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REVIEW: POLLINATION, POLLINATED AND POLLINATORS INTERACTION IN PAKISTAN

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ABSTRACT

The agriculture sector is important in the overall economy and export earnings of Pakistan. Pollination is an essential ecosystem service that depends on symbiosis between species, the pollinated and the pollinator. Animal mediated pollination contributes to the sexual production of over 90% species of modern angiosperms. Effective pollination results in increased crop production, quality improvement and more seed production. Many fruits, vegetables, edible oil crops, stimulant crops and nuts are highly dependent on bee pollination. Worldwide value of pollinators is €153 billion (217 billion US dollars). The production value of pollinated dependent crop in Pakistan is quantified to be 1.59 billion US$. There is serious deficit of pollinators worldwide and also in Pakistan. Small percentage of Pakistani population understands the process of pollination and its importance. It is essential to up scale the capacity of various stakeholders concerned with crop production in Pakistan.

INTRODUCTION

The agriculture sector is the major contributor in the overall export earnings of Pakistan. Its share alone in the total export of Pakistan for the year 2010-11 stood at 17.5 %. Agriculture is equally important for industrial development. Out of about 5,000 industrial establishments in Pakistan, about 60 % are agro-based.

The agriculture provides raw material for domestic industries like rugs and carpets, sugar, leather, foot ware and food products etc. The government policy is to ensure maximum food security through sustainable agricultural development and balanced growth of food sector to meet population needs and also to generate agricultural surplus to enhance the export of agricultural sector, which would eventually lead to enhance the country's growth performance (GOP. 2011).

In the crop production, one of the important factors is pollination in addition to many other inputs. Pollination is the transfer of pollen from one flower to another and is critical to fruit and seed production. Pollinators are agent that moves pollen from the anthers to the stigmas of flowers, thus effecting pollination. Agents are animals like bees, butterflies, hummingbirds, moths, some flies, some wasps, and nectar feeding bats.

Pollination is an essential ecosystem service that depends on symbiosis between species, the pollinated and the pollinator. The animal products like beef, mutton, poultry, and dairy products we consume are all derived one way or another from insect-pollinated legumes such as alfalfa and clover and some other plants.

More than half of the world's diet of fats and oils comes from oilseeds, coconut, cotton, oil palm, olives, peanuts, rape, soybeans, and sunflower; many of these plants are dependent upon or benefited by insect pollination. Perhaps one-third of our total diet is dependent, directly or indirectly, upon insect-pollinated plants. The value of insect pollination is not limited to cultivated crops but also on uncultivated areas where most soil holding and soil enriching plants

would die out. The aesthetic value of pollination to ornamentals, wild flowers, forests and range plants in terms of beauty of the landscape is recognized but cannot be measured in monetary shape.

Importance

Of the 308,006 angiosperm species 87.5% are animal pollinated with 78% species in the temperate and 94% in the tropics (Ollerton *et al.,* 2011). Animal mediated pollination contributes to the sexual production of over 90% species of modern angiosperms (Kearns *et al.*, 1998). Eighty seven crops, that is 70% of the 124 main crops used directly for human consumption in the world are dependent on pollinators (Klein *et al.,* 2007). The production of 84% of crop species cultivated in Europe depends directly on insect pollinators, especially bees (Williams, 1994). Biotic pollination improves the fruit and seed quality and quantity of about 70% of 1,330 tropical crops (Rouibik, 1995). Effective pollination results in increased crop production, quality improvement and more seed production. Many fruits, vegetables, edible oil crops, stimulant crops and nuts are highly dependent on bee pollination.

Worldwide value of pollinators is €153 billion (217 billion US dollars) which represented 9.5% of the value of the world agricultural production used for human food in 2005. Vegetables and fruits are worth €50 billion each, edible oil crops value is € 39 billion, stimulants are worth € 7.0 billion, nuts are € 4 billion, spices value € 0.2 billion and pulses 1.0 billion (Gallai *et al.,* 2008). In the USA, pollination value is $ 4.5 billion (Pimentel *et al.,* 1993); in Brazilian export of 8 important agricultural commodities it is € 7 billion (Freitas and Imperatriz- Fonesca, 2005); in East Africa it is equal to € 900 million (Kasina *et al*., 2009); in Uganda equal to € 370 million (Munyuli, 2011) and in Netherland it is equal to € 1 billion (Blacquiere *et al.,* 2010).

The economic value of insect pollinators in Himalayan region of Pakistan is 954.59 million US$ (Partap *et al.,* 2012). Recently the production value of pollinated dependent crop in Pakistan was quantified to be 1.59 billion US$. Of the total value, fruits are dominant with 0.98 billion, vegetables 0.32 billion, nuts 0.15 billion, oilseed 0.13 billion and spices 0.004 billion US $ (Irshad and Stephen, 2013).

The production of pollinated crops is not totally dependent on pollinators. There is a certain degree of dependence. Some figures have been derived from the data for Pakistani crops. The pollinator are essential (> 90%) for Melon, Pumpkin, Water melon; great (40< 90%) for Almond, Apple, Apricot, Cucumber, Loquat, Mango; modest (10< 40%) for Guava, Jujube, Mustard, Okra, Pomegranate, Rape seed, Sesame, Sunflower; little (0< 10%) for Chille, Papaya, Persimmon, Tomatoes. There are 61 important pollinated crops used as food in Pakistan which include 26 fruit crops, 7 oilseed, 4 pulses, 19 vegetables, 2 spices and 3 nut trees.

Important crops benefited by insect pollinations in Pakistan are: almond, apple, apricot, beans, cherry, coriander, citrus, coconut, cotton, cucumber, egg plant, fig, gourd/ pumpkin, guava, litchi, mango, melons, mustard, oil palm, okra, papaya, peach, pear, peas, persimmon, pomegranate, rape seed, safflower, sesame, soybean, strawberry, sunflower, and tomato. Other crops need pollinators not for production, but for seed. These include Brussels sprouts, carrot, cauliflower, lettuce, onion, and radish. Forage crops such as alfalfa and clover are also dependent on pollinator activity.

Pakistan produced vegetables worth 3.126 million and fruits 6.926 million tons during 2010-2011. These are main insect pollinated crops. Therefore pollination management will be most beneficial for these crops.

Pollination Deficit

There is serious deficit of pollinators worldwide and also in Pakistan. In Pakistan, Murree area was famous for apple cultivation from 1960 onward till codling moth, *Cydia pomonella* L., caused heavy damages each year. Blanket spraying was recommended mostly at the start of flowering period or fruit setting. This not only increased the cost of production but the natural complex was also destroyed. It can be visualized that pollinator fauna might have been reduced. Thus the whole apple cultivation was reduced to minimum level. Production deficit occurs in the absence of pollination ranged between 3- 5% in the developed world and up to 8% in the developing world (Aizen *et al.,* 2009).

Extensive negative impact of declining pollinator population can be seen in northern Pakistan where both farmers and institutions have failed to understand the importance of managed pollination. Disappointed with very low yields and quality of apples as a result of poor pollination, farmers in Azad Jammu and Kashmir have chopped off their Apple. One implication of the decline in pollinator population as well as diversity is that it has created the need for managed pollinators (Partap, 2003). One method of enhancing crop productivity in mountain area is through managed pollinators of crops using friendly insects which in process of searching for food perform this useful service to farmers (Partap and Partap, 2002).

In the Hindu Kush Himalayas, despite increasing the agronomic inputs there is clear decline in the production and quality of fruit crops such as apple, pears, almonds etc. The decline in productivity of apple has been so serious in some cases that disappointed farmers have cut their apple trees (Ahmad *et al.* 2004). In another case probably due to lack of pollinating agents there is indication in decline in fruit yields in Khyber Pukhtunkhwa (Partap and Partap, 1997). Significantly higher yield of apple is obtained when flowers are un caged as compared to caged (Khan and Khan, 2004). There is decrease of 64.4% in non Apis bee pollination and 97.03 % in self pollination in Loquat in Peshawar region (Khan *et al.,* 1986). More Kino (orange) fruits were set besides increase of fruit size, juice content and number of seeds due to pollination (Haq *et al.*, 1978). Rapeseed production in fields with bees was more than double that in fields where bees (*Apis cerana* F.) were absent (Latif *et al.,* 1960, 1965). The linseed pollinated by honeybees was of good quality and quantity with higher germination rate (Sabir, 1999). In plants under natural conditions yield, number of seed formed /inflorescence and number of pods/plot was high by 15.07, 37.78 and 11.26 % respectively over plants treated with insecticides (Kamal and Akhtar (1975).

The yield of sunflower was lowest (568.59 gram) in bagged inflorescence than left open (1646.96) and in cauliflower yield increased by 23% due to bees (Gondal and Haq, 1973). The honeybee increased the yield of cucumber by 28-32.5 % (Ahmad, 1991). These studies indicate that with proper pollination crop productivity can be significantly enhanced.

There are various reason of pollination deficit such as loss, destruction and degradation of habitats excessive tillage, destruction of trees, extensive weeding, deforestation, reduced genetic diversity of nectar plants, pests and pathogens, climate change, extensive and intensive use of pesticides especially insecticides and herbicides. All these factors individually or in combination are causing the deficit. The injury by pests sometimes may be so severe that economic yield of a crop may not be possible. In many cases, economic returns have only been possible by chemical control in addition to some other inputs. The most widely practiced method, the chemical control is now often and widely criticized for its ill effects especially for disturbing the ecological

system/balance. Consumption of pesticides and area sprayed in Pakistan has increased many folds (Fig 1-2).

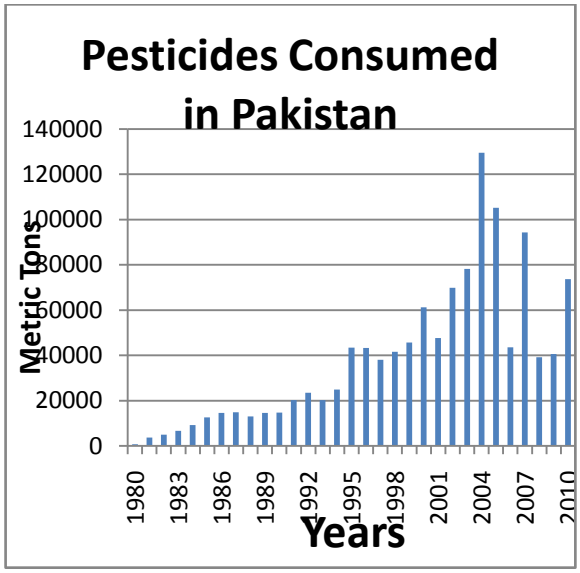

Fig 1

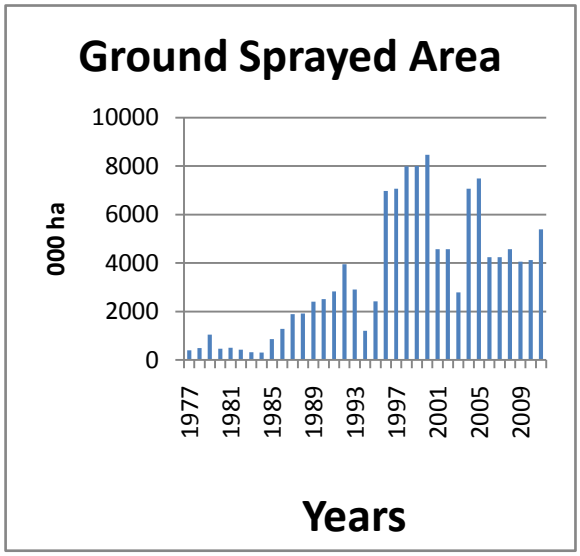

Fig 2

Chemical based control program in crops has actually increased the pest problems, disturbed the agro-ecosystem and has killed the non-target and environment friendly organisms such as parasitoids, predators and pollinators. To combat pollination deficit following measures are required. Minimum use of pesticides, application of biological based Integrated Pest Management practices, use of managed pollinators like *Apis mellifera* to be kept in farms to enhance pollination, providing non-*Apis* bee nesting cages for conservation of bees at different areas, conservation of blow flies by providing them artificial food, practice of intercropping to be encouraged, encouragement of foraging plants of pollinators.

Capacity Building

Small percentage of Pakistani population understands the process of pollination and its importance. Economic value of pollinators is not important with these stakeholders. Not to talk of quality the increase in production is not envisaged by these growers. Many farmers lump pollinators together with insect pests, and do not manage to conserve them. Lack of behavior among farmers about pollination is main constraint hindering the use of managed pollinators for crop pollination. If someone knows about pollination, then they do not know how to use them. The practical and theoretical knowledge of farmers on pollinator is either nil or meager. It is time now to realize that pollination is not a free service. Since the human resource on the topic is meager, therefore more people should be trained in pollination management to address the above issue. It is necessary to upscale this knowledge in managing pollinators and capacity building of stakeholders. For this various steps can be taken and training courses can be held. The module of training courses can have the following features.

Flower morphology, structure and importance of flower in crop production: It should cover importance of flower, types of flowers, pollen and pollination, conditions required for pollination to be effective, self sterility in plants, characteristics of some insect pollinated plants. Flower is the

important part where pollination and fertilization occur. The flowers are especially designed for the visit of insects for nectar.

Importance, types and agents of pollination: Like soil, water and nutrients, pollination is also a limiting factor in crop productivity. Pollinators provide essential ecosystem service that contributes to the maintenance of biodiversity and ensures the survival of plant species including crop plants. Agents of pollination are abiotic, biotic. Abiotic agents are wind, water, and gravity. Biotic agents are insects, birds, and mammals. Role of pollinators and pollinizer (An animal (insect/bird) that moves pollen from the anthers to the stigmas of flowers is pollinator. The plants pay with food for the pollinators. A pollinizer is the plant that provides the pollen for crop plants that require cross pollination, such as apple). Pollinator fauna of Pakistan (Majority of the pollinator insects belong to order hymenoptera and diptera. Hymenoptera is one of the largest orders of insects. Some other pollinators belong to Lepidoptera and Coleoptera.

Pollinator ecosystem analysis: It includes what is environment, what is eco-system, what is agro-ecosystem, what is analysis, what is ecosystem analysis and benefits of eco-system analysis. Environment is the surrounding and ecosystem includes all living and non-living things in the surrounding which affects the living things directly or indirectly. Ecosystem of crops and plants is called agro-ecosystem).

Role of pesticides and their adverse effects on ecosystem: Pest can be any species, strain, or biotype of plant, animal or pathogenic entity injurious to plants, plant products, human beings, animals and environment. A pesticide is any substance or mixture of substances intended for preventing, destroying or controlling directly or indirectly, any pest including vectors of human or animal disease, unwanted species of plants or animals causing harm. Injudicious use of pesticides creates problems. Environmental hazards are loss of biodiversity, wildlife, and animal and livestock death, residues in food, water pollution and high input cost. In beneficial insects, pollinators have been severely damaged, as these are directly exposed to insecticides.

Modern beekeeping and their importance in agriculture: Four species of honeybees are found in Pakistan such as *Apis florae* F., *A. dorsata* F., *A. cerana* F.and *A. mellifera* L. Feral honeybees are *A. florae* and *A. dorsata.* Domesticated honeybees are *A. cerana* and *A. mellifera.* Bees plays important role in flower setting. It also increases both quality and quantity of fruits, cereals and fodder crops. Without bees there would be no flowering plants, and without flowering plants there would be no bees.

The modern beekeeping requires seasonal management of bees for better quality queens, pests and diseases control and pollination of entomophilies crops.

Identification of pests and diseases of various crops: Insects, pests and diseases of crops in many cases cause extensive damage.

Science by farmers/How to lay an experiment/bee bowl traps: During flowering period it is done on each alternate day from 9:00 am to 3:00 pm. The color of traps is white, florescent blue and florescent yellow.

Pan traps are placed in three different places in the orchards/ fields with 8 traps in each place. The traps are placed 3-5 meters apart on the ground. Each pan trap is filled with water and a few drops of detergent are poured in it. At the end the liquid in pan traps is run through a strainer for extraction of pollinators. The flower visitors are also observed in the field. Moreover net sweeping is also part of this exercise.

***Best management practices*:** Complete removal of the top soil should be avoided. Excessive or deep tillage is not necessary. Grower should choose those values that flower at the same time, or substantially overlap. The pollinizer cultivar should be ones that produce abundant flowers

with viable pollen, flower annually and are known to bear fruit of commercial value. Summer pruning is advised to remove water sprouts, suckers and infected wood. Upper layer of the canopy should be more heavily pruned than the lower one. Application of pesticides should be done properly defined economic thresh hold levels of particular insect pests and diseases is necessary. Avoid direct spraying at natural nesting sites of bees. It is essential to maintain natural vegetation, leave uncultivated piece of land for pollinators who live in soil. Introduce managed pollination by bee keeping, provide nesting sites to solitary bees and other pollinators, plant maximum ornamentals to attract pollinators, provide alternate flowering crops/plants in orchards when mango bloom is over to retain/attract pollinators.

Record keeping of field data: The framers should have complete record of their expenses and profit. The cost of every input should be recorded. This will surely help them in management of pollinators). As far as researchers, university teachers, extensionists, environmentalists, journalists, agriculture students and policy makers are concerned they agree that pollination is important for crop production except few journalists. Some students and researchers consider it important as it is source of genetic diversity. The syllabi at various tiers of education are satisfactory except at post graduate level. Therefore changes are required at the higher level. More importance should be given to this subject at higher level education.

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