THE SEEDPLOT SYSTEM of producing QUALITY SEED POTATOES in small holder farms

Z.M. Kinyua, A. Baranyena, P. Namugga, S. Tindimubona,
B. Mateeka and J. Kinoti
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NATIONAL POTATO COUNCIL OF KENYA (NPCK)

What is National Potato Council of Kenya?
The National Potato Council of Kenya (NPCK) is a Public Private Partnership (PPP) and a multi-stakeholder outfit that has the responsibility of planning, organizing and coordinating activities of the value chains in potato subsector and developing it into a robust, self-regulating and competitive industry. Its organizational structure enables it to draw synergies from a wide membership representing all stakeholders and actors in the industry.

Vision statement
The potato industry will emerge as a major contributor to stable incomes, food security, and improved public welfare in Kenya. The NPCK will become a leader in Kenya’s agricultural development.

Mission statement
It is NPCK’s mission to coordinate and regulate Kenya’s potato industry, and help improve the industry’s profitability and the livelihoods of its various stakeholders.

Strategic objectives
The 2013 – 2015 NPCK Strategic Plan is anchored to six objectives:
1. To enable the improvement and growth of effective potato value chains in ways that will result in a self-regulating potato industry in Kenya.
2. To encourage collaboration and cooperation among stakeholders in order to mobilize and manage appropriate resources for the growth, stability, and prosperity of public private partnerships in the potato industry.
3. To promote best practices to standardize potato quality, improve yields, and enhance commercial value in local, regional, and global markets.
4. To collect, manage, and disseminate information relevant to the steady development of stakeholders in the potato industry.
5. To strengthen NPCK by effectively mobilising and managing resources for structural development and financial sustainability.
6. To identify cross-cutting and emerging issues within the potato industry and encourage transparency and cooperation in resolving problems.

The National Potato Council of Kenya approves & Recommend the use of this manual
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# Table of Contents

Acknowledgements ........................................................................................................ ii
Foreword .................................................................................................................... iii
Abbreviations ............................................................................................................. iv
Preamble ..................................................................................................................... 1
1. Selection of seed potato for seedplot establishment ............................................. 2
2. Site selection for seedplot establishment ............................................................... 3
3. Land preparation .................................................................................................. 4
4. Protecting seed-plot land from contamination ..................................................... 5
5. Planting .................................................................................................................. 7
6. Weeding and hilling ............................................................................................... 9
7. Pest and disease control ....................................................................................... 10
8. Tuber size control and harvesting ...................................................................... 12
9. Sorting and Grading ............................................................................................ 12
10. Post-harvest handling ........................................................................................ 13
11. Usage of seedplot tubers ................................................................................... 13
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The seed-plot technique that was part of the work done was validated in Kenya, Uganda and Burundi by a technical consortium led by KARI and comprising of collaborators from ISABU, KAZARDI and UNSPPA. In this light, the Director KARI and the Centre Director – KARI Kabete facilitated the technical consortium unreservedly. We also extend our appreciation to the Director General of NARO, Director of Research in ISABU and Gisozi Research Station Director.

Our thanks also go to the researchers, technicians and support staff in the three countries’ potato programmes and the ministries agricultural extension staff for providing initial and/or subsequent technical and logistical support to the work. In particular we would like to recognize the following persons: Miriam Otopa, Jane Ong’ele, Bornice Langat, Nancy Miruci and Winfred Muriithi in Kenya; William Wagoire, George Kimoana, Imelda Kasaija, Fidelis Karugaba, William Mayambi and Benia Biryomumaisho in Uganda; Nicolas Nko, Privat Ndayayanzamoso, Déo Nyawakira, Dieudonné Harahagazwe in Burundi, and Elmar Schulte-Geldermann Rogers Kakuhenzire of CIP. The consortium also worked closely with individual farmers and farmer groups whose support is gladly acknowledged.
Foreword

Potato (Solanum tuberosum L.) is increasingly becoming an important crop in many Sub-Saharan Africa countries due to its potential to meet subsistence and commercial needs of farmers and consumers, particularly through urban and industrial market outlets. However, production of the crop is faced with numerous constraints that lead to low productivity, with yields below 10 tonnes/ha in comparison to 40-60 tonnes/ha achievable under improved farming circumstances.

One of the major and most critical constraints has perpetually been the shortage of quality seed potato as most of the seed available to farmers is heavily infested by disease-causing agents. The common practice of recycling home-saved seed potato further complicates the situation as tuber-borne diseases continue to build up and depress potato yields. It is also noteworthy that the cost of seed potato constitutes a high proportion of the total costs of production of a commercial ware crop, usually above 50%. On this note, it is recognized that improving the availability of healthy seed potato to farmers would be a great stride towards increased yields and faster development of the potato sub-sector.

Since potato is a vegetatively propagated crop, starting with disease-free seed tubers and putting deliberate efforts to maintain the good health of potato plants from which subsequent season’s seed potato is to be obtained remain key aspects of increasing potato production. This handbook provides detailed information on how to practise a seed-plot technique that has effectively been used by smallholder farmers in some parts of Kenya, Uganda and Burundi to overcome the problem of lack of quality seed potato on their farms and beyond.

This handbook is intended to facilitate the upscaling of the seed-plot technique as potato farmers and trainers of such farmers put to use the information contained in it. This reference is also a useful resource for various potato industry stakeholders, including the agricultural sector ministries, the National Potato Council of Kenya (NPCK), Confédération des Associations des Producteurs Agricoles pour le Développement (CAPAD) – Burundi, Dr. Ivan Rwomushana (Staple Crops Programme Manager) ASARECA among others. In order to ease the practical implementation, the authors have extensively used photographs and illustrations based on the experience gained in the course of validating the technique. This aspect is particularly useful in training of trainers and on farm demonstration of the technique.

Dr. Ivan Rwomushana
Staple Crop Programme Manager
ASARECA
<table>
<thead>
<tr>
<th>Abbreviations</th>
<th>Description</th>
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<td>ADC</td>
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</tr>
<tr>
<td>ASARECA</td>
<td>Association for Strengthening Agricultural Research in Eastern and Central</td>
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<td></td>
<td>Africa</td>
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<td>CAPAD</td>
<td>Confédération des Associations des Producteurs Agricoles pour le Dû</td>
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<td>International Potato Centre</td>
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<td>Diffused Light Stores</td>
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<td>ECA</td>
<td>Eastern and Central Africa</td>
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<td>ELISA</td>
<td>Enzyme-Linked Immunosorbent Assay</td>
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<tr>
<td>FFS</td>
<td>Farmer Field School</td>
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<tr>
<td>ISABU</td>
<td>Institut des Sciences Agronomiques du Burundi (Burundi)</td>
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<td>KARI</td>
<td>Kenya Agricultural Research Institute</td>
</tr>
<tr>
<td>KAZARDI</td>
<td>Kachwekano Zonal Agricultural Research and Development Institute (Uganda)</td>
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<td>KEPHIS</td>
<td>Kenya Plant Health Inspectorate Service</td>
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<tr>
<td>MOA</td>
<td>Ministry of Agriculture</td>
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<td>National Potato Council of Kenya</td>
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<tr>
<td>TOT</td>
<td>Training-of-Trainers</td>
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<td>UNSPPA</td>
<td>Uganda National Seed Potato Producers Association</td>
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Preamble

On-farm potato production does not achieve potential yields due to the poor quality of seed potato commonly used by farmers. The seed potato is often biased towards undersized tubers from a ware cropping system. Such seed is usually infested by diseases such as bacterial wilt, those caused by viruses and other tuber-borne problems. In order to improve the availability of adequate quantities of high quality seed potato, an innovative way of multiplying seed potato known as seed-plot technique, has been developed for smallholder farmers. The technique is akin to a seed potato 'nursery'.

The technique allows a farmer to produce large quantities of seed potato from a relatively small piece of land through high density planting to maximize the production per unit area. The small size of the plots also encourages intensive crop management practices that lead to better quality seed potato. This is achieved through strict field hygiene and intensive control of pests and diseases which is practically easier than in large potato fields. Watering on a small scale can be done to produce off-season seed potato. The system requires 50% less land than the conventional production system to meet on-farm seed tuber requirements. It is recommended that the 'felled' land be managed as next season's seed plot by leaving it fallow or planting a short season non-solanaceous crop.

The handbook is organized into sections that provide the procedure and critical guidelines of producing and handling high quality seed potato through the seed-plot technique, which simply refers to the establishment and management of a 'potato nursery'. These include aspects of seed potato selection, site selection, land preparation, planting, prevention of land contamination, pest and disease control, tuber size control, harvesting and postharvest handling of seed potato from seed-plots. Collectively, these aspects constitute the seed-plot system, with the seed-plot technique as the backbone.
1. Selection of seed potato for seedplot establishment

Health of tubers. Initial tubers for seedplot establishment should be obtained from a reliable source, preferably a seed production centre or a recognised seed potato dealer. The tubers should not be infested with the bacterial wilt pathogen (*Ralstonia solanacearum*), viruses, nematodes and other tuber-borne pathogens (disease-causing agents) that lower seed potato quality. Ideally, testing for latent infections should have been done to ensure that the tubers are healthy. Tubers should also be free of pests such as the potato tuber moth, mites, aphids, etc.

Tuber size: Tubers should be within the range of 25-55mm in diameter. Generally, these are tubers that are considered to be the size of a chicken egg.

![Figure 1. Range of tuber sizes considered to be appropriate for seed. Note the relative sizes.](image)

Physiological age: Good tubers should have well-hardened skin and should be well-sprouted (multiple sprouts). Dormant or poorly sprouted tubers lead to uneven crop stands due to poor emergence. On the other hand, very old (senile) tubers should be avoided since they give rise to very weak plants.
Figure 2. Potato tubers with bruised skin (top left), dormant tubers (top right) and senile tubers (bottom right) should be avoided; instead, well-sprouted (bottom left) are recommended.

**Physical appearance**: Selected tubers should be devoid of any physical damage (e.g. bruises, cuts, etc) and should not be malformed.

2. **Site selection for seedplot establishment**

In potato-growing areas, the land that is conventionally used for potato production could at one time or another have been exposed to potato pests and diseases. However, a farmer can identify small portions of the land that have lower or no risk of such pests/diseases. Such portions are the ones targeted for establishment of seed plots (see Figure 3).

In order to avoid the risk of infestation by *Ralstonia solanacearum* (bacterial wilt) and other pests/pathogens, a seedplot must be established on land with the following characteristics:

- without a history of potato production or other solanaceous (potato family) plants such as capsicums, tomato and brinjals (eggplant), preferably for three (3) or more years.
- where volunteer hosts have not been allowed to establish during the non-solanaceous crop period.
- where no runoff water flows into such land.
where potato residue/peelings are not dumped.

where no manure/compost suspected to have been made from diseased host residue has been applied or deposited.

It is advisable to take a soil sample for laboratory confirmation of presence or absence of the bacterial wilt pathogen.

Figure 3. Site selection for seed-plot establishment. Critical considerations include previous cropping history and risk of contaminated run-off water.

Seed plots should be established on land recognized as fertile in order to provide for high tuber yields. In case the soil fertility levels are low, improvements can be made by application of appropriate inorganic fertilizers. Well-decomposed manure may also be applied but should not be made from host plant residues that could have harboured potato pests and diseases.

3. Land preparation
Selected land should be prepared well before the onset of rains. This may be achieved by ploughing with tractor- or animal-drawn ploughs or by hand digging. Harrowing may also be done in case of new land. The soil surface should be fine (without weeds or large soil clods). Soil should be loosened to a depth of about 20-30cm.
Figure 4. Well-prepared land (top) compared to a poorly prepared land. Properly prepared land enables adequate air circulation, good water or rainfall infiltration, free drainage and decomposition of plant residues to provide organic matter to the soil. This enhances the development of plant roots and tubers. Weed management during crop growth also becomes easy.

4. Protecting seed-plot land from contamination

Right from the beginning, land that has been earmarked for seedplot establishment should be protected from introduction of the bacterial wilt pathogen and other pests/diseases.

Disinfection of tools (hoes, machetes/pangas, ploughs), shoes/feet, sprinkler stands, containers, etc. should strictly be carried out. This can be achieved by using a solution of a disinfectant such as commercial bleach containing sodium hypochlorite (e.g. Jik). An
appropriate disinfectant solution can be prepared by putting about 10 litres of water in a basin and adding 500ml of commercial bleach (about 2 glassfuls).

In case the tools, shoes or containers are too soiled, removal of excessive soil by washing with water before disinfection is recommended. The disinfectant solution can be re-used several times but a fresh solution should be prepared if it becomes too dirty.

The practice of disinfection should be observed every time someone visits the seed potato production plots/fields.

Figure 5. Preparation and use of a disinfecting solution

Flaming of tools such as hoes can also be done as a way of disinfection to kill bacteria that may be adhering to their surfaces.

Additional protection of potato seedplots can be achieved by fencing off the seed-plot area or by simply putting a perimeter string around the plot to limit human criss-crossing and/or to enhance the practice of disinfection before entry.
5. Planting

Potato plants in seedplots should have a final spacing of 30 cm between rows and 30 cm from plant to plant in each row. On the appropriately prepared land, follow the steps below:

1. Mark out beds of 1.8 m width and a sufficient length depending on the on-farm seed potato needs (see Table 1). The bed should be narrow enough to allow for working without stepping inside the seedplot.

2. Broadcast the recommended fertilizer for potato production on the seedplot at the rate of 1 kg for every portion measuring 1.8 m width by 9 m length (space for 180 plants) or simply 1 kg fertilizer for 16 m².

   Fertilizers such as diammonium phosphate (DAP), Mavuno Planting or NPK 17:17:17 are appropriate depending on the usual practice in an area.

   Well-decomposed manure may also be spread on the surface if it is considered to be free of potato pests and diseases.

3. Mix the fertilizer with the soil using a rake or similar tools.
Figure 7. Fertilizer is broadcast on the seedplot. The fertilizer is then worked into the soil.

4. Using a hoe, make shallow furrows at a spacing of 30cm (1 ft) from one furrow to the next along the length of the bed; the furrows should be about 15cm (6 inches) deep.

5. Plant well-sprouted tubers at a spacing of 30cm (1 ft) along the furrows (6 tubers per furrow). The appropriate depth can be achieved by deepening the furrow with a sharpened stick or a "panga" (machete) at the time of planting; ensure that the sprouted end faces up.

Figure 8. Well sprouted tubers (left) are planted in furrows (right) and covered with soil appropriately.

6. Cover the tubers with soil. Watering may be done if necessary.
6. Weeding and hilling

Hand weeding is recommended; this is achieved by pulling out emerging weeds before they reach a competitive stage. In some areas, soil appears very compact after plant emergence and may need to be loosened. This can be achieved by using sharpened sticks or pangas at the time of weeding.

Ordinary hilling (earthing up) carried out in ware production fields is not necessary provided the recommended planting depth is adopted. However, disease-free soil from around the
seedplots should be added to the beds as soon as the potato plants emerge in order to cover the auxiliary buds, leading to increased tuber formation. This should be at the time of first hand-weeding.

7. Pest and disease control

Seedplots need to be inspected frequently to ensure that pests and diseases are controlled promptly. In particular, pests and diseases that directly impact on the quality of resultant seed tubers must be prevented or managed appropriately.

Bacterial wilt: This disease greatly reduces potato yields, leads to condemnation of seed potato and contaminates land over a long period of time. Bacterial wilt control starts with the planting of clean seed in disease-free soil.

In order to avoid the risk of bacterial wilt infestation in established seed plots, the following measures should be taken:
- Disinfection of tools before and after use
- Prevention of runoff water from nearby fields by digging trenches on the upper side of the seed plot
- Practising crop rotation to avoid potatoes, tomatoes, brinjals, capsicums and other hosts of bacterial wilt for 3 years or more
- Complete removal and disposal of volunteer potatoes in fields where rotation crops are planted.

In case bacterial wilt is noticed in a seed potato production plot that is for a farmer’s own use, the following measures should be taken:
- Roguing out and appropriate disposal of infected plants as soon as symptoms appear
- Marking of plants neighbouring infected ones at the time of roguing to facilitate subsequent separate harvesting for consumption.

The above measures would assist in two ways: prevention of the build up of the bacterial wilt pathogen and improving the quality of seed potato available to farmers who are unable to access certified seed.

Blights: Late blight and early blight are the most damaging foliar diseases of potato. They can be managed by:
- Application of protective/contact fungicides containing mancozeb (e.g. Dithane M-45, Mithane Super, Oshothein 80WP, Agrozeb, Greenzeb, Mancozeb) or containing copper (e.g. Cuprocalfaro micro 37.5WG, Nordoxy 75WG) every 7 to 10 days or more frequently under very humid weather conditions or fungicides with systemic/curative effects (e.g. Ridomil Gold MZ 68WG, Acrobat MZ, Galben 8-65, Agrolyxyl, Victory) as per manufacturer’s recommendations.
- Use of disease-free certified seed potato.
Cutting foliage (dehauling) when tubers reach an optimum size for seed to prevent tuber infection from infected foliage; this is ascertained by sampling plants to dig out and examine the tubers.

Ensuring appropriate sanitation measures such as destruction of cull piles and removal of volunteers in the main crop of potato or during rotation.

Growing resistant or tolerant varieties, if available.

**Viruses:** Virus diseases can be controlled by:

- Using virus-free seed.
- Roguing and destroying or burying plants infected with viral diseases.
- Controlling insects that can spread viral diseases e.g. aphids, thrips, mites and whiteflies.

**Insects and mites:** Pests such as aphids, leaf miners, cutworms, mealybugs, potato tuber moths, and spider mites can lead to serious reduction of potato yield and quality of the resultant seed. Aphids are also known to transmit potato viruses. Arthropod pests can be controlled by a selection of the following measures:

- Use of appropriately selected insecticides that are available from agrochemical shops. Common examples include Deltamethrin, Durban, Malathion dust, Sherpa, Agrothoate, Cypermethrin, etc.
- Use of traps made of yellow plastic pieces smeared with oil to control aphids around seed potato plots and in stores. The yellow color attracts aphids and they get stuck on the traps. Traps need to be changed periodically.
- Storage of seed potato in diffused light stores (DLS) with aphid-proof nets.
- Ensuring that tubers are well-covered with soil in the field to prevent potato tuber moth infestation.

![Figure 10. Yellow plastic traps for trapping aphids](image-url)
8. Tuber size control and harvesting

In order to prevent excessive enlargement of tubers, potato vines (haulms) should be removed earlier than would ordinarily be the case for ware potato production. The decision to remove the haulms is reached after inspecting to see that majority of tubers from randomly selected plants are in the seed-size range (chicken egg size). Removal of haulms also helps in faster hardening of the tuber skin to reduce bruises during harvest and reduces transmission of diseases to tubers. The haulms are removed by cutting them as close to the soil line level as possible; care should be taken not to injure the tubers in the soil.

Figure 11. A potato plant ready for dehauling as demonstrated by mature tubers (left), poorly dehaulmed potato plants (middle), and an appropriately dehaulmed potato plants.

Harvesting is done about 2 weeks after dehauling; again, inspection of tubers before harvest is important to ensure that the skin is sufficiently hard. Depending on experience and what someone is accustomed to, sticks or hoes can be used in harvesting as long as tuber injury is avoided.

9. Sorting and Grading

Sorting involves the removal of damaged/bruised, diseased and malformed tubers to leave good-looking ones from which seed potato can be selected.

Grading is the exercise of separating tubers according to their sizes for different purposes. The sizes include ware, seed and chats. Tubers in the seed size category have diameters ranging from 25 to 55mm and can further be graded into small-size, medium-size and large-sized seed.
Figure 12. Various sizes of tubers after grading. The tubers at the extreme left are too small while those at the extreme right are considered too large. The other categories represent seed-size tubers.

10. Post-harvest handling

For maintaining the quality of graded seed potato tubers, the following aspects should be borne in mind:

- Selected tubers should be stored under conditions of diffuse light and ample aeration. A wooden crate is ideal.
- Different grades should be stored separately.
- Cleanliness. The store should be thoroughly cleaned and disinfected.
- Transportation from the field. The seed should be transported in such a way that it is not bruised and damaged.
- Packaging. Different grades should not be mixed and seed packaged according to agreed standards.
- Curing. Harvested tubers should be spread on the floor for 4-5 days in order to cool from field heat and to heal any bruises before shelving. Removal of visibly diseased and damaged tubers should be done.
- Pest control. Aphids, rats, tuber moths, mealy bugs and other storage pests should be controlled effectively using recommended measures.
- Inspection. The stored seed tubers should be inspected regularly for disease and pest outbreak.
- Sprouting. Appropriate methods may be applied to induce or retard sprouting.

11. Usage of seedplot tubers

The seedplot system enables farmers to have a reliable on-farm source of seed potato that is of high quality for ware field production. As such, a farmer is encouraged to have a seedplot every season. Therefore, the tubers graded as seed from seedplots are divided into two lots: one lot is used in establishing a new potato seedplot and the other lot is planted in the main potato field at the recommended ware spacing for commercial production. Figure XX shows the schematic presentation of the seed-plot system.

Certified seed tubers used in a seed-plot system can be recycled for 3 to 4 seasons before new seed is sourced as long as no serious infestation by diseases is experienced.
Figure 13. Schematic presentation of seed-plot practice

Table 1. Approximate seedplot sizes to produce adequate seed tubers for ware fields

<table>
<thead>
<tr>
<th>Seed plot measurements</th>
<th>Estimated amount of seed to plant in a seed plot</th>
<th>Size of ware potato field to be covered with seed from a seed plot</th>
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<tr>
<td>Width (m)</td>
<td>Length (m)</td>
<td>Number of tubers</td>
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