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INTERNATIONAL TRANSFER OF FOREST SEED

by R.L. Willan

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This Technical Note was presented as a paper to the Regional Seminar on Forest Seeds, held in Ouagadougou, Burkina Faso, from 11-15 January 1988, under the auspices of the Interstate committee for Drought Control in the Sahel (CILSS). Many of the problems involved in International Transfer of Forest Seed and discussed in the paper, are applicable to other regions of the world, as well as to the Sahel. The Danida Forest Seed Centre is therefore distributing the paper as a Technical Note, with the object of reaching a wide audience.

SUMMARY

Over the past half-century there has been a marked increase in the use of exotics for tree-planting and thus in the quantity of forest seed being transferred between countries. This will continue in the future, with a growing emphasis on the identification and transfer of the best adapted provenancesfor specific sites, followed by the breeding, multiplication and exchange of superior genotypes. International seed exchange ean confer important benefits on all countries, but great care is needed to ensure maximum efficiency and minimum risk.

The main aspects of seed transfer to be considered are (1) Control of Genetic Identification, (2) Control of Physiological Quality, (3) Control of Pest and Disease Risk and (4) Control of Transit Arrangements. Adequate seed records are essential if users are to reap the full benefit from their seed imports,and standardisation of forms within a biogeographical region, as far as possible, is a practical way of improving international co-operation. Plant proteetion measures should be adapted to specific cases, with the stringency of regulations dependent on the virulence of the pest, its prior presenee orabsence in the introducing country, and the value of the crop at risk.

National seed legislation becomes necessary when a number of separate organisations become involved in international seed transfer. Legislation should be designed to promote safe and speedy transfer rather than rigid overall restrietions. Publication of national and international seed directories is another valuable contribution to seed transfers between countries.

1. INTRODUCTION

The use of exotics for afforestation has increased many times over during the last 50 years. Pines and eucalypts are outstanding examples of genera whichhave been widely planted throughout the tropics and subtropics, while in the drier parts of Africa *Cassia siamea* and *Azadirachta indica* have contributedsignificantly to both wood production and improvement of the environment. Although indigenous species will always have a vital role to play in many countries, there is no reason to think that the importance of exotics will diminish in the future. Whenever exotics are used, there must, at some stage, be a transfer of plant material between countries. Most often this is in the form of seed, Diekman *et al.* (1994) and Frison *et al.* (1991).

During the same period there has also been an increased appreciation of the extent to which many species, tropical as well as temperate, exhibit within species genetic variation. Foresters must therefore aim to plant not only the most productive and best adapted species for their local conditions but also the best suited provenances. The importance of provenance is still not fully realised in all countries, but correct choice of provenance or seed source is often a cardinal factor in deciding the success or failure of a planting project. This choice is best based on the results of well planned, replicated provenance trials under local conditions, supplemented by information from comparable environments elsewhere.

Ideally the introduction and improved use of exotics would pass through a number of stages:

(1) Species elimination trials. Introduction of small, research quantities of seed of a considerable number of possible species.

(2) Provenance trials, in one or more stages. Introduction of small, research quantities of seed of a considerable number of provenances of the most successful species identified in stage(1)

(3) Introduction of "semi-bulk" quantities of a few provenances which have shown superiority in the trials of stage (2), for the establishmentof local seed stands.

(4) Introduction of bulk quantities of the superior provenances of stage (2) for large-scale planting.

(5) Attainment of self-sufficiency in local seed supply from the seed stands of stage (3).

(6) Continuing improvement in genetic quality of seed, through successive cycles of individual selection, progeny testing and seed production from orchards of superior genotypes. Will often include exchange of superior genetic material between countries.

In practice the stages seldom follow such a logical order as that indicated above. More than one stage may be conducted simultaneously. The important fact to note, however, is that every stage except (5) involves transfer or exchange of seed between two or more countries.

There is also a big difference between species in the stages now reached. In the tropics many countries have reached stage (3) or (4) in the introduction/use of tropical pines and eucalypts, while for many social forestry species in dry areas progress has not gone beyond stages (1) or (2) (see e.g. Palmberg1983, Hughes 1985).

As National Seed Centres gain experience and learn the species and provenances in their countries which are of most interest for international transfer, it is highly desirable that they should publish national seed lists for the benefit of other countries. An example is that for Burkina Faso (Ouedraogo *et al.* 1985, FAO 1987a). Other relevant information of value includes delineation and description of seed zones and regions of provenance, and climatic data.

Consolidated international seed directories are also a valuable tool in seed transfer. Examples are FAO 1975 for forest trees in general and von Carlowitz 1986 for multi-purpose trees and shrubs. For arid zone species collected under the FAO Project on Genetic resources of Arboreal Species of Arid/semi-aridZones and stored in the cold storage facilities of the Danida Forest Seed Centre, a list of seedlots available has been published (FAO 1985a).

The aspects of international seed transfer which need particular attention are:

(1) Control af genetic identity
(2) Control af physiological quality
(3) Control af pest and disease risk
(4) Control af transit arrangements

It should, however, be emphasised that most af the measures needed to ensure safe and efficient movement of seed between countries are equally necessary within a country. The forester in charge af an afforestation project is no less entitled to expect full and reliable information on e.g. the origin and germination capacity af the seed that he receives from his own central seed store than his colleague in another country.

2. CONTROL OF GENETIC IDENTITY

A few decades ago foresters were satisfied if the seed they used was identified as regards species and country af origin. Nowadays they expect, or should expect, a lot more. The quality af information supplied with seed still often leaves a lot to be desired, but constant pressure from forestry authorities in both recipient and exporting countries can do much, and has already done something, to improve the situation.

Information on seed origin is best recorded on a standard form, commonly known as a Certificate of Seed Origin (CSO). The amount af detail and type of information received may vary according to country and to the type of stand from which the seed was collected, but should normally contain data on

(1) Seed lot identity (a number unique to each lot),
(2) Precise location of collection (latitude, longitude, altitude),
(3) Site conditions (climate, soil, topography),
(4) Stand description,
(5) Collection details (date, number of trees etc.), and
(6) Signature of person taking responsibility for correctness of data.

An example of such a CSO, used internationally in the FAO Project on Genetic Resources of Arid/Semi-arid Zone Arboreal Species for the Improvement of Rural Living, is shown in Annex 1 (Palmberg 1983). Other examples of CSOs are reproduced in Appendix IB of ”A Guide to Forest Seed Handling” (FAO 1985).

The amount of information entered on a CSO may be varied in accordance with the pre-existing knowledge of the recipient. Thus an origin of “Elburgon compartment 2A” for cypress seed would be adequate information for a Kenya forester, whereas a forester working in another country would usually need much fuller detail on location and site conditions. In such cases the CSO in international seed transfer should contain

fuller details than the CSO in use within the same country. As afforestation projects develop, there is a need for continuous improvement in the genetic quality of the seed or other reproductive material used in planting, whether the planting objective is timber, fuelwood, fodder or amelioration of the environment. The forester is then concerned not just with genetic identity but also with genetic, or at least phenotypic, superiority.

One system of international seed certification which has been adopted by a number of countries is the Scheme for the Control of Forest Reproductive Material Moving in International Trade, introduced by the Organisation for Economic Co-operation and Development (OECD). This scheme is open on a voluntary basis to all members of OECD and to other countries which are members of the United Nations or its Specialised Agencies. In this scheme (OECD 1974) four categories of material are recognised:

(l) Source-identified (no presumption of superiority).
(2) Selected (better than average phenotypic growth and adequate isolation from inferior stands; i.e. seed stands).
(3) Seed Orchards (with defined standards of management, design, isolation etc., but not progeny-tested).
(4) Tested (of proven genetic superiority on the basis of progeny tests).

Another feature of the OECD scheme is that for each cooperating country a single “Designated Authority” is responsible for the issue of all certificates for seed internationally transferred. This is normally the national Forest Service. This provision is important wherever a number of agencies (private, communal, national) engage in international seed transfer, and should ensure that uniform standards of control are applied to all seed exported. As anexample, for source-identified seed, the requirements are that

(a) the region of provenance where the seed is collected and the origin of the parent trees(which may be indigenous or non-indigenous) shall be defined and registeredby a Designated Authority and

(b) the seed shall be collected, processed and stored under the control of a Designated Authority.

The scheme distinguishes between “provenance” and “origin”. Provenance is defined as “the place in which any stand of trees (indigenous or non indigenous) is growing” ; origin for an indigenous stand is identical with provenance, but for a non-indigenous stand it is “the place from which the seed was originally introduced”. The problem of defining origin becomes more complex if there have been one or more intermediate generations, on different sites, between the initial movement of seed from the indigenous source and the final provenance seed collection recorded on the CSO. This is discussed in detail by Jones and Burley (1973). As tree improvement becomes a greater influence on tree planting practice, so will there be an increasingly strong case for including a seedlot pedigree, covering several generations, in eachCSO.

When international seed transfers are involved, the requesting country has an obligation to provide clear information, just as the supplying country has.This applies to such items as the number of plantable plants required from the seed and the number and description of different site-types to be planted. The information enables the supplier to send adequate but not unnecessarily wasteful quantities of valuable seed and to include only species/provenances which have a good chance of thriving on the sites in question. A summary of information needed from requesting countries, reproduced from FAO 1987, is shown in Annex 2.

Good seed documentation is worthless without good seed. It is essential that close supervision is exercised over all stages of seed handling, from collection to despatch, so that the information in the CSO real ly reflects the characteristics of the seedlot that it describes. Only in rare cases of small scale operations will the certifying officer be able personally to supervise every stage. In larger organisations careful selection and training of field staff is essential to ensure the best possible handling of the seed and ensure strict reliability of the seed information supplied.

3. CONTROL OF PHYSIOLOGICAL QUALITY

The forester needs to know not only the genetic identity but also the physiological quality of the seed he receives - the number of plantable plants that he can expect to obtain from it. This depends partly on the Nursery Recovery Factor, the percentage of germinated seedlings which survive to make strong, healthy plants for planting out, which is influenced by species and the conditions and efficiency of individual nurseries. But equally essential is information on the characteristics of the seed itself, number of seeds per unit weight, purity % and germination % of pure seeds.

The quality of a seedlot is estimated by conducting the various tests on a small sample of the seed. The essence of good testing is the application of reliable standard methods of examination to ensure that uniform and reproducible results are obtained (Turnbull 1975). International standardisation has been greatly facilitated by the work of the International Seed Testing Association (ISTA). An example of an ISTA International Seed Lot Certificate is shown in Annex 3. The International Rules for Seed Testing (ISTA 1993) give the prescribed conditions for testing different genera and species (e.g.substrate, light, temperature, seed treatment), but main emphasishas until recently been on agricultural crops and temperate trees.

Much simpler tests than the full range recommended by ISTA can still provide valuable information. The important item for the practising forester is the number of germinated seedlings to be expected from a given weight of seed as supplied. Therefore any information on germination (final percentage, germination period, date, test method and conditions, whether in nursery or laboratory) will be of great value to the recipient forester in planning his nursery programme.

The moisture content (MC) of seeds is a most important factor affecting their longevity both in storage and in transit. Information on this characteristic will enable the receiving forester to estimate whether he needs to carry out any additional drying treatment and what the life of the seed is likely to be. Seeds of most species moving in international transfer are orthodox and should have good transit and keeping properties if dried to a low MC of around 8% and then sealed in a container impermeable to moisture.

If any special treatment has been applied to seed (e.g. use of insecticides), this should be stated on the certificate of seed quality. The certificate should likewise include mention of any recommended presowing treatment appropriate for the seedlot in question.

In many countries the same authority (the Forest Service) will be responsible for issuing both the certificate of seed origin and the certificate of seed quality. In such cases it may be possible and desirable to combine the two together. Examples of combined forms from Canada, Thailand and Australia are shown in Annex 4.

An example of a photosanitary certificate from the Danish Plant ProtectionService is shown in Annex 5.

4. CONTROL OF PEST AND DISEASE RISK

The benefits of international seed transfer of forest trees have been very great in the past and are likely to be even greater in the future. The process should be encouraged. At the same time care must be taken to reduce to theminimum possible the risk of introducing serious pests with the seeds. For simplicity the word "pest" is here used in the sense of "any form of plant or animal life or any pathogenic agent injurious or potentially injurious to plants or plant products", as defined by the International Plant Protection-Convention (IPPC) (Chock 1979).

In some conditions natural spread of pests is easy. In the Sahel, for example, any continuous vegetation type such as *Acacia* scrub is likely to have the same assortment of pests throughout its extent; political boundaries can do nothing to affect their spread. But large physical or climatic boundaries (oceans, mountain ranges, deserts) can be highly effective barriers to the natural spread of pests. Where natural introduction of pests is unlikely, it is important to take measures against unnecessary man-made introduction. International trade and travel have increased enormously over the past century, but the possibilities of control are improved by the fact that international entry points are relatively few and are in any case controlled by customs and immigration authorities.

The means for international co-operation in plant protection is provided by the International Plant Protection Convention, which was approved by the 6th Session of the FAO Conference in 1951 and to which more than 80 countries have become contracting parties. Its aim is to "strengthen international efforts to combat important pests affecting plants and plant products and to prevent their spread across international boundaries" (Chock 1979). Each contracting party is required to establish an official plant protection organisation which, *inter alia*, is responsible for inspecting and/or disinfecting plant materials moving in international trade and for issuing official phytosanitary certificates. A standard phytosanitary certificate is usually worded in the format: "This is to certify that the plants or plant products described above have been inspected and found free from quarantine pests and substantially free from other injurious pests; and that they are considered to conform with the current phytosanitary regulations of the importing country".

Specific regional needs can be met through a number of regional plant protection organisations. For example the Inter-African Phytosanitary Council (IAPSC) is open to all members of the Organisation of African Unity (Addoh 1977 cited in Ivory 1984). Regional phytosanitary rules are usually more stringent in attempting to prevent the introduction of pests which are hitherto absent from the entire biogeographical region than those which are already present in some countries of the region but absent in others (Smith1979).

The great majority of plants or seeds involved in international seed transfer are agricultural or horticultural. Forest trees do not feature prominently in national phytosanitary regulations and the national plant protection service is commonly part of the Department of Agriculture, though responsibility for forest trees is sometimes delegated to the Forest Service. Much less is known about seed-borne pests of forest trees than about those of the major agricultural crops, so that precise rules for the inspection and treatment of forest seeds for specific dangerous seed-borne pests are hard to formulate. Much more research is needed on the subject. It is generally considered that introduction of seed poses less risk of introducing pests than does the introduction of soil or living plants. Tree seed can usually be imported without difficulty following inspection and treatment with pesticides, although some countries impose more stringent restrictions against specified pests or against imports from certain parts of the world (Ivory (1984), FAO(1990), Stout and Roth (1993)).

The strictness of control appropriate in any particular case should depend on:

(1) The economic value of the potential host plant.
(2) The virulence of the pest on individual plants.
(3) Its "epidemic potential" or rate of spread to other plants.
(4) Whether the pest is already present in the region of introduction (Neergaard 1977).

Particular attention needs to be paid to the risk that pests borne on the seeds of one species may be most dangerous as pests to a different and more valuable species. The possibility of new virulent strains arising in a hitherto insignificant pest should not be neglected. Phytosanitary regulations are most effective when directed to the development of specific methods for the detection or elimination of specific pests. In one investigation on tropical pines, it was found that 183 out of 210 species of seed-borne micro organisms identified were harmless saprophytes (Rees and Phillips 1986). Clearly it would be quite impossible to attempt to identify every microbial species carried on seed.

Much can be done to reduce pathogenic risk by good seed-handling procedures. Seed collection direct from the tree, avoidance of warm, damp conditions intransit from the forest, early extraction and drying and careful inspection for pests during routine germination tests in the country of collection all help to reduce risk (Rees and Phillips 1986). "It is easier and more effectiveto take preventive measures than to cure the results of contamination." Control of plant material may involve one or more of the following:

(1) Unconditional prohibition of entry.
(2) Prohibition of entry except through an "Intermediate" quarantine station. An intermediate station should be in a third country where any potential host species cannot survive, hence any pest which may escape there cannot survive either; e.g. in a temperate country for transfers between two tropical countries.
(3) A period of quarantine in a quarantine station in the country of introduction. For agricultural crops this may involve growing a full generation of the crop without symptoms of pests and releasing the next generation of seed. It is practicable for annual crops but not for forest crops with a long breeding cycle. Quarantine stations need efficient means of isolation, partial or complete control of the environment and skilled staff, with the aim of precluding the entry of locally existing pests and preventing the escape of those that may accompany introduced material (Berg 1977). They are expensive and still rare in the tropics, but examples are those at Muguga in Kenya and Ibadan in Nigeria.
(4) Incubation of a sample of seeds on agar or filter paper and identification of the micro-organisms which develop from the seedborne spores.
(5) Separation of spores from seed in a liquid, followed by centrifuging to concentrate them and microscopic examination. Only useful if spores of the target species are distinctive and easily recognised. These and other methods have been described by Rees and Phillips (1986).
(6) Use of X-rays to detect insect larvae within seeds.
(7) Visual inspection, with or without the aid of a lens or low-power microscope.

It must be acknowledged that (7) is by far the most common method in use. In a few cases control is extremely rigorous. Malaysia prohibits all imports of pine seed from Central America, except through an intermediate quarantine station, because of the danger of introducing *Dothidella ulei*, the leaf blight of rubber. The combination of a virulent but hitherto absent pest with a crop of immense national value fully justifies this level of rigour. India has similarly strict rules to prevent the entry of rust infection with

seed of five-needled pines from America. For the much commoner cases of visual inspection, the level of control is much lower but, for seed transfer of species without serious pests already identified in the country of origin, reduction, not elimination, of risk is the aim. If complete elimination of risk was the invariable aim, international seed transfer would soon grind to a halt.

The value of a phytosanitary certificate can be considerably increased by adding detail on the method of inspection, e.g. whether visual inspection was aided by magnification, the size of sample in methods involving destruction or germination of the seed.

An alternative or addition to inspection is chemical treatment of the seed. Rees and Phillips (1986) list a number of chemicals which have proved useful, e.g. thiram as a general fungicide and malathion as a general insecticide. Dusting with powder is often effective against seedcoat pests, less so against pests inside the seed. However, seed dressings are to some degree phytotoxic and dosages must be carefully controlled to avoid loss of seed viability and harmful effects on staff who have to handle the seed. Toxic effects are cumulative and an entire seedlot can be destroyed if seed is heavily treated before it leaves the exporting country and again after it arrives in the importing country. Exporting countries should make a clear entry as to any seed treatment on the phytosanitary certificate. It may be preferable to let the importing country do its own treatment on the arrival of the seed.

As an alternative to insecticides, the use of CO_2 to control insect infestation could be considered (Sara *et al.* 1993).

5. CONTROL OF TRANSIT ARRANGEMENTS

The benefits of transferring seed of high genetic and physiological quality, free of pests and with perfect documentation, may be entirely lost if the seed is destroyed in transit. Both the importing and exporting countries have an obligation to ensure safe and speedy arrival at the destination. Details for transit which the importing country should supply when ordering the seed are included in Annex 2. Sufficient copies of documents should be provided for the exporting country to be able to send a copy under separate cover as well as those attached outside and inside the package.

In a few countries there are restrictions on export of seed of certain species in other than minute quantities, but in most countries export presents no problems. For orthodox species seeds should be dried to around 8% and then placed in sealed moisture-proof containers for transit. Fluctuations in temperature are inevitable but, provided that moisture is controlled and time of journey shortened by use of air transport, no serious damage should becaused. Worst damage is often done by delays at the point of entry. The seed supplier should advise the recipient in advance by cable or fax of the date of arrival and flight number, so that the latter can clear the consignment through customs as soon as it arrives. Seed sent in exchange or otherwise free of charge has the advantage of not being subject to customs dues and can thus be cleared more quickly. It also avoids the problem of obtaining foreign exchange, which is often in short supply and is an additional cause of delayed transactions.

In some cases import permits are required and, in most cases, phytosanitary certificates from the exporting country are required.

Having received the necessary notice of shipment, the importing authority must take early action for customs clearance, so that the seed is either distributed for sowing or placed in suitable storage conditions with the minimum delay.

6. SEED LEGISLATION

The same observation applies to seed legislation as to all legislation; have as little as possible but ensure that what you do have is enforced. Where all international seed transfers in a particular country are handled by a single efficient organisation, national legislation may be unnecessary; the clear instruction of a strong Director of Forestry to his staff can be equally as effective as any law promulgated by politicians and civil servants.

As the scale of forest seed collection, handling and shipment increases, the tendency in many countries is for more than one organisation to become involved in international seed transfer. They may be private, communal or governmental. As soon as other organisations become involved which do not recognise the authority of the Forest Service, it becomes necessary to enact national seed legislation for international seed transfer which is binding on all parties in the country. A further reason for seed legislation is that it is usually mandatory for any country wishing to participate in, and benefit from, regional or global schemes of international co-operation.

Chock (1979) summarised a number of principles applicable to plant protection legislation, which are equally valid for seed legislation in general. Among the most important are:

(1) Seek to promote safe seed transfer (positive) rather than to restrict all seed transfer (negative).

(2) Introduce only those regulations which can be enforced.

(3) Use legislative measures only when less drastic measures are impracticable.

(4) Modify existing legislation in the light of new scientific knowledge.

(5) Take trouble on public relations, to obtain the co-operation and goodwill of both the general public and those engaged in export/import of forest seed.

As with the design of seed certificates, there are great advantages to be gained through achieving the maximum degree of legal standardisation between countries. Although universal standardisation is seldom possible, countries within a biogeographical zone such as the Sahel should aim to achieve common standards of seed legislation.

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