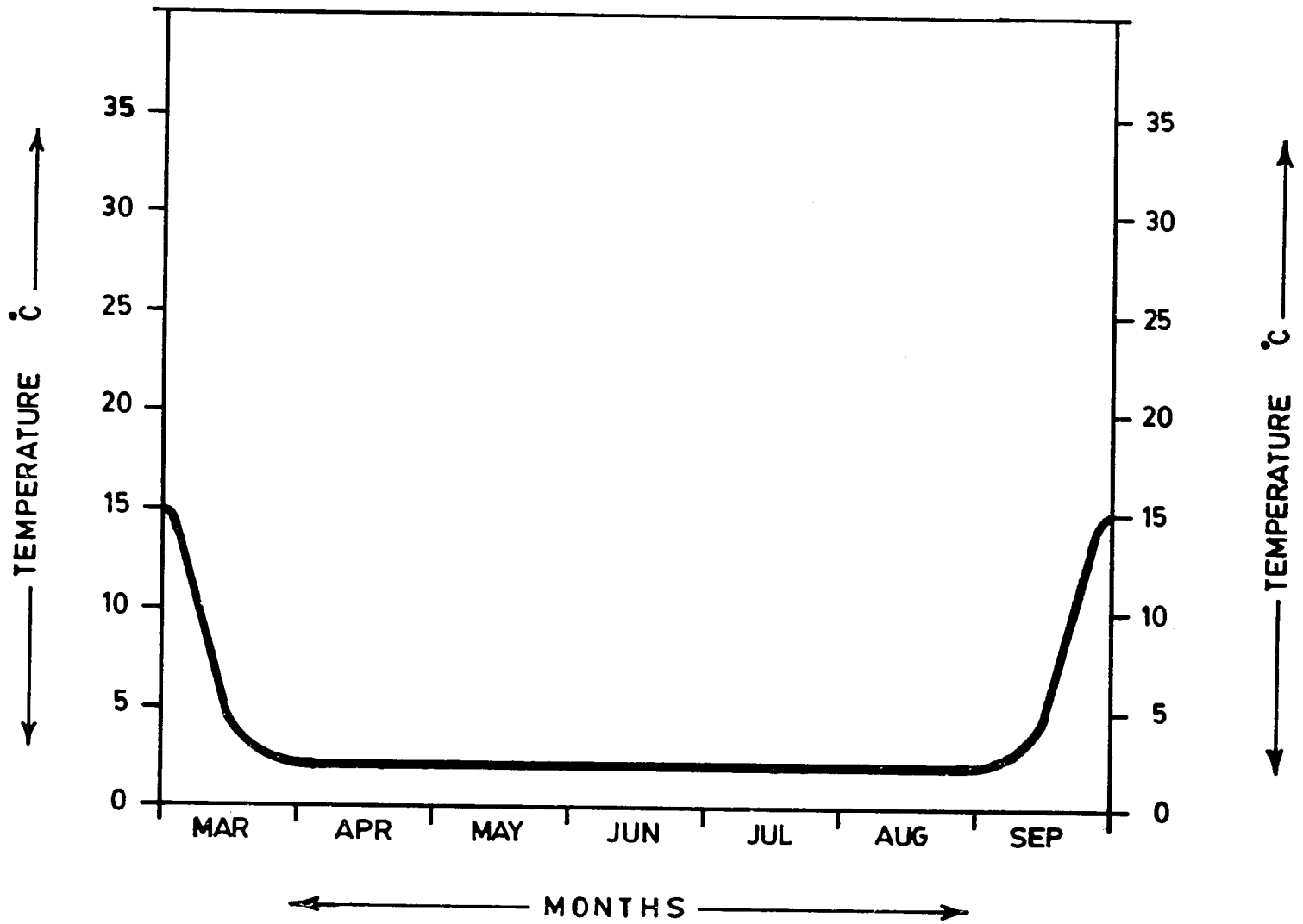
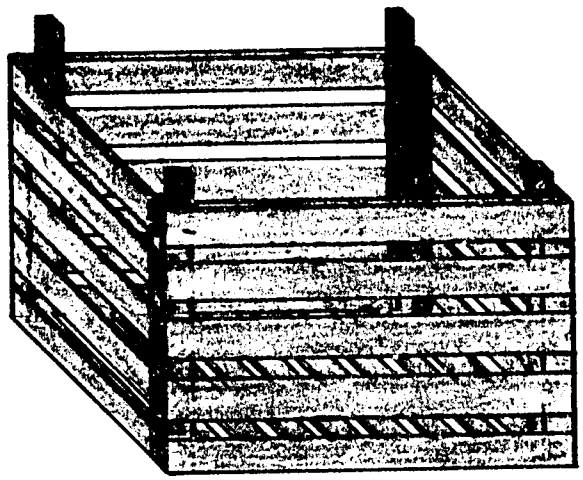
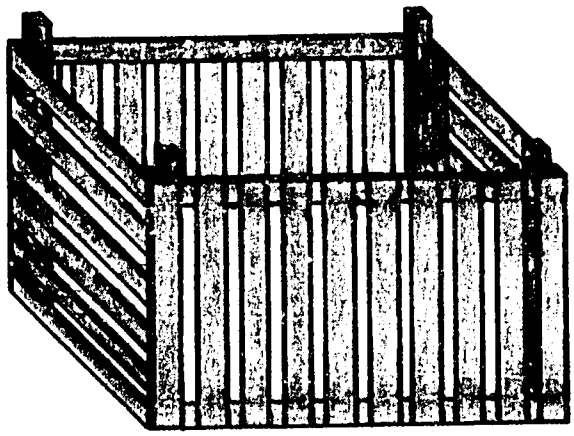


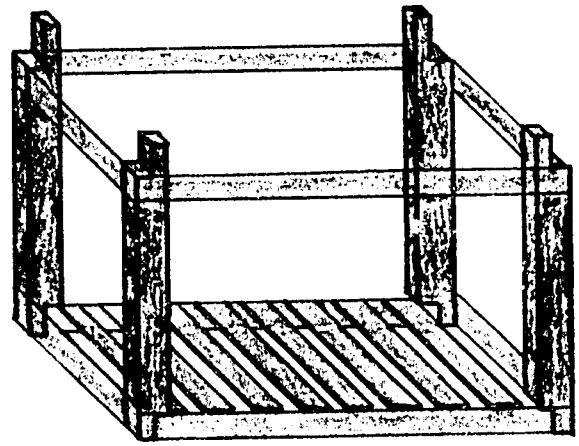
Fig. 14. Ideal cooling managed for cold stored seed potatoes in cold stores



(i)



(ii)



Structure detail

Fig. 15. Two models of potato crates made of poplar wood

cess. After 15th March, the dormancy condition of the seed will be ending and a much higher cooling energy will be required. In February - March, the seed during the morning hours has a temperature of 10 to 15°C. It should be cooled down to 3° to 4°C. Cooling down should be by 1 to 2°C per day. (see the diagram in fig 14). Spring seed potatoes should be loaded immediately after grading, preferably in the morning hours and will have an initial temperature of 20° to 35°C. They should be cooled down at a rate not faster than 2 to 3 C per day. It is more difficult to achieve a slow cooling down for spring seed, as cold stores are already loaded with other produce. For this reason it would be preferable to keep the seed (the lots are usually much smaller in spring) in the entrance hall of the store or a pre-cooling chamber for 3 to 5 days and load them in the store at a temperature of 15° to 20°C. Commercial potato stores and very large growers may produce sufficient spring seed to keep a separate chamber for spring seed lots.

7.5.3 Cold-store management during long storage

When and if seed potatoes have been loaded into the cold store during their dormancy period, and cooled down slowly, they should be kept ideally at a temperature of 3° to 5°C. As cold stores in Pakistan, during the months of April to July, are frequently affected by extended power interruptions, the thermostat is to be set at 2° to 4°C, to allow for a sufficient margin before the chambers warm up to detrimental levels. Those few cold stores which are equipped with stand-by generators are to be preferred for seed potato storage. Temperatures of 1° to 3°C, as often used for ware potatoes, are not suitable for the storage of seed potatoes.
The thermostat and the ventilation system must be visually inspected every day. Every month, a sample of about 20 tubers should be taken from different parts of the store. About 20 small open bags with test material should be placed at strategic points within the store for this purpose. Dehydration and the dormancy situation are the most important aspects to be checked. These samples will indicate the temperature and ventilation situation all over the store and allow the opportunity of taking early countermeasures if anything starts to go wrong.

7.5.4 Warming up, discharging from the store and drying of the seed potatoes

Seed potatoes for the production of commercial autumn crops are discharged from the cold chambers after the end of August. Seed potatoes intended for seed bulking during autumn are taken out at the beginning of October. Outside temperatures during this time may vary from 30° to 42°C. Some varieties, especially Patrones and Desiree, react very badly if the tubers kept at 4°C or less are instantly introduced into the hot and humid air. Physiological damage is likely to occur, so affecting germination. To avoid this, two alternatives are available:

- unload the seed lot to be planted into a "warming up" chamber about 10 to 15 days before planting and wait till the produce has reached at least 20° to 25°C. Then the produce is safe for discharging from the store and transporting. The process of warming up should be cut short with seed lots starting to sprout,

- increase the setting of the thermostat by about 5°C every second day during 8 days and then disconnect the chamber from the cooling system but leave the ventilation system working till the process of unloading has been completed. This can only be done if all the seed in the chamber is to be marketed and/or planted at the same time.

If the available infrastructure is not suitable for a gradual warming up process, the seed

potatoes, once unloaded, should at least be dried as soon as possible. This is best done by spreading the tubers on racks or on a clean floor on a layer of straw in the full shade and blowing air over them.

7.6 Transport to the end consumer

No seed which has become wet during the unloading process from the cold store should ever be transported without being re-dried. Cold-stored seed to be transported over long distances should be transported in crates, if possible. Otherwise the risk of bacterial rotting is greatly increased. If long distance transport with bagged seed potatoes is to be made in trucks, not more than 7.5 tonnes should be loaded on short trucks of 10 tonnes capacity and not more than 20 tonnes on long vehicles. This will reduce pressure damage and physiological shock. The loading should be supervised to ensure careful handling and to avoid bruising, etc. During transport the bags should be adequately stacked to allow for sufficient ventilation. The longer the storage period and transport distance after storage, the more care should be taken during transport. Long transports of seed potatoes at temperatures above 30°C is not advised. When seed potatoes are transported over long distances, the hottest parts of the route must be travelled at night. The produce should also be covered with a tarpaulin against sun and rain. Stops during the day should be restricted to those places where the truck can be kept under shade.

Seed potato tubers exposed to high pressure plus shaking during transport react by showing thumbnail cracks and losing sprouting ability. This can affect up to 50% of the consignment or even more if the seed lot has been exposed to high temperatures and inadequate ventilation.

One alternative is to store the seed tubers as close to the planting or marketing place as possible. This however may not be possible in view of the specialized storage management required for this produce.

Another alternative is that the seed potato enterprise is provided with sufficient removable pallets to allow partitioning of the truck beds in at least two layers. This will result in only 5 layers of bags being piled up instead of 10. The only difficulty is to organize the recovery of the pallets after the transport and bring them back to the point of origin. It has to be remembered that in Pakistan nearly all of the goods are transported in trucks hired from general haulers in the open market. Specialized transport for agricultural produce does not exist and very few farmers and wholesale traders own transport vehicles.

The third alternative is to transport the seed potato tubers in crates. Poplar wood is the cheapest and best suited material for the construction of potato crates. Another possibility is the use of foldable and re-usable plastic crates as introduced in some modern fruit and vegetable packing. The main limitation to this is the cost factor. Stable wooden crates cost about Rs 50 for 50 kg size. Bags cost about four times less. Crates can be re-used but they are difficult to transport. It is our opinion that it is worthwhile investing about 10% of the final produce price in packaging if this results in a similar gain in quality and an additional gain in security. Crates should be used at least for the high valued basic and pre-basic seed. (See fig 15 for different potato crates.) Potato crates must allow for a good ventilation during storage and transport.

8 ECONOMIC AND MARKETING GUIDE

The recommendations given in the chapters 1 to 7 are mostly targeted to help achieve considerable yield increases, especially of the seed size fraction, and to provide a safety margin for achieving the health and quality standard, in spite of the usually shorter production cycle of the seed crop. Some of the essential operations required to increase the seed quality and the fact that most seed crops are planted later and harvested earlier than the ware potato crop, will have an effect on the production costs per unit of clean seed (18). This may range from 25 to 45 % as compared to the ware potato production (19). These cost increases are unavoidable. They have to be recovered through a higher price of the produce and/or an increase in yield, if the produce is replanted by the producer himself. The relationship between seed production techniques, cost of production and marketing of the final produce are discussed hereunder.

8.1 Budget preparation

This is the first operation to be performed before setting up any seed multiplication activity. The budgeting exercise has to be repeated every year. One precondition before preparing the budget is the availability of a complete and detailed plan of operations. Only when all the required activities are known and scheduled, the costs can be calculated correctly. Models of operational plans and budgets are presented in tables V and VI.

Table V: Model of the operational plan for a seed potato multiplication managed by a seed company

CROP OPPER./ MONTH:	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR
select contractor	***									
land selection		**								
input purchase		****	***							
land preparation		****	**							
pre-irrigation				*						
seed bed prep.			*	*						
first fert. appl.			*	*						
seed preparation			*	*						
pre-plant.-irrig.				*						
planting/ridging				**						

CROP OPERATION:	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR
crop-irrigation				****	****	****				
herbicide appl.				**						
second fert. appl.					**					
mite/jassid contr					***					
other pests, diseases					cutw ****	LB ***	aph ***	*		
hoeing/earthing up					**					
roguing						*	*	*	*	
field inspection						**	*	**		
haulm cutting							***			
chemical haulm destruction							**			
pre-harvest-irrig.							*	***		
harvesting							*	***		

POST HARVEST OPERATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
wound healing heap	***	**							
grading/FSCD sealing		*	**						
shifting			**						
cold store loading			***						
storage management			**********	**********	**********	**********	**********		
after store handling									***
final sealing									***
sales booking							**********		
sales/distribution								***	

*Note: Each * represents one week, during which the operation takes place.*

Table VI: Model of an autumn seed potato multiplication budget plan considering all the known costs, developed for a private seed company.

CROPPING OPERATIONS:	units	Rs/unit	Rs/acre
land rent	1 acre		
fertilizer	estimated		
herbicide (Stomp)	1.25 l		
herbicide (Grammoxone)	O,5 l		
insecticide (50% incidence)	0.5 l		
fungicide (50% incidence)	0.5 l		
miticide (25% incidence)	0.25 l		
land preparation	estimated.		
fertilizer application	2 tractor		
seed preparation/treatment	15 bags		
irrigation cost (tubewell) canal) (labour)	8 times		
planting/ridging	estimated		
herbicide application	1 tractor		
mite control	0.25 tractor		
hoeing/earthing up	1 tractor		
roguing	2 times		
pesticide application	1 tractor		
field inspection	1 acre		
haulm destruction (manual)	8 labour		
chem. haulm destruction	0.5 tractor		
harvesting (machinery)	2.5 tractor		
harvesting (labour)	100 bags		
TOTAL CROP OPERATIONS WITHOUT SEED & POST-HARVEST:			= = = = =

basic seed (from hills)	600 Kg		
certified seed I (from plains)	1500 Kg		
average seed price	estimated		
TOTAL INCLUDING SEED PRICE			= = = = =
post harvest handling	100 bags		
purchase seed bags	130		
purchase big bags	35		
shifting, handling to store	130 bags		
storage of seed	130 bags		
TOTAL POST HARVEST:			= = = = =
TOTAL FIELD PRODUCTION COSTS			
contingencies 10 % on costs			
GRAND TOTAL INCL. POST HARV.			
seed unit management costs			
overheads admin. + interests			1000
seed marketing costs	130 bags		
TOTAL COSTS ACRE			
revenue from table potatoes	35 bags		
break even revenue for seed 100 acres in plains	130 bags		
break even revenue for 500 acres in the plains	130 bags		
total budget agriculture			
marketing budget 100 acres	13000 bags		
marketing budget 500 acres	65000 bags		

The estimates of the costs of each item must be revised every year, at the latest in July for the autumn, and in October for the spring crop. A simplified version of the plan for farmers multiplying seed potatoes on their own fields is presented in tables VII and VIII.

Table VII: Model of the operations plan for the autumn seed potato multiplication plot managed by a private potato grower

CROP OPERATION	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR
land selection	*	*								
input purchase		****	***							
land preparation		****	**							
pre-irrigation			*							
seed bed prep.			*	*						
first fertil. appl.			*	*						
seed preparation			*	*						
pre-plant.-irrig.				*						
planting/ridging				**						
crop-irrigation				****	****	****				
herbicide appl.				**						
second fertil.appl.					**					
mite/jassid contr					***					
other pests, diseases spray					cutw ****	LB ***	aph ***	*		
hoeing/earthing up					**					
roguing						*	*	*	*	
haulm destruction							***			
pre-harvest-irrig.							*	***		
harvesting							*	***		

POST HARV. OP.	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
wound healing heap		****	**						
grading		*	**						
shifting			**						
cold store loading			***						
storage management			**********						
after store handling									***

Table VIII: Model of an autumn seed potato multiplication budget plan considering all the known costs, developed for a private seed grower.

CROPPING OPERATIONS:	units	Rs/unit	Rs/acre
land opportunity costs	1 acre		
fertilizer herbicide (Stomp)	estim. 1.25 l		
herbicide (Grammoxone)	O,5 l		
insecticide (50% incidence)	0.5 l		
fungicide (50% incidence)	0.5 l		
miticide (25% incidence)	0.25 l		
land preparation	estim.		
fertilizer application	2 tractor		
seed preparation/treatment	15 bags		
irrigation cost (tubewell) (canal) (labour)	8 times		
planting/ridging	estimated		
herbicide application	1 tractor		
mite control	0.25 tractor		

CROPPING OPERATIONS:	units	Rs/unit	Rs/acre
hoeing/earthing up	1 tractor		
roguing	2 times		
pesticide application	1 tractor		
haulm destruction (manual)	8 labour		
harvesting (machinery)	2.5 tractor		
harvesting (labour)	100 bags		
TOTAL CROP OPERATIONS WITHOUT SEED & POST-HARVEST:			= = = = =
certified seed (plains)	1500 Kg		
TOTAL INCLUDING SEED PRICE			= = = = =
post harvest handling	100 bags		
purchase seed bags	130		
purchase big bags	35		
shifting, handling to store	130 bags		
storage of seed	130 bags		
TOTAL POST HARVEST:		= = = = = =	
TOTAL FIELD PRODUCTION COSTS			
contingencies 10 % on costs			
GRAND TOTAL INCL. POST HARV.			

In large seed multiplication operations, it is essential that the preparation of the operational plan and the budget be delegated to the technical field staff responsible for supervising the field work. Sanctioning every activity and cost item by a distant and centralized management is not feasible.

8.2 Monitoring the progress of work

There is no use in having plans if there is no provision for plan monitoring. As seed multiplication is a delicate job with little room for the correction of mistakes, the management must

monitor the application of the plan of activities at least twice a month. The seed grower is required in the field for monitoring every week during the cropping season. Absent landlords are therefore less suitable for seed multiplication operations as compared to medium size potato or vegetable growers, who live on their farms. The seed stock in the store has to be monitored twice a month by the management. Correct expenditure of the budget should be monitored on the basis af bimonthly financial reports.

8.3 Economics of the production of seed potatoes

The production of seed potatoes is definitely more expensive than the production of table potatoes, which is reflected in a higher sales price. In table 6, a model is presented which may demonstrates the reasons for this. The main cost differences are:

- higher costs for basic seed,
- costs of crop rotation (the seed grower can not select market opportunities freely),
- the fertilizer dose on the seed crop can be reduced, as maximum yields are not aimed for, but costs may increase by the application of FYM.

Additional costs have to be faced if certified seed is produced:

- higher costs for roguing,
- costs of official inspections and intensive monitoring,
- less yield per unit of land as compared to ware potato production due to early haulm destruction,
- higher handling, packaging and storage costs,
- higher management overheads,
- higher marketing costs,
- higher risk of loss of quality and of market fluctuations as compared to ware potatoes.

All these factors added together may result in:

- field production costs per unit of produce higher by 25 to 35%, representing 80% of the total cost increase incurred in seed multiplication,
- handling and marketing costs increased by 200 % or more but representing only about 20% of the total cost increase.

8.4. Marketing

Seed potatoes are sold by:

- growers with "surplus" production,
- seed multiplication companies,
- commission agents and traders (27).

Selling a perishable product is a tricky business requiring some specialized knowledge. Some of the main problems are presented hereunder.

8.4.1 Quality aspects of marketing

In Pakistan the denomination of legally certified seed will soon be protected and the selling of non-seed as seed will be illegal. Till now, only about 7% of the so called "seed potatoes" traded in the country deserve this qualification. The problem resides in the lack of quality consciousness of the majority of the potato growers purchasing so called "market seed". Quality consciousness of the traders and commission agents is usually high. Currently they do not just purchase potatoes to sell them as seed. Normally they try to develop more or less stable markets by searching for some known source of potatoes with low disease incidence. The risk of failure is covered by selling the produce, especially when it is given on credit, with a profit margin of up to 100 %. However, this premium is only achievable when the quality of the seed is confirmed. If the quality is sub-standard, the margin will be lost. Thus, when seed multiplication companies develop a market for autumn-to-autumn seed, they have to take extreme care to monitor the quality before and after the storing operation.

One way to do this is to take samples of 100 tubers from each batch of seed bags shortly before the sales and to plant these lots in a carefully laid out seed source demonstration plot. If the farmers (seed customers) have claims of germination failures, the seed supplier should take them seriously, in order to protect his reputation. The affected field should be immediately inspected and the probable cause and the extent of the problem recorded. These data should then be verified in the seed source demonstration plot. If the results in the plot are similar to those in the affected field, the supplier should take full responsibility for the loss, supply some vegetable seed for re-planting and supply seed free of cost in the next season. If the results in the plot are normal, over 90% germination, handling mistakes by the farmer during pre-planting and at planting must be assumed. Usually they are not difficult to be discovered. However, in this case, they often could have been avoided if an "after-sales" advice service on the correct cultivation of high value seed would have been provided by the seller. The provision of such a service is well worthwhile to protect the "brand-image" and build up customer's goodwill.

8.4.2 Handling and Transport aspects of Marketing

Seed handling and transport has already been discussed in detail in chapters 7.5 and 7.6. The

principal recommendation for autumn seed is to store it as near as possible to the customers' fields. Stored potatoes of some varieties do not tolerate long transport in high stacks on narrow trucks like the ones predominating in the Pakistan transport system. In the central Punjab, with better access roads, large lots of 15 to 20 tonnes or more can be transported on long trailer vehicles by loading a maximum of 20 tonnes on a long vehicle designed for 30 tonnes. The stacks should not exceed six bags high. The second handling aspect of marketing is the pre-sales storage and the handling of non-delivered seed. Whenever possible the seed should be delivered from the store directly to the end consumers' field. Some farmers may fail to procure some booked lots. Some lots without booking may be distributed to market outlets. These seed bags must then be stored in well-ventilated places and returned immediately if not sold. It is always preferable to leave the seed in the coldstore until booking has taken place.
If the seed has no customers for autumn planting in the Punjab, there is always the possibility of selling it as seed in Sindh or in the worst case as ware potatoes during the high price period at the end of November.

8.4.3 Pricing aspects of marketing

The cardinal rule in pricing is that the seller must be responsive to the prevailing market situation and be competitive. This means that a flexible pricing policy must be adopted, so that (i) an adequate price is paid to contract growers, to ensure delivery of the seed and offers them a fair return in any given market situation, (ii)the final selling price should not be too low in relation to the competition, e.g. domestic seed for spring planting should be priced relative to imported seed and not sold too cheaply. (i) and (ii) are interrelated; if you do not charge a high enough price to the buyers when the demand is there, you cannot pay the contract growers a sufficient price.

Given the above points, the following suggestions can be made to assist in determining the price level.
A selling price of the certified autumn-to-autumn seed of about 200 to 250% above the price of table potatoes in years of low prices and 100 to 150% above this level in years of high prices, is more than justified for the additional cost related to the production of seed.

The opportunity cost of high quality seed sold in the spring is near to the cost of imported certified seed. The price of autumn-to-autumn certified seed should reach 50 to 75% of this value in years of high demand. In years of glut the minimum value of the seed should stabilize at 100 to 150% above the average wholesale price for table potatoes for the months of August-September. Another model would be to calculate the price on the basis of the cost of production of the first autumn seed out of imported seed, increased by 20% for higher quality and by 40% for the increased market flexibility of those growers purchasing certified seed for direct autumn planting. In both cases, the end value would be more or less the same.
The strategy recommended is to delay the call for booking of the autumn seed as long as possible. Booking should start at mid to end July, when the price trend for summer potatoes and the quality of the produce in the stores is more or less known. In Pakistan, perishable seed is normally marketed through advance bookings. If booking is carried out too early, there is the risk of fixing the price too low or of the produce not being available, due to failures in the store.

8.4.4 The demand for seed potato

This is a derived demand, that is, it is a function of the price of ware potato: the higher the anticipated ware potato price for the following season, the more seed will be purchased. In discussing this, it must be borne in mind that many farmers, particularly in the Punjab, retain tubers from their own harvest for using as seed. Also the cash availability with farmers is a limiting factor: after a bad year, they will have less funds with which to buy seed and other inputs.

There is no true seed market, except for the small quantities of imported and local certified seed. The so-called "market" seed is in effect ware potato. Thus at times, it is difficult to distinguish a separate market for seed, although market seed may be pre-sorted by traders to give some quality advantages over unsorted ware potato. There is, however, no way of selecting out virus-infected tubers.

Certified seed is required for further multiplication. Typically, the produce from it is multiplied several times. The imported seed is distributed among growers through formal distribution networks established by importers. Certified seed from the Northern Areas is also distributed through a network of agents. The Punjab Seed Corporation has its own direct outlets with farmers.

Through these channels, around 1 to 4 thousand tonnes of certified seed are distributed annually, although the volume varies markedly from year to year.

The Punjab spring crop, in which both imported and high hill seed are multiplied, has an estimated seed requirement of 10 to 15 thousand tonnes. The high hills are the main suppliers (60-70%) of seed to the spring crop, although with the exceptions noted below, the bulk of the high hill production is sold as ware potato. The Northern Areas have assumed particular importance in recent years as a producer of quality seed.

Around 20 thousand tonnes of seed potatoes are required for the production of the high hills crop and this comes mainly from the plains or else is the farmers' own seed held over from the previous season.

The Punjab autumn crop requires around 100 to 120 thousand tonnes of seed. This is derived from the spring crop and increasingly from farmers' own seed plots from the previous autumn crop. The eventual elimination of the spring crop as a seed source is a feasible long-term goal, particularly as PSPDP has demonstrated that early-harvested cut Northern Areas seed from the summer crop can be successfully introduced directly into the same year's Punjab autumn crop. However, it appears that the spring crop is increasingly being grown for consumption purposes.

The demand for imported seed is expected to decline as high quality local seed becomes increasingly available from the existing seed schemes, from the expansion of micropropagated basic seed through the tissue culture route, and from the extension of the large farmers' own seed plots. It is also likely, and desirable for the improvement of seed quality in general, that production on seed plots surplus to the farmers' own needs will be marketed generally through the wholesale markets, replacing the inferior "seed" currently available. The immediate opportu-

nity for domestic certified seed is to substitute for imports, giving a likely market of up to 4 thousand tonnes annually. The potential demand for certified seed could be as much as 12 thousand tonnes annually i.e. three or four times its present level. However, this will depend on technological and management factors which will allow output to be expanded and costs and prices to be cut.

8.4.5 Production planning

The proportion of the varieties to be multiplied has to be taken from the prevailing market situation and the underlying trends. The knowledge of the trends in favour or against certain varieties is very important, because usually the decision about varieties is taken 2-4 years before the final produce is sold. If the basic seed is multiplied in the Northern Areas or imported, some flexibility can be gained by reducing or increasing the total number of multiplications.

8.4.6 The market outlets for certified seed potatoes produced in the plains of Pakistan

The main market is the autumn crop in the plains of Punjab and NWFP, with a potential demand of 5 to 8 thousand tonnes.

The second largest market is Balochistan with a potential demand for up to 1000 tonnes of certified seed. For this market, advance bookings are made in February and delivery takes place by mid March. Only lots harvested early should be considered. The produce will be cheaper than in the plains because storage costs, losses-in-storage risks and financing costs, etc, will be reduced. These cost factors are higher than the transport costs to Quetta.

The third market is Sindh. It is much smaller, with a potential demand of 30 to 40 tonnes of certified seed. Surplus from the Punjab autumn sales can be sold here.

The fourth market lies scattered over the northern hills, with a maximum demand of about 25 tonnes of autumn seed.

Future prospective export markets could be in Afghanistan, Iran, Central Asia and possibly South East Asia, although in terms of ability to pay, only the last market would be attractive.

8.4.7 The distribution network

In order best to meet the customers' needs and best exploit the market potential, the most effective way would be to set up a regional distribution network, rather than just work from a head office. However, the costs of doing this must be carefully assessed and, initially at least, it would be best to limit the distribution outlets to the most important potato-growing areas, or those that show most market potential. Instead of appointing one's own staff to the regional offices, it may be more cost-effective to use agents, paying them a commission on the volume of sales but using their premises and other facilities. If agents are used who already deal in agricultural products like fertilizer, pesticides etc, then the agent will already have contacts with potential customers.

It is also better for technical and logistical reasons to store the seed in the plains areas. Therefore the agents should have easy access to a cold store to where the seed can be delivered after harvest and from which to arrange delivery at the appropriate time. In appointing agents, only those of integrity should be selected who display a capability of being responsive to clients' needs, of wanting to inform themselves of necessary technical aspects and are motivated to develop the sales volume.

As well as a distribution network, a sales unit at headquarters will be needed to coordinate the production and marketing, to supervise the activities of the agents and to provide overall control of the marketing operations, including promotion. The accounting procedure used, should ensure that all seed supplied to the agents is fully paid for at the agreed or booking price at the time of delivery to the farmers and there is no scope for diverting the seed or receiving "under the counter" payments, so undermining the confidence of regular customers.

8.4.8 The sales campaign

The seed will not sell itself; the producer has to put in an effort to make the potential buyers aware of what is on offer and the advantages that the potential buyer will gain if he places an order. This is partly a factor of buyer education (technical details of increased yields obtainable, purity of seed etc) and partly a factor of persuasion (encouraging the potential buyer to invest in the product to increase his net income).

If the aim is to expand the market, then a sales campaign will be needed. This could take the form of bringing all the agents and salesmen together for a pre-season sales meeting, to stress the selling points, to train in selling techniques and to allocate targets (with extra incentives for meeting these). An approach could be to target a particular important potato-producing area and set up a sales force to visit farmers and establish outlets. Advertising in the media could be used to make the availability and advantages of the product known, as is done with pesticides for example. Over the longer term, on-farm seed demonstrations are an effective way of showing the value of the product, but there is no point in demonstrating the seed if there will be insufficient supply available to meet anticipated demand. The agents therefore should be supported so that they know how much they should aim to sell and this quantity can be guaranteed to the buyers. The failure to fulfill bookings can only lead to loss of confidence and be damaging for future sales prospects. Similarly, the acceptance of bookings without a firm commitment to buy, may lead to a situation of oversupply and the return of unsold seed if there is a downturn in the market, inviting a financial loss if no other buyer can be found.

REFERENCES

1. Ahsan S. (1985) "Seed potato certification". Proceedings of National Seminar on Potato in Pakistan, held at NARC, Islamabad, Published by PSPDP/PARC. PP. 103-108.

2. Ahsan S. (1985) "Minimum seed certification standards". Proceedings of a National Seminar on Potato in Pakistan, held at NARC, Islamabad. Published by PSPDP/PARC., Islamabad, PP. 109-112

3. Ali M.(1983) "New approach for potato seed production in the Punjab" Published by Punjab Seed Corporation, 4-Lytton Road, Lahore. PP. 14

4. "Asian Potato Association Proceedings: Symposium on improved potato planting material". June 21-24, 1988. (CIP) Kunming China. PP. 94.

5. Banaras M., Khan M.B. and Farooq K. (1985) "Yield survey of Autumn survey potato crop in Punjab Plains, 1983-84" Published by PSPDP/PARC., Islamabad, PP. 16.

6 Beukema H.P., and Zaag D.E. vd, (1990) "Seed requirements - Seed treatments". Introduction to Potato Production. Published by I.A.C. Pudoc, Wageningen. PP. 77-84.

7. Cortbaoui R., (1984). "Roguing potato". Published by International Potato Centre, Lima, Peru. PP. 13.

8. Devaux A. (1988) "Study on seed degeneration of potential improved potato seed sources through the autumn-to-autumn cycle in the Punjab plains". Published by PSPDP/PARC., Islamabad, PP.21.

9. Devaux A., Khalid S., Mughal S.M. and Shaheen T., (1988) "Detection of potato viruses in Pakistan". Papers published in the Asian Potato Association Proceedings, Second Triennial Conference. PP. 2.

10. Devaux A., Masood M. and Tariq A.H., (1988). "Evaluation of Hunza seed as a potential improved potato seed source for starting the autumn-to-autumn cycle in the plains of Pakistan". Published by PSPDP/PARC. Islamabad, PP. 33.

11. Grewal J.S. and Jaiswal V.P. (1990) "Agronomic studies on potato under all India Coordinated potato improvement project". Published by Central Potato Research Institute (Indian Council of Agricultural Research) Shimla 171 001 (HP) INDIA. PP. 122.

12. Grewal J.S., Sud K.C. and Sharma R.C. (1990) "Water management in potato." (Technical Bulletin No.28). Published by Dr. J.S. Grewal, Director, Central Potato Research Institute, Shimla 171 001 (HP). PP. 28.

13. Grewal J.S. and Trehan S.P. (1990) "Micronutrients for potatoes" (Technical Bulletin No.23) Published by Dr. J.S. Grewal, Director, Central Potato Research Institute, Shimla 171 001 (HP). PP. 24.

14. Grewal J.S., Trehan S.P. and Sharma R.C. (1991) "Phosphorus and potassium nutrition of potato" (Technical Bulletin No.31). Published by Dr. J.S. Grewal, Director, Central Potato Research Institute, Shimla 171 001 (HP). PP. 43.

15. Ham J.v and Luitjens E. (1982) "Potato seed multiplication programme" (Report II July 1981 to April 1982). Published by BADC-Seed Potato Multiplication Programme. Dhaka. PP. 55.

16. Horton D. (1982) "Partial budget analysis for on-farm potato research" Published by International Potato Centre Lima, Peru. PP. 16.

17. Horton D.E., Kim Y.C., Hahn B.H. Kim. K.K., Mok I.G. and Lee B.N. (1987) "Korea's seed potato program" Published by International Potato Centre (CIP) in collaboration with Republic of Korea, Ministry of Agriculture and Fisheries. Rural Development Administration. PP. 68.

18. Hooker, W.J.(1981) "Compendium of potato diseases" Published by American Phytopathological Society, Potato Association of America, CIP Lima, Peru, Department of Botany and Plant Pathology, Michigan State University, Michigan State Foundation. PP. 125.

19. Hussain I. and Hanif M. (1990) "Vegetable Production in Pakistan". Proceedings of a workshop on Vegetable Research and Development in South Asia. Asian Development Bank, Asian vegetable Research and Development and Pakistan Agricultural Research Council, Islamabad, Pakistan. PP.52-57.

20. Khan A., Khan B.A., Haq I. Mughal S.M. and Jan N. (1985) "Potato disease survey in Kalam and Malam Jaba valleys (District Swat)" Published by PSPDP/PARC., Islamabad, PP. 28.

21. Khan M.B. and Devaux A. (1987) "Yield survey of autumn potato crop in Punjab plains 1984-85" Published by PSPDP/PARC. Islamabad, PP. 18.

22. Khan M.B. and Naumann K. (1989) "Guidelines for prebasic potato seed production" Published by PSPDP/PARC., Islamabad, PP. 17.

23. Khan M. B., and Naumann K. (1989) "A study on mechanization of the Punjab potato crop in relation to seed production and multiplication" Published by PSPDP/PARC. Islamabad, PP. 33.

24. Kokab A.A. and Smith A.E (11/1989) "Marketing potatoes in Pakistan" Published by PSPDP/PARC. Islamabad, PP. 88.

25. Monninkhof G., Hussain A. and Anwar J.(1985) "Cold Storage and Potato Marketing in the Punjab" Published by PSPDP/PARC. Islamabad, PP. 13

26. Naumann K. (1/1990) "Current situation and future strategy in seed potato production for Pakistan; A discussion paper" Published by PSPDP/PARC. Islamabad, PP. 31.

27. Rosskamp R. and Leppack E. (1979) "Potato Storage in Panama" (A solution for tropical and subtropical climates). PP. 90

28. Sharma R.C., Grewal J.S. and Upadhaya N.C. (1991) "Nitrogen management in potato" (Technical Bulletin No.32) Published by Dr. J.S. Grewal, Director, Central Potato Research Institute, Shimla 171 001 (HP). PP. 74.

29. Turkensteen L.J. (1986) "Survey on bacterial and fungal diseases of potato in the hilly areas of Pakistan" August 14 to September 11th, 1985. Published by PSPDP/PARC. Islamabad, PP. 41.

30. Turkensteen L.J. (1987) "Survey on bacterial and fungal diseases of potato in the plains of Pakistan in Punjab province and Pabbi area of NWFP" Dec. 22nd to 31st 1986. Published by PSPDP/PARC., Islamabad, PP. 24.

31. Turkensteen L.J. (1988) "Survey on bacterial and fungal diseases of potato in Baluchistan province of Pakistan" August 16th-21st, 1987. Published by PSPDP/PARC., Islamabad, PP. 11.

32. Verma K.D. (1990) "Potato aphids" (Technical Bulletin No.26) Published by Dr. J.S. Grewal, Director, Central Potato Research Institute, Shimla 171001 (HP). PP. 24.

Annex I

MINIMUM SEED CERTIFICATION STANDARDS - POTATO

(Solanum tuberosum)

TYPE OF SEED POTATO

There shall be two types of seed potatoes, namely the Hill and Plain grown. Hill grown seed potatoes shall be raised in the Hills about 2500 metres above sea level or in conditions found technically suitable for seed production. Plain grown potatoes shall be raised in only such conditions with tolerable aphid infestation (Haulms must be destroyed when population of *Myzus persicae* reaches 10 per 100 leaves). It is not advisable to grow spring crop for seed potato production due to very high aphid population (3).

I. CROP STANDARDS

Land requirements:

1. Seed potatoes shall not be grown on land where potatoes were produced within previous two years and on such land where a normal potato crop management is not possible eg. land with poor drainage, salinity problems, heavy soil etc. Plot size for certified seed shall not be less than two "Kanal" for Hill seed and two acres for plain seed. Multiplication fields shall also be accessible for inspection.

2. Production of seed potatoes shall not be done on land where potatoes are likely to be infected with wart and potato nematodes (root knot and cyst nematodes) and where soil was found infected with the above mentioned nematodes.

3. Areas declared by the Plant Protection adviser to the Government of Pakistan or by the Provincial Government unfit for seed potato production shall not be eligible for growing certified seed crops.

II. CROP INSPECTION

Crop inspections shall be carried out for pre-basic, basic and certified classes preferably at the crop stages given below:

- The first about 45 days after planting;
- The second 30 days after the first inspection and before haulm cutting; and
- The third after haulm cutting and before harvesting.

While conducting first and second inspection, the certifier shall verify the presence of offtypes and occurrence of disease infection (7). During second inspection it must be ensured that the severe mosaic, leaf roll, black leg and heavily rhizoctonia infected plants have been up-rooted alongwith the tubers and destroyed outside the fields and roguing of offtypes has been completed.

While conducting third inspection, it must be ensured that the haulms have been destroyed in time and that no re-growth has come up.

The seed grower and the certifier shall agree on the date and site of final inspection of the harvested and graded tubers.

III. CROP PURITY STANDARDS

Isolation

An isolation distance of 10 metres for pre-basic and basic seed classes and 5 metres for certified class from plots planted with other varieties, other seed classes or ware potatoes shall be maintained to avoid mixing. Where mixing has occurred only at field border in bigger plots, the affected areas can be selectively rejected.

Specific requirements

1. A crop of seed potatoes must conform to the following standards:

a) All haulms must be destroyed as close to the ground as possible before the date specified by the Federal Seed Certification Department. Failure to destroy the haulms in time, shall make the crop liable for rejection. Heavy irrigation immediately after haulm cutting shall also make the crop liable for rejection.

b) All diseased plants and offtypes must be up-rooted alongwith the tubers and destroyed before the date of second inspection. At the time of the second inspection, there should not be more than 10% gaps in the fields.

Field Standards

Factors	Stage	Maximum permitted percentage				
		Pre-basic 1	Pre-basic 2	Basic 1	Basic 2	Certified.
Offtypes*	2nd inspection	None	None	0.5	0.5	1.0
PVY	2nd inspection	None	None	0.5	0.5	0.5
PLRV	2nd inspection	None	None	0.5	0.5	2.0
PVX, PVA	2nd inspection	None	None	0.5	0.5	2.0
Other viral diseases	2nd inspection	None	None	0.5	0.5	2.0
Maximum all viruses	2nd inspection	None	None	1.0	2.0	4.0
Fusarium wilt	2nd inspection	None	None	0.2	0.5	1.0
Black leg	At any stage	None	None	0.5	0.5	1.0
Rhizoctonia,leaf curl and mild verticillium	At any stage	None	None	5.0	5.0	10.0
Severe verticillium (albo-atrum)	At 2nd & 3rd inspection	None	None	1.0	1.0	3.0
Brown rot & ring rot	At any stage	None	None	None	None	None
Early blight	At any stage	Only relevant if masking other diseases.				
Late blight	At any stage	Haulms must be destroyed immediately.				

** If offtypes do not exceed 2% roguing can be recommended during first inspection.*

Annex II

GLOSSARY OF TECHNICAL TERMS:

active ingredient: the chemical element present in a formulation which will cause the desired effect when the formulated product is used

ammonium sulphate (AS): chemical fertilizer used to increase the availability of Nitrogen in the soil

annual: plants living one year or less

aphids: small insects of the order Homoptera (vernacular. "tela")

armyworm: black migrating caterpillars, larvae of the genus *Spodoptera*

basic seed: a quality of certified seed used as mother stock

black leg: severe disease of the potato plant caused by bacteria

black scurf: a symptom caused by the *Rhizoctonia* fruiting bodies on the potato skin

canopy: aerial part of the crop after large parts of the field are covered with foliage

center pivot: a type of automatic irrigation machine covering round field plots

certified seed: seed produced under the supervision of the seed certification authority

clone: set of vegetatively reproduced plants stemming from a genetically identical mother

crop rotation: the technique to avoid consecutive planting of the same crop in the same field

crop uptake: the amount of a nutrient or other agrochemical absorbed by the crop.

cut seed: seed potato tubers cut into 2 - 4 pieces using a special technique. Cut seed can not be used for planting the main autumn crop.

cutworm: subterranean caterpillar, larvae of the genus *Agrotis*

diammonium phosphate (DAP): chemical fertilizer used to increase the availability of Nitrogen and Phosphorus in the soil

digging: harvest operation which separates the tubers from the soil and deposits them on the surface for collection

Dithane M 45: a commercial fungicide containing 45 % Mancozeb

denitrification: organic Nitrogen is reduced to molecular Nitrogen by the activity of soil organisms. **Denitrification** is intensified during warm temperatures

dormancy: condition of the freshly harvested potato tuber causing a 5 to 10 week delay in sprouting

drainage: removing excess water from the field

early blight: a fungal disease of the potato leaves

earthing up: re-shaping the ridges after the hoeing operation.

elevator belt: conveyor belt used for lifting of goods

fallow: the field is kept without any crop

formulation: a chemical produce in its ready-to-use form, usually mixed with some non active components for technical reasons.

Fusarium: a fungus causing plant wilting or tuber dry rot

germination: emergence of strong and healthy potato sprouts at the soil surface.

goolies: vernacular for small size seed tubers (20-30 mm)

grade, grading: sorting into a range of established sizes .
harvester: equipment performing the full harvest operation
haulm: aerial stems of the potato plant
haulm cutting (destruction): removal of the haulms to prevent diseases and enhance crop maturity
healthy (seed) stock: a lot of disease free seed
hectare: unit of land surface comprising 10.000 square meters
hill: see potato hill
hoeing: loosening the soil with a hoe, especially to destroy clods and weeds to facilitate earthing up.
hopper: container box for seed or agrochemicals mounted on agricultural implements.
late blight (LB): devastating fungal potato disease attacking under humid weather conditions
leaching: reduction of the soil fertility by the effect of water
leaf hopper: small, elongated insect jumping on the leaves, most l.h. are serious pests
Mancozeb: a carbamate fungicide for the treatment of plant diseases
minimum standards: levels of minimum tolerance for deviation from the best possible condition
mite: small arachnid arthropod; some are plant pests
miticide: agrochemical used to control mites
mosaic: a plant diseases caused by viral infection
mouldboard: type of plough
off-type: plant of a different variety or with a different aspect than the "type" or typical plant of a seed plot
perennial: plants living currently more than two years.
physiologically mature: non dormant potato tubers, ready to produce vigorous sprouts and to germinate fast and uniformly when planted
physiologically weak seed: seed potatoes affected by excessive aging.
post emergence herbicide: contact or hormonal herbicide applied to the small weed plants after their emergence, but before the crop has emerged. If the crop has already emerged, the crop can be spared by "protected band application"
potato hill: truly speaking, each potato sprout is a separate plant; therefore the plants emerging from one mother seed tuber or seed piece are called a hill of potato plants
potato variety: the potato variety is a clone of genetically identical plants or planting material stemming from a single mother plant obtained by controlled crossing.
pre-basic seed: non commercial strictly controlled seed used to produce basic seed
pre-emergence herbicide: contact or hormonal herbicide selectively preventing the weed seeds to germinate. They are applied before the emergence of weeds and crop, usually a few days after planting
primary virus infestation: infestation has occurred during the present crop
residual fertilizer: fertilizer applied to, but not used by the crop nor lost but left in the soil after harvest
Rhizoctonia: a soil and seed borne fungal disease
ridger: agricultural implement used for shaping ridges in a seed bed or field

roguing (to rogue out): Technique to remove diseased or otherwise undesirable plants from a seed plot.

rouni: vernacular for soil conditioning irrigation before planting

rotation: see crop rotation

scorching: a pathological condition of the potato leaves causing thickening and drying of leaf blades, amongst other symptoms

secondary virus infestation: plant has been infected through the seed tuber

seed multiplication: increasing the volume of the seed through crop and seed production techniques

seed plot technique: seed multiplication in separate plots of land

seed stock: a certain volume of seed available for planting

sprouting: sprout emergence in the sprouting eyes of the potato tuber

stem canker: a disease symptom caused by *Rhizoctonia* stem pruning: see Rhizoctonia above

siphon: short and bent tube (about 1 to 1.5 m) used to apply controlled quantities of water to a limited number of furrows in the field

sulphate of potash: chemical fertilizer containing Potash

swath: line of harvested crop laying on the field, usually for drying

tandem equipment: arrangement of equipment, one after the other, behind the same tractor, to perform several field operations at the same time

tie-ridge: a short ridge connecting two parallel ridges and therefore interrupting the flow of water in the furrow.

triple tuperphosphate: chemical fertilizer used to increase the availability of Phosphorus in the soil

tuberization: tuber setting and growth during the bulking stage

variety: see potato variety

seed degeneration: process of accumulation of diseases caused by viruses and virus-like organisms. In Pakistan potatoes are affected by at least 9 different viral diseases. One or two of these agents are sufficient to destroy the yielding potential of a potato tuber. Virus infected tubers are considered degenerated

virus vector: Living creature of any kind capable of transmitting virus diseases

water logging: excess water is retained in the soil either due to poor infiltration or too high water table

White mold: a disease symptom caused by *Rhizoctonia*

wilting: condition of the potato plant evidenced by hanging leaves and caused by lack of water or by bacterial/fungal diseases of the vascular system of the potato haulm

Zinc sulphate: chemical fertilizer containing the element Zinc.

SUGGESTION'S SLIP

GUIDELINE FOR SEED POTATO PRODUCTION IN PAKISTAN PLAINS

Dear reader!

Do you agree with the contents of the guideline?

Yes/No

Do you think that this book is helpful for seed potato production in the plains of Pakistan?

Yes/No

Is there something useless/harmful for improved seed potato production?

Yes/No

If your answer is yes, please point out the article/s.

Your suggestions to improve the book.

----------Fold----------

Coordinator Potato Project
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Islamabad.

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