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Future Prospects of Artificial Pollination In Tree Crop Production: A Review

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ABSTRACT
Artificial pollination has been chosen as the substitute against entomophily (pollination by bees) where pollens are manually sprayed to the stigma for the further fertilization, multiplication, production and formation of seeds and fruits. The size and quality of the fruit is comparatively higher than through natural pollination. It has higher financial gains in terms of yield. Artificial pollination efficiency depends on many parameters such as pollen quality (germinability, humidity, and conservation), pollination system (dry or liquid), coadjuvantes, and flowering stage. Meanwhile, growers have already started to use the application of mechanical pollination, applying pollen as dust with puffers carrying them on backpack or mount on an all-terrain vehicle. The advancement in the artificial pollination includes Ionic Liquid Gels(ILG's). Ionic liquid gels exhibit various physiochemical properties. The use of biotechnology for ionic liquid gels (ILGs) enables to device aversatile complex that are fully controlled through sorted pairing of consisting molecules. A mechanized pollinator facilitated with ILG-coated functionalized fibres can effectively adsorb and desorb pollens from flowers.A critical review can be considered in favouring artificial pollination and use of artificial pollinators in tree crop production.
KEYWORDS: Artificial pollination,Bees, Drones,Ionic Liquid Gels, Pollen,Pollination

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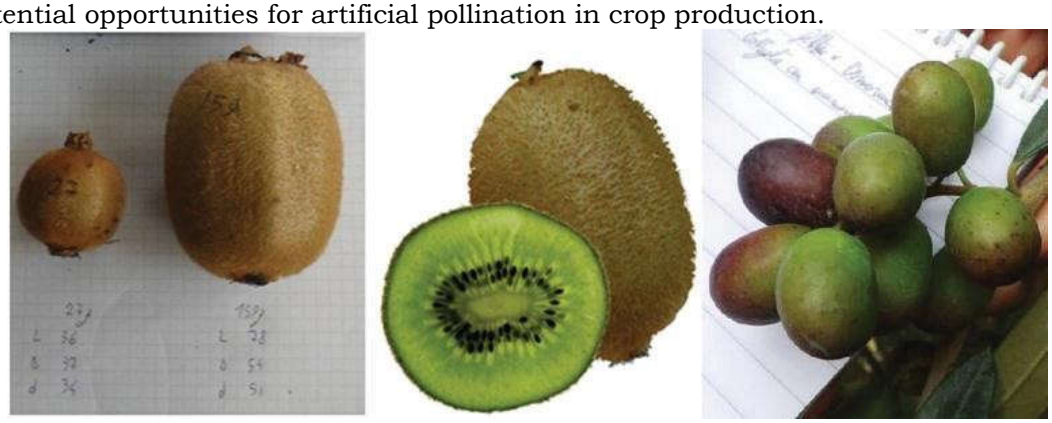
INTRODUCTION

"As the world seeks to slow the pace of climate change, preserve wildlife, and support billions of people, trees inevitably hold a major part of the answer. Multiplication of trees in the ecosystem is a must for the sustainability. Reproduction of plants could be done either by using seeds or through pollination or asexually."

In agriculture, pollination is an important input of crop production, comparable to any other input such as fertilizer, labour, pesticides etc. Pollination is the act of transferring pollen grains from the male part(anther) of a flower to the female part(stigma). The goal for every living organism, including plants, is to create offspring for the next generation. The only way a seed can be produced is by the transfer of pollen between flowers of the same species. For pollination, to take place the pollen must be taken from the stamen (male part) to the stigma (female part). The transfer of pollen grains from anther to stigma of same flower or different flower of same plant is called self-pollination. While, the transfer of pollen grains from anther to stigma of a different plant is called cross pollination. Cross-pollination produces stronger plants. The plants must be of the same species. The dependability that reproduction of most fruit crops has from pollination makes it of paramount importance in agricultural production. Adverse environmental conditions can negatively affect the production and the transport of pollen, either carried out by biotic or abiotic vectors [1-3]. The transportation of pollen by insects may be affected by factors such as the use of

pesticides and diseases. Agricultural economies like India are at greater risk of bee decline. Amongst the 160 million hectares (ha) cropped area in India, some 55 million ha depends on honeybees for pollination. Without them India's food production will reduce by one-third [28].

To compensate the need of bees as pollinators, the pivotal role now is played by, yet another form called: artificial pollination. Artificial pollination came to existence when humans interrupted with the natural pollinating process. They carry pollen from one flower to another, allowing the pollen to fertilize the ovaries and develop seeds that will further transform into fruits and new plants [4]. The process is often done with the help of a cotton swab or small brush but can also be done by removing the petals from a male flower and brushing it against the stigmas of female flowers, or by simply shaking flowers in the case of bisexual flowers such as tomatoes. Hand pollination is used with date palms to avoid wasting space and energy growing enough male plants for adequate natural pollination [5]. Artificial pollination also leads to increased final set, weight, kernel recovery, and, in many cases, fruit quality in terms of nutritional characteristics and shelf life(figure 1).This pollination technique is more economical and allows proper use of pollen as well as adequate control of the timing of pollination. Dried pollen could originate from the last season, from early maturing males of the same season, or from few days' old male flowers. It has taken the charge over the years due to the decrease in the population of bees (natural pollinating agent). In countries like China, 100% of some crops are pollinated artificially. The need to develop an innovative pollination tool does not require time and effort to achieve pollination with a high success rate is urgent [5-7]. This paper outlines the potential opportunities for artificial pollination in crop production.



(Figure 1) Different size of kiwifruit due to inefficient natural pollination.

ARTIFICIAL POLLINATION

"Around 70% of crops need cross pollination; however the number of insect pollinators has fallen dramatically over the past 50 years, a problem that threatens the future of food industries. Eloise McLennan explores whether robotic bees could provide a solution as a part of artificial pollination."

Artificial pollination is where human beings interrupt the natural pollination process and manually dust pollen onto the stigma of the flowers where the number of pollen is comparatively more than pollination through bees. It acts as an alternative against the decline of population of bees and guarantees the increase in financial yields in terms of fruit quality and quantity. Financial gains of millions in food are possible only from efficient pollination that has been proved through research experiments. Artificial pollination could also be called as mechanical or biological pollination. The mechanical pollination involves the use of hands, drones or other mechanical equipment whilebiological pollination includes the use of ILGs (Ionic Liquid Gels). Artificial pollination can be accomplished with the use of a brush to apply the pollen on stigma of the flower. Plant breeders improvise the parent plant varieties and create new offspring with improvement in their appearance, resistance to disease, yield and other characteristics using this technique. Different varieties of maize, rice and wheat were introduced by using artificial pollination method. Artificial pollination is not a recent topic; it was carried out in the old times by the name of caprification, consisting in the pollination of Smyrna figs through fig wasps [27]. Artificial

pollination can solve the problems of crops that cannot produce fruits naturally example Vanilla. It can also sort the problem due to lack of pollen dispersed on the flower. Moreover, the work done by bees is completely decreased at the time of bad weather conditions like rain, storm, drought etc. hence artificial pollination acts as an alternative against it. Presence of diseases or pests in the locality may also effect natural pollination and hence favours artificial pollination. It must be taken as the insurance against fail of natural pollination. Artificial pollination also leads to increase final set, weight, kernel recovery, and in many cases, fruit quality in terms of nutritional characteristics and shelf life. This allows complete control over the pollination process making it the most reliable source for production of tree crops. This paper outlines the potential opportunities for artificial pollination in tree crop production.

ARTIFICIAL POLLINATION IN CERTAIN TREE CROPS:

KIWI FRUIT TREE-

Kiwifruit(*Actinidia chinensis var. deliciosa*) is a dioecious plant, and in order to have good pollination, in orchard, there are female and male flowers in the ratio 6:1 and growers use artificial pollination as the only source for its production in most parts of the world (MacDaniels 1931)(figure 2). Growers collect pollen manually from male flowers and spread it onto female flowers. Scientists are experimenting different ways to find the best way to do this, including the appropriate time to pollinate kiwifruit flowers and what amount of pollen to use. In the recent years, kiwi fruit vine artificial pollination has gained popularity and has become a widespread practice to increase the quality of the fruit [6-8]. The size of the kiwi fruit is directly proportional to the number of seeds or the number of fertilized ovaries. Kiwifruit artificial pollination was first studied by Dr. Hopping in New Zealand and in Italy, in collaboration with Dr. Cacioppo and Dr. Galimberti in Latina, in the late nineties [9]. High-quality pollen is basic for good results: germinability, germination energy, and humidity were evaluated under different conditions of pollen harvesting, conservation at different temperatures and time of interpretation at different temperatures and operated before and during pollination in different pollination systems i.e. dry and liquid. The experiment conducted on the pollination of kiwifruit stated that the highest pollen quality was obtained when the pollen was picked up from the collecting machine frequently during the day (about every hour), to avoid any stress [10]. The complete research and the statistical data showed that Kiwifruit artificial pollination, in conventional orchard, increases the production up to 30% due to bigger fruit size [19-23]. Pollination by manual dusting machine, although with somewhat inferior results, is faster and appears to be an interesting option at least complementing the bee population. Non pollinating flowers have poor fruit set and develop pigmy fruits, most of them dropping before the harvest. Good pollination is essential in order to obtain high production and optimal size and fruit quality.

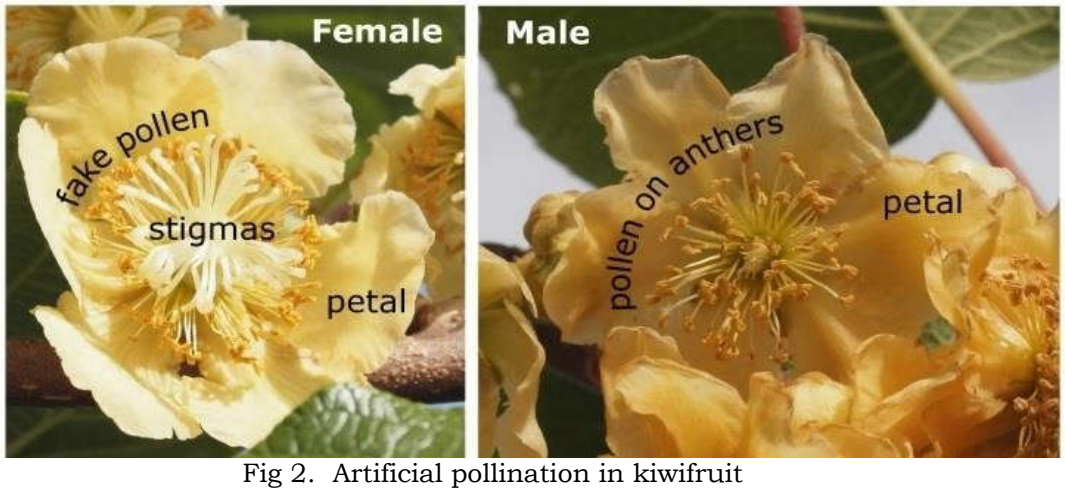


Fig 2. Artificial pollination in kiwifruit

DATE PALM TREE-

The term "artificial pollination" refers to the aid in pollination by humans with a desired pollen source, to improvise various fruiting traits in a dioecious fruit crop like date palm. Artificial pollination is especially suitable for dates [8-10]. Pollen production in this species is huge. Artificial pollination makes it possible for the improvisation of the yield and quality traits of dates. The selection of the pollen source greatly determines the desired success in the artificial pollination programmes. In case of artificial pollination in date palm (*Phoenix dactylifera*), some pollen parents contribute towards the increase in yield, whereas some improves the fruit quality or hasten the physiological maturity period [20]. These trees are cultivated not only for their valuable fruits (dates), but also for producing fuel, fibre and as shelter for ground crops. It also provides a favourable environment for the cultivation of other species such as olives, figs, vegetables and so on. Lack of effective pollination leads to the formation of triple parthenocarpic fruits that are of no economic value. Although fertilization and fruit set are the two major results of pollination, there is still another interesting but uncommon effect called "Metaxenia": the direct influence of pollen on the maternal tissues of the fruit. It has been observed that some date cultivars had better yield when pollinated with selected males rather than with others. With all the research experiments and surveys conducted, it is quite evident that the conventional date palm breeding is a time-consuming process and constitutes a laborious task. Indeed, because of metaxenia, the selection of pollen from other species to pollinate females could improve yields, fruit size, quality and even produce seedless fruits [14, 17, 18]. The long-term continuity of plant breeding programs and associated researches must be in concordance with the future crop profitability. On the other hand, market niches and production chains must be studied, as a way of avoiding wrong decisions about the crop possibilities.

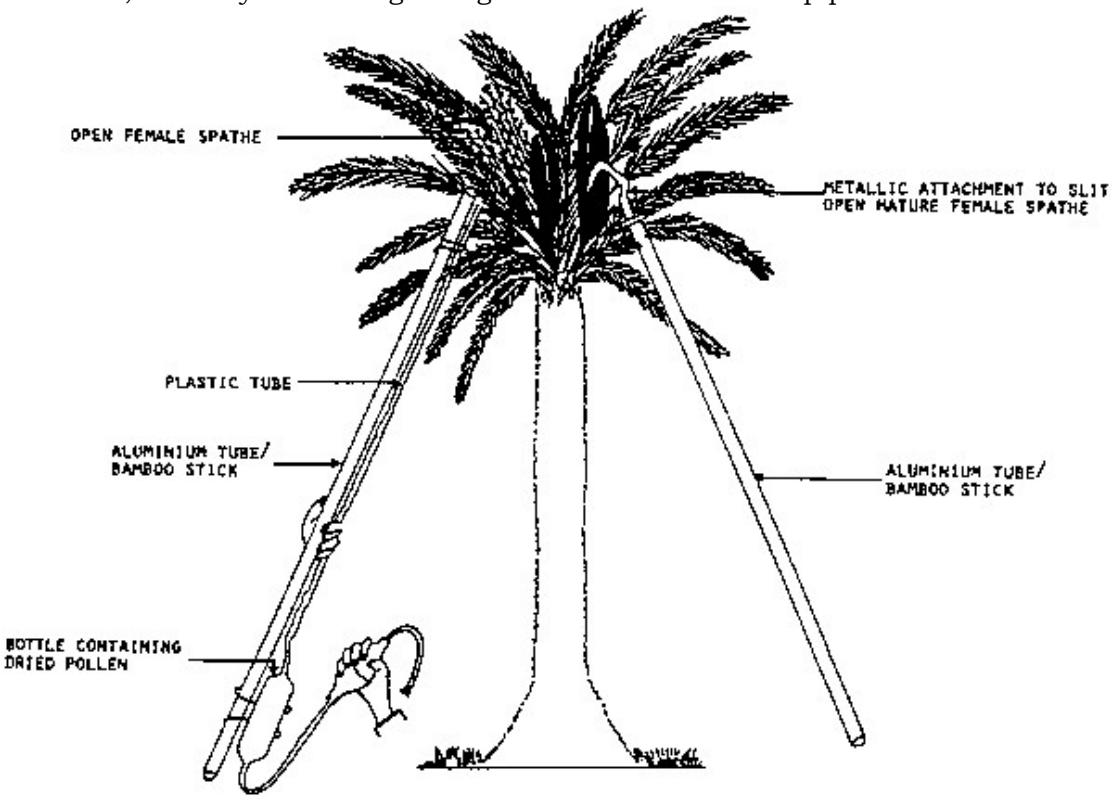


Fig 3. Various components of the hand pollinators being used in date palm

POLLEN APPLICATION METHOD:

In both anemophilous and entomophilous species, hand application of pollen to the flower or inflorescence, using brushes or sprayers, often produces the best results in terms of increasing production and improving fruit quality. To reduce the cost of artificial pollination, mechanized application methods have been proposed. These methods reduce time and labour but require large amounts of pollen since usually the whole tree is sprayed with pollen. These devices can be either carried by workers or mounted over vehicles;

occasionally, forklifts are used to pollinate large trees [2]. The application of pollen with the help of air crafts or helicopters is more profitable due to speed and homogeneity [21]. In the anemophilous date palm, aerial pollination by air crafts has generally been considered [22-25].

Fig 4. Hand pollination

Numerous authors have tested mechanical sprayers as the source for artificial pollination with mixed results. Electrostatic forces have been used recently as an aid for mechanized pollen application in date palm.

Pollen is normally dry-applied, although in some cases the application of pollen in a water-based suspension by using pollen sprayers has proven successful. The amount of pollen required for artificial pollination depends on the species, the effectiveness of the application method, pollen viability, and the number of needed applications. Ground application in an all-terrain vehicle provided with an adapted leaf blower placed behind the driver or with a duster controlled by an operator has also demonstrated usefulness [24].

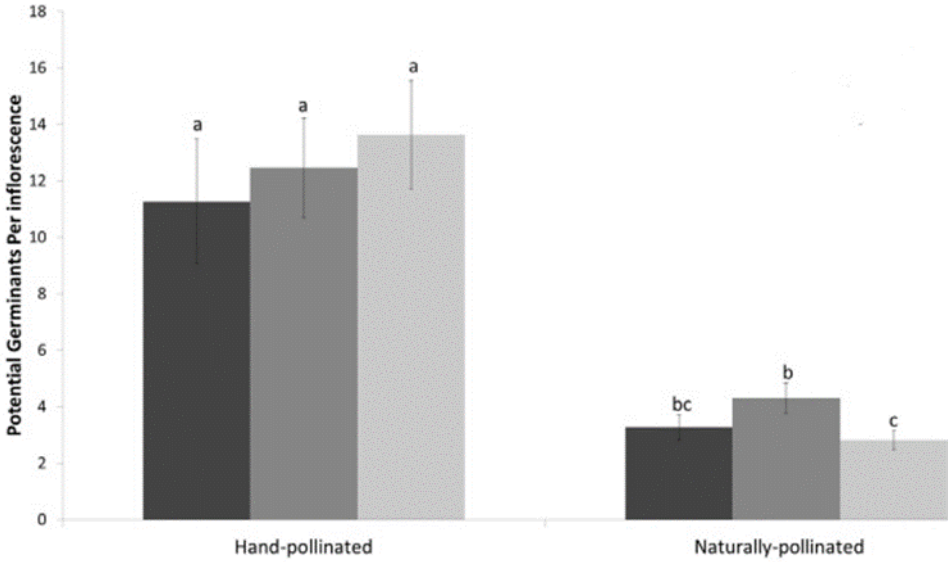


Fig 5. No. of potential germinant per inflorescence in case of hand pollination and natural pollination

USE OF ARTIFICIAL POLLINATION IN FUTURE

Will we have fruits in future without the bees? So, it's certainly true that the loss of bees and other pollinating insects would limit our fruit choices [15]. But what would be the scenario if bees extinct completely? We surely have an alternative for it. In many countries like China, humans pollinate 100% of fruit trees by hand. Artificial pollination is a substitute which offers an effective pollination in tree crops and reduces the unreliability arising from natural pollination reducing the need of plant pollinizer cultivars. In

agriculture, pollination is an important input of crop production, comparable to any other input such as fertilizer, labour or pesticides. Improvement of assisted pollination depends on an economic process of pollen harvesting [16-20].
One pollination technique requires the application of pollen with an artist's brush or cotton swab from male to female flowers.
An insect sized drone capable of artificial pollination. They are coated with a blotch of horse hair bristles and an ionic liquid gel, these pint-sized robots have the ability to collect and transfer pollen from one plant to another (Fig6)

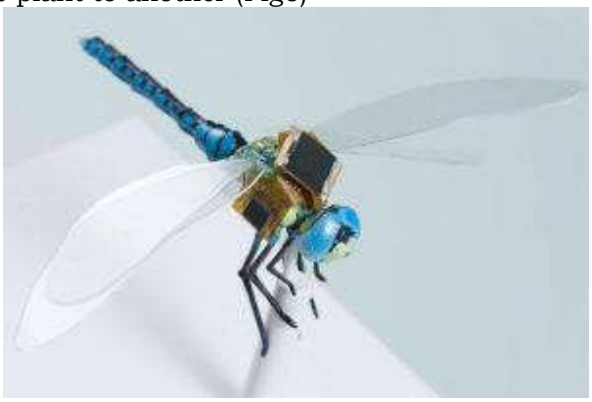


Fig 6 Pollinating drones

Other in the list is ILG. Ionic liquid gels exhibit various physio-chemical properties. The gel-coated fibres allow effective pollen collection. In contrast, ionic liquids show great potential for use in numerous scientific and technological applications in various fields [22].
Another advancement in this field uses a spray machine, such as a gun barrel and pneumatic ejector.

CONCLUSION

The vision for precision pollination systems that do not include pollinators appears plausible. Clearly the results should be considered promising yet preliminary. Pollinating artificially is the key practice just like the use of fertilizers or pesticides nowadays. The use of pollinators like robotic drones, chemical usage must be favoured in order to avoid any shortage of fruits and vegetables in the coming future. Artificial pollination will act as a substitute against the declining population; making it convenient to reduce any loses and manually pollinate the crops. Many programs and research projects are on the way to overcome this problem by using friendly management practices in horticulture. Subsequently, artificial pollinators like robotic drones will function similar to bees and help the farmers in promoting pollination and production of crops that use to pollinate by insects. The use of artificial pollinators will further reduce the wastage of pollens and extra space required to store them in case of in vitro. Pollination through this technique would help to conserve pollens and produce bigger fruits in comparison with natural pollination which will decline in future. For some fruit trees artificial pollination suits economically beneficial and adds to the natural pollination. Implementation of pollinating tree crops artificially requiresleast expensive and efficient method for pollen conservation, storage, multiplication and utilization. The science and technology in this field will improvise the sight of artificial pollination. Industries will be developed to ensure and check the pollen viability and this would help farmers to apply pollens efficiently.

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