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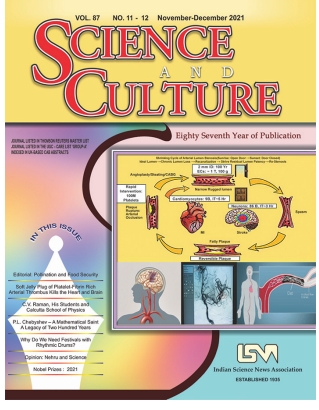
EDITORIAL

POLLINATION AND FOOD SECURITY



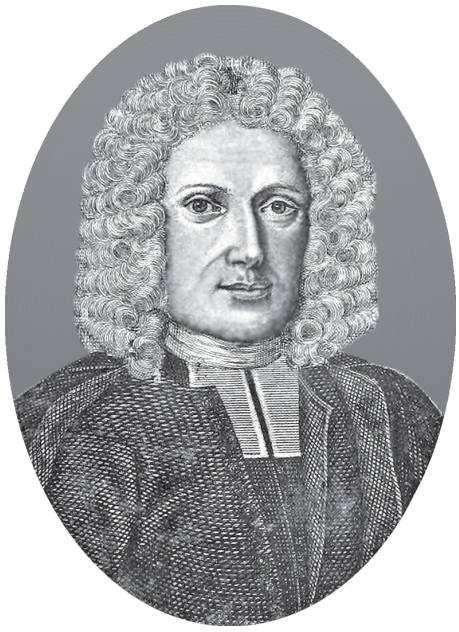
India is a country with a great diversity of natural endowments such as soil, climate, ecological regions, flora and fauna. When we look the growth in food grain production from the planned era of development, it is clear that Indian agriculture is progressively moving up in spite of troughs in food grain production in some years. This has been possible largely due to the massive application of science and technology in the field of agriculture jointly by the Government and our farmers to achieve the green revolution. The success came only with the help of high-yielding varieties which are efficient in converting plant food into human and animal food. These high-yielding seeds are also high-eating seeds; they can consume a lot of fertilizers and manures. Bio-fertilizers are cost effective supplements to chemical fertilizers and can help us economize on the high cost of developing our fertilizer industry. It is, therefore, necessary to understand the critical importance of biotechnology of which bio-fertilizer is only one part.

More than 218,000 of the world's 250,000 flowering plants, including 80% of the world's species of food plants, rely on pollinators for reproduction. Globally, of the estimated 1330 crop plants grown for food, beverages, fibers, spices and medicines, approximately 1000 (75%) are pollinated by animals. It has been calculated that pollinators deliver one out of every three mouthfuls of food we eat, and beverages we drink. Pollen, the male partner in the fertilization process of flowering plants, provides an excellent material for several physiological and biochemical studies of fundamental and applied nature. The study of anthesis, pollen production and release in different vegetation types might be needed in various fields. The production of pollen grains and their dispersal are important aspects of reproductive biological studies related to the formation and production of fruits and seeds for food security. In flowering plants, pollen productivity is referred to as the number of pollen grains produced per anther of the flower. The total pollen production of a particular plant depends on the number of anthers per flower and the number of flowers per plant. The dispersal in the air is controlled by several factors such as morphology of the flowers, flowering season, anemophily, entomophily and amphiphily. It has also been proved that the plants with high pollen production are more capable of inducing flowering phenology.

Pollen grains are the carrier of male gametes in seed plants and an ideal system for manipulating the plant genome in the techniques of genetic engineering, as it is a direct contributor into the genetic constitution of the next generation. The understanding of pollen biology should be essential to a plant breeder and agronomist aiming at producing high yielding and resistant cultivars by hybridization. Cryopreservation of pollen has been a very potent way of conserving in gene banks the germplasm of fast disappearing wild ancestors of the present day cultigens, for such a conservation is of critical importance in saving the disease and stress resistant genes. The emerging technologies available to breeders are : (i) Pollen selection, (ii) Use of pollen for screening plants with desirable genes, (iii) Application of a range of techniques to overcome barriers to hybridization, (iv) Production of androgenic or gynogenic embryos. The effective integration of these technologies to the conventional breeding not only reduces the time and cost of breeding but also makes it more efficient. A good fruit set and high crop yield depends on healthy pollen grains. Tests for successful germination is essential to know the length of pollen viability which varies from species to

species. Plant breeders and horticulturists are often interested in getting new and improved varieties by cross breeding experiments. Now storage of pollen grains is practiced to enable long distance transport of selected varieties. For this "Pollen banks" should be established in different regions through which viable pollen of any desired species can be obtained at any time at any place.

Pollination is a basic force for gene recombination in flowering plants, playing a key role in plant breeding programmes. In angiosperms the pollination mechanism is typically developed in three phases: (a) release of pollen from anther, (b) transfer of pollen from anther to stigma, and (c) finally successful placement of the pollen on the receptive stigma surface, followed by germination of pollen grains which begins the next phase of fertilization. Each of the three phases shows great diversity. Pollination, pollen germination and stigma receptivity must be analysed critically on a species by species basis, as it reflects the basic criteria for breeding programmes. Besides, pollen viability and nutrient requirements differ from species to species. Structural, physiological and cytochemical features of the stigma is of prime importance in the biology of sexual reproduction and seed formation.



Rudolf Jacob Camerarius

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Rudolf Jacob Camerarius (1665-1721), Director of the Botanical gardens at Tubingen, Germany, established the plant sexuality for the first time and the function of the sexual parts of the flower. He published his own careful and painstaking experience in a letter ***De sexu plantarum epistola*** dated 25th August 1694 and concluded that the stamen and pistil must work together to produce ripe seeds and these two are sexual organs of the plants.

Christian Konad Sprengel (1750-1816) published ***'The Secrets of Nature Revealed in the Structure and Fertilization of Flower'*** in 1793. He observed that cross pollination was obligatory to some plants. Besides, his observations were nectar protection, the function of the corolla as an organ of advertisement and the difference between day and night flowers, mutual adaptation of flower and its pollinators. He is most famous for his **research on plant sexuality**. Sprengel was the first to recognize that the function of flowers was to attract insects, and that nature favoured cross-pollination.

Paul Johannes Bruhl (1855-1935) – German origin Professor and the first Head of the Department of Botany, University of Calcutta (appointed by Sir Asutosh Mookerjee, the then Vice-Chancellor), published the **first research paper from India on pollination biology i.e. : P. Bruhl and J. C. Sen Gupta (1927). On**

Christian Konad Sprengel

the production of ripe seeds by artificial pollination of *Eichhornia speciosa*. *J. Dept. Sci. Cal. Univ. 8:1-8.*

Pollination is a crucial ecosystem service to crops and is essential for sustainable crop production. Pollination is important as it leads to production of fruits and seeds which creates more plants. Pollination begins with flowers which have male parts that produce pollen grains. Morphological parameters of a flower is closely related to the pollination mechanism as flower visitors are attracted by means of different attractants like colour, odour, nectar and pollen. *Xylocopa*, *Apis*, *Anthophora* and *Ceratina* found as regular flower visitors. Pollinators include bees, butterflies, thrips, birds, beetles, and bats having an important contribution to agriculture and vital role in maintaining the health of the ecosystem and supports agriculture through pollen grains for the formation of fruits and seeds. Successful pollination results in the -production of healthy fruits and fertile seeds. Pollinators affect 35% of global agricultural land, supporting the production of leading food crops worldwide. Pollination-dependent crops are 5-times more valuable than those do not need pollination (http://www.fao.org). The risk of losing the essential role of pollinators required for the successful propagation of plant communities and wildlife habitats. As plantings have grown larger, the need for concentrated pollinators at bloom time has grown. At the same time populations of many pollinators has been declining, and this decline has become a major environmental issue. The study of pollinator decline is also interesting to some scientists, as pollinators have the potential to become a keystone indicator of environmental degradation. Today the pollination systems are threatened by the inadequacy of sustainable managed, indigenous or imported pollinators. The declination of pollinators is one of the reasons of environmental degradation as well as have adverse effects on plant population . The main causal agents for extinction of species are human beings as they alter habitats, chiefly forests, wetlands and also freshwater bodies. Extinction of gene pools is even more widespread than the species. Wild gene pools are also destroyed. The domesticated gene pools are lost through the replacement of traditional crop varieties and livestock breeds by modern ones.

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Production of transgenic plants or plant transformation is also a part of an important discipline of biotechnology. Genes expressed in pollen

Paul Johannes Bruhl

and pollen specific genes are one of the major event. Many pollen specific genes show temporal regulation during anther (pollen) development. Pollen development requires a large number of genes expressed both in sporophytic and gametophytic tissues. One of the best studied pollen specific genes is Zm-13 from maize which is expressed in the stages of microspores development. Transfer of foreign gene material using pollen as a vector for the transforming DNA was conducted by different scientists globally for getting the better results for food production. The germinating pollen are incubated with exogenous DNA and then used for pollination and fertilization. The transformed progenies with phenotypically distinction have been observed with better results.

According to United Nations' Committee on World Food security, Food security is defined as meaning that all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their food preferences and dietary needs for an active and healthy life. The availability of food irrespective of class, gender or region is another issue. Currently global warming and water shortages are the major crisis affecting security of our food supplies. World wide around 852 million people are chronically hungry due to extreme poverty, while up to 2 billion people lack food security intermittently due to varying degree of poverty (disabled-world.com). Food security is not just a poverty issue; it is a much larger issue that involves the whole food system and affects every one of us in some way. Global Food Security must exist to meet the challenge of providing the world's growing population with a sustainable, secure supply of good quality food. The United Nations (UN) recognized the Right to Food in the Declaration of Human Rights.

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The food security has three major components, namely : (i) adequacy in food production; (ii) stability in food supply, and (iii) physical and economic access to food on the part of vulnerable sections of the population. In India we have achieved a five-fold increase in food production in the last 75 years. Our success in the agricultural front has been due to timely and adequate supply of inputs i.e. (i) technology, (ii) seeds, (iii) fertilizers, (iv) pesticides, (v) machinery, (vi) irrigation, and (vii) credit. Agriculture being the largest sector of our economy, its contribution to the overall economic growth hardly needs any emphasis. It has been recognized by planners

that in the initial stage of development, agriculture has to support industrialization by providing a source of labour, capital and raw materials and by generating demand for industrial products. In other words, its relationship with the industrial sector becomes rather one of mutual interdependence and complementarity. Sustainable use of biological resources is an effective tool to conserve biodiversity and combat poverty to achieve sustainable development. However, for fulfilling these roles in the process of development, agricultural production must be increased.

Food supply for the future will be secured if we protect pollinators and their habitats. Pollinators are responsible for $20 billion in food-related products. Honeybees are responsible for $15 billion in the U.S. alone. It has been found that native plants are the key to the ultimate survival of native pollinators. There are over 4,000 species of native pollinators in the U.S. An article has been published in *Ecological Economics* "Valuing Pollination Services to Agriculture". A case study reflects that Watermelons are totally dependent on insect pollination. In the field study of watermelon, it was observed that a total of 6,187 bee visits (2,359 by honey bees and 3,828 by native bees) on a test plot. Overall, the testing results indicated that native bees provide 91% of the pollination services. The estimated annual net income value of the watermelon crop in New Jersey and Pennsylvania combined is $3.63 million a year, leading to estimates of $2.25 million for the pollination services provided by native bees and $1.38 million for honey bees. Every season, pollination from honey bees, native bees and other pollinators deliver billions of dollars in economic value. Between $235 and $577 billion worth of annual global food production relies on their contribution. Market cap revealed on honey bees: $20B, native bees: $4B, even the little midge that pollinates coca beans: $5.7B. So the valuation of pollination, pollinators and natural/native habitats is in the billions of dollars. Native pollinators are a huge part of the billion-dollar equation requiring native plants and habitats for their survival (https://www.nurserymag.com/article/native-tongue-the-price-of-pollinators)

The ultimate goal of the pollinator conservation system is to ensure healthy and self-sustaining populations of pollinator resources in botanical and agricultural curriculum. This will focus the recent problems and future prospects of plant and pollinator resources, pollen types, and pollen specific genes in the context of environmental degradation and global warming for biodiversity conservation. The present editorial broadly indicates the potentiality of pollination biology with a range of additional tools in applied area of plant improvement programme for better crop yield and food security for sustainable development. ❐

Sudhendu Mandal
Editor-in-Chief, Science and Culture
Indian Science News Association, Kolkata
e-mail: chiefeditorscienceandculture@gmail.com