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Value of insect pollinators to agriculture of Pakistan

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Key words: Pollination value, crops, pakistan, pollination deficit.

Abstract

Pollination is important for crop production. Due to pollination deficit and ecological disturbances it is essential to quantify the economic value of pollination. In Pakistan, such values are not available. Using bioeconomical methods these values were quantified. The production value of pollinated dependent crop was 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 $. Non pollinated crops values 7.45 billion US $. This study is helpful in planning stratagies for pollination management. Moreover material and technical inputs required can be better asked in the light of this study.

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Introduction

Agriculture is important sector in the economy of Pakistan. There had been fluctuating production quantitity of food commodities and many factors are involved both biotic and abiotic. Pollination plays an important role in crop production. Pollination services have not been considered of any significance in Pakistan. Pollination is a free ecosystem service. It depends on symbiosis between the pollinated and the pollinator. The insect pollination is of value both in cultivated crops and in uncultivated areas. In the latter case most soil holding and soil enriching plants would die out in the absence of pollination. The animal products which human being consume are derived one way or other from animal pollinated plants. There are some publications in which number of plant species dependent on pollinators is given. 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). Animal mediated pollination contributes to the sexual production of over 90% of the approximately 25,000 species of modern angiosperms (Kearns *et al.*, 1998). Of the 87 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). Of the 308,006 angiosperm species 87.5% are animal pollinated and there are 78% species in the temperate and 94% in the tropics (Ollerton *et al.,* 2011).

Insect pollinated crops in the USA valued $ 4.5 billion (Pimentel *et al.,* 1993). The total economic value of pollination worldwide amounted to €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 were the leading crop categories in value of insect pollination with about €50 billion each, followed by edible oil crops, stimulants, nuts and spices (Gallai *et al.,* 2008). The economic value of insect pollinators in Himalayan region of Pakistan is 954.59 million US$ (Partap *et al.,* 2012).

Recent and old surveys of farmers reveal that small percentage of Pakistani understands the process of pollination and its importance. It is time now to realize that pollination is not a free service. To go further it is imperative to quantify the exact values of pollinators. It is necessary for future planning and promoting pollinator related studies in Pakistan.

The aim of this study was to quantify the economic value of pollinators in crop production. This information lacks in many countries of the world and also in Pakistan.

Materials and methods

The economics of pollination in agriculture are complex and difficult to assess. Various methods have been used to date to assess the monetary value of pollinators. In conventional methods, the total value of insect-pollinated crops was assessed previously. This approach has been used at a national scale in the USA (Levin, 1984). However, production of crops is partially reduced and the crop value can not be attributed wholly to the pollinators. In line with this Gallai *et al.,* (2008) modified this approach. In the present study this method was followed. This is bioeconomical approach. Impact of pollination is defined in production as increased fruit set, fruit weight and/or quality, and seed number and/or quality, when pollinators have access to the flowers in contrast to pollinator exclusion experiments.

Firstly FAOSTAT 2011 was tried to obtain data on production and costs of Pakistani crops. As this data is spread on a global scale therefore the information was not sufficient for this study. This data could not provide relevant information for many crops of Pakistan. So production quantity of crops grown in Pakistan was taken from various statistic books (GOP, 2006, 2011). Xcel sheet "Array for the economic valuation of the contribution of insect pollination to agriculture and impact on the welfare" was also used. To have better results the prices of Almond, Apple, Banana, Grapes, Mango, Oranges, Peach, Pear, Plum, Sesame, Soybean, Sunflower and Walnut were obtained from FAOSTAT 2010. In the rest of cases

either published data in statistical books of Pakistan were used or prices obtained from the market. The quantification of the economic loss that could result from the total disappearance of insect pollinators on agricultural output was based on calculations on the dependence ratio recently published for the crops (Klein *et al.,* 2007). This dependence ratio enables the calculation of the production loss.

The variable used in this study were Average value per ton is the producer price (this was caslculated from various statistical books); Total value of crop (TVC), is the multiplication of the price per ton by total production; Dependence ratio (D) is the level of dependence on pollination for the production of fruit or seed; Economic Value of insect pollination (EVIP)) is the economic value of crop because of pollination; Ratio of vulnerability (RV) is the ratio of economic value of the insect pollination to the current total of crop.

Materials and methods

The economics of pollination in agriculture are complex and difficult to assess. Various methods have been used to date to assess the monetary value of pollinators to satisfy the need of pollination management.

Conventional methods

In conventional methods, the total value of insect-pollinated crops was assessed. This approach has been used at a national scale in the USA (Levin, 1984). However, production of crops is partially reduced and the crop value can not be attributed wholly to the pollinators. Therefore it did not find favor with economic biologists. In line with this Gallai *et al.,* (2008) modified this approach and based the approach to bioeconomical. In the present study this method was followed.

Bioeconomical method

In this approach impact of pollination is defined in production as increased fruit set, fruit weight and/or quality, and seed number and/or quality, when pollinators have access to the flowers in contrast to pollinator exclusion experiments. This method concentrates on the fractional contribution of pollinators as whole production is not dependent on pollinators. The dependence value of pollinators is used here to know the contribution of pollinators in the crop production.

Collection of data

In this study, the first step was to obtain production data of crops followed by costs of production /value of crop. For this purpose first FAOSTAT 2011 was used for Pakistani crops. As this data is spread on a global scale therefore the information was not sufficient for this study. This data could not provide relevant information for many crops of Pakistan. Afterwards production quantity of crops grown in Pakistan was taken from various statistic books (GOP, 2006, 2011). The prices of Almond, Apple, Banana, Grapes, Mango, Oranges, Peach, Pear, Plum, Sesame, Soybean, Sunflower and Walnut were obtained from FAOSTAT 2010. For the rest of the crops either published data in statistical books of Pakistan were used or prices were obtained from the market. A programme “Array for the economic valuation of the contribution of insect pollination to agriculture and impact on the welfare” was first used but this did not work. Consequently excel sheet was used.

Quantification of data

The quantification of the economic loss that could result from the total disappearance of insect pollinators on agricultural output was based on calculations on the dependence ratio recently published for the crops (Klein *et al.,* 2007). This dependence ratio enables the calculation of the production loss. The variable used in this study were Average value per ton is the producer price (this was calculated from various statistical books); Total value of crop (TVC), is the multiplication of the price per ton by total production; Dependence ratio (D) is the level of dependence on pollination for the production of fruit or seed; Economic Value of insect pollination (EVIP)) is the economic value of crop because of pollination; Ratio of vulnerability (RV) is the ratio of

economic value of the insect pollination to the current total of crop.

Results

There are total of 80 plants which are cultivated for the benefit of population of Pakistan. Among these, 60 are pollinator dependent and 20 are not dependent on pollinators (Table 1& 2). Majority of these plants are used for human food but a few are fodder for animal. Production of many crops increases with pollinating animals. But because most of these crops are not entirely dependent on animal pollination, the amount of production directly attributable to animals is lower than this value. Only insects are demonstrated pollinators of these crops. The production increase with pollinators for seeds of vegetatively propagated crops permits breeding progress and hybridization for the development of new varieties.

Table 1. Pollinator dependent crops of Pakistan beneficial for human beings.

Botanical name	Local Name	Botanical Name	Local Name
1.*Abelmoschus esculentus*	Okra	31.*Helianthus annuus*	Sunflower
2. *Allium cepa*	Onion**	32.*Lactuca sativa*	Lettuce
3.*Ananas comosus*	Pineapple	33.*Litchi chinensis*	Litchi
4.*Benincasa hispida*	Gourd	34.*Lycopersicum esculentum*	Tomato
5.*Brassica campestris*	Mustard	35.*Malus pumila*	Apple
6. *Brassica oleracea*	Broccoli	36.*Mangifera indica*	Mango
7.*Brassica oleracea*	Cauliflower**	37.*Manilkara zapota*	Chiko
8.*Brassica oleracea var. gemmifera*	Brussels sprout	38.*Medicago sativa*	Clover *
9.*Brassica napus*	Rape seed	39.*Momordica charantia*	Bitter gourd
10.*Brassica rapa*	Turnip*	40.*Musa sapientum*	Banana
11.*Camellia sinensis*	Tea	41.*Olea europaea*	Olive
12.*Capsicum annuum*	Chillli	42.*Phaseolus* spp.	Beans
13.*Carica papaya*	Papaya	43.*Pisum sativum*	Peas
14.*Carthamus tinctorius*	Safflower	44.*Pistacia vera*	Pistachio
15.*Citrullus lanatus*	Water melon	45.*Prunus amygdalus*	Almond
16.*Citrus* spp.	Citrus	46.*Prunus. armeniaca*	Apricot
17.*Cocos nucifera*	Coconut	47.*Prunus avium*	Cherry
18.*Coriandrum sativum*	Coriander	48.*Prunus domestica*	Plum
19.*Cucumus melon*	Musk melon	49.*Prunus persica*	Peach
20.*Cucumis sativus*	Cucumber	50.*Psidium guajava*	Guava
21.*Cucurbita maxima*	Pumpkin	51.*Punica granatum*	Pomegranate
22.*Daucus carota*	Carrot **	52.*Pyrus communis*	Pear
23.*Diospyros lotus*	Persimmon	53.*Raphanus sativus*	Radish **
24.*Eriobotrya japonica*	Loquat	54.*Rubus idaeus*	Raspberry
25.*Ficus carica*	Fig	55.*Solanum melongena*	Egg plant
26.*Foeniculum vulgare*	Fennel	56.*Trachyspermum ammi*	Ajwian
27.*Fragaria ananassa*	Strawberry	57.*Trifolium resupinatum, T. alexandrinum*	Alfalfa *
28.*Glycine max*	Soybean	58.*Vernonia anthelmintica*	Kala Zeeri
29.*Gossypium hirsutum*	Cotton	59.*Vitis vinifera*	Grapes
30.*Grewia asiatica*	Phalsa	60.*Zizyphus mauritanicus*	Ber

Table 2. Non pollinator dependent crops of Pakistan beneficial for human beings.

Botanical Name	Local Name	Botanical Name	Local name
1.*Allium sativum*	Garlic	11.*Saccharum officinarum*	Sugarcane
2.*Avena sativa*	Oat	12.*Secale cereal*	Rye
3.*Beta vulgaris*	Sugarbeet	13.*Solanum tuberosum*	Potato
4.*Cicer arietinum*	Chick pea/gram	14.*Sorghum bicolor*	Jowar
5.*Curcuma longa*	Turmeric	15.*Spinacia oleracea*	Spinach
6.*Hordeum vulgare*	Barley	16.*Triticum aestivum*	Wheat
7.*Lens culinaris*	Masoor	17.*Vigna mungo*	Mash
8.*Oryza sativa*	Rice	18.*Vigna radiata*	Mung
9.*Pennisetum glaucum*	Millet (Bajra)	19.*Zea mays*	Maize
10.*Phoenix dactylifera*	Date palm***	20. *Zingiber officinale*	Ginger

- * Fodder
- ** Increase seed production
- *** Hand pollinated

Table 3. Economic value of pollinators in Pakistan (Rs=Pakistani Rupee;$ US dollar).

Crop	Total value of crop (TVC) = Price x Production (000)	Economic value of insect pollination (EVIP) = (TVCx D) (000)	Ratio of vulnerability (RV) = EVIP/TVC %
Fruits	Rs 211,333,652 $ 2,201,392	Rs 94,400,871 $ 983,342 (0. 98 billion $)	44.66
Vegetables	Rs 123,283,500 $ 1284,203	Rs 308884475 $ 321,713 (0.32 billion$)	25.05
Nuts	Rs 48,360,232 $ 503,752	Rs 15,172,888 $ 150,210 (0.15 billion $)	2.98
Oilseed	Rs 52,495,476 $ 546,827	Rs 12,662,468 $ 131,900 (0.13 billion $)	24.12
Spices	Rs 6,963,432 $ 72535	Rs 397,382 $ 4,291 (0.004 billion $)	5.91
Total	Rs 463,334,657 $ 4,826,402	Rs 153,518,084 $ 1,591,456 (1.59 billion $)	20.5

Pakistan produces both pollinated and non pollinated crops. There are 60 pollinated crops covering 25 fruit crops, 7 oilseed, 4 pulses, 19 vegetables, 2 spices and 3 nut trees which are used as food by human beings. There was significant difference in different crops regarding dependence on pollination. The production value of pollinated dependent crop was 1.59 billion US$ (Table 3). 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 $. The value of crops not dependent on pollination is 7.4 billion US$. Ratio of vulnerability is highest in fruits (44.66 %) followed by vegetables (25.05). In a previous study, Partap *et al*., (2012) reported that in Pakistani Himalayan region the pollination value is 954.59 million (0.95 billion) US$. According to them Himalayan region of Pakistan encompasses mainly the northern parts of the country including Khyber Pukhunkhah, Gilgit , Baltistan, Azad Kashmir and parts of Baluchistan. Their production figures are for year 2009. In the present study the total value of our crops is 1.59 billion which is 0.64 billion $ more. It is logical that whole of Pakistan is much bigger than Himalayan Pakistan. Moreover they pooled data of 25

crops (10 each of fruit and oilseed, 1 pulse, 2 each of tree nut and vegetables). But in our study there are 50 crops (20 fruits, 9 oilseed, 3 nut, and 18 vegetables). It is evident that this study is much expanded then the previous study related to Himalayan region of Pakistan. Stephen and Irshad (2012) have stated that with enhancement of pollinator activity the production of certain crops can be increased in Pakistan.

Work on pollination in Pakistan is inadequate with few publications (Irshad *et al.,* 2010). However, some investigations reveal increased in yield due to activity of pollinators. It has been reported that sarson yield increase by 48 and 59 % (Abbas, 1957), 20% (Latif *et al.,* 1960), 12.1% (Latif *et al.,* 1965), 15% (Kamal and Akhtar, 1976); radish 18.7% (Gondal and Haq, 1973); cauliflower 23.6% (Gondal and Haq, 1973); cucumber 28-32.5% (Ahmad, 1991),13% (Suhail *et al.,* 2001); 3-33% (Sarwar *et al.,* 2008); loquat 64.4-97% (Khan *et al.,* 1986); orange 1.8-4.7 % (Din , 1976); bitter gourd fruit set, number of seed and seed weight increases by 76.2, 22.8 and 2.3% respectively (Saeed *et al.,* 2012) due to pollinator activity. There is concern of pollination deficit due to habitat destruction. This may be the case in Pakistan. 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).

Conclusions

Now some loss figures have been derived so that policy makers must begin devising programs that reward farmers for implementing practices to protect habitats of wild pollinators and provide incentives for those who wish to manage a wider variety of pollinators to assist farmers and orchard growers. The current environmental policies of Pakistan are not much detrimental for conservation of pollinators but the importance of the pollinators in different eco conservation projects is not evident. In communities of the developed world, people know the value of insect visiting flowers but in Pakistan this is not the situation. It is due to the fact that their importance has not yet been recognized in the absence of scientific evidence. The economic value of non pollinated crops is 7.72 billon US $. This is much higher than the pollinated crops.

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