Genetic Resources and Enhancement

Pod and Seed Storage: Cost-Benefit Study for Groundnut Germplasm Conservation

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The Genebank at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India conserves about 15,342 accessions of groundnut germplasm assembled from 93 countries. The germplasm is stored in the form of pods under medium-term storage conditions (4°C and 30% relative humidity). Pod storage, however, requires far greater storage space compared to seed storage; hence it is likely to be more expensive, especially when the storage temperature and relative humidity are controlled by mechanical means. Recently, Rao et al. (in press) found only marginal advantage in terms of seed longevity with pod storage compared to seed storage. Hence they recommended that active collections of groundnut germplasm could be conserved in the form of seeds to reduce the conservation costs. We compared the actual costs of conservation of pods and seeds in two groundnut cultivars JL 24 and ICGS 76 under medium-term conditions.

The groundnut germplasm accessions conserved as pods in ICRISAT Genebank, occupy two large storage rooms (each of 260 m^3) and this requires about 100,000 kWh yr^{-1} of electricity. Pods occupy more than three times the volume required for storage of seeds (Rao et al., in press). Hence when pods of groundnut accessions are shelled and stored in the form of seeds, they could be accommodated in one small modular room of about 130 m^3, requiring only 30,000 kWh yr^{-1} of electricity to maintain similar storage conditions. The overall annual storage costs of pods and seeds were estimated at US$ 0.97 and 0.38 per accession, respectively (Table 1). The costs included electricity, quasi-fixed labor, and equipment maintenance charges (but excluded capital items such as storage module). Thus, the cost saving per accession is US$ 0.59 or about US$ 9,050 per year for conserving the entire collection of groundnut by changing to storage of seeds instead of pods. However, the slightly longer survival due to pod storage results in less frequent regeneration. Therefore, when evaluating

Table 1. Annual cost (US$) for conservation of groundnut germplasm under different protocols at ICRISAT Genebank, Patancheru, India.

Item	Pods	Seeds
Quasi-fixed labor (e.g., senior manager, scientist, etc.)	1 500	1 500
Equipment maintenance		
Labor (e.g., technicians, daily labor, etc.)	900	450
Non-labor (e.g., supplies)	500	250
Electricity	12 000	3 600
Total cost of conservation of 15,342 accessions	14 900	5 800
Conservation cost per accession	0.97	0.38

the cost-efficiency in the context of long-term maintenance of germplasm, the regeneration cost under different methods of storage also needs to be included. The cost of regenerating one accession of groundnut is estimated at US$ 13.06 for pod storage, and it increases to US$ 13.26 for seed storage due to the extra labor cost incurred for shelling (Koo et al. 2001).

At ICRISAT, groundnut germplasm accessions are regenerated when seed germination falls below 75%. Based on the estimates of seed longevity derived by probit analysis, Rao et al. (in press) predicted that germination of seeds of ICGS 76 from pods stored under medium-term conditions could decrease from 100% to 75% in about 4266 days compared to 4179 days in shelled seeds. Similarly in JL 24, the germination of seeds from stored pods is expected to decrease from 100% to 75% in 4732 days compared to 4652 days in seeds. Assuming an 11-year regeneration interval under both storage methods, the cost of storing and regenerating an accession forever would be US$ 62.49 for pod storage and US$ 47.72 for seed storage when the real rate of interest is 4% (Table 2). Thus the total cost of conserving 15,342 groundnut accessions in perpetuity would be US$ 958,716 for pod storage and US$ 732,126 for seed storage. The net cost saving by switching to storage of seeds, therefore, would be US$ 226,590, without significantly compromising storage longevity. However, it should be noted that in the present ICRISAT scenario, the labor cost for shelling that contributes to regeneration cost is very low compared to electricity cost that affects storage cost. If the structure of costs is reversed, the size of the savings due to the change of protocol may be different.

Table 2. In-perpetuity cost (US$) of storing and regenerating groundnut germplasm under different protocols at ICRISAT Genebank, Patancheru, India.

Item	Pods	Seeds
Storage cost[1]	25.22	9.88
Regeneration cost at 11 years interval[2]	37.27	37.84
Total regeneration cost per accession	62.49	47.72
Total regeneration cost of all 15,342 accessions	958 716.00	732 126.00

1. The in-perpetuity cost of an operation that is performed annually with a cost of X from time zero is given by

$$C_0^1 = X + \frac{X}{(1+r)} + \frac{X}{(1+r)^2} + \cdots = X\left[1 + \frac{1}{(1+r)} + \frac{1}{(1+r)^2} + \cdots\right] = \frac{X}{1-a}$$

whereas $a \equiv \frac{1}{(1+r)} < 1$ and r is the real rate of interest.

For example, if it costs US$ 2.07 to store one accession of groundnut germplasm pods per year, the present value of the cost of storing that accession in perpetuity is US$ 53.82 with 4% interest rate.

2. The in-perpetuity cost of an operation that is performed every n^{th} year from time zero with a cost of X is given by

$$C_0^n = X + \frac{X}{(1+r)^n} + \frac{X}{(1+r)^{2n}} + \cdots = X\left[1 + \frac{1}{(1+r)^n} + \frac{1}{(1+r)^{2n}} + \cdots\right] = \frac{X}{1-a^n}$$

For example, if the regeneration cost of groundnut is US$ 13.06 and it is done every 11 years, then the present value of the cost of regenerating an accession in perpetuity is US$ 37.22 with 4% interest rate.

References

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Aneuploids in Groundnut

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Interspecific hybridization was attempted between cultivated tetraploid groundnut (*Arachis hypogaea*) cultivar J 11 under section *Arachis* as female parent and wild perennial diploid species, *Arachis paraguariensis* under section *Erectoides* as pollen parent under field conditions during rainy season. A total of ninety-two probable cross pods from the above cross were collected and seeds were grown in the field for identification of hybrid plants. But none of the plants were found to be hybrids. However, one plant was morphologically like the female parent but poor in vigor. Meiotic chromosome analysis in pollen mother cell (PMC) confirmed that the plant with poor vigor and 19 bivalents was a nullisomic, the 2n chromosome number of groundnut being 40. The nullisomic plant had narrow leaflets and blooming was delayed by nearly two hours; about 95–98% fertile (stainable) pollen was produced which germinated normally in aqueous medium standardized for groundnut.

Meiotic analysis revealed that pairing behavior at Metaphase I in the nullisomic plant was normal. The PMC having 19 bivalents constituted the modal class. Univalents and trivalents in the PMCs were rare. The mean chromosome configuration per PMC at Metaphase I was 0.63 univalents and 18.54 bivalents. Similar pairing of chromosomes in nullisomic was reported earlier by Singh et al. (1981) in groundnut. Equal distribution of chromosome 19/19 in Anaphase I was observed in about 50% PMCs. Rest of the PMCs showed unequal separation of 20/18 or 21/17. The occurrence of nullisomy and univalents in PMC suggest that groundnut is amenable for producing an aneuploid series.

Table 1. Phenotypic comparison between groundnut cultivar J 11 (female parent) and the nullisomic plant.

Plant characters	J 11	Nullisomic plant
Leaflet area (cm^2)	9.22	4.30
Leaflet length (cm)	4.65	3.99
Leaflet width (cm)	2.52	1.68
Petiole length (cm)	3.24	2.30
Stipule length (cm)	2.40	2.03
Sepal length (joined) (cm)	8.00	8.46
Sepal length (single) (cm)	10.00	10.13
Hypanthium length (cm)	27.33	15.54
Stomatal length (mm)	0.02	0.02
Stomatal width (mm)	0.02	0.01
Petal length (mm)	13.60	11.26
Standard length (mm)	8.00	7.73
Wing length (mm)	8.80	8.00
Pollen size (mm)	0.06	0.07
Anther length (mm)	13.02	11.26

The mode of origin of nullisomy in interspecific crosses is not understood fully. The species used as pollen parent had a different genome (E1) which is cross incompatible with other species. At maturity, the nullisomic plant produced a total of eleven mature pods of which only four progeny plants were raised successfully. Of the four plants, two were confirmed as nullisomic having 2n chromosome number of 38. Some phenotypic differences were observed between J 11 and the nullisomic plant (Table 1).

Reference

Singh D, and **Joshi BC.** 1981. Aneuploids in groundnut. Indian Journal of Genetics 41:161–163.