DEPARTMENT OF AGRICULTURE
Ministry of Agriculture and Forests

Standard Evaluation Guidelines for Field & Horticultural Crops

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ROYAL GOVERNMENT OF BHUTAN

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Thimphu: Bhutan

Foreword

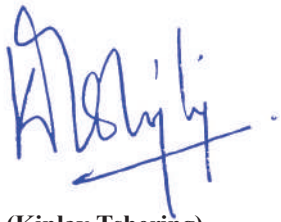
Farming sector in Bhutan provides employment to around 66% of its population. Developing and sustaining programs that contribute to food self-sufficiency and security, as well as employment generation along with import substitution is a formidable challenge when pitted against an increasing pressure on limited arable land and natural resources. Several interventions and investment are being made into the agriculture sector to stimulate production such as commercialization, farm-mechanization, organized marketing, private sector participation, infrastructure and credit access.

However, these efforts entirely rely on the Ministry of Agriculture & Forests' ability to generate new farm technologies that enhance crop production. Upscaling crop production within a limited arable area warrants the increase in production per unit area. Improved crop varieties with high inherent genetic potential therefore, offer much higher opportunities in increasing productivity per unit area. Exploiting the advances made in plant breeding through the introduction, evaluation and use of more resilient and high yielding crop germplasm is one of the simplest ways to increase crop productivity.

Introduction and evaluation of crop germplasm often follow procedures that are cumbersome and obsolete. Records indicate that to date the Department of Agriculture alone has introduced, evaluated and released around 217 improved varieties of field and horticulture crops. Although these varieties offer a comprehensive basket of available and improved technology to our farmers, it involved innumerable processes that often varied with the institutes associated, and at times also relied on individual initiatives.

The Department of Agriculture is therefore, pleased to bring out this publication on standard evaluation procedures for horticulture and field crops. Through this publication the Department hopes to not only standardize crop introduction and evaluation system but also safeguard our rich native biodiversity by prohibiting the introduction of restricted germplasms. The publication is also expected to bring on board other relevant institutes including private bodies who are increasingly engaged in ventures in agriculture, and help effectively manage and share information on crop germplasm.

We acknowledge all personnel involved for their earnest efforts in putting together this important publication, and hope to bring out revised editions at later stages to make it inclusive.



(Kinlay Tshering)

DIRECTOR

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Abbreviations & Acronyms

AET	**Advanced Evaluation Trial**
BAFRA	**Bhutan Agriculture & Food Regulatory Authority**
CBD	**Convention on Biological Diversity**
CGIAR	**Consultative Group on International Agricultural Research**
CIP	**International Potato Centre**
DoA	**Department of Agriculture**
DUS	**Distinctness, Uniform and Stable**
FAO	**Food and Agriculture Organization of the United Nations**
GLS	**Gray Leaf Spot**
GM	**Genetically Modified**
Ha	**hectares**
HH	**Household**
HIDAP	**Highly Interactive Data Analysis Platform**
IET	**Initial Observation Trial**
IPR	**Intellectual Property Rights**
ITPGRFA	**International Treaty on Plant Genetic Resources for Food and Agriculture**
Kgs	**Kilograms**
m	**meters**
MC	**Moisture Content**
NaOH	**Sodium hydroxide**
NBC	**National Biodiversity Center**
NPK	**Nitrogen, Phosphorus & Potassium**
NSB	**National Seed Board**
NSC	**National Seed Center**
NSSC	**National Soil Services Centre**
OECD	**Organization for Economic Cooperation and Development**
PET	**Participatory Evaluation Trial**
PPT	**Participatory Production Trial**
PVS	**Participatory Variety Selection**
QPM	**Quality Protein Maize**
RCBD	**Randomized Complete Block Design**
RNR RDC	**Renewable Natural Resources Research and Development Centers**
SES	**Standard Evaluation System**
SET	**Station Evaluation Trial**
SMTA	**Standard Material Transfer Agreement**
SOT	**Station Observation Trial**
TLB	**Turcicum Leaf Blight**
TRC	**Technology Release Committee**
TSS	**Total Soluble Solids**
UPOV	**International Union for the Protection of New Varieties of Plants**
VCU	**Value for Cultivation and Use**
VRC	**Variety Release Committee**

1. Standard Evaluation Guideline for Field Crops Germplasm

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Ganesh Bdr.Chhetri (Department of Agriculture)

1.1 Background

Bhutan possesses a rich diversity of crop genetic resources which are both wild and domesticated. However, many of the traditional crop varieties have become susceptible to new pests and diseases which can be directly or indirectly attributed to the effect of climate change. Most traditional crop varieties despite being highly adapted to the micro environments have a relatively low inherent genetic production potential. The demand for food is always increasing and one of the pathways to enhance food production is by increasing the yield per unit area of cropland. Furthermore, crops and varieties vary in their inherent ability to adjust and adapt to changing environments. In the light of this fact, improved crop varieties that are robust with high genetic production potential and resilient to abiotic and biotic stresses need to be introduced, evaluated and utilized.

Good varieties can be developed, selected or introduced from different sources and made available to the farmers. The underlying objective of a crop breeding and evaluation scheme is that a suitable variety for a target environment should be made available to the farmers in the shortest possible time. It is in this context that a prudent and prompt selection and evaluation procedure is required.

1.2 Rationale

Improved crop varieties with high inherent genetic potential offer much higher opportunities to increase productivity per unit area. Such varieties can be accessed and adapted to the benefit of the farmers. The rationale to develop or introduce and adapt improved germplasm emanates from the following:

i. Advances in plant breeding have led to the development of many crop varieties with suitable traits that can substantially contribute to the overall goal of poverty alleviation and food security. Such varieties can be accessed and adapted at no extra cost.
ii. The limited scope to increase arable area warrants increased production per unit area to achieve the objective of food security. The development or introduction and use of more resilient and high yielding crop germplasm is one of the simplest ways to increase crop productivity.
iii. The occurrence of new pests and diseases and the increasing susceptibility of traditional varieties require development or introduction of tolerant crop genotypes that can withstand abiotic and biotic stresses.
iv. Limited technical capacity for research and development in the country and the very nature of adaptive research necessitate taking advantage of development done elsewhere.

v. Crops with improved nutritional qualities like the quality protein maize (QPM), Golden rice with high pro-vitamin A and other nutrient dense cereals are rapidly being developed, which can substantially improve the nutritional aspect of food security.

1.3 Need for a standard germplasm introduction and evaluation system

The need to develop a standard crop germplasm development, introduction and evaluation system is felt internationally as well as nationally. The International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) requires standard procedures for accessing germplasm. This international agreement advocates global food security through pooling of genetic resources and sharing the benefits from their use in modern plant breeding and biotechnology. A multilateral system for access and benefit-sharing is put in place and conditions for access to germplasm and benefit sharing are set out in a standard material transfer agreement (SMTA). Hence, access to germplasm requires fulfilling certain international norms and protocols such as:

i. Bhutan has ratified the ITPGRFA and is a party to the Convention on Biological Diversity (CBD). It is therefore obligatory to fulfill all norms while introducing crop germplasm.
ii. The need to sign the SMTA while requesting new germplasm.
iii. Unlike in the past, both formal and informal flow of germplasm has become stricter due to the Intellectual Property Rights (IPR) regimes and regulations.

Nationally, there are more reasons to streamline our crop germplasm introduction and evaluation system:

i. Procedures followed for development, introduction and evaluation of germplasm are often cumbersome and outdated. There is an urgent need to institute a standard system which can be clearly followed across the field crops research system.
ii. The duration to evaluate crop varieties is apparently ***too long*** and should be replaced by a rapid process through the use of ***already available information*** on the variety. These are now easily accessible due to reliable information sharing systems.
iii. Introduction and development are sometimes based on individual initiatives; hence there is a need to institutionalize introduction mechanism.
iv. There is no decent system of management and sharing of information on different crop germplasm which leads to duplication of effort.
v. Many private entrepreneurs are increasingly engaging on Public Private Partnership ventures in agriculture and would need information on crop germplasm.

vi. The National Biodiversity centers serve as a national repository for conserving all crop germplasm and should be a party to the germplasm introduction and management process.

vii. The chances of wrong introduction and subsequent development, especially Genetically Modified (GM) crops which are restricted, and the entry of new and dangerous pests and diseases, are high in the absence of an efficient and transparent system.

1.4 Authorized Institutions for crop germplasm introduction and development

ARDC Bajo, being the National Field Crops Program Coordinating Center shall be designated as the apex institution for coordinating the introduction and development of any new field crops germplasm in the country. It may, however, delegate some of the authority to access germplasm based on the expertise and relevance to other ARDCs. Although a single window for introduction seems most desirable, it will not be pragmatic as it would be difficult to manage different crops, multiply seeds and maintain small field collections. The National Biodiversity Center (NBC) which acts as the custodian of genetic resources shall be informed of introduced genetic materials. All released crop varieties, selected introductions and elite breeding materials shall be conserved in the gene bank of NBC. The introduction of open pollinated varieties is fairly straight forward as seeds can be produced and propagated further. Hybrid varieties demand fresh seeds every planting season and create dependence on seed companies. Thus, introduction of hybrid varieties would require a careful analysis. Any institution that proposes to introduce a hybrid should seek the approval of the Department of Agriculture. A technical committee at the Department level needs to be instituted to authorize any introduction of hybrids.

For other normal introduction and access, relevant institutions based on their current expertise are assigned different commodities as in Table 1-1.

Table 1-1 Institutions responsible for introduction and maintenance of field crops germplasm

No	Institutions	Crops	Responsibilities
1	**ARDC Bajo**	1. Rice – For high and medium agro-ecology 2. Grain legumes for all ecologies 3. Wheat, barley, rye, oats, triticale	• All agencies maintain proper passport information of germplasm
2	**ARDC Yusipang**	Oil crops for all ecologies	
3	**A RDC Bhur**	1. Rice – For Subtropical irrigated agro-ecology 2. Rice – For subtropical rain fed ecology 3. Other cereals – Buckwheat, Finger Millets, Fox tail millets, Pear millet, Little millets, Sorghum, Pyrilla, Amaranth and other additional species	• Carry out rapid and rigorous evaluation • Undertake seed production, maintenance and conservation
5	**ARDC Wengkhar**	1. All types of Maize for all agro-ecology	
6	**National Seed Center & Projects**	1. Commercial varieties of all Field Crops on the approval of National Seed Board (NSB)	• Seek approval of NSB
7	**DoA committee**	1. Commercial hybrids of field crops	• Analyze the scenarios and provide recommendations

1.5 Standard Evaluation Procedure

At present, the variety evaluation procedure varies with the crops and the research centers. Crop germplasm are mostly introduced from international and regional institutions while a few are developed locally. These new germplasms are tested for up to 4 years in on-station trials (Introduction nursery, Observation nursery, Initial Evaluation Trial (IET) and Advance Evaluation Trial (AET). The best performers from the station trials are then promoted to farmers' fields at multi-locations and subjected to participatory selection. The best ones are finally proposed for release to the Variety Release Committee (VRC). Once a variety is released it is passed on to the National Seed Center (NSC) which is then responsible for seed production and supply to the farmers. The formal evaluation process thus takes a minimum of 6-8 years before a variety can be put up to the VRC for release.

Keeping in mind the need to provide good materials to farmers as quickly as possible and the type of materials to be evaluated; two different evaluation schemes are proposed for all field crops. The proposed evaluation schemes adopt the same principle as practiced earlier by initially testing at the research station and validating the performance in the farmers' fields. It however cuts short the time required to undertake the evaluation. The following three standard evaluation systems should be followed depending on the type of genetic materials to be evaluated.

A. **Normal Evaluation:** This scheme should be used to evaluate and release breeding lines, elite lines, populations, synthetics, and introduced germplasm which are in the early stages of selection. Such materials are often not uniform and segregating would require very careful selection. At least 2 years of station and another 2 years of on-farm evaluation will be required. Thus, a minimum of 4 years will be required before proposing such materials for release.

B. **Fast Track Evaluation**: This scheme should be used to evaluate and release varieties already released (elsewhere), mega-varieties (adapted in large areas with similar agro-environments) and any outstanding varieties. For such materials all the information available should be compiled, reviewed and analyzed to support the release. As these types of materials are stable, there may not be a need to test them in the Station Observation Trials. Such varieties can be proposed for release within three years.

C. **Fast Track Evaluation for Hybrids**: At present not many hybrids have been introduced in field crops. It is very likely that hybrids will be introduced in future given its high production potential. It is proposed that proven hybrids could follow the **Fast Track Evaluation** scheme as in case of mega varieties. Hybrids developed and available for testing through the international trials programs of the CGIAR centers whose performance is not yet proven could follow the **Normal Evaluation** system.

Some of the additional features of the proposed evaluation systems are:

- A minimum set of data based on Distinctness, Uniformity and Stability (DUS) will be mandatory while proposing and releasing new variety, including distinguishing agro-morphological characteristics of the new varieties.

- Test materials remain in the research centers for 2 years only in normal cases. However, in cases where a researcher is unsure of either discarding or promoting a test material after 2 years in the station, another year of evaluation may be done before taking a final decision.

- Farmers can have access to the new germplasm by the third year. Once the system is fully adopted and a full test cycle is completed.

- Extension staff and farmers are involved in the evaluation and selection of new materials alongside the researchers.

- Plot size for trials is specified and standardized in Table 1-2, 1-3,1-4and 1-5. Likewise, standard crop wise research protocols are developed for trial data collection.

- Elite materials and released varieties are preserved at the national repository with NBC.

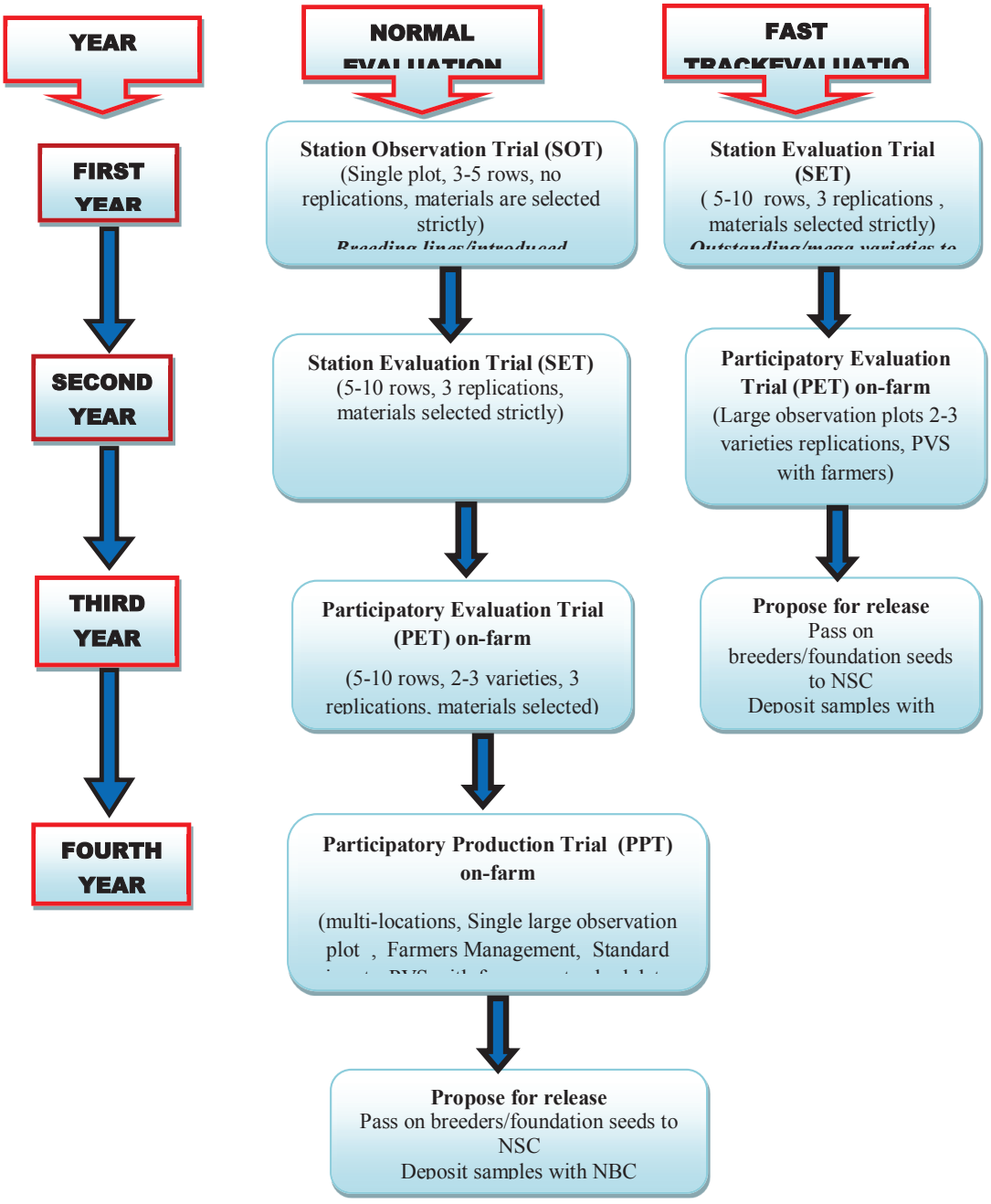

Figure 1-1 Standard evaluation procedure for field crops

Table 1-2 Plot size and other standard parameters for evaluation of rice and wheat

No	Type of Trial	Plot size and other Details	Replications	Harvest Area	Minimum Set of Biological data to be collected
1	Station Observation Trial (SOT)	3-5 rows of 3-5 m length spaced at 20 cm	None	Minimum 3 rows X 3 m X 0.2m = 1.8 m^2	**1.** Date to 50% heading **2.** Leaf blast based on a IRRI Standard Evaluation System (*SES)* **3.** Days to Maturity **4.** Plant height in cm from 5 randomly selected hills **5.** Tiller count from 5 randomly selected hills **6.** No. of panicles /m^2 , count panicles from 5 randomly selected hills **7.** Neck Blast Based on IRRI SES **8.** Plot yield in gms **9.** Moisture content
2	Station Evaluation Trial (SET)	10 rows of 5 m length spaced at 20 cm X 20 cm	3	6 rows X 4.2 m X 0.2 m = 5.04 m^2	
3	Participatory Evaluation Trial (PET)	4 rows of 3-5 m length spaced at 20 cm X 30 cm	Sites or farmers as replication	3m x 2m = 6m^2	
4	Participatory Production Trial (PPT)	Large single plots	3-5 locations, locations as replications	2 crop cuts per plot from 3 m X 2 m = 6 m^2	**1.** Plot yield in kgs **2.** Moisture content **3.** Socio-economic data from farmers based on farmers selection criteria (see Table 3) **4.** Milling recovery (%)

Table 1-3 Socio-economic data to be collected during participatory variety selection of rice/wheat

Name of variety	No of farmers	Farmers Selection Criteria	Rank 1-5*	Overall Rank of the varieties in relation to each other	No of HH growing the variety in the Geog	Remarks
Variety No 1		Maturity				For overall ranking farmers could be asked to tag the varieties with colored cloth tags and the number of tags can help to determine the overall ranking
		Plant height				
		No of tillers				
		Lodging				
		Ease to Thresh				
		Yield				
		Grain types				
		Tolerance to pests &diseases				
		Eating quality				
Variety 2		Maturity				
		Plant height				
		No of tillers				
		Lodging				
		Ease to Thresh				
		Yield				
		Grain types				
		Tolerance to pests &diseases				
		Eating quality				
Variety 3						

1= Best, 2= Very Good, 3= Good, 4= Satisfactory, 5= poor

Table 1-4 Plot size and other standard parameters for evaluation of maize

No	Type of Trial	Plot size and other Details	Replications	Harvest Area	Minimum Set of Biological data to be collected *(see Table 6 for descriptions of parameters and note for disease score scales)*
1	Station Observation Trial (SOT)	4 rows X 5 m X 0.75 m =10 m^2 Plant to Plant spacing of 0.25 m	None	Two middle rows 2 rows X 5 m =10m^2	**1.** Days to 50% tasseling **2.** Days to 50% silking **3.** GLS score based on scale of 1-5 **4.** TLB score based on scale of 1-5 **5.** Plant height in cm from 5 randomly selected plants **6.** Ear height in cm from 5 randomly selected plants **7.** Stem lodging based on a scale of 1-5 **8.** Root lodging based on a scale of 1-5 **9.** Husk cover based on a scale of 1-5 **10.** Ear aspect based on a scale of 1 -5 **11.** Yield of de-husked cobs in Kgs **12.** Grain type- flint, dent, semi dent **13.** Moisture content
2	Station Evaluation Trial (SET)	4 rows X 3 m X spaced at 0.75m = 12 m^2 Plant to Plant spacing of 0.25 m	Two	Two middle rows 2 rows X 3 m = 6m^2	
3	Participatory Evaluation Trial (PET)	4 rows X 5 m X spaced at0.75m = 20m^2 Plant to Plant spacing of 0.25 m	Three	Whole plot 4 rows X 5 m = 20m^2	

4	Participatory Production Trial (PPT)	Large single observation plots 10 – 15 rows spaced at 75 cmPlant to Plant spacing of 0.25 m	3-4 locations, locations as replications	2 crop cuts per plot 4 rows x 5 m x 0.75 m = 15 m^2	1. Plot yield of de-husked Cobs in Kgs 2. Moisture content 3. Socio-economic data from farmers based on farmers selection criteria *(see Table 5)* 4. Kharang recovery (%)

Source: CIMMYT-Managing Trials and reporting

Table 1-5 Socio-economic data to be collected during participatory variety selection of maize

Name of variety	No of farmers	Farmers Selection Criteria	Rank 1-5*	Overall Rank of the varieties in relation to each other	No of HH growing the variety in the Geog	Remarks
Variety No 1		Maturity				For overall ranking farmers could be asked to tag the varieties with colored cloth tags and the number of tags can help to determine the overall ranking
		Plant height				
		Ear height				
		Lodging				
		Tolerance to pests &disease				
		No of cobs per plant				
		Husk cover				
		Yield				
		Grain types/ quality				
		Ear aspect				

		Eating quality				
		Storing quality				
Variety 2						

1= Best, 2= Very Good, 3= Good, 4= Satisfactory, 5= poor

Note:

1. Disease Score should be rated on a scale of 1-5 where 1 indicates no diseases and 5 very heavy infection
2. Husk cover based on a scale of 1-5 where 1 is excellent (Husk tightly covers tip and extends beyond it); 5 – grain exposed (poor Husk cover, tips clearly exposed)

Table 1-6 Definitions and explanations of biological parameters of maize and how to measure them

No	Parameters	Abbreviations	Descriptions
1	Days to 50% Tasseling	Days to Tassel	The number of days from planting to the time when 50 % of the plants have tassels emerged
2	Days to 50% Silking	DAYS SILK	The number of days from planting to the time when 50 % of the plants have silks emerged
3	Gray Leaf Spot	GLS	Scored on a scale of 1-5 where 1=No lesions are visible 2=Few lesion seen on two lower leaves (1-25% of total leaf area dead) 3=Lesions visible on most leaves below the ear (26-50% of total leaf area dead) 4 = Many Lesions visible on leaves above the ear (51-75% of total leaf area dead) 5= All Leaves dead (76-100% of total leaf area dead)
4	Turcicum Leaf Blight	TLB	
3	Plant height	PLANT HT	Average height of plants, in centimeters, as measured from the base of the plant to where tassel branching begins
4	Ear height	EAR HT	Average height of the ear, in centimeters, from the base of the plant to the node bearing the highest ear.
5	Stem lodging	STEM LDG	The percentage of the plants that are stalk lodged
6	Root lodging	ROOT LDG	The percentage of the plant that are root lodged
7	% ear rot	% EAR ROT	The percentage of the ears affected by ear rots

8	Ear rot	EAR ROT	Scored from 1to 5. A score of 1 indicates the ears have no ear rot and 5 indicate that ears are heavily rotted
9	Ear aspect	EAR ASPCT	Scored from 1 to 5. A score of 1 indicates that the harvested ears are free from disease and insect damage, ear size is uniform, grain filling good, etc. A score of 5 indicates those ears are poor on the basis of this evaluation
10	Husk cover	HUSK COVER	Scored from 1 to 5. A score of 1 indicates good husk cover and 5 indicates poor husk cover
11	% percent moisture	MC	Percent moisture in the grain at harvest
12	Yield	KG	Yield of de-husked cobs in Kgs. To estimate grain yield Kg/ha at 15 % , 80% shelling recovery is assumed

Source: CIMMYT-Managing Trials and reporting

2. Standard Evaluation Guideline for Fruit Crop Germplasm

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2.1 Background

In general, procedure for crop evaluation and release encompasses development of new planting material (crop/variety), its introduction and assessment of performance to until it is available for cultivation. Standard guideline is a prerequisite for uniformity and comparison across temporal and spatial dimensions. Crop evaluation guideline is used mainly to analyze value for cultivation and use (VCU) of the given crop/variety. The general criteria for VCU include yield, resistance to abiotic and biotic stresses, time of maturity and postharvest quality, though it might differ among the crops. Hence, overall aim of crop evaluation and release is to transfer new planting materials from research centres to growers' fields while making reliable assessment of the value of the crops to growers. Newly developed planting material should be put through DUS testing: it should be distinct (D) from other varieties, uniform (U) among the given population and stable (S) among successive generation of multiplications.

2.2 Evaluation Procedure

This guideline for fruits evaluation was developed mainly with reference to the common fruits grown in the country. A number of standards and guidelines followed in other countries were referred especially those developed by the Organization for Economic Cooperation and Development (OECD) countries and International Union for the Protection of New Varieties of Plants (UPOV). Though this guideline may not be as comprehensive as to accommodate all fruit crop species, at least, it is expected to contribute towards streamlining research in fruits and nuts in the country

Normally it takes at least 13 years from development stage to release. However, in our case, since it is mostly adaptive research, and given the shortage of released varieties in the market, the duration for evaluation and release has been shortened while still trying to maintain important aspects of evaluation and release procedures. Development of single evaluation guideline is often difficult since fruits comprise both annuals and perennials. Hence, it is divided into three categories based on the gestation period of the crops.

2.2.1 Short duration crops: These include Banana, Papaya, Passion fruit, Pineapple, Strawberry and Watermelon. These crops can be evaluated after one year of establishment since they reach uniformity and yield stability within a season or a year.

2.2.2 Intermediate duration crops: Citrus, guava, grapes, pomegranate, gooseberry and temperature fruits (such as apple, peach, pear, plum, etc) reach field uniformity and yield stability 3 to 4 years after establishment.

2.2.3 Long duration crops: Avocado, jackfruit, mango and other tropical fruits (such as mangosteen, rambutan, wood apple, etc.) need 6 to 8 years to provide economic yield.

In our situation, normal procedure for crop evaluation and release mainly comprises introduction and establishment of ready-made planting materials, field observations, yield assessment and proposal for release. Adaptive evaluation of crop, even if it is released elsewhere, is necessary since we have complex orographic features that create unique micro-climate within a short span of distance. Hence, its adaptability and reactions to the given microclimate could differ significantly. Therefore, it is also important to carry out multilocation trials specially if the crop is to be released for cultivation in wider agro-climatic zones.

However, instead of multi location trial, we can also use modern techniques such as ecological niche modeling tools like Climate Analogue Tool to predict suitability range for the given crop. For proper comparison, use of appropriate check variety is essential.

In the case of traditional varieties or landraces that are being grown in the locality, after due evaluation of their performance in relation to the given check, they are notified rather than release as a new crop/variety.

2.2.4 Checklist for crop evaluation

Table 2-1 gives the general checklist for various stages of crop development to release stage, while Table 2-2, 2-3 and 2-4 provide the checklist for crop evaluation and release especially in the context of adaptive research for aforementioned three categories of crops.

Table 2-1 General checklist for crop development and release

Stages	Duration	Activity description
Variety development	1st - 7th year	Cross bred or carry out mutagenesis
		Growand select promising progenies (F1 to F7)
Introduction and evaluation trial	8 – 9th Year	Introduce and establish in the field/set up multilocational trials
		Observe growth habit and phenology
		Observe reactions to abiotic and biotic stresses
		Observe any other special characteristics such as precocity

		Evaluate preliminary yield performance
Variety release trial	10–12th year	Observe bearing habit (biennial bearing or regular)
		Evaluate yield performance for at least 2 years
		Do DUS testing
Proposal for release	**13th year**	

Table 2-2 Checklists for short duration crops

Stages	**Duration**	**Activity description**
Introduction and evaluation trial	1st year	Introduce and establish in the field/set up multilocational trials
		Observe growth habit and phenology
		Observe reactions to abiotic and biotic stresses
		Observe any other special characteristics such as precocity
		Evaluate yield performance
Variety release trials	2nd year	Evaluate yield performance
		Do DUS testing
Propose for release	**3rd year**	

Table 2-3 Checklists for intermediate crops

Stages	**Duration**	**Activity description**
Introduction and evaluation trial	1st– 2ndyear	Introduce and establish in the field/set up multilocational trials
		Observe growth habit and phenology
	3rd– 4th year	Observe growth habit and phenology
		Observe reactions to abiotic and biotic stresses
		Observe any other special characteristics such as precocity
		Evaluate preliminary yield performance

Variety release trial	5 – 6th year	Observe bearing habit (biennial bearing or regular)
		Study yield performance for at least 2 years
		Do DUS testing
Propose for release	**7th year**	

Table 2-4 Checklists for long duration crops

Stages	**Duration**	**Activity description**
Introduction and evaluation trial	1st– 3rdyear	Introduce and establish in the field/set up multilocational trials
		Observe growth habit and phenology
	4th– 5th year	Observe growth habit and phenology
		Observe reactions to abiotic and biotic stresses
		Observe any other special characteristics such as precocity
		Evaluate preliminary yield performance
Variety release trial	6th – 8th year	Observe bearing habit (biennial bearing or regular)
		Study yield performance for at least 2 years
		Do DUS testing
Propose for release	**9thyear**	

2.3 Data measurement

It is essential to adopt common procedure in sampling and data measurement for reliability, uniformity and meaningful comparison. Under this section, only most common parameters used in crop evaluation across broad spectrum of fruits and nuts are discussed. At the specific crop level, it might differ and should be adopted accordingly.

2.3.1 Experimental design

Randomized Block Design (RBD) and Randomized Complete Block Design (RCBD) are two of the most commonly used experimental designs in crop evaluation. Design should be done such that blocks are arranged across the nutrient gradient, if there is any. Generally, it is advisable to have at least 3 replications per treatment. Data should be collected systematically so as to reduce error and capture the maximum likelihood of varietal differences.

2.3.2 Quality parameters

Only those fruit quality parameters that apply across broad range of fruits and nuts are listed here. For details with respect to specific crops, refer International Standardization of Fruits developed by the Organization for Economic Cooperation and Development (OECD). In our context, Pome fruits include mainly apple and pear; Stone fruits comprises of apricot, nectarine, peach and plum; Drupe includes avocado and mango, and almond, hazelnut, pecan and walnut make up nuts.

Table 2-5 Most commonly used fruit quality parameters

Parameters	Citrus	Drupe	Pome	Nuts	Stone	Dragon fruit	Kiwi	Grapes	Papaya	Passion fruit	Persimmon	Strawberry	Watermelon
Diameter	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Height	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Weight	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bunch weight								Yes					
Skin colour	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Skin hairs (presence or absence)					Yes		Yes						
Hardness			Yes		Yes		Yes				Yes		
Flesh colour	Yes	Yes	Yes		Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes
Rind thickness	Yes												
Juice content	Yes												
Pulp weight	Yes									Yes			
Total soluble solids (TSS) or Brix	Yes		Yes		Yes	Yes	Yes	Yes			Yes	Yes	Yes
Acidity	Yes							Yes					
Number of seeds	Yes							Yes					

Pit or Stone weight		Yes			Yes								
Stone character (cling or free)					Yes								
Shell thickness				Yes									
Kernel weight				Yes									
Astringency											Yes		

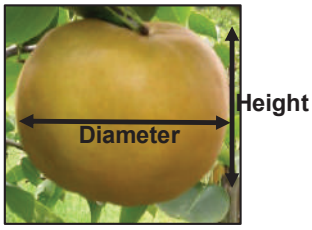
For morphological characterization of the plants, DUS guidance prescribed by International Union for the Protection of New Varieties of Plants (UPOV) maybe followed.

2.3.3 Data collection and measurement

Do random sampling from whole lot to ensure that data are as representative as possible. For measurement of data like yield or any other given quality parameters, randomly pick at least 10 samples from the whole lot. The yield data should be for at least 2 consecutive years, and preferably for 3 consecutive years to ensure that it accounts for biennial bearing habit, if any. Since the sample size and measurement method affect the outcome, it is critical to have standard protocols across research centers within the department for uniformity and meaningful comparison. Under this section, only those commonly used quality parameters that are highly likely to be affected by measurement methods are discussed.

2.3.3.1 Determination of diameter, height and weight

Total of 10 randomly selected fruits are measured for their diameter and height using Vernier Caliper. Weight is measured using Balance.

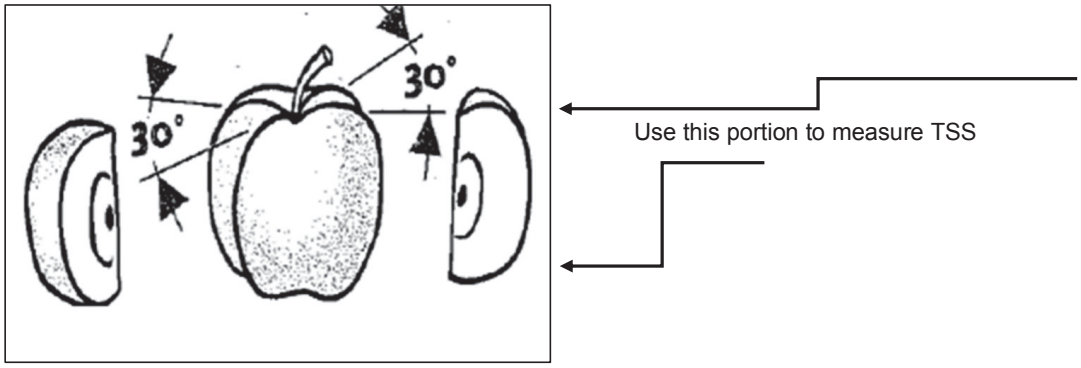


2.3.3.2 Determination of Total Soluble Solids (TSS)

It measures sweetness (sugar content) of a fruit. Either handheld or digital refractometer are used to measure TSS since sugar deviates (refracts) lights. For uniformity, it is advisable to follow uniform sample preparation method for juice extractions. To measure TSS, equal number of juice drops should be used for all samples.

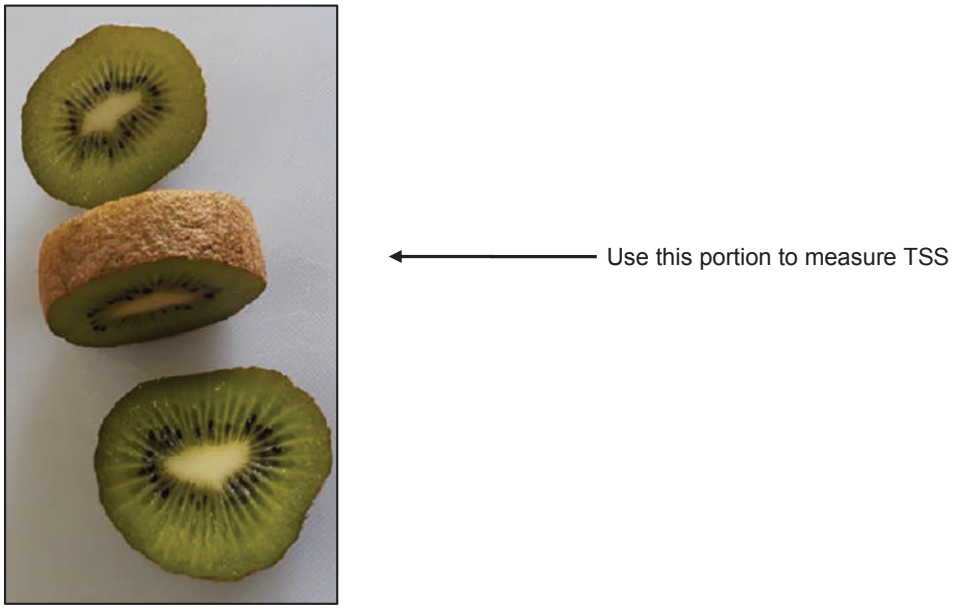
Pome and Stone Fruits

From each fruit, cut out two longitudinal slices, one from the most coloured side and one from the least coloured part of a fruit. Remove cores if any and squeeze from the slices and mix the juice to measure TSS.



Kiwi fruit

Cut out middle portion (about 15mm thick) between stem end and blossom end of a fruit, squeeze out juice and use it to measure TSS.

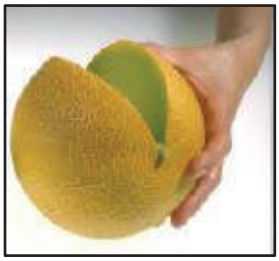


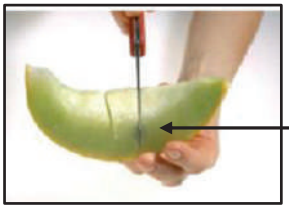
Grapes, Strawberry and Citrus

For grapes and strawberry, squeeze a whole fruit to extract juice and use for TSS measurement. Similarly, for citrus, cut across into two halves and squeeze juice and mix them to measure TSS.

Watermelon

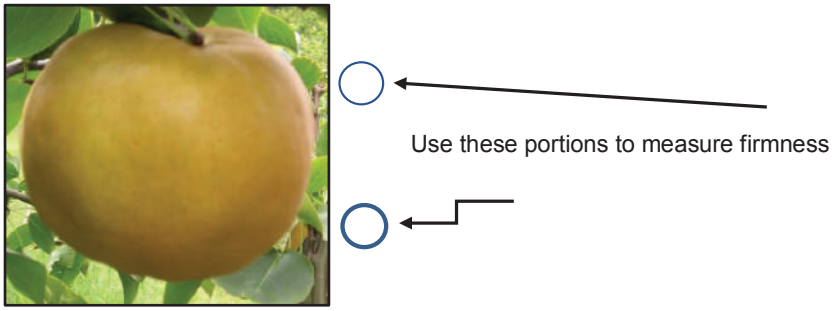
Slice out two longitudinal portions between stem to flower end, one from the side that touches the ground and one from the opposite side. Squeeze the juice, mix them and use for measurement of TSS.





3.3.3 Determination of firmness (kg/cm^2)

Hardness of the fruit is measured using penetrometer. It helps to ascertain the stage of ripeness, shelf life and suitability for transportation. Specific detachable plungers are used for different types of fruits. To measure firmness, peel off (just the cover) from two opposite sides of the equatorial area of a fruit. If a fruit is of mixed colour, firmness should be measured from area between the highest and lowest coloured portion of the fruit.

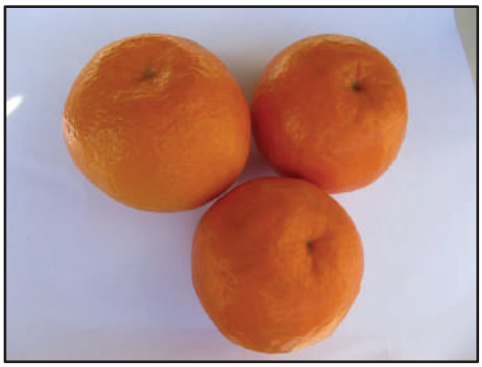


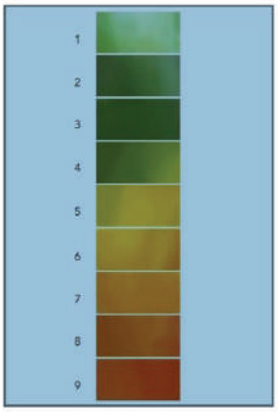
2.3.3.4 Determination of rind/shell thickness

Use Vernier Caliper to measure rind thickness in citrus and shell thickness in nuts. Cut open a fruit into two halves and measure one from the thinnest side and other from the opposite side.

2.3.3.5 Determination of colour

Colour is measured using suitable colour chart as shown below. Measure colour from the side that represents more than 50% of the total fruit.





2.3.3.6 Determination of Acidity

TSS acid ratio gives the real taste of a fruit. To determine acid content in a fruit, the most common method is acid base volumetric titration. Commonly used reagents are 0.1M Sodium Hydroxide (NaOH) solution for titration and 1% w/v solution of Phenolphthalein in 95% v/v Ethanol as indicator. Multiplication factors used for most common acids are provided below:

Table 2-6 Multiplication factors of common acids in fruits

Fruits	Acid	Factor
Citrus	Citric acid	0.0064
Apple	Malic acid	0.0067
Grapes	Tartaric acid	0.0075

Use the following formula to determine acid percent $= \frac{\text{Titre value (ml) x Acid factor}}{\text{Volume of juice used (ml)}} \text{ x } 100$

3. Standard Evaluation Guideline for Potato Germplasm

Yadunath Bajgai

(ARDC-Yusipang)

3.1 Background

Potato (*Solanum tuberosum L.*) is the fourth most important crop after wheat, rice, and maize. Apart from its wide adaptability, it has the capability to provide more nutritious food from less land in less time than other crops such as wheat, maize or rice. In Bhutan, potato is one of the widely produced, consumed and traded horticultural crops. This is due to the existence of favorable agro-ecological conditions for potato production. It is usually grown at the altitude range of 2000 and 3500 m above mean sea level and is the most important crop for the farming community above 2500 m. a.s.l. About 22%of the rural households cultivate potato as it is one of the non-cereal food crop, cash crop and a vegetable. It contributes to rural household income more than any other horticultural crops. Over the past four decades, potato cultivation has picked up rapidly and has transformed the Bhutanese agriculture from subsistence to an emerging market-oriented economy. Famers in some high-altitude Dzongkhags, for examples, Bumthang and Haa, rely on potato crop for their livelihood since they depend on the revenue generated by potato to buy rice, and thus potato acts as food crop indirectly. Nationally, sale of potato generated about Nu. 797 million in 2016 and is the highest revenue-earner amongst the agricultural commodities with further potential for revenue increase. Average yield and production of potato from 2012 to 2016 was 9.64 ton/ha and 51,034.4 ton, respectively. The potato yield slightly increased from 2012 to 2014 but it dropped in the following years (Table 3-1). Besides stagnation of yield, the crop productivity in Bhutan is one of the lowest in the South Asian region as yields in Bangladesh, India and Nepal were 19.4, 22.9 and 13.7 tons/ha, respectively, in 2014.

Table 3-1 Cultivated area, yield and production for 2012 to 2016

Year	Cultivated area (ha)	Yield (ton/ha)	Production (ton)	Source*
2012	5,078.11	8.47	43,000	Agriculture Statistics 2012
2013	5,419.26	9.30	50,390	Agriculture Statistics 2013
2014	5,174.02	10.36	53,612	Agriculture Statistics 2014
2015	4,859.57	10.16	49,358	Agriculture Statistics 2015
2016	5,923.51	9.93	58,822	Agriculture Statistics 2016
Average	5290.89	9.64	51,036.4	

* Annual publications (2013 to 2017) of the Department of Agriculture, Ministry of Agriculture and Forests

Data from over last one decade indicate that potato productivity in Bhutan has somehow stagnated. This is possibly due to lack of diversity of varieties, degeneration of potato seed quality, infestation by late blight and climatic disturbances. Therefore, it is generally recommended that high-yielding, late

blight resistant, climate resilient, nutrient-dense and consumer-preferred genotypes should be carefully selected and evaluated as a mechanism to counter-act some of the identified challenges in our potato industry.

3.2 Experimental design

The evaluation trials should be conducted on-station (mother trial) and on-farm (baby trial) representing main potato agro-ecological areas in Bhutan. For example, trials can be conducted under Bumthang district (~2650 m.a.s.l) representing high altitude agroecological zone and in Khangma (~2100 m.a.s.l) under Trashigang district representing mid-altitude agroecological zone. Generally, the experiments can be laid out in a randomized complete-block design (RCBD) with three replicates in mother trial whilst baby trial should consist of plantings in three different sites in farmers' field. However, the design may vary according to the specific aims of the investigation or conditions of experimental plot. The evaluation trial should consist of a set of genotypes that are selected through the pre-evaluation or observational trial, and standard check/control should be included in the experiment. It is a general convention to include a control variety so that the traits and performance of the new clones/genotypes can be meaningfully compared with.

For both mother and baby trials, identical plot size of 2.8 m^2 (2 m x 1.4 m) should be maintained for each treatment and twenty tubers should be planted in two rows per treatment. Land can be ploughed with power-tillers or oxen and ridges can be prepared manually or mechanically. Potato tubers should be planted at 20 cm distance between the plants and 70 cm between the rows. The potato crop is recommended to be fertilized at 79:89:40 N:P:K kg/ha (NSSC 2013), but this can change depending on the soil fertility status of the experimental site. To supplement mineral fertilizer and for improvement of soil health farmyard manure at 12 ton/ha is essential.

3.3 Trial management

The trial can be irrigated or grown under rain-fed condition. Spraying fungicide may be necessary if late blight resistance/susceptibility is not part of the research question. Proper weeding should be done as and when necessary. However, earthing up should be done only once before flowering stage to avoid disrupting and disorienting stolen and roots of the potato plant. Plants of wrong genotypes or volunteers from the previous season should be systematically removed – referred to as roguing. At times roguing may be necessary to remove infected/diseased plants (e.g. leaf roll virus). A record of crop health is required to be maintained. Once the crop attains flowering stage, Participatory Varietal Selection (PVS) at flowering stage is conducted and when the crop attains maturity, PVS workshop on harvesting stage is conducted.

3.4 Purpose of adopting participatory methodology

When crop attains flowering and harvesting stages, participatory varietal selection workshop is conducted with the growers. The purpose of involving farmers during the selection process is to capture the traits of farmers' interest and to avoid the likelihood overlooking the traits that are required by the growers. The primary advantage of PVS exercise is that the farmers are involved in the selection process for selecting the variety of their choice and requirement. Further, the participatory selection process enables easier adoption of varietal technology generated. Therefore, the participatory varietal selection (PVS) method has been successful in identifying varieties in shorter time by involving farmers and consumers. It is reported elsewhere that PVS method has helped in reducing the costs of research and in increasing the adoption rate.

This PVS method acknowledges the preference of farmers and the existing socio-economic conditions while assessing and selecting genotypes. The main idea is to involve relevant farmers for evaluating promising genotypes in at least one to two locations for at least for two years.

3.4.1 PVS workshop at flowering stage

The PVS at flowering stage is conducted to mainly understand farmers' preference for the vegetative characteristics such as plant bushiness, plant height, number of tillers, resistance to late blight, frost tolerance and so on. Ideally, the evaluators should consist of both female and male farmers to get a balance perspective and to avoid gender bias. A minimum number of 20 participants are advisable. Farmers and participants are briefed on the PVS method which is somehow similar to that of the voting process for electing national or local leaders.

During the workshop the participants should be briefed that the objective of the exercise is to facilitate selection of most preferred variety for their farming purpose. In the flowering stage preference of the vegetative characteristics of the new potato clones is the main purpose. The participants would be asked to provide list of their preferred vegetative characteristics. These characteristics are listed on a chart paper. Farmers are asked to interact freely. Some of the answers solicited are tall plant height, medium height, thicker stem, late blight tolerance, early maturity, frost tolerance and resistance to potato leaf roll virus. After listing, the preferred characteristics are labeled and placed within a jar for voting.

The farmer evaluators are provided with six grains each: corn for men and beans for women to identify gender. Then they should be asked to rank the characteristics by voting for the three best criteria based on their preferences. The ranking process involves voting of 3 grains for the most important, 2 for the

second important and 1 for the third most important without discussing with their peers to avoid bias. Desiree may be used as a standard check to compare with other clones. During this exercise, the facilitators should help confused farmers, and also monitor and maintain accuracy of the process. The total grains of each corn and bean for each characteristic is counted, recorded and thereby the rank of the characteristics is worked out. The results are then shared with farmers, and data is recorded Table 3-2 for further analysis.

Table 3-2 Free listing and ranking criteria

SN	Criteria	Score (men) in no.	Score (women) in no.	Total score (no.)	Rank
1					
2					
3					
4					
5					
6					
…					
	Total	x	y	z	
	No. of participants	x÷6	y÷6	z÷6	

After this exercise farmers should be taken to the research plots to see and evaluate the clones for themselves. There should be two sets of trials: the mother and baby trials. In the field, a jar each should be fixed with each clone. Farmers should be again given six grains each - corn for men and beans for women. They should to be asked to vote using the same method as in the case of ranking vegetative characteristics. The three replications in research station and three in farmers' field should be voted for. Results should be shared with the participants. All the outcome of the voting processes is recorded in Table 3-3 for further analysis.

Table 3-3 Ranking of clones/variety by plot in mother/baby trials

Location…….Trial type: …….. Replication: ……Date……

SN	Clones/variety	Score (men) in no.	Score (women) in no.	Total score (no.)	Rank
1					
2					
3					
4					
5					
6					
…					
	Total	x	y	z	
	No. of participants	x÷6	y÷6	z÷6	

3.4.2 PVS at harvesting stage

Once the crop reaches maturity PVS is conducted at the harvesting stage. The farmer evaluators should be gender representative and thus both female and male farmers are required to attend. Farmers should be briefed on the objective of the exercise as to facilitate selection of the most preferred variety. They should be asked on the preference of the crop productivity-related characteristics of the new variety potato. The preferred characteristics like tuber size, shape and distribution, yield, tuber colour and so on could be listed. Farmers can interact freely during this exercise. The maximum numbers of the characteristics should be listed on the chart paper. The solicited characteristics regarding tuber yield and related attributes preferred by the farmers are labeled and placed with a jar for the voting. To rank the characteristics, the same voting method mentioned in the flowering stage is used (see Table 3-4) for example).

Social data record form

Table 3-4 An example of farmers' criteria of potato genotype selection in Bumthang

Location: …… Trial type: …….. Replication: …… Date: ……

SN	Criteria	Score (Men)	Score (women)	Overall score	Rank
1	High yield				
2	Oblong shape				
3	Floury texture				
4	Medium and uniform size				
5	High nutrients				
6	Scab resistant				
7	Chipping quality				
	Total	x	y	z	
	No. of participants	x÷6	y÷6	z÷6	

These should be the same sets of trials as seen during the flowering stage, first at research station called mother trials with three replications, and the second at three sites in farmers' fields called baby trials. Similar to the PVS workshop at flowering stage, farmers should be briefed on the objectives of the exercise to facilitate selection of the most preferred variety. After listing and ranking of the preferred characteristics, the farmers should be taken to the mother and baby trials where the crop is harvested and yields assessed. Tubers are segregated into three categories: table size (> 65 g/tuber), seed size (30-65 g/tuber) and non-commercial size (<30 g/tuber). Both tuber counts and tuber weights for three categories of tuber are recorded as in Table 3-5.

Table 3-5 Tuber counts and yield of three tuber sizes

Location: …… Trial type: …….. Replication: …… Date: ……

SN	Clone/variety	Tuber counts (nos.)				Tuber weight (kg)				Rotten
	Clone No./ Variety	Commercial		Non-C	Total	Commercial		Non-C	Total	tubers (no.)
		Table	Seed			Table	Seed			
1										
2										
3										
4										
5										
6										
…										

Non-C = non-commercial

The tuber produced from different clones/variety is to be piled up in a line for voting. A labeled jar is required to be placed with each type of clone/variety. Desiree is generally used as a standard check as it is a popular variety in Bhutan. Farmers should be then asked to vote for their preferred clones/variety using the method explained in the flowering stage. The process is completed for all the replications and for all the baby trials in the farmers' fields. Gender-wise votes are recorded using Table 3-4 for further analysis.

In addition to yield measurement and preference ranking organoleptic test is conducted at harvest stage. Some of the harvested tubers are cooked and displayed for organoleptic test. Each participant should be asked to observe different clones/variety carefully through observation, taste, and by getting a feel for texture of each clone/variety. Normally equal number of participants of each gender (e.g., 10 men and 10 women) would provide a balanced perspective. After each participant observes and samples each clone/variety, the feedback on quality of appearance, taste and texture should be asked and recorded in Table 3-6.

Table 3-6 Organoleptic test format for mother/baby trial

Location: …….. Panelist no.: …….. Sex: …….. Date: ……

		Clones/variety							
Factor	**Grade**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**….**
Appearance									
Excellent	5								
Fair	3								
Poor	1								
Taste									
Excellent	5								
Fair	3								
Poor	1								
Texture									
Mealy (floury)	5								
Intermediate	3								
Soggy (watery)	1								

3.5 Storability of potato tubers

Other important characteristic that needs to be assessed for new genotypes is the storability of potato tubers. Potato tubers are stored in country stores and should be assessed for sprouts numbers and sprout lengths for randomly selected five tubers per clone/variety at 45, 90 and 120 days after harvest. Table 3-7 shows an example of the form to be used during the post-harvest assessment of potato tubers in the country stores, and similar form can be used for recording data on sprout length of five random

tubers. Weight loss for tubers and number of rotten from a random sample needs to be recorded to find out weight loss% and rotten tuber%.

Table 3-7 Evaluation of storability of potato after harvest

Location: …….. Trial type: …….

Clone/Varity		Sprouts											
	Store	45 days after harvest					Average	90 days after harvest					Average
1													
2													
3													
4													
5													
6													
7													
…													

3.6 Statistical analyses

Yield and vote data generated should be analyzed using an appropriate statistical package. A statistical software package called Highly Interactive Data Analysis Platform (HIDAP) developed by the International Potato Centre (CIP) is free user-friendly software which is highly useful for statistical analysis in potato research. HIDAP is available online from the CIP website. For preparation of graphs and compute standard errors, Microsoft Excel can be used. The output of statistical analyses is the basis for scientific decisions on whether to release a new variety from the set of clones or not.

3.7 Process of releasing a new variety and technology transfer

After a minimum of two years of evaluating genotypes/variety in one to two locations decision to propose for their release can be made if data shows a promising clone. An appropriate variety release

proposal form is duly filled and submitted to the Variety Release Committee (VRC) for their review. If a proposal is acceptable will recommend making a presentation to of the committee. If the committee is satisfied with the data and justifications presented the proposal is endorsed. A summary of the processes involved from import to dissemination of a varietal technology is presented in Table 3-8.

Once a new variety is released, its seeds are provided to the National Seed Centre for multiplication on a commercial scale. As a newly generated technology, efforts should be put in to take the new variety to new locations for demonstration and for early adoption.

3.8 Summary of processes

Table 3-8 Summary of processes involved in import of genotypes to release of a variety

SN	Activity	Technical processes	Time
1	Import of genotypes (e.g. from the International Potato Centre (CIP)	Process documents through head of the Ministry of Agriculture and Forests and apply for import permit from BAFRA. Put up a requisition to CIP for specific germplasm with an import permit and follow up until materials are delivered in in-vitro form. Potato genotypes cannot be imported as tuber to avoid transmission of diseases.	½ year
2	Laboratory multiplication of in-vitro materials	Tissue culture technology is used to multiply the genotypes to produce micro-tubers	½ year
3	Mini-tuber/tuber production	The materials are further multiplied using aeroponics/greenhouse.	1 year

4	Seed multiplication and pre-evaluation assessment	The potato tubers produced in aeroponics/greenhouse are transferred to field plots for multiplication. The process continues for the second year to multiply seed and for pre-evaluation assessments. The idea is to produce enough seed for mother and baby trials in at least two agro-ecosystems. A minimum of 240 healthy tubers are needed to start a replicated evaluation trial using the mother-and-baby approach in two agro-ecosystems.	2 years
5	Research station (mother) and on-farm (baby) trials	*Evaluation of genotypes against a standard check or control*. Since, Desiree has been a popular existing variety it is used as a control in replicated germplasm evaluation trials. Total number of healthy tubers needed to start the trials is 240, i.e. 20 tubers per genotypes per replication x 6 replicates x 2 agro-ecosystem. If the genotypes are suitable for different agro-ecosystem, then it can be taken to three agro-ecological locations, if not, one can carry out trials in one to two suitable agro-ecological sites. The trials should be temporally replicated for at least two times to rule out any agronomic performance related to conditions in the year. Crop is assessed using Participatory Varietal Selection (PVS) method where crop performance as well as growers feedback is measured, ranked and compiled at flowering and harvesting stages for all mother and baby trials. The process of carrying out PVS is most important part of the germplasm evaluation in potato commodity.	2 years

	Release of a new variety	Research data is checked, compiled and validated for conducting statistical analysis. Data on potato yield, growers' preference ranking and organoleptic tests are subjected to statistical analyses. A minimum of two-year data for all mother and baby trials is required to have spatially and temporally replicated result to generate a representative and reliable result. If the outcomes of the data analyses indicate that there is a possibility of releasing a new variety, an appropriate variety release format is to be filled and submitted to the Variety Released Committee (VRC) for formal endorsement.	1 year
	Technology transfer to farmers. Provide seed of new variety to NSC.	*Demonstration of new varietal technology to farmers for adoption.* This activity is carried out in collaboration with extension colleagues. After the release of a new variety, seed of that variety is to be provided to the National Seed Centre for commercial multiplication and supply to farming community on a commercial basis.	After release of a variety

The PVS processes in flowering and harvesting stages should be conducted at least for two years in at least one to two locations. This will ensure sufficient representation of the crop performance data as well as social assessment including organoleptic tests. It also ensures both spatial and temporal replication. The data collected is analyzed and informed decision on whether to release a new variety from the set of clones is made. A variety selected using this method is easy to disseminate.

4. Standard Evaluation Guideline for Vegetable Germplasm

Kezang Tshering, Tashi Gyalmo, Dawa Dema and Kinley Tshering
(ARDC-Yusipang)

4.1 Background

Bhutan has many traditional vegetables and wild edible plants that are used as vegetables. Wild edible vegetable plants fetch good price in the market. The most common traditional vegetables are chilli, brinjal, mustard green, radish, beans, gourds, bunching onions, chives, etc. Wild vegetables include ferns, bamboo and shoots, banana flowers, leafy edible plants, etc. However, the yield of most traditional vegetable varieties is lower, and is also susceptible to new pests and diseases, although they are highly adapted to the micro- climatic conditions. With the increase in population demand for vegetables is increasing, and the only alternative to meet this rising demand is to increase the productivity of vegetables crops. Moreover, different crops and varieties have different inherent characters to adjust and adapt to different environments. It is therefore imperative to introduce, evaluate and promote improved varieties that are resilient to both abiotic and biotic stresses, and have high potential for production and productivity.

With the enhancement in modern technology, many improved varieties can be developed, selected or introduced from different sources and made available to farmers. However, the main objective of the variety evaluation system should address the suitability of varieties and the availability of them to farmers in the shortest possible time. Therefore, a standard procedure for selection and evaluation of new vegetable varieties is required for quick assessment of high yielding potential varieties.

4.2 Rationale for introduction of vegetable germplasm

Breeding of improved varieties of vegetables has led to a significant increase in their production and productivity. These improved crops possess inherent genetic potential to augment productivity per unit area. While breeding is a protracted process involving enhanced technical skills and capacity, farmers stand to readily derive the benefits of such crops with superior traits by simply growing them following their adaptability and performance evaluation.

4.3 Authorized Institutions for Vegetable germplasm introduction and development

Recently, RDC-Yusipang has been designated as the coordinating center for National Vegetable Research and Development. Hence, the center is entrusted with the authority to introduce, evaluate and develop new vegetable germplasm in the country. Nevertheless, the center may also authorize some of the ARDCs in germplasm accession based on expertise and relevance. The National Biodiversity Center (NBC) which acts as the custodian of genetic resources shall be informed of introduced genetic materials. All released vegetable varieties, selected introductions and elite breeding materials shall be conserved in the gene bank of NBC. The introduction of open pollinated varieties is

straightforward as seeds can be produced and propagated further. However, the introduction of hybrid seeds which needs replacement every year, dependence on the seed companies. Hence, its introduction would need a prompt evaluation and careful analysis. As per the Seed Rules and Regulations of Bhutan 2017, the National Seed Centre, Paro, under the Department of Agriculture is the authorized agency for import and distribution of hybrid seeds while competent Private Seed companies or enterprises will also be allowed to import hybrid seeds based on the terms and conditions set by the Ministry of Agriculture and Forests and approved by the National Seed Board.

4.4 Standard Evaluation Procedure

Variety evaluation procedure varies with crops and research centers. New vegetable germplasm are mostly introduced from international and regional institutions and are tested for up to 3-4 years depending on the capacity and success of trials. There is no set limit in the number of years of test. After few years of trials, the best performing varieties are finally proposed for release to the Variety Release Committee (VRC) following which the released varieties are handed over to the National Seed Center (NSC) for seed production and supply to farmers. The proponent institute maintains breeders seed.

The existing evaluation process takes a minimum of 3-4 years before a variety can be put up to the VRC for release. It is imperative that a quick evaluation system is put in place especially in evaluation of hybrid varieties since the continuity in availability of seeds of a particular variety is not assured.

Therefore, the following two standard evaluation systems are required depending on the type of genetic materials to be evaluated.

A. **Normal Evaluation:** This scheme should be used to evaluate and release breeding lines and introduced new germplasms of Open Pollinated (OP) varieties. It should be evaluated at-least for two years or seasons to confirm yield potential and stability under diverse agro-climatic conditions

   First Year

   In the first year, it should be tested on-station to evaluate for yield and resistance to major diseases and pest. On-station trails could be conducted simultaneously in other ARDCs depending on the quantity of seeds available. The trials should have minimum three replications with RCBD. Data on yield, days to maturity, resistance to pests & disease and other important morphological characters should be recorded. Based on the results of on-station trials, the best performing varieties should be evaluated in the on-farm trails in the following year.

Second Year

Depending on the result of on-station trials, the best performing varieties should be evaluated in on-farm trail in as many locations as possible so that the performance is tested under different agro-ecological conditions. The trials should have minimum three replications with RCB design and the plot size should be larger than on-station trials. Data on yield, duration of maturity, resistance to pests and disease and other important morphological characters should be recorded. All required information should be compiled, reviewed and analyzed and the best performing variety should be then proposed to VRC for official release. Thus, a minimum of 2 years will be required before proposing new varieties for release.

B**. Fast Track Evaluation**: This scheme should be followed to evaluate hybrid varieties which may be imported by seed supplying agencies. Hybrid seeds with their superior traits donot require to go through the usual and time-consuming process of varietal evaluation since they are already bred and acknowledged for their performance.

Further, as continuity in supply of hybrid seeds is not quite assured, a rapid testing regime for a season/year is recommended for its adaptability and suitability in a particular agro-ecological zone before recommending it to growers. In such cases, all the information available should be compiled, reviewed and analyzed to support for notification by VRC/NSB after one season/year of on-station evaluation trial.

Some of the additional features of the proposed evaluation systems are:

- A minimum set of data based on the yield performance, maturity and distinguishing agro-morphological characteristics of the new varieties will be required to propose for release.
- Test materials shall remain in the research centers for 2 years only in normal cases. However, in cases where a researcher is unsure of the results after two years, another year of evaluation may be done to confirm the results before taking a final decision.
- Farmers can have access to the new germplasm by the third year in case of OP varieties and one year for Hybrids.
- Extension staff and farmers should participate in the evaluation and selection of new materials alongside the researchers.
- Plot size and other parameters of trials for data collection are provided in Table 4-1.
- Elite materials and released varieties should be preserved in the national repository

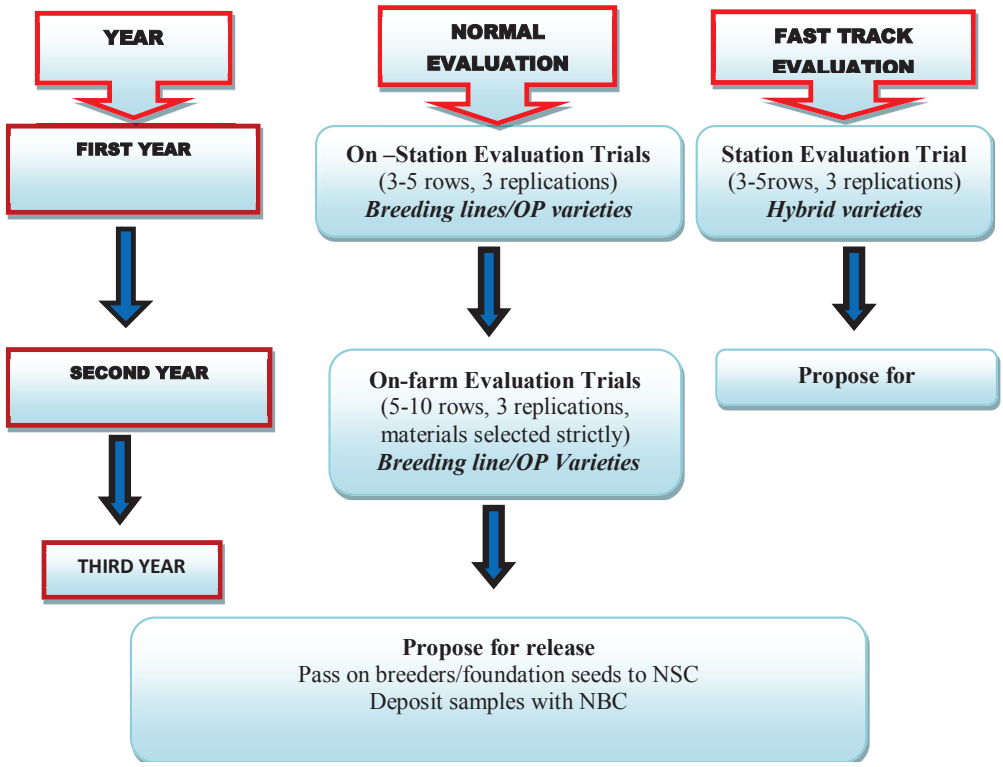


Figure 4-1 Standard evaluation procedure for vegetables

Table 4-1 Plot size and other parameters for evaluation of vegetable varieties

Sr. No	Type of Trial	Details	Harvest Area	Minimum data to be collected.
1	**FIRST YEAR** **On-station trial** *(OP & HYBRID VARIETY)*	Plot size: 4-10m^2 Rows /plot = 4 No. Replication =3 No. Entries ≥ 2 No. Location= 1-5	All rows in a plot (equivalent to the area of one plot)	1. Days to maturity 2. Average Size (diameter in mm) of a head/root/fruit/pod from 10 randomly selected samples. 3. Average length/height (cm) of a head/root/fruit/pod from 10 randomly selected samples. 4. Average Weight (gm) of a head/root/fruit/pod from
		Plot size: 10-20m^2 Rows /plot = 8	All rows in plot (equivalent to	

2	**SECOND YEAR** **On-farm trial** (*OP VARIETY)*	No. Replication=3 No. Entries ≥2 No. Location =5-10	the area of one plot)	10 randomly selected samples. **5.** Average yield/plot (kg) **6.** Average Yield/acre (mt) **7.** Record incidence of pest and diseases if any.

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