AJAB

Asian J Agri & Biol. 2017;5(3):140-150.

Review Article

A review: risk assessment of pesticides on honey bee and pollination of agriculture crops in Pakistan

Saboor Ahmad*, Muhammad Asif Aziz

Department of Entomology, PMAS Arid Agriculture University, Rawalpindi, Pakistan

Received:
May 15, 2017

Accepted:
July 03, 2017

Published:
September 30, 2017

**Corresponding author email:*
saboorahmad86@yahoo.com

Abstract

This paper reviews the importance of honey bee as pollinator of agriculture crops, fruit, vegetables, seeds etc. and losses in agriculture, honey bee and honey production due to use of chemical pesticides. Honey bee (Hymenoptera: Apidae) is economically important insect. Honeybees are existing all around world excluding extreme Polar Regions. Honey bees (*Apis mellifera*) add approximately US $200 billion to the global economy every year, mainly through crop pollination. Productivity worth of pollination dependent crops equal to US$ 1590 million in Pakistan where 61 main pollinate crops are considered as foodstuff (26 fruits, 19 vegetable, 7 oilseeds, 4 grain legumes, 2 flavoring crops and 3 nut shrubs) depend on honey bee pollination. Honey bee population is declining with alarming speed all around the world and it is endangering global food security because one third of agriculture production depend upon on pollination particularly by honey bee. Current reduction in honey bee population for agriculture pollination is threatening to nuts, fruit, vegetable and seed production in Pakistan. Several factors responsible for decline of honey bee colonies including climate change, predation by other insects, air pollution, ecosemiotic collapse, the alteration of the bee microbiome, electromagnetic radiation from the sun, expose to initial life stress, nano materials, and biochemical pesticides, diseases, parasites surroundings of honey bees. The toxic chemicals are transported in hive through the pollen and nectar which may destroy the entire honey bee colony. Pesticides pattern applied in agriculture have been changed in last decade. This review research indicates how pesticide is used in agricultural crops for control of pests affecting on honey bee health and decline of bee populations. Then concludes with intensive studies on current management protocols would support in procedure formulation and resolution making polices regarding to shelter honey bees and management of pollination for agriculture purpose, which is lacking.

Keywords: Honey bee, Agriculture crops, Pollination, Beekeeper, Pesticides

Introduction

The domesticated honey bee (Hymenoptera: Apidae) is economically important insect (Michener, 1969). Honey bees are present all around world excluding extreme Polar Regions. In Pakistan, four species of honeybee are present among them three bee species (*Apis dorsata*, *Apis florae*, *Apis cerana*) are indigenous while *Apis mellifera* is exotic imported from Russia and Australia during 1979 (Jadran, 2011; Hikmat et al, 2016). Honey bee producing different products including honey, royal jelly, bee venom, pollen, bee wax and propolis that are used in food commodities, medicinal drugs and further marketable products (Wakhal et al., 1999). In Pakistan 400,000

honey bee colonies making 10,000 MT honey annually, almost more than 4000 beekeepers were involved in raising of *Apis mellifera* and 27000 household were getting income from beekeeping industry (PARC, 2010).

Beekeeping remains significant for agricultural and environmental activity. Beekeeping plays a parallel role in cross-pollination of economical farming crops and medicinal plants with the manufacturing of honey. Honey bees increase the production of different fruit crops up to 30-40 % (Jadran, 2011). Pesticides requirement increase over last decade in most developing countries and increased in Pakistan during 1990 (Osteen and Fernandez, 2013; Khan et al., 2002). De A et al. (2014) demonstrated the percentage of pesticides being used 45 % in Europe and 25 % in USA, 4 percent in India and in other parts of world 26%. This value of consumption of pesticide is almost € 36 billion annually (Popp et al., 2013; De A et al., 2014). Pakistan is second largest purchasers of chemical substances in South Asia, 27% pesticides used within fruits, vegetables crops and annually application of pesticides is increasing up to 25 % (Hussain et al., 2004). Honey bees and beekeepers are suffering from the excessive usage of pesticides every year in agriculture sector due to beginning of agriculture modernization (Maini et al., 2010). Honey bee life depends upon flowering plants. Honey bees foragers collect nectar from nectariferous plants, collect pollen only from polliferous plant and some bee foragers collect nectar and pollen on the same plant (Pătruică, 2006). Pollination is an essential process for production of fruit plants, variety of flowering plants and deals fundamental ecosystems facilities to human welfare (Kevan, 1999; Klein et al., 2007). It is confirmed that most of flowering plants are pollinated by insects, animals; including 70 % reproduction occurring in world's flowering plants is due to pollination (Ollerton et al., 2011). Among the pollinators, *Apis mellifera* has been playing crucial role for improving the agricultural crops production throughout the world (Allen-Wardell et al., 1998). Extensive use of pesticides leads to loss of honey bee population and also decrease in pollination process (Chauzat et al., 2006).

Influence of pesticides on honey bee and honey production

The bee population is reducing all around world since 2006. Average death rate of honey bee colonies are 30 % in USA and some beekeeper claimed even greater injuries (Ellis et al., 2010; Lee et al., 2015). About 25-30 % honey bee population decline in European countries and Canada is due to extreme use of higher concentration of pesticides (Van Engelsdorp and Meixner, 2010; Neumann and Carreck, 2010). There are several factors responsible for decline in honey bee population across the world including weather alteration (Le Conte and Navajas, 2008), air contamination (Girling et al., 2013; Mc Frederick et al., 2008), ecosemiotic collapse (Harries-Jones, 2009), adaptation of the honey bee microbiome (Mattila et al., 2012; Cox-Foster et al., 2007), electromagnetic radiation from the sun (Ferrari, 2014), honey bee colony exposure to primary life pressure (Wray et al., 2011; Clare CR et al., 2015), nano-materials (Milivojevic et al., 2015), and biochemical background of bees (Mullin et al., 2015). The population of honey bee is decreased from 1966-1979 due to excessive use of organophosphorus, organochlorine, carbamate and pyrethroid pesticides contact. The ratio of pesticides usage is comprising 74 percent insecticides, 14 percent weeds killer, 9 percent fungicides, 2 percent acaricides and 1 percent fumigants in Pakistan (Khan, 1998), in which most of pesticides used for cotton (60%), rice (7%), cereals (4%), sugarcane (2%) and rest of pesticides (27%) used for other crops (Kang, 2013). Pesticides are broadly used in Pakistan to controlling the agriculture pest, excessive use of chemical disturb the ecological system and cause pest resistance, kill ecofriendly insects (Predators, Parasitoids and Pollinators) .The consumption of pesticides (Fig 1) as well as the sprayed crops area increased many folds (Fig 2).

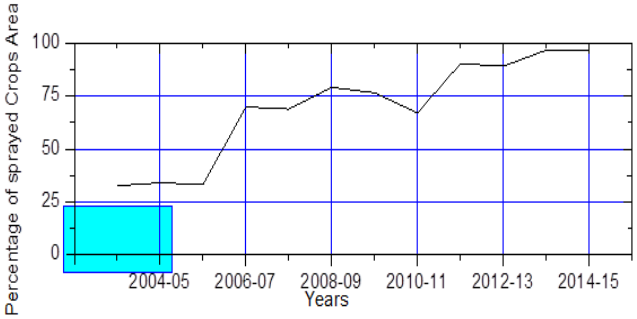

Fig 1: Consumption of pesticides in Pakistan (Agriculture statistic of Pakistan 2014-15)

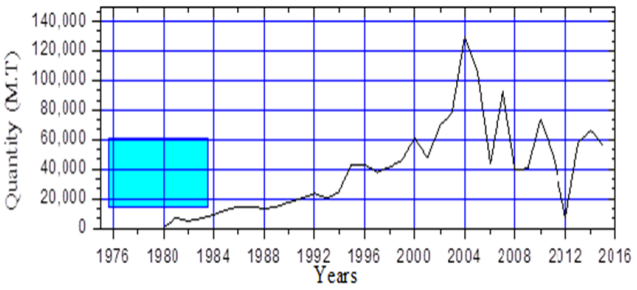

Fig 2: Percentage of Sprayed Crops Area covered by ground plant protection measures in Pakistan (Agriculture statistic of Pakistan 2014-15)

In Pakistan most of pesticides used by farmers are insecticides and fungicides. Table 1 shows grouping of pesticides, chemical group, WHO Hazard Category and their target pest. It was observed that farmer also used highly toxic insecticides containing carbofuran and moderately toxic (endosulfan) which are hazardous to human, arthropods including honey bee (Asif et al., 2014).

Table 1: Characterization of pesticides with toxicity class applied in agricultural crops and residual effect on honey bee health (Jivan and Marian, 2013; Asif et al., 2014; Douglas, 2015).

Pesticides common name	Chemicaly Group	Toxicity class	Residual activity	Usess
Imidacloprid	Nicotinoid	ll	<8 hours	Sucking pests
Endosulfan	OC	ll	<8 hours	Against lepidopterous larvae
Chlorpyrifos	OP	ll	4-6 days	Acaricide
Diafenthiuron	Urea	lll	3-4 days	Sucking pests &mite
Mancozeb	Dithiocarbmate	U		Downy mildew
Profenophos	OP	ll		Against lepidopterous larvae
Cypermethrin	Pyrethroid	ll	3 days	Against lepidopterous larvae
Sulfur	Inorganic	lll		
Thiamethoxam	Nicotinoid	lll	7-14 days	Sucking pests
Lambda-Cyhalothrin	Pyrethroid	ll	> 7days	Chewing & sucking pests
Dimethoate	OP	ll	3 days	Sucking pests
Acetamiprid	Nicotinoid	ll		Sucking pests
Permethrin	Pyrethroid	lb	1-2 days	Acaricide
Emamectin	Avermectin	ll		Lepidopterous Fruit worms
Thiophanate methyl	Benzimidazole	U		Powdery mildew
Spinosad	Bacteria	ll	<2 hours	Against lepidopterous larvae, thrips
Abamectin	Avermectin	ll		Against lepidopterous larvae
Metalaxyl	Anilide	ll		Downy mildew, ealry blight of tomatoe
Bifenthrin	Pyrethroid	ll		Against lepidopterous larvae
Pyridaben	Unclassified	ll	<2 hours	Sucking pests
Lufenuron	Urea	ll		Against lepidopterous larvae
Difenoconazole	Conazole	ll		Early blight of tomato, Powdery mildew diseases
Carbofuran	Carbamate	lb		Used for lepidopterous larvae
Acephate	OP	ll	3 days	Chewing & sucking pests
Manzate	Ethylene bisdithiocarbamate	lll		Black spot, flower blight, rust
Chloranthraniliprole		U		Against lepidopterous larvae
Malathion	OP	lll	2-5 days	Chewing & sucking pests
Monomehypo	Nereistoxin	NR		Against lepidopterous larvae
Deltamethrin	Pyrethroid	ll	4 hours	Chewing & sucking pests
Copper Oxychloride	Inorganic	ll		early blight of tomato
Azoxystrobin	Unclassified	lll		Powdery mildew, downy mildew stripe rust, haustorium
Indoxacarb	Oxadiazine l	lll		Sucking pests and chewing

Ib=highly toxic; II=Moderately toxic; III=Slightly toxic; U=Unlikely toxic

Toxicity of insecticides is usually determined by measuring critical contact toxicity standards LD_{50} (It is value which cause 50 % of mortality of population when exposed to pesticides). Honey bee threshold level to toxicity is normally set at extremely lethal (acute LD_{50} < 2 µg /honey bee); moderately lethal (acute LD_{50} equal with 2 - 10.99 µg/honey bee); somewhat lethal (acute LD50 equivalent toward 11 - 100µg/honey bee); non-lethal (acute LD50 > 100µg/honey bee) to developed honey bees (Antonina and Marian, 2013). Honey bee visit in pesticides treated agriculture field and the toxic chemicals are transported in hives through the pollen and nectar, it may kill the entire honey bee colony. The polluted pollen and nectar in bee colony may be impressed due to residual poisonous result of pesticides. When the toxic honey comb introduced into new family of bee brood colony it may also be affected severely (leading to death). The toxic chemicals can entirely destruct the bee population or decrease the population within the bee colony. This weaken colony may enter the winter with short food and may cause the collapse of colony over winter season (Atkins, 1992). There are different situations through which honey bees are exposed to pesticides; exposure through contact when honey bee may be poisoned in flight during application of chemicals or contact with residue on treated plants (Bura et al., 2000); by ingestion when bees collect pesticide contaminated food and it will be used by entire colony which results into colony destruction and storage food (nectar and pollen) in which nectar can be used instantly but pollen need time for fermentation to be digestible for honey bees and it will be used during the period outside the harvest particularly in wintertime, harvested pollen in August can be used in March, April next year (Villa et al., 2000). Insecticides may cause lethal and sub lethal effect on biological system of honey bees. Insecticides with different mode of action effect on molecular level lead to initiation of noticeable and unobservable effect, damage physiological function (thermoregulation and muscle activity), behavior (foraging) and cognitive activities (Belzunces et al., 2012).

Sub-lethal effect of pesticides

Sub-lethal influence of pesticides upon honey bee health and former beneficial insect were determined in most publications. For example sub-lethal doses of pesticides (Parathion, Diazinon) disturb the movement of honey bee behavior (familiarize over short distances, familiarize over long distances), harvesting, transport of nectar, development, fertility, fecundity, survival, feeding behavior and thermoregulation (Vandame, 1995; Desneux *et al.*, 2007). Anjum et al. (2001) determined mortality of honey bee in treated cucumber crops with Polo (Diafenthiuron 50 EC) and Endosulfan (35 EC) after 7 days interval. Mortality percentage was 34.64 and 66.64 % respectively after 48 hours .Plant protection products also show negative effect on honey bees on lives, immune capabilities and other behaviors which are important for better development of colony like bee brood feeding, building comb, swarming, and balancing worker and drone population between comb, transferring of information with in new building of colony (Colin et al., 2004).

Dilbar et al. (2014) conducted an experiment on three honey bee species (*Apis florea, Apis mellifera and Apis dorsata*) to determine the persistence data of confined bee against expose to seven insecticides including bifenthrin, spinosad, indoxacarb, emamectin benzoate, carbosulfan, imidacloprid and chlorpyrifos with concentration (1000, 500, 250,125 and 0 ppm). Carbosulfan and imidacloprid (1000 ppm) were more toxic with LD_{50} after exposure of 4 hrs used for *A. mellifera* while chlorpyrifos and imidacloprid having concentration (1000 ppm) extremely lethal with LT_{50} after expose of 5 hours to *A. florea*. Chlorpyrifos having concentration (1000 ppm) was highly lethal with LT50 after 5 hrs to A. *dorsata.* Therefore spinosad having concentration (125 ppm) with LT50 was enhanced to 15 hours, 18 hours and 20 hours against *A. florea, A. mellifera* and *A. dorsata* respectively.

Ping-Li et al. (2010) examined toxicity of some pyrethroids including deltamethrin and bifenthrin which are extensively applied in agriculture crops (fruits, vegetables, forestry crops). Bifenthrin has highly toxic effect on honey bees health including weight of egg, hatching, weight of larvae, emergence rate, and capping rate in each development stage while deltamethrin influence on larval weight, capping rate, advent rate in uncapped brood stage. Spinosad has also toxic effect on honey bee and causes high mortality when exposure time is increased. Chlorpyrifos and imidacloprid were highly toxic against three species of honey bee (*A. floria, A. mellifera and A. dorsata*) which caused 100 % mortality after 6 hour exposure to these insecticides with high concentration (Johnson et al., 2010). One neonicotinoids pesticide, imidacloprid is broadly used in agricultural crops effecting on the foraging behavior of honey bee and lead to honey bee

colony collapse disorder (CCD) (Lu et al. 2014; Karahan *et al*. 2015). Three nonicotinoids pesticides (clothianidin, imidacloprid, thiamethoxam) should not be applied during in oilseed rape and maize during flowering season to save honey bee colonies (Cressey, 2013).

The synergistic effects

According to (Colin and Belzunces, 1992) and (Pilling and Jepson, 1993) synergistic effect of mixture of fungicides and pyrethroids applied on honey bee in control condition enhanced toxicity 10 to 100 fold. When different pesticides (pyrethroid and fungicides) applied in agriculture field mixing in the same tank, synergism in their toxicity may happen accidently and show negative effect on insects.

Different insecticides including clothianidin, imidacloprid and thiamethoxam (neonicotinoid) are highly toxic pesticides to honey bees. Krupke et al. (2012) conducted a study to determine exposure of pesticides including neonicotinoids clothianidin, thiomexotham, atrazine (herbicides) and fungicides applied in agriculture during the foraging period. He concluded that propionazole (fungicide) showed synergism with neonicotiniod and pesticide residue becomes a part of soil, plant, pollen and nectar and when bees visit these plants, mortality occur directly (nectar) and indirectly (pollen storage).

Neonicotinoids insecticides are used directly in agriculture crops and also for seed treatment. These neurotoxic chemicals are systemic and become a part of plant including pollens and have been showed negative effect on honey bee health since 1990s (Henry et al., 2012; Kessler et al., 2015). Muhammad et al. (2016) demonstrated the residual effect of neonicotinoids on honey bee in laboratory experiments. Imidacloprid highly lethal than thiamethoxam followed by acetamiprid when use by wet surface method while nitenpyram and thiacloprid least lethal after 3 and 6 hour of exposure. Imidacloprid, acetamiprid extremely toxic than thiamethoxam to worker honey bee when expose to wet surface after 24 and 48 hours. Thiamethoxam, acetamprid and imidacloprid showed highly toxicity whereas thiacloprid and nitenpyram less toxic after 3 to 6 hours when exposure to oral application. Therefore, thiamethoxam was more lethal followed by thiacloprid, imidacloprid while acetamiprid and nitenpyram was less lethal after 24 and 48 hours through oral application. Thiacloprid and nitenpyram should be used nearby blossoming season to protect the honey bee. France and Germany prohibited the use of neonicotinoids during 2008 due to decline of bee colonies. Pesticides which are applied in agriculture field, among them most pesticides are fat soluble and larger quantity of pesticides store in bee wax than honey. Many scientific studies showed that the pollution of bee product in that order; propolis is most polluted followed by wax, pollen and honey (Bogdanov, 2003)

In Pakistan honey bee hives produces an average of 10-15 kg honey in each season but in Australia bee hives produces 25-30 kg honey per season due to good bee breeding facilities (Izhar, 2016). There are several reasons for less production in Pakistan including climatic changes, untrained beekeeper and extensive use of pesticides has severely affected the honey bee colonies and beekeeper annual loss of 5661 MT honey which equal to loss of 9.91 million rupees. In swat valley Wild honey also reduce up to 75 percent due chemical application and now not easily accessible on the marketplace. Farmers keep honeybees with their agricultural crops but pesticides are the main obstacle in beekeeping and also expected 90 percent honey bee deaths every day by bulky application of pesticides (Mohammad *et al.,* 2008). Honey production has declined up to 40% in Pakistan due to major changes in (habitat, biodiversity) and widely application of pesticides lead to reduce honey bees population within the Hindu Kush Himalayan region (Muhammad, 2016).

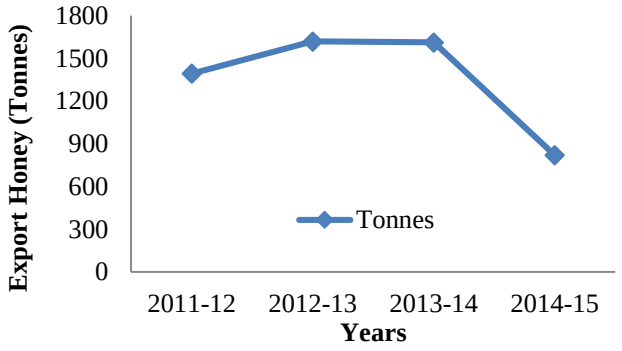

Fig 3: Export of natural honey from Pakistan (Pakistan Bureau of Statistics)

Role of pollination

Above 25,000 species of bees pollinate almost 70% of crops (87 of the 124 main crops) which are directly used for human consumption in the world. Production increase 5 to 50% in most agriculture crops as a result of pollination done by bees (Klein *et al*., 2007).

Almost 90 percent of all angiosperms depend on pollinators to survive. Honey bees responsible for third of pollination in agriculture sector. In Pakistan important crops including alfalfa, clover, almond, melon, soybean, sunflower, cucumber, apricot, cherry, peach, citrus, pear, persimmon , prune, apple ,plum, cantaloupe, okra, rape seed carrot onion, avocado, kiwi, cranberry blueberry are mostly require honeybee pollination (Mohammad and Elizabeth, 2014).

In Agriculture worldwide profitable value of pollination service is USA$193 billions annually. Annual economic worth of insects pollination for pulses crop is $2.7 millions, oil seed crops $ 233.1 millions, tree nut crops $ 50.5 millions, for seasonings are $ 5.5 millions and fruit and vegetables are $ 2.3 billions and 78.5 millions respectively (Gallai et al., 2009). In Europe 84% productions of crops depend upon the insect pollinator (Williams, 1994). Production value of pollinated dependent crop was equal to 1.59 billion US$ in Pakistan, therefore fruit crops are leading with 980 million, vegetable crops 320 million, nuts crop 150 billion, oil-rich seed crops 130 million and spices 4 million US $ (Muhammad and Elizabeth, 2013). Now Pakistan has 61 essential pollinated crops regard as foodstuff containing 26 fruits crop, 7 oil-rich seed crops, 4 grain legumes crop, 19 vegetables crop, 2 spices and 3 nut shrubs which are depend on honey bee pollination (Mohammad and Elizabeth, 2014).

According to (Stephen and Irshad, 2012) production of mustard crops increased 30 % and production of sarsoon (*Brassica rapa trilocularis*) and toria (*Brassica napus*) increased 47 % by increasing the bee hives. The presence of honey bee pollination cucumber and cauliflower yield increased up to 28-32.5 % and 23 % respectively. Different district of Pakistan including Matli, Badin and Golarchi yield of radish, sunflower increased 18.7 and 22 % respectively and seed set of onion increased 62-93 % due to honey bee pollination. Clover yield increased 100 % due to honey bee pollination. Anjum et al. (2001) found the foraging activity of honey bee in cucumber crops. Due to honey bee pollination germination of cucumber crops increased 90.33 % and yield obtained 352.7 kg per hectare. Muhammad et al. (2009) investigated honey bee pollination efficacy in canola crops. Number of pods and number of seed per pod are 815 and 20 with presence of bee pollination while 349 and 15 without pollination, yield of canola crops and weight of seed also increased due to bee pollination. Oz et al. (2009) determined that sunflower hybrid production enhanced seed set ratio, seed weight, number of filled seed per head and seed yield per head due to honey bee pollination.

Table 2: Economic values of honey bee pollination in different part of world (Uma and Tej, 2012: Mohammad and Elizabeth, 2014).

Country	Economic values (billion USA Dollar)	References
America	14.6	(Morse and Calderone, 2001)
Canada	1.2	(Winston and Scott, 1984)
China	0.7	(Chen, 1993)
New Zealand	2.3	(Matheson and Schrader, 1987)
European Union	3	(Williams, 1992)
United Kingdom	0.15	(Carreck and Williams, 1998),
Brazilian	8.75	(Freitas and Imperatriz-Fonesca, 2005)
East Africa	1.2	(Kasina *et a*l., 2009)
Uganda	0.46	(Munyuli, 2011)
Netherland	1.25	(Blacquiere et al., 2010)
Himalayan region of Pakistan	0.95	(Uma et al., 2012)

Deficit of pollination

According to current population growth rate high level of farming production will be needed to support the world population. The practices which are applied to enhance the yields damaged our ecosystem depict most susceptible to pests. To improve better health, length and quality of human life, food requirement have enhanced, and demanding the efficient pest control by using different pesticides. Approximately two billion individuals involve in agricultural business that mostly used chemical control to save their field crops and farm animals. Pesticides are applied also extensively in garden, throughout home and frame work of public fitness programmed (Oerke, 2006). In USA incomes of some fruit crops, seeds and nuts crop decline more than 90 percent in absence of insect pollinators (Southwick and Southwick, 1992). In USA pesticides have been consider as major factor for loses of honey bee colonies, reduction in honey production, wax yield and pollination to cause losses about $283 millions per year. It is estimated approximately $210 millions losses due to declining of honey bee

pollination of crops, residue of pesticides have been found in bee wax, pollen , adult bee and bee pupae (David, 2009; Mullin, 2010). In Pakistan yield of some fruit reduced up to 33.4% due to pollination shortage (Aslam et al., 2004). According to Gallai *et al.* (2008) three main crops categories will be affected due to decline of pollination , in which mainly fruits and vegetables production reduced with losses estimated at 50 billions for each and 39 billions Euros losses by edible seed crops. In Himalayan region of Pakistan the population of pollinator decline due to farmers and institution unawareness about pollination benefits. In mountain region of Azad Kashmir of Pakistan yield of apple decrease every year due to absence of pollinators and farmers replace their apple trees to agriculture crops (Uma and Tej, 2002). Uma et al. (2012) found production of agriculture crops increasing in mountain region of Pakistan by managing the honey bee pollinators. In Peshawar production of loquat decline 64.4% due to absence of honey bee pollinator and apple production also decreases (Khan, 1986; Khan, 2004). Aslam et al. (2004) determined that inflorescence and fruit seed set was in un caged and caged tree 42.5 and 28.3 % respectively, yield decrease 33.4 % due to decline of honey bees pollination. Zafar et al. (2016) examined the residual effect of Malathion (0.002 gm/ml) on pollinator insects including honey bee, bumble bee, syrphid fly and butterflies in *Calendula officinalis* field. After 10 days interval it was observed the forceful decrease in number of pollinator particularly honey bee due to insecticide treatment but significantly higher number of insect pollinator was detected in control field. In current senario colonies of honey bee are declining due to excessive use of chemical pesticides resulting into declining of food production in the absence of pollinators (Chauzat et al. 2006). Therefore excessive application of pesticides not only preserved within fruits and vegetables but also pollute the water and soil then enter into food chain and also enter into human blood through this food and water, pesticides is main cause of environmental pollution, damage the biodiversity and decline of natural habitats (Cerejeira *et al.*, 2003; USAID and I-LED, 2006-2009). It is claimed by many commercial companies of insecticides and fungicides that their products are harmless or only slightly toxic to honey bees but pesticides are dangerous to bees and other pollinators when applied on flowering crops (Abramson *et al.*, 1999). Large amount of insecticides are used to control the pests also having effect on natural enemies (Predators, Parasitoids, Parasites) of agriculture pests, sub-lethal doses of neonicotinoids have shown clearly effect on scrounging activity, natural selection, colony health and new honey bee and bumble bee queen production (Henry *et al.*, 2012; Schneider *et al.*, 2012: Whitehorn *et al.*, 2012) , Herbicides effect directly and indirectly on beneficial arthropods and may indirectly decreases the fitness of pollinating insect (Egan *et al.*, 2014).

Conclusion

Honey bee is an important pollinator for agriculture crops and increasing the production of fruits, seeds and vegetables crops without any additional investment. Pollination process is helping to improve crops quality, quantity, and genetic diversity and improve over all ecosystems. 15 % of world crops are pollinate by succeeded honey bee colonies and rest of world crops are pollinated by solitary bee and other animals. In developed countries *Apis mellifera* colonies are rented by farmers for pollination in their agricultural crops**.** It is continuous challenge to excessive use of pesticides in agriculture crops to control the pest. Every year new pesticides are coming to market with new formula and these are hazardous to biodiversity and may cause the animal and livestock death, pesticides residue present in food and water and honey bees severely damaged when exposed to pesticides. Pesticides treatment should avoid in plantation and crops during flowering and pesticides application should ensure protection of honey bee health. If honey bee takes polluted nectar and pollen in hive it may cause mortality of honey bee foragers result in destruction of whole colony. Farmers should use ecofriendly pesticides (derived from plant extracts etc.) like nicotine, quassin, rotenone, ryan, tephorosia, pyrethrins, veratrine, and anabasine which have less toxic effect on honey bee. Farmers must apply integrated pest management practice for control of pests in their agriculture field and should not only rely on chemical control measures.

References

Asif AJ, Amber RS, Najma M and Shafi MN, 2014. Current scenario of pesticides practice among farmers for vegetables production: A case study in Lower Sindh, Pakistan. Int J. Dev. Sustain. 3(3): 493-504.

Abramson C, Aquino I, Ramalho F and Price J, 1999 - The effect of insecticides on learning in the Africanized honey bee (*Apis mellifera* L.). Arch. Environ.Contam. Toxicol. 37: 529-535.

Allen-Wardell G, Bernhardt P, Bitner R, Burquez A, Buchmann S, Cane J, Cox PA, Dalton V, Feinsinger P, Ingram M, Inouye D, Jones CE, Kennedy K, Kevan P, Koopowitz H, Medellin R, Medellin-Morales S, Nabhan GP, Pavlik B, Tepedino V, Torchio P and Walker S, 1998. The potential consequences of pollinator declines on the conservation of biodiversity and stability of food crop yields. Conserv. Biol. 12: 8-17.

Anjum S, Zain UAD, Javad I, Muhammad I, Umair W, Rab NS and Ikram HQ, 2001. Insecticidal Mortality and Pollination Role of Honeybee (*Apis mellifera* L.) on Cucumber (Cucumis sativus L.) Crop. Int. J. Agri. Biol. 3(4): 501-502.

Antonina J and Marian B, 2013. The Impact of Pesticides on Honey Bees and Hence on Humans. J. Anim. Sci. Biotechnol. 46 (2)

Aslam, M, Razzaq M, Hussain S and Akhter W, 2004. Effect of insect pollinators on fruit setting on Mango (*Mangifera indica* L.). J. Sci. Res. 15:53-58.

Atkins EL, 1992. Injury to honey bee by poisoning, pp. 1153–1208. In: Graham JE (eds),The Hive and the Honey Bee, Dadant and Sons, Hamilton, Canada.

Belzunces LP, Sylvie T and Jean-Luc B, 2012. Neural effects of insecticides in the honey bee. Apidologie, 43:348–370.

Blacquiere T, Van SN and Bitter R, 2010. Bijen-Fascinerend, essentieel enbedreigd. Cachiers Bio-wetenschappen en Maatschappij, kwartaal 4, The Hague, Stiching Bio wetenschappen en Maatschappij.

Bogdanov S, Imdorf A, Charrière JD, Fluri P and Kilchenmann V, 2003. Qualite des produits apicoles et sources de contamination, Rev. Suisse d'Apiculture, 99 (11-12): 8-12.

Bura M, Pătruică S and Bura VAl, 2005. Tehnologieapicolă; (ed.). Solness, Timişoara.

Carreck N and Williams IH, 1998. The economic value of bees in the UK. Bee World. 79: 115–123.

Cerejeira MJ, Viana P, Batista S, Pereira T, Silva E, Valerio MJ, Silva A, Ferreira M and Silva-Fernandes AM, 2003. Pesticides in Portuguese surface and ground waters. Water Res. 37: 1055-1063.

Chauzat MP, Faucon JP, Martel AC, Lachaize J, Cougoule N and Aubert M, 2006. A survey of pesticide residues in pollen loads collected by honey bees in France. J. Econ. Entomol. 99: 253-262.

Chen YC, 1993. Apiculture in China. Agriculture Publishing House Peoples, Beijing, China.

Clare CR, Coombs CB, Frazier M, Grozinger CM and Robinson GE, 2015. Early-life experience affects honey bee aggression and resilience to immune challenge. Sci. Rep. 5: 55-72.

Colin ME and Belzunces LP, 1992. Evidence of synergy between Prochloraz and Deltamethrin in Apis mellifera L. a convenient biological approach. Pest. Sci. 36: 115-119.

Colin ME, Bonmatin JKM, Moineau I, Gaimon C, Brun S and Vermandere JP, 2004. A method to quantify and analyse the foraging activity of honey bees: relevance to the sublethal effects induced by systemic insecticides, Arch. Environ. Contamin. Toxicol. 47: 387- 395.

Cox-Foster DL, Conlan S, Holmes EC, Palacios G, Evans JD, Moran NA, Quan PL, Briese T, Hornig M, Geiser DM, Martinson V, vanEngelsdorp D, Kalkstein AL, Drysdale A, Hui J, Zhai J, Cui L, Hutchison SK, Simons JF, Egholm M, Pettis JS and Lipkin WI, 2007. A metagenomic survey of microbes in honey bee colony collapse disorder. Science, 318: 283–287.

Cressey D, 2013. Europe debates risk to bees: proposed pesticide ban gathers scientific support as some experts call for more field studies. Nature, 496 (7446): pp. 408.

David P, 2009. Environmental and Economic Costs of the Application of Pesticides Primarily in the United States, pp. 89–111. In Peshin R and Dhawan A (eds.), In Integrated Pest Management: Innovation-Development Process. Springer-Verlag, New York, USA.

De A, Bose R, Kumar A and Mozumdar S, 2014. Worldwide pesticide use, pp. 5–6. In: De A, Bose R, Kumar A and Mozumdar S (eds.), Targeted delivery of pesticides using biodegradable polymeric nanoparticles. Springer, New Delhi, India.

Desneux N, Decourtye A and Delpuech J M, 2007. The sublethal effects of pesticides on beneficial arthropods, Annu. Rev. Entomol. 52: 81-106.

Dilbar H, Qasim M, Saleem M, Akhter M and Khan KA, 2014. Bioassay of insecticides against three honey bee species in laboratory conditions. Cercetări Agronomice în Moldova. 2: 158.

Douglas S, 2015. Pesticides – a guide to their effects on honey bees. 2nd ed. New South Wales Department of Primary Industries, Goulburn, Australia.

Egan JF, Bohnenblust E, Goslee S, Mortensen D and Tooker J, 2014. Herbicide drift can affect plant and arthropod communities. Agric. Ecosyst. Environ. 185:77–87

Ellis JD, Evans JD and Pettis J, 2010. Colony losses, managed colony population decline, and colony collapse disorder in the United States. J. Apic. Res. 49(1): 134–136.

Ferrari TE, 2014. Magnets, magnetic field fluctuations and geomagnetic disturbances impair the homing ability of honey bees (Apis mellifera). J. Apic. Res. 53(4): 452–465.

Freitas BM and Imperatriz-Fonseca VL, 2005. A importanica economica da polinizacao Mensagem Doce. 80: 44-46.

Gallai N, Salles JM, Settele J and Vaissiere BE, 2008. Economic valuation of the vulnerability of world agriculture confronted with pollinator decline. Ecological Econom. 68: 810-821.

Gallai, N, Salles JM, Settele J, Vaissière BE, 2009. Economic valuation of the vulnerability of world agriculture confronted with pollinator decline. Ecological Econom. 68: 810–821.

Girling RD, Lusebrink I, Farthing E, Newman TA and Poppy GM, 2013. Diesel exhaust rapidly degrades floral odours used by honeybees. Sci. Rep. 3: 27-79.

Harries-Jones P, 2009. Honeybees, communicative order, and the collapse of ecosystems. Biosemiotics, 2(2): 193–204.

Henry M, Béguin M, Requier F, Rollin O, Odoux JF, Aupinel P, Aptel J, Tchamitchian S and Decourtye A, 2012. A common pesticide decreases foraging success and survival in honey bees. Science. 336: 348–350.

Hikmat UK, Syed IA, Nighat S and Baharullah K, 2016. Honey production potential of the honey bee (*Apis mellifera*) in Karak and Kohat, Pakistan. J. Entomol. Zool. Stud. 4(6): 559-564.

Hussain S, Aslam M, Razzaq M and Akhter W, 2004. Effect of insect pollinators on fruit setting on Mango (*Mangifera indica* L.). J. Sci. Res. 15: 53-58.

Izhar U, 2016. From modest farms to millions: Peshawar's neglected honey industry. (https://www.dawn.com/news/1234013).

Jadran KK, 2011. Measurement of economic efficiency for the projects of bee raising inside and outside towns in Wasit Governorate. Al-Anbar J. Vet. Sci. 9(3): 112-121.

Jivan A and Marian B, 2013. The Impact of Pesticides on Honey Bees and Hence on Humans. Anim. Sci. Technol. 26 (2): 272-277.

Johnson RM, Ellis MD, Mullin CA and Frazier M, 2010. Pesticides and honey bee toxicity–USA. Apidologie. 41(3): 312-331.

Kang SA, 2013. Impacts of pesticide use in Pakistan agriculture: their benefits and hazards. (http://zaraimedia.com/2013/02/13/impact-ofpesticides-use-in-pakistan-agriculture-their-benefitsand- hazards/).

Karahan A, Ibrahim C, John MH, Ismail K and Harrington W, 2015. Sublethal imidacloprid effects on honey bee flower choices when foraging. Ecotoxicol. 2: 15-37.

Kasina JM, Mburu J, Kraemer M and Holm- Mueler K, 2009. Economic benefits of crop pollination by bees: a case study of Kakamega small holder farming in western Kenya. J. Economic. entomol. 102: 467-473.

Kessler SC, Tiedeken E J, Simcock KL, Derveau S, Mitchell J, Softley S, Stout JC and Wright G A, 2015. Bees prefer foods containing neonicotinoid pesticides. Nature, 521(7550): 74-76.

Kevan PG, 1999. Pollinators as bio indicators of the state of the environment: species, activity and diversity. Agric. Ecosyst. Environ. 74: 373-393.

Khan BM, Shahid M and Chaudhry MI, 1986. Effect of honey bee pollination on the fruit setting and yield of loquat, *Eriobotrya japonica*. Pak. J. Forestry. 36(2): 73-77.

Khan MA, Iqbal M, Ahmad I, Soomro MH and Chaudhary MA, 2002 Economic evaluation of pesticide use externalities in the cotton zones of Punjab, Pakistan. Pak. Dev. Rev. 41:683–698

Khan MR and Khan MR, 2004. The role of honey bees (Apis mellifera L.) (Hymenoptera: Apidae) in pollination of apple. Pak J. Biol. Sci. 7(3):359-362.

Klein AM, Vaissiere BE, Cane JH, Steffan-Dewenter I, Cunningham SA, Kremen C and Tscharntke T, 2007. Importance of pollinators in changing landscapes for world crops. Proc. R. Soc. L. 274: 303-313.

Krupke C, Hunt G, Eitzer B, Andino G and Given K, 2012. Multiple routes of pesticide exposure for

honey bees living near agricultural fields. PLoS ONE. 7(1): 68-92.

Le Conte Y and Navajas M, 2008. Climate change: impact on honey bee populations and diseases. Revue Scientifique Et Technique-Office International Des Epizooties. 27(2): 499 –510.

Lee KV, Steinhauer N, Rennich K, Wilson ME, Tarpy DR, Caron DM, Rose R, Delaplane KS, Baylis K, Lengerich EJ, Pettis J, Skinner JA, Wilkes JT, Sagili R and vanEngelsdorp D, 2015. A national survey of managed honey bee 2013–2014 annual colony losses in the USA. Apidologie. 46(3): 292–305.

Lu C, Warchol KM and Callahan RA, 2014. Sub-lethal exposure to neonicotinoids impaired honey bees winterization before proceeding to colony collapse disorder. Bull.Insectol. 67(1): 125-130.

Maini S, Medrzycki P and Porrini C, 2010. The puzzle of honey bee losses: a brief review. Bull. Insectology. 63(1): 153-160.

Matheson AG and Schrader M, 1987. The value of honeybees to New Zealand's primary production. Nelson, New Zealand: Ministry of Agriculture and Fisheries.

Mattila HR, Rios D, Walker-Sperling VE, Roeselers G and Newton ILG, 2012. Characterization of the active microbiotas associated with honey bees reveals healthier and broader communities when colonies are genetically diverse. PLoS One. 7(3): 29-62.

McFrederick QS, Kathilankal JC and Fuentes JD, 2008. Air pollution modifies floral scent trails. Atmospheric Environ.. 42(10): 2336 –2348.

Michener C, 1969. Comparative social behavior of bees. Annu. Rev. Entomol. 14: 299-342.

Milivojevic T, Glavan G, Bozic J, Sepcic K, Mesaric T and Drobne D, 2015. Neurotoxic potential of ingested ZnO nanomaterials on bees. Chemosphere. 120: 547–554.

Mohammad I and Elizabeth S, 2013. Value of insect pollinators to agriculture of Pakistan Int. J. Agron. and Agric. Res. 3(5): 14-21.

Mohammad I and Elizabeth S, 2014. Review: pollination, pollinated and pollinators interaction in Pakistan. J. Bioresource Manage. 1(1) 19-25.

Mohammad N, Hizbullah K and Mohammad RJ, 2008. Pesticide Use in Swat Valley, Pakistan Exploring Remedial Measures to Mitigate Environmental and Socioeconomic Impacts. Mt. Res. Dev. 28(3): 201-204.

Morse RA and Calderone NW, 2001. The value of honey bees as pollinators of US crops in 2000. Bee Cult. 128: 1–15.

Mohammad ZK, 2015. Pakistan is losing its honey bees to climate change. (https://www.thethirdpole.net/2015/11/24/pakistan-is-losing-its-honey-bees-to-climate-change/).

Muhammad W, Munir A, Muhammad AA and Muhammad N, 2016. Lethal and sublethal effects of new chemistry insecticides against honeybees, *Apis mellifera*. 13th Asian Apicultural Association Conference, Jeddah, Kingdom of Saudi Arabia. Page numbers?

Muhammad SM, Shazia R, Mahjabeen S, Shahid N and Muhammad A, 2009. The pollination by honeybee (*Apis mellifera* L.) increases field of canola (*Brassica napus* L.) Pak. Entomol. 31(2).

Mullin CA, Chen J, Fine JD, Frazier MT and Frazier JL, 2015. The formulation makes the honey bee poison. Pest. Biochem. Physiol. 120: 27–35.

Mullin CA, Frazier M, Frazier JL, Ashcraft S, Simonds R and Pettis JS, 2010. High levels of miticides and agrochemicals in North American apiaries: Implications for honey bee health. PLoS ONE. 5: 54-97.

Munyuli MBT, 2011. Pollinator biodiversity in Uganda and in Sub Sahara Africa: landscape and habitat management strategies for its conservation. Int. J. Biodivers. Conserv. 3: 551-609.

Neumann P and Carreck NL, 2010. Honey bee colony losses. J. Apic. Res. 49(1): 1–6.

Oerke EC, 2006. Crop losses to pests. J. Agric. Sci. 144:31–43

Ollerton J, Winfree R and Tarrant S, 2011. How many flowering plants are pollinated by animals? Oikos. 120: 321–326.

Osteen CD and Fernandez-Cornejo J, 2013. Economic and policy issues of US agricultural pesticide use trends. Pest. Manag. Sci. 69:1001–1025

Oz M, Karasu A, Cakmak I, Goksoy AT and Turan ZM, 2009. Effects of honeybee (*Apis mellifera*) pollination on seed set in hybrid sunflower (*Helianthus annuus* L.). African J. Biotechnol. 8(6): 1037-1043.

PARC. 2010. Honeybee, Annual Report of PARC. 2010-11. pp. 98.

Pătruică S, 2006. Tehnologia creşterii albinelor, Curs universitar, Edit. Eurobit. Timişoara.

Pilling ED and Jepson PC, 1993. Synergism between EBI fungicides and a pyrethroid insecticide in the

honeybee (*Apis mellifera* L.). Pest. Sci. 39: 293-297.

Ping-Li D, Wang Q, Sun JH, Liu F, Wang X, Wu YY and Zhou T, 2010.Effects of sublethal concentrations of bifenthrin and deltamethrin on fecundity, growth and development of the honeybee *Apis mellifera* ligustica. Environ.Toxicol. Chem. 29: 644-649.

Popp J, Peto K and Nagy J, 2013. Pesticide productivity and food security: A review. Agron. Sustain. Dev. 33:243–255.

Schneider CW, Tautz J, Grünewald B and Fuchs S, 2012. RFID tracking of sublethal effects of two neonicotinoid insecticides on the foraging behavior of *Apis mellifera*. PLoS One. 7: 23-30.

Simeria G, Popescu G and Giuchici C, 2001. Combaterea biologică în sens strict" a patogenilor şi dăunătorilor plantelor, Ed. Mirton. Timişoara.

Southwick EE and Southwick JL, 1992. Estimating the economic value of honey bees (Hymenoptera: Apidae) as agricultural pollinators in the United States. J. Econ. Entomol. 85: 621–633.

Stephen E and Irshad M, 2012. Economics impact of pollinators in crop production of Pakistan. UNEP-GEFFAO Project. Islamabad, pp. 10.

Uma P and Tej P, 2002. Warning signals from the apple valleys of Hindu Kush- Himalayas: Productivity concerns and pollination problems. International Centre for Integrated Mountain Development, Katmandu, Nepal. Page numbers?

Uma P, Tej P, Harish KS, Pushkin P, Aungsathwi M, Nar BT, Tan K and Muhammad SM, 2012. Value of insect pollinators to Himalayan agricultural economies. International Centre for Integrated Mountain Development, Kathmandu, Nepal.

USAID and I-LED, 2006-2009. Pesticide Evaluation Report and Safer Use Action Plan. Pakistan.

Vandame R, Meled M, Colin ME and Belzunces LP, 1995. Alteration of the homing-flight in the honey bee *Apis mellifera* L. exposed to sublethal dose of deltamethrin. Environ. Toxicol. Chem. 14: 855-860.

Van Engelsdorp D and Meixner MD, 2010. A historical review of managed honey bee populations in Europe and the United States and the factors that may affect them. J. Invert. Pathol. 103: 80–95.

Villa S Vighi M Finizio A and Serini GB, 2000. Risk assessment for honeybees from pesticide-exposed pollen. Ecotoxicol. 9: 287–297.

Wakhal MD, Bhujbal M and Pais EVD, 1999. Analysis of Honey, pollen and royal jelly by high performance liquid chromatography-A review. Apiacta. 30(4): 6-11.

Whitehorn PR, Oconnor S, Wackers FL and Goulson D, 2012. Neonicotinoid pesticide reduces bumble bee colony growth and queen production. Science. 336: 351-352.

Williams IH, 1994. The dependences of crop production within the European Union on pollination by honey bees. Agric. Zool. Rev. 6: 229–257.

Williams IH, 1992. Apiculture for agriculture. pp. 14–18. In British Beekeepers' Association, Spring Convention, Stone Leigh, UK.

Winston ML and Scott CD, 1984. The value of bee pollination to Canadian agriculture. Canadian Beekeeping, 11: 134.

Wray MK, Mattila R and Seeley TD, 2011. Collective personalities in honeybee colonies are linked to colony fitness. Anim. Behav. 81(3): 559-568.

Zafar IK, Hafiz MT, Salma B, Kafeel A, Saira B, Rabia Y and Ijaz RN, 2016. Toxic effect of Malathion on insect pollinators visiting marigold flowers. Biologia. 62 (1): 1-7.