Coconut artificial pollination management system

The coconut palm (*Cocos nucifera*) is a member of the family Arecaceae and the only species in the genus *Cocos*. There are two types of trees, talls and dwarfs. Talls are predominantly cross-pollinated, whereas the dwarfs are predominantly self-pollinated[1,2]. Major achievement in crop improvement has been the development of high-yielding varieties, including hybrids[3]. Heterosis among seedlings of crosses between talls and dwarfs has been the basis for developing hybrids in coconut[4]. Since then, many hybrids have been developed and released for commercial cultivation. Production of hybrid seedlings in coconut involves several steps, including laborious pollination that has to be carried out on the crown. Planning, monitoring and recording data in a pollination programme assume importance when hybrids in large numbers are to be produced. Managing a pollination programme in coconut can be made efficient by developing an intelligent computing system that can help in planning and monitoring. The system developed can be used for other crops of similar nature, especially tree species.

Knowledge on intricacies of floral biology in coconut is the first requirement in developing a pollination database. Coconut produces leaf primordial approximately at the rate of one leaf in a month. Each leaf axil in an adult palm produces a spadix or inflorescence. It is a monoecious tree with the female and male flowers present on the same inflorescence. The coconut palm is protandrous and male flowers open immediately after splitting of the spadix. Anthesis starts from tip of the distal spikelets and progresses towards the bottom (proximal) of the inflorescence. In tall palms, the duration of male phase is about 18–22 days, depending on the characteristics of the palm, the growing conditions and season. It is estimated that an inflorescence contains about 180–360 million pollen grains. Female flowers become receptive when they open with three protruding stigmas and nectar is secreted. The female phase is much shorter than the male phase and lasts for about 5–7 days in tall palms and twice as long in some dwarfs. In the coconut tall palm, there is a distinct gap between the male and female phases aiding cross-pollination. In dwarf palms and hybrids, the interval between the two phases is either nil or negligible, thereby increasing the chances for self-pollination. It takes about 11–12 months for the flower to develop into a fully mature fruit after fertilization. Only about 25–40% of the female flowers develop into fruits.

Artificial pollination for hybrid production starts with emasculation, the removal of male flowers from the inflorescence of the female parent to avoid self-pollination. To avoid contamination, this is done on the day of inflorescence opening. Bagging of emasculated bunches is required for the entire period of the female phase and pollination. Male flowers from an inflorescence are collected 6–8 days after opening. Flowers are then processed to collect pollen. For effecting pollination, pollen is released to cover the female flowers in an inflorescence within the bag. The process is repeated on the first, third and fifth day starting from the day when the first female flower comes to receptivity. The bags are removed 2–3 days after completion of pollination. Each inflorescence is labelled to complete the artificial pollination. Pollinated nuts are harvested 11–12 months after pollination is completed. All the operations in artificial pollination like emasculation, bagging, application of pollen and bag removal are timed from the date of bunch opening, i.e. when the inflorescence splits open to reveal the spikes.

Meticulous planning and execution are required to ensure fertilization and nut set on artificial pollination. Supervision and monitoring the pollinators are important in timely completion of pollination. Record-keeping and tracking each palm is essential to increase efficiency of the artificial pollination. When a large number of palms is pollinated using many pollinators, monitoring and tracking become difficult. Developing a database to aid in the process will make the work more efficient. The database is required to help in both decision-making and tracking the process of pollination. Based on the above requirement, the database, coconut artificial pollination management system, has been developed for managing artificial pollination in coconut.

The database meets the two requirements of review of work done and planning for future work. 'Input data' includes bunch opening date, bagging date, date of pollination, number of flowers pollinated, source of pollen, number of nuts set, date of harvest, number of nuts harvested, name of pollinator and name of supervisor. 'Output' includes the number of bunches pollinated in a palm, number of female flowers pollinated in a bunch and in a palm, percentage of nut set, number of nuts harvested from a bunch and a palm, number of pollinations effected by a pollinator, number of nuts obtained per pollinator, number of nuts obtained per male parent, etc. In addition to these calculations, the database also helps in decision-making by analysing data of the previous year. It is possible to estimate date of emasculation, bagging, pollination, bag removal, etc. in advance based on the bunch opening date. Knowing the date on which a particular bunch in a palm has to be emasculated, bagged, and pollinated, it becomes easier to plan and monitor the pollination process.

For database implementation, data were stored in MySQL running on a Linux server. The database interface was implemented using PHP and HTML.

Data entry can be done by clicking the 'Data entry' option (Figure 1). This is protected by username and password. The data entry form contains 23 fields.

Figure 1. Data entry fields. ***a***, Login field; ***b***, Data entry form.

Figure 2. Data retrieval fields. ***a***, History: for retrieving data in the database; ***b***, Plan: for planning work on a palm; ***c***, Monitor: for knowing work to be carried out on a particular day.

'Palm number' is the first field, which identifies a palm. The second field is the 'plot'; the field in which the particular palm is located. Next is the 'pollinator' field, identification of the pollinator who is doing the artificial pollination for that particular palm. The next two succeeding fields are 'male parent' and 'female parent' of that palm. 'Bunch number' is the next field. 'Bunch opening date' has to be entered after the bunch number. Each bunch is unique, that can be identified by a combination of bunch opening date and palm number. 'Emasculation date' and 'bagging date' are the next two entries. 'Number of female flowers' in a bunch is the next field. 'Pollination date' consists of two columns: 'pollination date' and 'number of flowers pollinated'. In each bunch, there are many female flowers that become receptive sequentially. Hence, the process of pollen application may extend for two or more days. 'Bag removal date' is the next field to enter. This is followed by the 'date of harvest' field. 'Initial', 'first' and 'second settings' are the next three fields. The last field is the 'number of nuts' harvested. There are three options at the base of data entry form, viz. 'insert', 'reset' and 'edit'. The 'insert' option is used to insert data into the database; for resetting at middle of an entry, the 'reset' option can be used; any change after entry can be made using the 'edit' option. It is also possible to edit existing data by entering palm number, plot, year and bunch number.

In the home page of the database there are three options: 'history', 'plan' and 'monitor' (Figure 2). Under 'history', all details of pollination work done till date in a year on a particular palm or individual bunch, can be retrieved by entering the palm number, plot, bunch number and year. There is a 'Generate Excel' option in the page which can be used to get entire data in the database in an Excel work book (Figure 2 *a*).

The next option is 'plan'. This is provided to plan pollination work on a particular palm. On clicking 'plan', a window pops up where details like palm number, plot number and bunch number can be given. The system will estimate probable dates on which the particular bunch in a palm has to be emasculated, pollinated, bagged or bag removed. The estimate is based on the bunch opening date that is already entered into the system and on the basis of the previous year's pollination behaviour of the palm (Figure 2 *b*).

'Monitor' is the next option which helps monitor the pollination works. There are three input sections in this page. Monitoring is possible at three levels; work of an individual pollinator, various work to be carried out on a particular day, and what work to be carried out on a particular palm on which date. It is possible to monitor the work of a pollinator. For this, the pollinator's name is given to get his/her work on a particular day. Next level of monitoring is on palm. Here, by giving the palm number, it is possible to get information on a particular day's work or that for the next few days on that palm. By inputting a date, the system will generate information on work to be carried out on that day allowing complete monitoring (Figure 2 *c*).

The Coconut Artificial Pollination Management System has been in use at ICAR-Central Plantation Crops Research Institute, Kararagod, Kerala for the last three years. The system has been validated during these years by testing in the field pollination process and has been immensely beneficial in terms of decision-making and also tracking and monitoring the process of pollination. The system developed allows generation of data in an Excel work book that helps in analysis and further refinement of the pollination process. The system can easily be adapted to other perennial tree crops, especially for palms like arecanut. The database can be accessed at http://14.139.158.118/bioinfo_db/hybridization/index.html. Login details will be provided, on request, for academic purposes.

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ACKNOWLEDGEMENT. We thank the Department of Biotechnology, Government of India for fund (Distributed Information Subcentre).

Received 29 October 2015; revised accepted 1 March 2017

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