

# General Considerations in Testing and Evaluating Crop Varieties for Agroforestry Systems<sup>1</sup>

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**Abstract:** Introduction of new crops in agroforestry is often suggested as a way to improve productivity. This paper provides general guidelines in selecting companion plant combinations and general considerations in evaluating, testing, naming, maintaining genetic purity and distributing crop varieties to farmers.

Agroforestry systems in the American Pacific range from subsistence to commercial levels. At the subsistence level, farming activity is focused on production for the family, including distant relatives and friends. A minimum level of selling to neighbors, friends, etc. of produce possibly occurs. Common subsistence crops include breadfruit, banana and root crops such as taro and yam. This system is very common in American Samoa and Federated States of Micronesia. Hawaii, Guam and the Commonwealth of the Northern Marian Islands, on the other hand, have proceeded to the level of commercial farming. The integration of production, processing, distribution and consumption of produce is well pronounced, particularly in Hawaii. Added values for produce are made through processing, which also lessens the problem of post-harvest losses from glut of production. In effect, farming is profit-oriented from the farm to the point of final end-users under commercial agroforestry systems. Whatever system is involved, selection of appropriate crop varieties is an important decision producers have to make for their farming endeavor. This paper provides general considerations in selecting suitable crops and, particularly, factors important in testing and evaluating varieties with specific emphasis on agroforestry systems.

## Crop Combinations

Multi-storied cropping is typical in tropical agroforestry systems. Full-grown trees of coconut or forest trees usually form the top canopy layer. Breadfruit, banana, and root crops such as taro and yam are at the lower canopy layers. Once cash crops such as vegetables are included in the system, the following factors must be considered:

- a) shade-tolerance
- b) provision of good crop nutrition
- c) compatible crop combinations based on occurrence of pests and diseases and yield.

Below is a list of plants that grow well in companion plant combinations:

|              |                                                                                                 |
|--------------|-------------------------------------------------------------------------------------------------|
| Sweet potato | Okra, eggplant, tomato, yard long bean, winged bean, lima bean, maize                           |
| Cassava      | Sweet potato, swamp cabbage, pechay, lettuce, garlic, squash, peanut                            |
| Taro         | Sweet potato, swamp cabbage and underneath any crop grown on trellis if canopy is not too thick |
| Yam          | On fruit trees or trellis                                                                       |

## Development of New Crop Varieties

To develop a sound crop breeding program, the needs of concerned groups such as farmer/producers, traders, processors, and consumers must be considered. What crop traits are important to them? Duration and method of crop improvement would depend on breeding objectives. For example, to improve a commercial tomato grown in a certain community, problems encountered by the growers, and processors and the likes and dislikes of the consumers need to be evaluated. The next logical step is to determine what germplasm (whether local or foreign) is available and appropriate for the breeding objectives.

Options in breeding methods include introduction, selection, and hybridization:

**1. Introduction-** This is the quickest and most convenient way of producing a new crop variety, especially if all traits present in the introduction are superior over the presently grown commercial crop varieties. The introduction could also be a parent in the breeding program for certain traits absent in the locally available commercial varieties. Guidelines in using introductions in breeding programs are:

- a. Proper recording of introductions - A record book detailing the Plant Introduction number, country of origin, date received, and special characteristics is a must.
- b. Preliminary evaluations of introductions - The introductions are planted in short rows (1m) unreplicated in the experiment stations. Check varieties are included in the evaluation as reference. Characteristics such as reactions to certain pests and diseases, climate conditions, quality attributes potential/promising end-products, and other traits are recorded and made available to public agencies and private sector. It is the responsibility of the requesting breeder to report to the donor institution the results of evaluation in his/her location. Instances when the originating source of introduced materials have to be acknowledged publicly by the recipients of these materials:

- i. When materials are increased or distributed in their original form;
- ii. When distributing unique or novel line by modifying the genetic make-up of the original PI through

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conventional (inbreeding selection) or unconventional (fusion, DNA);

iii. Specifying what specific traits are derived from the plant introductions.

2. *Selection* - Two primary sources of selections are the introduction of improved or relatively unimproved strains and varieties of crops from domestic or foreign sources, and well-adapted local varieties that are found to be variable.

3. *Hybridization* - This is an expensive and long-term endeavor but results are rewarding. Important considerations in pursuing this program are available financial support, facilities including land, cold storage room, special equipment for special traits such as high amino acid contents, available germplasm, and trained manpower.

## Evaluation and Testing Procedures

Whatever forms of varieties are used (introduction, selections, or hybrids), they should undergo preliminary and advanced trials prior to public use.

### Preliminary Testing

In preliminary testings of promising elite lines of crop varieties, short rows (2m-5m), unreplicated and situated in experimental stations are utilized. Two preliminary tests, such as during wet and dry seasons, are conducted to select the entries for further testings. Information obtained from preliminary test data (yield, number of days from emergence to maturity, pest and disease reactions and plant height) are important considerations in selecting entries to be included in multi-location trials. Enough seeds are produced for distribution to the prospective cooperators in the sites (usually farmers' fields).

### Multi-Location Testing or Advanced Testings

In each testing site, a local coordinator committed to set-up the experiment is needed. These coordinators from the different sites should meet once or twice a year to discuss problems and developments in the testings.

The following are the essential components of testing and evaluating crop varieties: selection of experimental sites, layout of the experiment, care and management of crops; data collection, and analyses.

1. *Selection of experimental sites*- Criteria for site selection are:

- Accessibility to road to facilitate transport of agricultural supplies and hauling of produce;
- Representativeness of the area to soil and growing conditions in the community;
- Level or of uniform slope;
- Soil texture, depth, and type homogeneous over site;
- Irrigation water and drainage available when needed;
- Free from wind damage;
- Other considerations, e.g., willingness of the farmer cooperator to share land and perhaps labor, and local government willingness to promote the experiment

2. *Layout of experiment*- The following are the general considerations in layout of experiments: experimental design, plot size and shape, block size and shape, number of replications, and arrangement of blocks and plots.

a. *Experimental Design* - Two commonly used experimental designs in variety trials are simple lattice and randomized complete block designs. The simple lattice design is very useful when handling a large number of varieties/lines during preliminary trials. It also reduces soil variation within the experiment. Furthermore, it allows the block size to be small. The block size is equal to the square roots of the total number of varieties tested. Two replications are acceptable in this design.

The randomized complete block design is used if entries are less than 20 for multi-location or regional testing. The experimental error is reduced by the blocking which will account for soil heterogeneity caused by soil fertility gradients, soil slopes, etc.

b. *Blocking* - Blocking is influenced by two factors—selection of the source of variability to be used, which is based on large and highly predictable source of variation such as soil heterogeneity, direction of insect migration and slope of the field; and selection of the block shape and direction. The guidelines for selecting the appropriate block shape and direction are:

- When there is only one gradient, use long and narrow blocks. The blocks are oriented perpendicular to the direction of the gradient

- When fertility gradient exists in two directions with one gradient much stronger than the other, consider the stronger gradient and follow the aforementioned guidelines.

- When fertility gradient occurs in two directions with both gradient equally strong and perpendicular to each other, use any of these options:

- Use square blocks as much as possible;
  - Use long and narrow blocks with their length perpendicular to the direction of one gradient and use the covariance technique for the other gradient;
  - Use latin square design with two-way blocking.
- If the pattern of variability is not predictable, blocks should be as square as possible. The idea is to maximize the variability of the block but to decrease variability between plots in each block.

3. *Number of replications*- The number of replications is influenced by:

- Inherent variability of the experimental material;
- Experimental design used;
- Number of treatments to be tested;
- Degree of precision desired.

In general, the number of replications suitable for a variety trial is from four to eight.

## Release of Germplasm

After a new variety has been found acceptable through evaluation and testing, the next step is to release it to the public. In the United States, the State of Agricultural Experiment Sta-

tions (SAES) are responsible for the development and releases of improved varieties to their own states (ESCAP 1988). The following outlines the guidelines for the release of the new germplasm in the United States, which also may be useful for developing countries:

**1. Availability and use of basic genetic materials**

- a. Germplasm from the SAES's programs are to be made available to foster research and cooperation by public and private scientists;
- b. Basic genetic materials (referring to plant materials possessing one or more potentially desirable characters useful for breeding work) will be released to all plant breeders who request them;
- c. Periodical releases of information will be made on the limitations of use and amount of materials for distribution;
- d. No monopoly of use of genetic materials is to be held by any interests. Inbreds, experimental lines and basic genetic materials should not be released prior to their release in the US;

**2. Release of finished genetic materials**

- a. Variety should not be released if not yet proven distinctly superior to existing varieties in one or more characteristics or in performance in areas where adapted.

**3. Policy Committee or Board of Review for Variety Release**

- a. SAES Director should decide on what varieties to release to the public;
- b. SAES should form a policy committee or board of review responsible for reviewing the release of new varieties based on information such as performances, area of adaptation, specific use values, seed stocks, proposed methods of varietal maintenance, increase and distribution.

**4. Interstate or Inter-agency Release Procedures**

- a. If and when interstates test simultaneously the newly released variety, regional advisory committee may set guidelines for sharing of foundation seed stocks among states;
- b. If no interstate testing is done prior to variety release by the state, the state that develops the variety should offer seeds to all interested states for testing and increase;
- c. If the development of a variety is a cooperative effort from a state or states and a federal agency (USDA/ARS or USDA/SCS), there should be an opportunity for joint release by the concerned agencies. To determine the novelty and cataloguing of new varieties, the Services of the Association of Official Seed Certifying Agencies, US Plant Variety Protection Office, and the U.S. Patent and Trademark Office are tapped.

**5. Protection and Restricted Release-**The individual stations may elect to protect and restrict release of certain germplasm for enhancing and supporting research through two ways, such as Plant Variety Protection (PVP) and utility patents. Unlike PVP Protection, utility patents do not allow automatically for the use of patented materials in research or plant improvement without approval or com-

pensation to the patent holder. The following are recommended to facilitate use of restricted germplasm:

- a. Research clause stating exemption from seeking approval for research use;
- b. Waiver of certain dominance rights of a patent over future patents on materials derived from the initial patent. Holders of patents on marketed materials derived from an earlier patent should be required to compensate the holder of that earlier patent only during the first five years of the life of that patent rather than the 17 years stipulated in the law. In both cases, users of patented materials should acknowledge the source of germplasm.

**6. Preservation of Genetic Identity-**The genetic identity (or parents) of all genetic materials should be known to the users. The genetic identity is established through such techniques as analyses of seed proteins, isozyme, and nuclear restriction fragment length polymorphism.

**7. Naming and Registration of Varieties**

- a. Designation - The International Code of Nomenclature of cultivated plants is recommended for use in naming new varieties. Designation should be brief. If a designation is a name, one or two short words are acceptable. Meaningful number designations or combinations of words, letters, and numbers consistent with accepted procedures are also acceptable.
- b. Use of Names - The Federal Seed Act (53 Stat 1275) has provisions for use of varietal names. Identical germplasm should not be distributed or sold under different names, varieties or brands. Using a variety name more than once in a given crop and giving similar names are to be avoided. As to the proposed names for the variety, check with Seed Branch, Check Grain Division, Agricultural Marketing Service, for clearance to avoid possible confusion, etc.
- c. Registering Varieties- After release of the crop variety as recommended by the review board, contact Crop Science Society of American (CSSA) or American Society for Horticultural Science (ASHS). Procedures for the registration of varieties are available from CSSA and procedures for listing of varieties are available at ASHS. Materials registered at CSSA become part of the National Plant Germplasm System and small amounts of seeds are distributed to *bona fide* researchers.

## Classes of Certified Seeds and Certification Standards

The "Certification Handbook," published by the Association of Official Seed Certifying Agencies, defines the various classes of certified seeds and certification standards and procedures.

### Increase and Maintenance of Seeds

**1. Breeder Seed**

- a. Responsibility of Maintenance - The originating station has to prepare a statement of plans and procedures

for maintenance of breeder and foundation seeds. If it ceases to maintain breeder seed of a variety, the originating state should notify in advance the interested states. A satisfactory plan has to be formulated between the originating state and the interested states concerning the above situation or when the variety is distributed in several states.

**b. Supplying Sample of Seed to National Seed Storage Laboratory** - The originating state needs to provide a sample of breeder seed of all newly released varieties to the National Seed Laboratory (NSL), Fort Collins, Colorado. This deposit is also required by CSSA for registration of said new varieties.

## **2. Foundation Seed**

**a. Multiplication of foundation seed** - Authorized parties will be designated to multiply foundation seeds.

**b. Foundation Seed Program** - Foundation seed program should recognize the following:

**i.** Qualified seed growers and seedsmen should have an opportunity to obtain appropriate planting stocks at equitable costs. However, selective allocations may be necessary to achieve quality increases to meet the needs of potential users.

**ii.** When limited release is anticipated, federal and state agencies and private growers or seedsmen should be notified and given an opportunity to bid for that release.

**iii.** Planting stocks of varieties developed cooperatively with the agencies of USDA ordinarily will be made available through or with the concurrence of the seed stocks or certifying agency of the cooperating state(s) at an equitable cost of qualified growers and seedsmen. Under condition #2, consideration may be given to applying for certificates of variety protection under the Plant Variety Protection Act or some other form of protection.

## **Preparation and Release of Information**

### **1. Coordination of publicity among states and agencies**

The following information should be prepared by the fostering state(s) and agency(ies) for information to the seed producers, distributors, and users:

**a.** Pertinent information such as basic facts of origin, variety characteristics, and data justifying the increase and release of a new variety;

**b.** Information used in deciding upon release of a new variety;

**c.** Regional adaptation for National or Regional Adaptations;

**d.** Uniform date of release;

**e.** Actions concerning patent, PVP including certification requirements.

### **2. Matching seed production and demand for varieties**

Promotional publicity in advance of the release of a new variety or before seed is available or incomplete publicity following its release are not desirable.

## **Recommendations**

With the fast developments observed now on some of the American Pacific Islands, the possibility of extinction of rare species of crops is high. Clearing of forests or portions of them will certainly disturb the ecosystem and possibly cause losses of some species of crops due to cutting or burning. Hence, it is time to organize a regional collection of exotic and wild species of crops, especially indigenous varieties. For efficiency of collection and maintenance, it is recommended that regional and national germplasm centers for priority crops in the American Pacific be established.

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