Piñon Pine Seed Production, Collection, and Storage

Richard M. Jeffers[1]

Abstract.—Key phases in the seed production cycle of piñon are summarized. Seed production is cyclic and good crops occur at 2-7 year intervals. During the 58-year period, 1936 to 1994, good seed crops were produced on the average every 4.1 years. Seed usually becomes mature and collectible in mid-September, which is about 26 months after the start of the seed production process. Seed yields on individual trees may exceed 20 pounds. Good seed stands produce an average of about 250 pounds of seed per acre in good seed years. Seed yields per acre can be increased through careful selection and retention of the best and most consistent seed producers, and elimination of poor seed producers by thinning in selected high yielding stands. Seed production can be further increased by transplanting good seed producers into high yielding stands and/or establishment of seed orchards. Seed orchards can be established by transplanting seed bearing trees selected on the basis of heavy and consistent seed production (transplant orchards), or with seedlings produced from seed collected from selected heavy seed producers (seedling seed orchards). Currently, most piñon seed is collected by manually picking seed from the ground. Collection of seed from individual trees in enhanced seed stands could be mechanized. In seed orchards seed collection can be highly mechanized through use of a net retrieval system such as used in southeastern pine seed orchards. Good quality piñon seed can be stored for 5-10 years or more when stored in sealed containers, at 5-10 percent moisture content, and at 0-20 degrees F. A recommendation is made for the establishment of a complete piñon seed enterprise which would include seed production, collection, treatment, storage and marketing.

INTRODUCTION

Probably the most important cash crop produced by piñon (*Pinus edulis* Engelm.) is the high quality, edible seed (nut) crop. There is a very high demand for piñon nuts because of their excellent taste and high nutritional value. Piñon seeds are sold as edible nuts and are used in candies, cookies, and other home and restaurant foods. In addition, piñon seed is also used for production of seedlings for landscaping purposes in the Southwest.

While piñon nuts have been a food staple by the American Indian in the Southwest for many centuries, and a significant portion of the nut crops remain in the Southwest, the majority of piñon nuts are shipped to large eastern cities, especially New York City (Lanner 1981).

The annual demand for pine nuts of all species (shelled and unshelled) exceeds 6 million pounds. In 1991 and 1992 it was estimated that as much as 7 million pounds of piñon nuts (unshelled) were harvested and an additional 5.3 million pounds of shelled pine nuts were imported (Delco et al. 1993) for a total of 12.3 million pounds of nuts for both years for an average of 6.16 million pounds per year. Annual imports of pine nuts into the U.S. appear to be inversely related to the availability of piñon nuts. Delco et al. (1993) reported that shelled pine nut imports declined from 4.0 million pounds in 1989, a poor piñon seed year, to 2.6 million pounds in 1992, which was a good piñon seed year. During this same period the import price per pound of shelled pine nuts increased from $2.19 in 1989 to $4.69 in 1992. And, it appears

[1] *Regional Geneticist, USDA Forest Service, Southwestern Region, Albuquerque, NM.*

that piñon nuts are not currently being offered to the food industry at prices that are competitive with these import prices.

It seems logical then, that any increase in the annual supply of piñon nuts would be of substantial benefit to the piñon nut industry and, in turn, would provide added income to the people of the Southwest.

Increases in the annual supply of piñon nuts, at more competitive prices, can be achieved relatively easily by: 1) harvesting more seed during good seed years, 2) increasing seed yields per tree by selection of consistent high seed yielders, 3) increasing seed yields per acre by increasing the number of high seed yielders per acre, 4) using cultural techniques to increase seed yields per tree, 5) improving seed collection efficiency through mechanization, 6) use of long-term (up to 10 years) seed storage, and 7) development and utilization of a piñon nut marketing strategy.

Basic information on piñon seed production, collection and storage is provided in this paper that can be used in the development of a strategy for the establishment of a piñon seed enterprise, which would include all phases of a seed business including seed production, collection, storage, packaging, and marketing.

SEED PRODUCTION

Seed Production Cycle

For most north temperate coniferous species, the seed production cycle (the entire time period between initiation of reproductive initials and mature seed is produced) takes place over two consecutive growing seasons (2-year cycle) for species such as Douglas-fir, the spruces, and true firs, or three growing seasons (3-year cycle) for most pine species, including all of the piñon species (fig. 1).

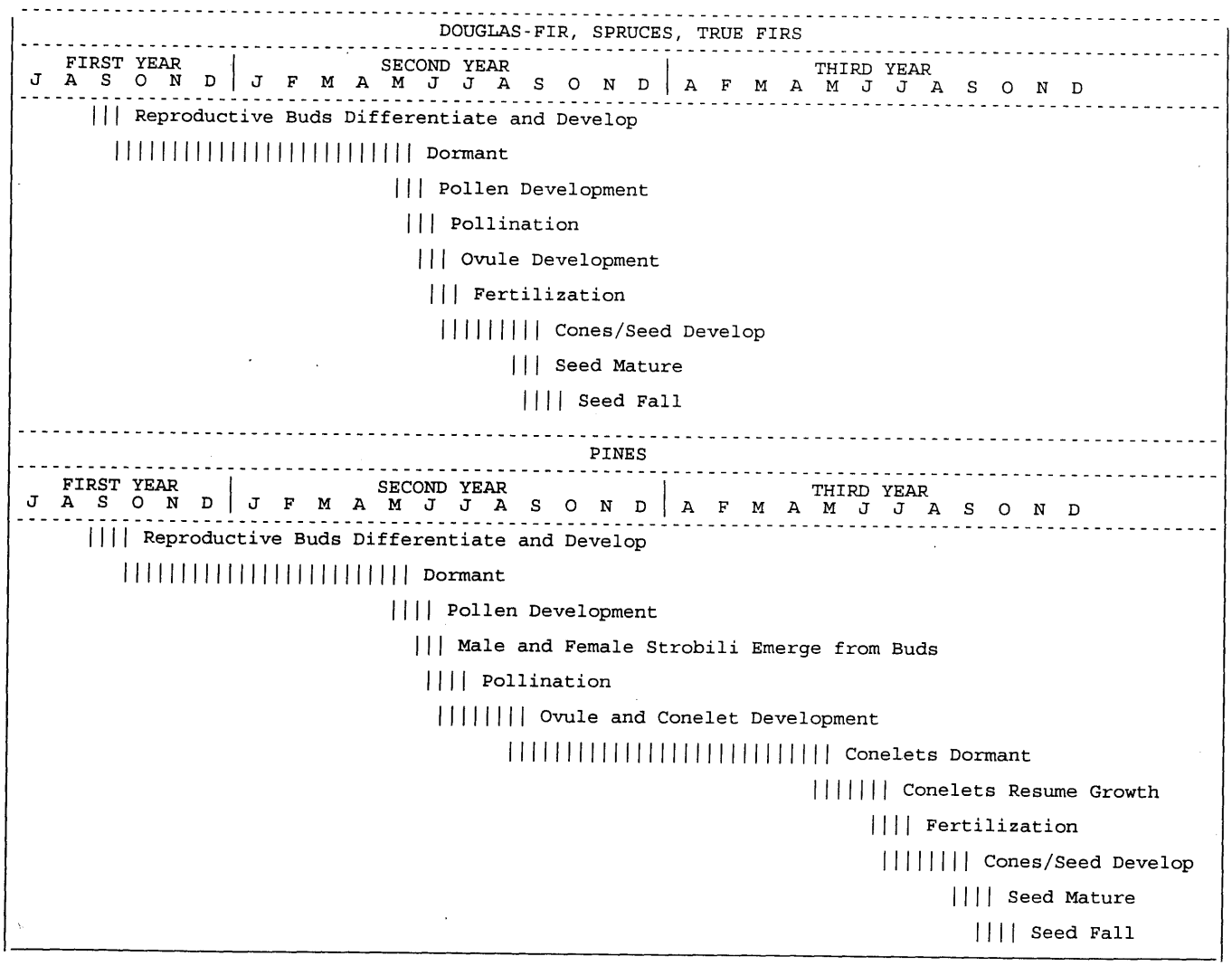

Figure 1.—Cone and seed production cycles of Southwest conifers.

In the Southwest, male and female reproductive structures in the conifers are initiated in late summer and mature male and female reproductive structures (strobili) emerge from reproductive buds the following spring. In the 2-year cycle species, the remainder of the seed production cycle from pollination to seed maturity, occurs between May and September of the second growing season. In contrast to the 2-year cycle species, most of the pine species, including piñon, require another full year for mature seed production to occur. In Southwestern pines, male and female reproductive structures are initiated in late August and September, after height growth has been completed, of the first growing season. Growth of these initials is completed by October. These structures remain essentially dormant until they emerge from the reproductive buds in late May to early June of the second growing season. This stage is followed shortly thereafter by pollination. At this stage, mature pollen grains are shed and disseminated by wind to females, usually on adjacent trees. After reaching the females the pollen grains germinate and form pollen tubes. The pollen tubes and ovules, which later develop into seed, then start to rapidly develop; but their growth is soon arrested and these structures remain essentially in a resting condition throughout the remainder of the second growing season and second winter. Growth of the dormant females resumes about one year after pollination in late May to June of the third growing season. Fertilization, the fusion of a single sperm cell (male) and an egg cell (female), then occurs in late June to early July of the third growing season. The fertilized egg then divides and differentiates to form the embryo. Soon after fertilization the cone and enclosed embryos rapidly develop and the cones and seed become mature in late August to September of the third growing season. These key phases in the seed production cycle of piñon, first described by Little (1938a and b), are summarized in Table 1.

Table 1.—Key phases in the seed production cycle of piñon [1].

Pinus edulis Engelm

First Year

1. August 15 - September 30
   Buds containing male and female primordia differentiate and develop.

Second Year

2. May 15 - June 15
   Male and female reproductive structures (strobili) emerge from buds.
3. June 15 - June 30
   Pollination occurs.
4. June 15 - August 31
   Rapid conelet and ovule (develop into seed) development.
5. August 15- December 31
   Conelets dormant.

Third Year

6. May 1 - May 15
   Conelets resume growth.
7. June 21 - July 7
   Fertilization occurs.
8. July 1 - August 31
   Rapid cone and seed development.
9. September 1 - September 15
   Seed mature.
10. September 7 - October 31
    Seed fall.

[1] *After Little 1938a,b and Ronco 1990*

Cone and Seed Crop Frequency

Cone and seed crops in the conifers do not occur on a regular annual basis; they occur periodically. This annual variation in cone crop production is related to and affected by the biological characteristics of individual species, internal nutrient supplies, and by external conditions such as weather, insects, diseases, and predation by birds and mammals (Eremko et al. 1989). Intervals between good cone crops may be as little as 2 years as in jack pine, lodgepole pine, and Scots pine; 3-4 years in the spruces and Douglas-fir; or every 4-5 years for other pines, such as the white pines, ponderosa pine, and piñon in the Southwest. Good seed crops in all southwestern pine species tend to be synchronous, occurring in the same year over large geographic areas; that is, when a good seed crop occurs in one pine species then there are usually good seed crops in the other pine species throughout the Southwest. In piñon, good seed crops usually occur every 4 to 7 years over the entire piñon area in New Mexico, eastern Arizona and southern Colorado (Barger and Ffolliott 1972). During the 58-year period, 1936 to 1994, reports in the literature (Little 1941, Barger and Ffolliott 1972, Betancourt et al. 1993) and seed collection records showed that good piñon nut crops occurred throughout the Southwest in 14 years, for an average of 4.1 years between commercially collectable crops. In local areas the interval between good nut crops may vary from as little as 2 to 5 years, or may be more than 10 years (Little 1941). Very rarely are good nut crops produced in consecutive years, such as occurred in 1991 and 1992 (Betancourt et al. 1993). It does appear that another good crop will occur in the fall of 1994, and if this occurs, then good crops will have been produced in 3 out of the past 4 years, a very rare occurrence.

Seed Yields

Cones often occur on trees 3 to 4 feet in height and 10 to 20 years in age, and significant numbers of cones may be produced on trees that are 5 to 10 feet tall and 20 to 30 years old. However, the largest crops are produced on mature trees which are usually 20 to 30 feet tall with wide, full crowns. Piñons of this size may be 75 to 100 years old, and individual trees may produce cones for centuries (Phillips 1909, Botkin and Shires 1948, Ronco 1990). It should be noted that while seed production is indirectly related to tree age, seed production usually begins after a tree reaches a minimum specified size and height; for piñon that height appears to be 3 to 4 feet.

Individual cones usually produce 10 to 20 seeds, but may produce up to 30 seed (Ronco 1990). During good seed years, good individual seed producers may produce up to 8 bushels of cones (Phillips 1909). At 3.3 pounds of seed per bushel and 1900 seed per pound (USDA Forest Service 1974), this translates to 26 pounds of seed or over 50,000 seed.

In good seed years piñon stands produce an average of about 250 pounds of seed, or 475,000 seed, per acre (Kline 1993), but the best stands may produce as much as 300 pounds of seed per acre (Phillips 1909). In any particular year, seed crops are either good or poor, but seldom intermediate (Ronco 1990). The total piñon nut crop harvested annually in New Mexico, eastern Arizona, and southern Colorado averages between 1 and 2 million pounds. Crops harvested during good seed years probably average about 4 million pounds, with a range of 3 to 6 million pounds. The largest piñon nut harvest, which occurred in 1936, totaled almost 8 million pounds (Little 1941).

The size of the nut crop harvested in good seed years is often regulated by the price that large seed dealers are willing to pay collectors; when seed supplies become plentiful, seed dealers lower the price paid to collectors. Increases in nut harvest during good seed years can be achieved simply by seed dealers providing modest increases in the average price paid to seed collectors from the current rates of $1-2 per pound to $2 or more per pound (Tanner and Grieser 1993).

SEED PRODUCTION IMPROVEMENT

Early seed production and seed yields per tree are under strong genetic control; consequently, seed production in stands can be increased substantially through individual tree selection. Seed production per acre can also be enhanced by concentrating seed production on the more productive piñon sites, increasing the number of good seed producers per acre, use of cultural treatments to increase seed production per tree, and by protecting the trees and stands from damaging insects and seed predators such as birds and rodents. By utilizing some or all of these methods and techniques, a relatively simple and cost efficient seed improvement program can be developed.

Stand and Individual Tree Selection

Currently, in the U.S., the piñon nut (primarily *Pinus edulis* Engelm.) is the only commercial nut crop collected entirely from "wild" trees (Little 1993). Some stands are inherently good and consistent seed producers and they are usually found on the more productive sites. These sites generally have deeper soils, with higher nutrient levels, and occur at higher elevations where annual precipitation is higher and better distributed throughout the growing season. A selection program can begin by conducting surveys on the more productive lands to locate the highest nut yielding stands. Identified stands should be marked and reserved for use as seed production stands.

Over 50 years ago Little (1940) recognized that some individual piñon trees are consistently good nut producers, and others, consistently poor. He also noted that some trees produce more cones than others and some trees produce larger cones with more nuts per cone.

The second phase of a selection program would be to identify individual high seed yielding trees within selected high seed yielding stands. The entire individual tree selection program could be accomplished within two to four years depending upon the number of individuals trees to be selected for inclusion in a seed production improvement program. Two types of individual tree selections can be made: Type 1 selections which are large, mature, high seed yielders that are to be left in place, and Type 2 selections which are relatively small (10-20 feet tall), young (15-20 years old), good seed producers, that can be transplanted into enhanced seed production stands or into orchards.

Enhanced seed production stands are those that have been selected as high seed yielders and enhanced by transplanting Type 2 selections among Type 1 selections, at fairly regular spacings to increase the number of high seed yielders per

acre. Seed production could be further enhanced in these stands by using one of more of the following cultural treatments: cultivation to remove competing vegetation, irrigation, fertilization, and shaping of the crowns to increase the cone bearing surface.

SEED ORCHARDS

The most intensive, and therefore most costly, way to increase seed production would be to establish seed orchards on productive, agricultural type lands. Establishment and maintenance of piñon nut orchards would be similar to that of other nut orchards, such as the pecan and pistashio orchards in the Southwest.

Two types of orchards could be established: transplant orchards or seedling seed orchards. Transplant orchards can be established by transplanting Type 2 selections to an orchard site at regular spacings, such as 15 x 20 feet, after the site has been thoroughly prepared similar to an agricultural field.

Seed orchards can also be established with seedlings produced from seed collected from Type 1 selections. This type of orchard may appear to have little promise since piñon typically exhibits very slow growth under natural conditions. However, relatively fast growing seedlings can be produced as containerized stock that are intensively cultured in a greenhouse-shadehouse growing complex. When grown under these conditions 6-8 inch tall seedlings can be grown in 6 months and 3-4 foot tall trees in 3 to 4 years. If intensively cultured, container-grown trees, are then planted to fairly productive sites where they can cultivated, irrigated, and fertilized, they can be grown to moderate seed production size in less than half the time it takes under natural conditions and 8-10 foot tall trees can be grown in 10 years from seed.

During and after transplanting of Type 1 selections or planting of intensively cultured seedlings, the orchards should be periodically cultivated, irrigated, and fertilized to promote seed production. Established orchard trees can be shaped to increase the cone producing surface of individual trees. In addition, a pruning program, designed to remove basal branches up to 5 feet above the ground, should be used to increase seed yields per cone, increased seed size, and increase yield of full seed per cone (Montano et al. 1980).

The orchards should also be protected from cone and seed insects through maintenance of a intensively controlled pesticide application program and from seed predators, such as birds and rodents.

Potential Yields from Orchards

The following example of a small seed orchard illustrates potential seed production from a piñon transplant orchard. The type of orchard established, its size and age, and mix of cultural treatments used will determine actual amounts of seed that can be produced at any particular time after orchard establishment.

Orchard: Type—transplant orchard
Size —10 acres
Spacing—15 x 20 feet
Total trees—1450 (145/acre)

Assumptions: Time frame—10 years after establishment completed
Average seed yield—10 pounds per tree
Good seed year every 4 years

Seed Yields: 14,500 pounds of seed (1450 trees x 10 pounds/tree) every 4 years
3,600 pounds of seed per year
360 pounds of seed per acre per year
Plus any seed produced in intermittent years.

A seed orchard of this size is probably not an economically sound venture because of the initial high unit costs of establishment and maintenance; however, yields estimated here can be easily converted for any multiples of 10 acres. Prior to any orchard establishment a series of economical analyses would have to be made in order to determine the minimal orchard size needed to provide a modest economic return from the orchard.

SEED COLLECTION AND STORAGE

Collection

By far the vast majority of piñon nuts are picked by hand, one at a time, from the ground, after the majority of cones have opened. Perry (1922) estimated that 22 pounds of seed picked by hand is considered a fair day's gathering, although some especially dexterous persons can pick up to

40 pounds a day. More enterprising individuals spread sheets, blankets, tarps, plastic, etc. under individual trees, then shake the trees one or more times to dislodge seed from open cones. This method of collecting seed could be enhanced by mechanizing the collection process. This could be done by developing a harvester/shaker that would place a collecting surface around the base of the tree and thump or shake the tree to dislodge the seed. This method of collection would be most efficient if used in enhanced seed production stands or in seed orchards. In a seed orchard situation where the trees are all spaced at regular intervals, seed collection could be highly mechanized by use of a net retrieval system that is used in southeastern pine seed orchards (Edwards and McConnell 1982, McConnell and Edwards 1984). With this method of seed collection a net material, originally developed from carpet backing material, is laid in continuous strips under the trees prior to cone opening. When the majority of cones have opened naturally, individual trees can be shaken to dislodge seed. After essentially all of the seed has fallen onto the netting, the netting is retrieved by pulling individual netting strips from one end with a machine that collects the seed and places it into collection bins as it rolls the netting onto storage rolls.

Seed Storage

Routinely, unshelled pine seed can be stored successfully for up to 10 years, or more, when it is stored in sealed containers, at temperatures of 0 to 20 °F, with moisture contents between 5 and 10 percent. Unfortunately no published information is currently available listing the optimum, long-term storage conditions for piñon to maintain seed viability, and nutritional status and taste of the nuts. Piñon seed, however, can be stored under these conditions for a minimum of 10 years without appreciable loss in seed germination if the seed is of good quality when it is put into storage. Research and/or administrative studies are needed to determine the optimum long-term storage conditions necessary to maintain seed viability, and the high nutritional value and taste needed in the commercial nut industry.

RECOMMENDED PIÑON SEED ENTERPRISE

Currently, there are few commercial piñon seed dealers in the Southwest. Consequently, only relatively small amounts of piñon seed are available on a consistent annual basis, and very little shelled seed is available to U.S. markets. However, there continues to be a very high demand for piñon nuts as reflected by the volume of pine nuts imported annually into the U.S.. Delco et al. (1993) noted "that there may be a real window of opportunity to market the piñon nut throughout the U.S. at this time" and "An understanding of the market place and the potential for developing a economic and environmental policy for growing, harvesting, shelling, and marketing piñon nuts is key to competing in the U.S. and world markets with these nuts".

A group of individuals and/or an agency in the Southwest having extensive holdings of piñon lands could take advantage of this opportunity by establishing and operating a complete piñon seed enterprise which would include: 1) purchase of seed from local collectors, 2) establishment and maintenance of a seed improvement program to provide additional seed on a more regular basis, 3) long-term seed storage, 4) development and use of nut roasting and shelling equipment, 5) seed packaging, and 6) a seed marketing program. Development of this type of enterprise could result in a more stable supply of piñon seed at competitive prices for the food, landscaping, and reforestation industries in the Southwest.

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