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Breeding strategies in Neem

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Strategies for long-term breeding

Breeding strategies are normally evaluated in terms of genetic gain expected for traits of importance, usually over a period of time. Expected gain could be utilized by a proposed selection and propagation system. Several long-term breeding strategies are now available, which are designed to retain sufficient genetic variability to counteract the risks of inbreeding in future generations. In recent years, different strategies and methods have been proposed and used to widen the genetic base of breeding populations for long-term breeding. The Multiple Population Breeding Systems (MPBS) and Hierarchical Open-Ended systems (HOPE) have been suggested for breeding allogamous tree species (Namkoong 1989). In the former, intensive recurrent selection is practiced within multiple independent populations, to create broad differences among them in relation to their source germplasm, their traits and adaptabilities. The latter case, HOPE, is maintained as a very large base population, which is open-ended as far as receiving new materials is concerned. MPBS may be the better choice for neem because it is better suited for combining the highest possible genetic gains and highest possible genetic diversity. It also gives the breeders more options for shifting breeding goals with changing environments and demand (Namkoong 1989; Eriksson et al 1993).

Tree breeders evaluate the genetic resources available for improvement, and select genes of great utility and economic importance and package them in genotypes that can be used to establish commercial plantations. Tree breeders also identify superior genotypes in existing provenances and propagate them clonally to tap both additive and non-additive genetic effects governing commercial traits. In the study, the neem tree has been shown to be an allogamous species. For long-term progress in neem breeding, a general flow chart may be suggested. The following major approaches may be included in a long-term improvement program.

1 Introduction of provenances (40-50 trees/provenance)
2 Establishment of seed production areas (SPA)
3 Genetic testing and establishment of seed orchards (SO) include
    - selection of plus trees in the provenances
    - progeny testing of plus trees and
    - establishment of seed orchards for long-terms genetic gains
4 Clonal strategies include
    - clonal propagation for selected plus trees for large genetic gains
    - establishment of clone trials and clone banks
5 Conservation of genetic diversity

From the above long-term breeding population, short-term breeding populations (5-100 individuals) could be drawn, which are adapted to the local climate having the desired traits. Some promising genotypes may be possible to select for clonal tests directly. The long-term and short term breeding populations will be maintained by continuous population improvement, which would ensure a wide genetic base and long-term progress in neem breeding. The essential features of this long-term breeding population are that the improvement will result from mild selection, which increases the frequency of desirable genes without the loss of neutral genes.

Breeding objectives and methods

Breeding strategies differ considerably with the aims and objectives of the tree improvement program. The neem can be bred for many purposes such as higher fruit yield and other desired agronomic traits. The first category includes the uses as medicine, pesticides, fungicides, nematicides, cosmetics, fodder and organic manure. The latter category includes timber and fuelwood, agroforestry species, shelterbelts, avenue trees, drought and disease resistance.

Multiple stems that produce high biomass, high wood density, and large quantities of fruit with high limonoid and oil content, should be the criteria for selecting provenances for fuel wood production, charcoal, pharmaceutical and pesticide industries. For early establishment of a plantation, especially in dry areas, provenances of neem that show high survival rate and fast growth may be the best choice. In the long-term for utilization as timber, provenances that have a straight stem and more promising intraspecific hybrids could be among the selection criteria. For agroforestry species, a narrow crown with deep-rooted habits; for shelterbelts, resistance to high wind-run and persistent leaf habits; for avenue trees, a larger crown with evergreen features could be selection criteria.

Net photosynthesis is also an important trait affecting yield. Leaf and leaf stomatal characters, stomatal density, and total guard cell length per unit leaf area, as reliable indicators of stomatal conductance, were suggested as important components for yield. Leaflet ratio, shoot: root ratio, and leaf area could be easily measured traits in breeding for drought tolerant neem.

The strategy to improve several characters simultaneously depends on whether they are controlled by a single major gene or groups of genes. If the characters are positively correlated, improving of one character would improve the other and selection becomes efficient. Independent characters could be selected successively or simultaneously. Strongly negatively correlated traits should be carefully estimated, since improving one character always amounts to lowering the level of other(s). To improve several characters simultaneously, index selection is probably the best choice.

In neem breeding, most of the characters mentioned are probably quantitative in nature. The recent studies indicate that seed diameter, leaflet ratio, and leaflet area were all independent. These traits could be improved without having negative effects on other. In the preliminary studies, no significant negatively correlated traits were observed. The economic traits of interest in this species could be growth, straight bole, crown form, and seed oil, including limonoid contents.

A natural hybrid (A. siamensis × A. indica) found in Thailand indicates that hybridization among related species is possible and promising for further neem improvement. Natural or artificial hybrids could be introduced both in long- and short-term breeding programs. When breeding neem for biochemicals it may be advantageous to advance to the F2 generation and select in the recombinant generation.

The usefulness of polyploid and mutation breeding in neem are still questionable. Gene transfer techniques could be useful for producing transgenic neem (Naina et al. 1989). Genes that control drought tolerance and genes for high 'azadirachtin-A' contents could be usefully exploited. The establishment of seed production areas (SPO) from provenance trials is featured as the most effective and time-efficient strategy for short-term neem improvement. For long-term sustainable tree production as well as fruit yield, seed orchards (SO) are suggested.

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