

Excellent *Coffea canephora* hybrid varieties



The cultivation of *Coffea canephora* trees, which produce coffee known commercially as Robusta, is extensive in most cases on the African continent. Yields from this crop reach 600 kilograms of merchantable coffee per hectare per year in Asia and Latin America, as opposed to 300 kilograms in Africa. Under optimum conditions, yields can exceed 2 tonnes of merchantable coffee per hectare per year. Fluctuating coffee prices, ageing plantations and limited use of selected *C. canephora* planting material (from 10 to 20% of plantings), are generally the reasons given to explain the gap between optimum yields and those actually achieved.

In Côte d'Ivoire, the *Centre National de Recherche Agronomique* (CNRA) and CIRAD have been working together for more than three decades on the genetic improvement of *C. canephora*. The setting for this collaboration has evolved over the years and now takes the form of a strong partnership based on clearly defined joint research objectives; these include the identification of high-yielding varieties that are easy to distribute to smallholders.

***Coffea canephora* clones and hybrids**

A clone is a set of trees corresponding to the same genotype. A hybrid is a set of progenies derived from a hybrid combination between two parents or clones.

Production of hybrids and clones

The biology of the species *C. canephora* makes it possible to create either hybrid varieties in seed form, or clonal varieties in cutting form.

In Côte d'Ivoire, hybrid seeds are produced in bicalonal seed gardens. The strict cross-fertilization of *C. canephora*, along

with geographical isolation of the seed gardens, guarantee that all the seeds harvested are derived from the cross between the two parents of which they are composed. One hectare of seed garden produces 500 kg of seeds per year, on average, for approximately 1,000 ha of new plantings. The viability of the seeds lasts barely more than two months under uncontrolled conditions, but it can be maintained for up to a year with relatively simple methods.

Clonal varieties are propagated from cuttings of green orthotropic branches, with a rooting phase in trays, then transfer to bags. Direct cutting in a propagating tunnel improves the efficiency of the technique. A one-hectare budwood garden can produce up to two million cuttings per year, for approximately 1,000 ha of plantings.

Recent developments in *in vitro* micro-cutting techniques and somatic embryogenesis suggest that increasingly high multiplication rates can be achieved. Little use is yet made of these techniques, except in Uganda, where somatic embryogenesis by temporary immersion (RITA) is used.

Coffee growers very often use seeds collected from selected varieties (hybrid or clonal) to set up new plantings. Unfortunately, seedlings obtained in that way are of a limited agronomic level; only seeds from seed gardens guarantee strong agronomic potential.

The key to choosing between clones and clone hybrids

The biology of *C. canephora* enables the selection either of hybrid varieties distributed in seed form, or of clonal varieties distributed in cutting form.

The strict self-incompatibility of *C. canephora* means that there is a certain degree of heterozygosity in hybrid parents. In theory, the progeny of a hybrid combina-

tion thus possesses a degree of genetic variability that can be exploited through clonal selection. The genetic progress provided by the best trees can rapidly be fixed through cuttings.

Seedling production is ten times cheaper than plant production from cuttings. Moreover, growers have a clear preference for seeds, as they offer many practical advantages over cuttings. Clones are distributed in rooted cutting or budstick form (for direct planting in a propagating tunnel). In both cases, the material is fresh and has a limited storage life: a few days. The conditions and duration of transport between the cutting production centre and village nurseries sometimes result in fatal deterioration of a large number of cuttings and budsticks.

Seeds are less fragile, easier to transport and can be kept longer: a few weeks. Coffee growers are perfectly familiar with seedling rearing techniques.

Hybrid varieties distributed in seed form would therefore seem to be more interesting from a socio-economic point of view. In Côte d'Ivoire, as in many countries, clones have nonetheless been chosen. In fact, the yields of the best clones were 30 to 40% better than those of the best hybrids. Of course, one of the aims of *C. canephora* varietal improvement is to identify hybrid varieties that are equivalent to the best clonal varieties.

Rational use of *Coffea canephora* genetic diversity

Up to the end of the 70s, *C. canephora* variety creation involved carrying out a large number of controlled or uncontrolled crosses, with a view to detecting clones with a strong general combining ability. However, these crosses were carried out at random and did not amount to exploitation of known genetic diversity in the species.

At the beginning of the 80s, two major genetic groups were identified within the species *C. canephora*: the Guineans, which originated from West Africa (Guinea and Côte d'Ivoire) and the Congolese, which originated from central Africa (Congo, Gabon, Democratic Republic of Congo, Cameroon, Central African Republic, Uganda, Angola). In addition, natural progenies derived from parents between these two groups, and the clones from such progenies, revealed vigour likely to have resulted from a heterosis effect. A reciprocal recurrent selection scheme (RRS) using

Guinean and Congolese materials as the base populations was subsequently proposed.

CNRA and CIRAD then set out resolutely down that path in Côte d'Ivoire. The RRS programme was launched in the mid-80s (figure). The first genetic gains expected for yield through the selection of between-group hybrids from RRS were estimated at 60% compared to the mean of the hybrids under test.

Hybrids as high-yielding and as uniform as clones

The first RRS cycle is now finished. The second cycle began in 1998. The highlights of the first cycle were presented in a thesis.

Following a comparison of the best parents from each population in a complete factorial design, it turned out that the production of the best between-group hybrids from the first selection cycle (RRS hybrids)

was equivalent, on average, to 85% of that of the best clonal control currently disseminated (clone 461). Among this set of elite hybrids, the highest yielders exceeded the clonal control, reaching 120% of its production. The potential of hybrids has therefore been virtually doubled in less than three decades (table).

These hybrids give very satisfactory average yields, at around 2.5 to 3 tonnes of merchantable coffee per hectare per year in absolute values—on-station potential—and reveal surprising genetic homogeneity. Their coefficients of variation for yield vary between 25 and 40%, corresponding to the coefficients of variation observed for clones. Moreover, in view of such remarkable homogeneity any attempt to select exceptional trees from these hybrids in order to identify clones that are better than the hybrid mean is difficult.

The good performance of the hybrids does not involve yield alone. Some of the

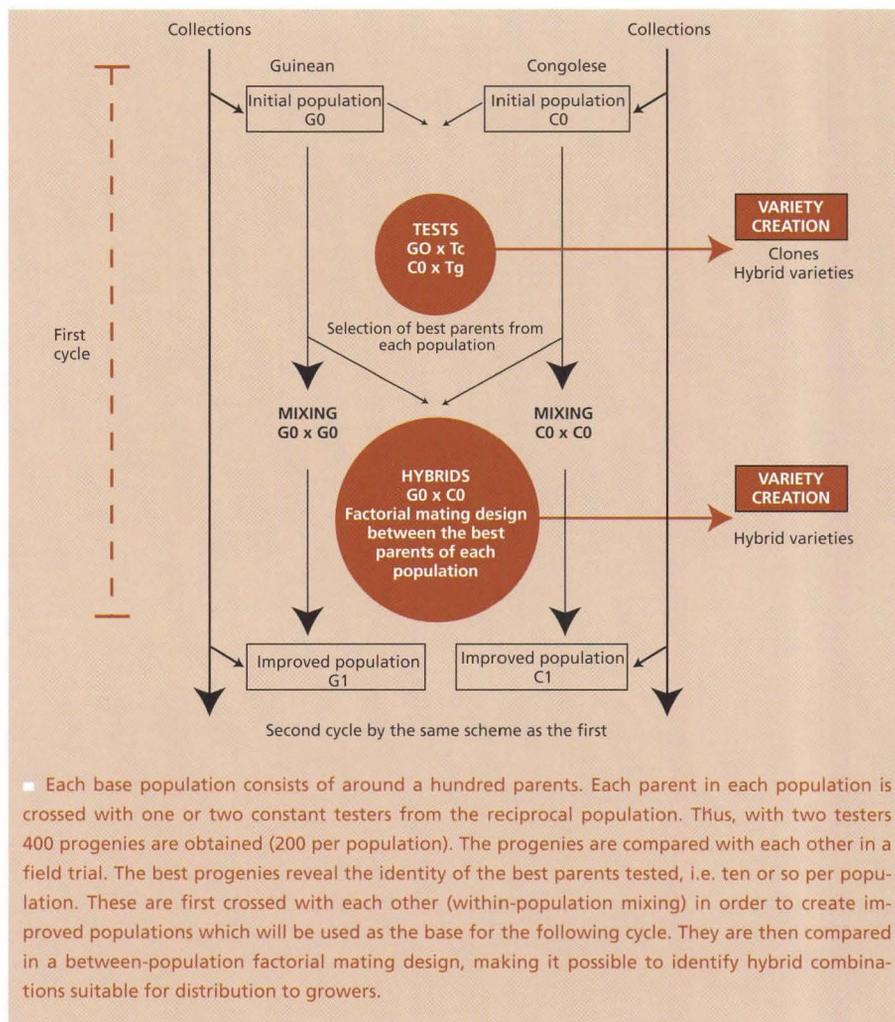


Figure. Reciprocal recurrent selection programme applied to *Coffea canephora* in Côte d'Ivoire (according to Leroy, 1993).

most spectacular genetic progress obtained for these new varieties has been for their compact and bushy architecture (photo). This architecture offers several advantages: easier harvesting, better ground cover limiting weed development, and increase in the harvest index (ratio between production and vegetative development), possible suitability for modernization of cultural techniques (increase in density combined or not with topping).

Bean size is acceptable (between 13 and 14 g for 100 beans with a 12% moisture content) and these varieties have leaf rust tolerance. Chemical and organoleptic analyses under way reveal quality that satisfies Robusta market expectations.

Conclusion

C. canephora varietal improvement has made a remarkable quality leap with the creation of hybrids that perform just as well as clones. This progress is down to active collaboration between CNRA and CIRAD.

Seed gardens are already being set up in Côte d'Ivoire and seed production for this new generation of hybrids can begin in the near future.

Proposing these hybrids to growers in seed form could "reconcile" them with improved varieties, from which many had turned away, discouraged by the problems encountered with obtaining and rearing clone cuttings in the nursery. ■

Photo. Four-year-old *Coffea canephora* hybrid variety.



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Table. Production potential of clonal and hybrid varieties before and after introduction of the reciprocal recurrent selection scheme (RRS).

	Clonal varieties	Hybrid varieties
Before RRS (1970s)	100	65
After RRS (2000 and beyond)	120	120

Production potential, base 100, for clonal varieties before reciprocal recurrent selection.

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