SCIENTIFIC APPROACHES FOR SEEDLING PRODUCTION IN COCOA

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Cocoa became an important plantation crop in the present horticulture scenario and is being cultivated widely under coconut and arecanut shades from 1970 onwards and contributing effectively to the environment with its heavy litter fall. The demand for dry beans in Indian chocolate industry and confectionaries is portrayed as 30,000 tonnes for the year 2015. The present area under cocoa in India is 46,318 ha and the total production is 12,954 tonnes. To bridge the gap and meet the requirement an additional of 60,000 ha to be brought under cocoa for which around 10 million seedlings are required. The foremost necessity to get sustainable and profitable yield in this perennial crop is the supply of good planting materials. Management of mother trees, selection of seed pods and method of raising seedlings in the nursery decides the performance of cocoa in the field and ultimately the quality of produce. Under National Horticulture Mission (NHM), with central/ state sector schemes, and with fundings by Directorate of Cashewnut and Cocoa Development (DCCD), Cochin, state departments of horticulture/ agriculture in southern states are entrusted with the work of multiplication of cocoa. Kraft Foods (Cadbury India Pvt ltd.) and Central Arecanut & Cocoa Processing and Marketing Co-operative Ltd. (CAMPCO) and regional nurseries identified by DCCD are also participating in the task of area expansion by raising nursery, production of seedlings in large numbers and supply to farmers under subsidized rates as well as free of cost. It is important that officers, extension officials and planters who are relatively new to this crop cocoa should have an exposure to both the basic and advanced nursery techniques. And so this article detailed the methods of cocoa propagation and efficient management strategies for cocoa nursery.

Common propagation methods

Cocoa can be multiplied both by seeds and vegetative means. Seed is the cheapest and simplest propagule of cocoa, which is available in large quantity and give a convenient growth habit. Seedling multiplication become advantageous in production of hybrid varieties since hybrid vigour is established. Vegetative propagation through grafting and budding is generally practiced in cocoa to get early yield and true-to type plants. This paper discuss about the seed propagation which is adopted widely.

Self incompatibility

The factor that affects the general fruit set in cocoa is incompatibility which is the failure of setting with the pollen from the same plant (self-incompatibility) or with pollen from other plants (cross-incompatibility). The incompatibility in cocoa is widely observed as gametophytic, where the pollen tubes develop normally but the male gamete does not fuse with the female gamete. But if the self incompatible clones are cross compatible they can be widely used in hybrid development. This incompatibility phenomenon varies with types of cocoa, for example Amelonado cocoa types are self compatible. Using multiple self incompatible clones may lead to lots of variability among progenies. Worldwide a variability level of 25% is accepted among cocoa populations of seedling origin. To overcome this limitation, seed gardens/ clonal orchards should be raised with few clones of known parentage and performance.

Seed gardens/clonal orchards

Identifying self-incompatible but cross-compatible high yielding parents through selection, multiplying them vegetatively and

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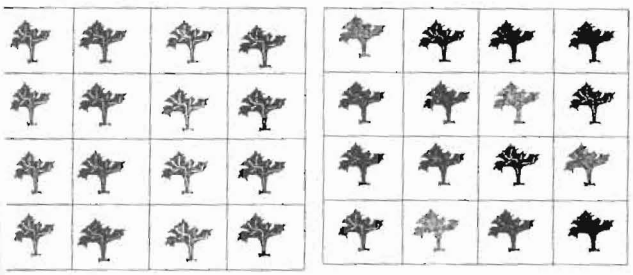
assembling them in an approved design or order is the concept of seed gardens/ clonal orchards. With two known parents they are called bi-clonal orchards and with multiple clones as poly-clonal orchards. It has been estimated that one acre of such a seed garden could produce enough seed to plant 500 acres in the fourth year and 1500 acres by the eleventh year. At Central Plantation Crops Research Institute (CPCRI), Research Centre, Kidu, Nettana, Kamataka, 6 bi-clonal and 1 poly-clonal orchards were established with a total of 1500 trees with selected high yielding clones. These pre-designed and well established gardens in isolation exclusively prevents undesirable crosses and produce genetically vigorous planting materials. Only research institutes like CPCRI and KAU are maintaining these types of clonal orchards for production of F1 seedlings. It is therefore necessary that Agri universities, state departments and AICRP centres should raise the clonal orchards to actively participate in the systematic cocoa area expansion programs with selected parental materials which are the output of long term research. DCCD in collaboration with CPCRI established 17 regional nurseries for this purpose.

Bi clonal orchard **Poly clonal orchard**



Regional nurseries established by CPCRI with DCCD funding

State	No.	Parental clones supplied
Kamataka	9	11,250
Andhra Pradesh	2	2,500
Tamil Nadu	3	3,750
Maharashtra	2	2,500
Goa	1	1,500
Total	17	21,500

Selection of mother trees

If a seed garden is not available nearby, the criteria for selection of mother trees should be strictly followed from among the cocoa population available.

- ✓ Mother tree should be more than 10 years old if it is of seedling origin or 6 years if it is of clonal origin.
- ✓ Generally trees of Forastero types, with green pods when immature and yellow when ripe, may be selected. Pods of Trinitario type (mixed pods) is also now widely used in Asian countries.
- ✓ High yielders>70 pods per tree per year should be selected and the international standard is 100 pods per tree per year.
- ✓ Pods of>350 g weight, with smooth or shallow furrows on the surface without prominent constriction at the neck can be selected.
- ✓ Husk thickness of pods to be more than 1 cm, it is advantageous to hinder the spread of pod rot or infection by sucking pests.
- ✓ Pod value (number of pods required to produce 1 kg wet beans) to be not more than 12.
- ✓ Number of beans per pod should be more than 35.
- ✓ The dry weight of single bean should be >1 gram.

Selection of seed pods

The stage of maturity is important in selecting seed pods. Cocoa pods will mature in 150 days under Karnataka and Kerala conditions.

- ✓ When the colour changes from green to yellow or red to orange, the pods may be harvested at $^{3}/_{4}^{th}$ maturity. Immature pods will give poor seedling growth and leaf abnormalities and over ripe pods tend to have

viviparous germination and rodent attacks will be more if pods are allowed to ripe on the tree itself.

- ✓ Seed pods free of *Phytophthora*, thrips, mealy bugs and tea mosquito bugs should be selected. If the damage is minimal they can be used, since the husk is protecting the spread to the seeds. Pods half eaten or damaged by rats and squirrels can be strictly avoided.
- ✓ Harvesting of seed pods should be done with a sharp knife. Since flowering in cocoa is cauliflorous *i.e.* fruiting in the trunk, care should be taken not to damage the flower cushions. Picking pods by pulling from tree will more often tear away the bark which affect the next season flowering in the trunk/ cushion.
- ✓ CPCRI developed a cocoa harvester with light weighted telescopic pipe and blades sharpened at both sides for smooth and efficient harvesting of cocoa pods.
- ✓ Well matured seed pods can be broken by hitting against a hard surface or with a wooden hammer and the seeds can be extracted without placenta.
- ✓ Cutting seed pods gently with knife may also be practiced with due care without damaging the seeds.

Seed standards and viability

- ✓ Seeds for sowing should be bold, large, weighing around 3 grams when wet and 1 to > 1 gram when dry.
- ✓ The best seeds for sowing are those from the middle of the pod. Flat beans develop at pod ends and they may be rejected.
- ✓ Seeds in cocoa are recalcitrant without dormancy period and so beans once extracted from pods should be sown immediately before loosing viability.
- ✓ Seeds start germination in about a week and will continue for another one week. Epicotyl type germination is noted where cotyledons are taken above ground in the process and is called soldier phase.
- ✓ Healthy seeds from well matured pods usually give a germination of 90 to 95 per cent. The rate of germination of cocoa seeds varies with maturity status, bean size and other inherent and external factors. Larger beans hastened germination and if shade is beyond 50% in the nursery it affects the growth and development of seedlings.
- ✓ Cocoa seeds will germinate at any time of the year with adequate irrigation. Seeds of clones begin germination within 10-15 days after sowing and seeds of hybrids germinate in 7-10 days after sowing. Seeds that do not germinate within 15 days after sowing as well as those with dead sprouts can be removed from the nursery.
- ✓ Matured pods will be available during May month under Kamataka condition and so sowing can be started. Sowing should be completed before the onset of monsoon otherwise continuous showers will affect the germination. Glass houses may be utilized during rainy season with mild misting facilities. May sown seedlings will be readily available for planting during September-October, the post monsoon season in the high rainfall zones like Kerala and Karnataka.
- ✓ Compact blocks on varieties raised with grafted plants showed second season of bearing during post monsoon season which will be good for nurseries in operation the whole year and it favours planting during June- July with onset of monsoon in low rainfall zones.

Storage of seeds

- ✓ Seed pods harvested at third fourth maturity can be kept upto 4 days in shade without breaking, but once open, the seeds should be

sown immediately and so the procurement of seed pods should be pre- planned if mother trees are not available.

✓ Correct stage of maturity favours long distance transports. If seed pods are stored beyond 4 days, viviparous germination will occur, which affect the number of good seeds, germination percentage and performance.

✓ Incidence of pod rot is observed if stored under humid conditions. Fumigation of seed stores with formalin may be followed.

✓ Germinability of freshly extracted beans can be extended for some more days by storing in moist charcoal and packed in poly bag for a period of four to six weeks, which favours transport of beans to far away nurseries instead of pods. This is mainly followed in hybrid exchange between countries. CPCRI received seeds stored in saw dust after removal of mucilage from Malaysia, Indonesia and Philippines, which showed 80% germination after 20 days.

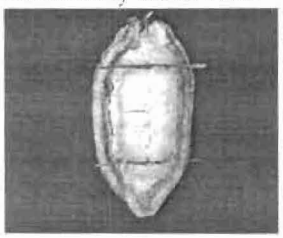
Seeds treatment, sowing and preparation of nursery

✓ Cocoa seed is surrounded by a mucilaginous pulp which contains a germination inhibitor. Germination can be speeded up by removing this pulp. Rubbing of the beans carefully with dry sand or wood ash to remove the mucilage is practiced in India. If sown with mucilage insects/ pathogens will be attracted.

✓ Seeds should be kept horizontally or vertically with hilum end down and just covered with sand. Pushing of seeds deeply into the potting mixture should be avoided.

✓ The normal practice is to plant the fresh beans directly into the bags in nursery for easy loading and transportation. However, germination in sand/ raised beds has been advocated by planters in their gardens to get uniform seedlings and for their own planting material production.

Extraction of middle beans



Removal of mucilage with sand

Raised bed nursery-by planters

✓ Small, plain and flat plot with adequate sun light (25- 50%), rich soil and water source should be selected for cocoa nursery in raised beds.

✓ Soil should be tilled fairly deeply and lumps of earth should be broken up to get a fine tilth and can be added with farm yard manure and sand.

✓ Beds of 90-120 cm width and of any length are preferable. A path of 60 cm as walking space between one bed and the next to monitor the nursery is needed.

✓ While sowing, enough space between furrows and seeds should be given which will enhance better growth before transplanting to main field.

✓ The seed beds can be covered with suitable mulch as shallow layers with coconut leaves, straw or green leaves etc. to conserve moisture and check the weed growth. But it should be removed in appropriate time not to affect the epigeal germination.

✓ Upto 4 months seedlings can be kept in the nursery beds. Transplanting to poly bag or repotting may be practiced after the fall of cotyledons or at two leaves stage, if required.

✓ Young cocoa seedlings are very delicate and should be protected from the sun by putting them under shade net at 180 cm high above each bed or by covering with palm fronds.

✓ Sorting of healthy seedlings is possible in the nursery bed. Seedlings which are smaller and late germinated can either be moved to

another bed or poly bag to prevent them from crowding or can be thrown away if they are weak.

Polybag nursery- by govt. and private nurseries

- ✓ To get better root and shoot growth, to make the planting and transportation easy sowing seeds in polythene bags is being followed. Polybags are usually cheaper, more durable and simpler to store.
- ✓ Polybags of 6"x 9" size, 250 gauge thickness, black colour with around 9 drainage holes, filled with potting mixture 2:1:1 Soil: Sand: FYM is standardized at CPCRI. Early and high percentage of germination was observed with farm yard manure. Black polybags are providing more solarisation effect.
- ✓ Big poly bags of 30 cm length and 20 cm width can also be used if the seedlings are to be kept in the nursery for longer periods and for use as rootstocks for grafting/budding.
- ✓ Organic manures like coir compost, vermicompost and bean shell also been used in potting mixtures as alternate sources.
- ✓ Soil solarization by sun drying and covering of potting mixture or nursery bed with black polythene sheet during March- April and green polythene sheet during post monsoon season will enhance seedling vigour and health. Soil solarization for 30 days in April resulted in effective germination, growth of seedlings and reduced weeds and die back incidence.
- ✓ Biopriming is an advanced technique of application of plant growth promoting microbes to potting mixture to enhance seedling growth and health. Different microbial cultures isolated from cocoa gardens of various locations are tested for their efficiency and the fluorescent pseudomonads, *Pseudomonas putida* biovar A. KDSF 23 and *Pseudomonas sp.* KDSF 7 are identified as suitable for cocoa, which are isolated from cocoa gardens of CPCRI, Research Centre, Kidu. After completion of soldier phase of germination, i.e. 1 month after sowing 20 gram of culture powder was added which enhanced the vigour and health of seedlings.
- ✓ Arranging poly bags in rows of 10, bulk of 1000, leaving 1 ft path between for monitoring and irrigation, supporting with strips of bamboo and covering with shade nets or by thatches during hot season are advisable for good management.
- ✓ The initial shade is usually quite heavy, somewhat in excess of 50 percent but decreases as the seedlings grow. Shade net (75%) nursery with permanent pillars in an area of 2 acres will hold 50,000 bagged seedlings.
- ✓ Young seedlings needs lots of water and should be irrigated gently every day in summer and once in alternate days in other seasons. Sprinkler/microjet irrigation is suitable for cocoa nurseries during early stages of germination and growth, whereas hose method is practiced in the later stages.
- ✓ For efficient quarantine, production of seedlings in mist chambers, glass/ green houses etc. with automated temperature controls is preferred. Upto 2 months they can be kept in glass/ green house with fine misting and can be taken out after that because bending of seedlings was observed with altering temperatures.

Seedlings in glass house *Seedlings in net house*

Nursery diseases

Seedling blight *(Phytophthora palmivora)*

The symptoms develop on the leaves and stem of the seedlings. On leaves, small water soaked lesions appears which later coalesce resulting in leaf blight. On stem, water soaked linear lesions develop initially and later turn to

black colour. Stem infection develops at any point on the stem causing the death of seedlings. Severely infected seedlings should be removed from the nursery and destroyed. Drainage should be improved and shade should be adjusted. Spraying 1% Bordeaux mixture or 0.3% Copper oxychloride or 0.3% Potassium phosphonate just before the onset of monsoon and thereafter at frequent intervals is recommended.

Vascular streak die-back (VSD) *(Oncobasidium theobromae)*

This disease is prevalent in Central Kerala. The first indication of the disease is the characteristic chlorosis of one or two leaves on the second or third leaf behind the tip. The pattern on the diseased leaves develop as small sharply defined green spots scattered over yellow background. Diseased leaves fall within a few days after turning yellow. Leaves above and below the first diseased leaf soon begin to show yellowing with green patches and these also fall off finally resulting in death of the seedlings. Leaf scars from the fall of chlorotic leaves are sometimes covered by a white, loosely adherent fruiting body of the fungus. If the diseased stem is split longitudinally the xylem is found to be discoloured by brown streaks. The seedlings may be destroyed as and when symptoms appear in the nursery. KAU developed resistant varieties which may be grown.

Nursery pests

Myllocerus weevils *(Myllocerus viridanus)*

Adult weevils skeletonise the foliage and this is serious in young plants during July to September. Spraying under surfaces of the foliage with Fenitrothion 0.05% or Quinalphos 0.025% or Fenthion 0.05% is recommended.

Nursery management in diseased tract

Nursery shouldn't be raised in areas susceptible to vascular streak die back (VSD) and Bioversity international listed whole pods and budwoods under high risk and seed at low risk category for exchange and germplasm movement and intermediate quarantine is recommended. For *Phytophthora* pod rot transfer as seeds/ seedlings will reduce the risk of spread than pods. Poly green house can be utilized for screening, protection and hardening of seedlings. As cocoa is very sensitive to drought, daily watering should be done during summer and drainage facilities should be improved during rainy season to avoid die back and seedling blight. Preventive spraying with copper fungicides may be practiced. Seasonal surveillance and control for pests and diseases should be taken up. Neem coated urea or other composts may be added to enhance vigorous and healthy growth. The nursery should be kept free of weeds to allow good growth of the seedlings.

Nursery recognition

Labeling seedlings with details of date of sowing, age of seedlings, name of varieties, size and health of seedlings is the responsibility of nurseries run by research institutes to assure the quality of seedlings. Standards of both seedlings and vegetatively propagated plantlets are developed for cocoa. With all these scientific methods of nursery raising, cocoa nurseries of CPCRI at Vittal and Kidu got 48* recognition by National Horticulture Board. Selection of seed centres with sufficient high yielding parental source plays a major role in perennial crops. Before taking up nursery works, basic needs of mother trees, shade and water source should be verified. Further implementing the technological advancements related to cocoa, seasonal operations and timely management will enhance production of quality planting materials in sufficient quantity.