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Research paper

Effect of Some Air Pollutants on Forage of *Apis cerana indica* Fab. in Semi-Field Condition

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ABSTRACT

Studies were carried out in semi-field condition to assess the effect of impact of selected aerosol pollutants viz. Agrochemical pesticides, Vehicular smoke and *crop* residual smoke on forage of Asianhoneybee (*Apis cerana indica*) visits on sunflower (*Helianthus annuus*). The highest average number of honeybee visits was observed in the morning followed by noon and afternoon (9 AM to 2 PM) on sunflower. The maximum number of honeybee visits was recorded 85% on control and the maximum average time spent by the honey bee noticed was 58 min. The minimum honeybee visits was and maximum average time spent noted was 40 min on the pesticide treated sunflowers. Whereas the maximum average time spent on the vehicular smoke polluted flowers was 36 min. analysis demonstrated that a significant effect between the head diameter and the number of seed settings in relation with the number of honey bee visits on all 3 polluted fields of sunflower. The foraging activity, toxicity effects, sub- lethal behavioral effects were depending upon the time of exposure to the contaminants.

1. Introduction

Bees enact decisive role as a pollinators, *Apis cerana indica* is one among to maintain healthy Ecosystem. Pollinators encounter many factors, one such lesser-known threat is air pollution. Several recent studies have found that air pollution changes invertebrate recognition of biogenic Volatile Organic Compounds (VOCs) from plants and flowers. In one study, honeybees exposed to petrol exhaust emissions (primarily NOx) took significantly longer to learn plant VOCs and also forgot them faster than unpolluted ones (R. J. Leonard et al., 2019). Another recent field study found that ozone and NOx at levels below standards set for the protection of sensitive habitats reduced pollinators visits to flowers by 83-90% (James M.W. Ryalls. et al., 2022). Air pollution results in it being more difficult for pollinators such as honeybees to recognize, locate and memorize the location of their floral resources which impacts foraging efficiency and consequently pollination. Particulate pollution can also be an issue for pollinators as the fine hairs on their bodies that become electrically charged to attract pollen can also attract other fine particulates, including dust and heavy metals (Capitani, G. Papa et al., 2021). Rapid urbanization, intense agriculture, and poor emission control have led to enormous air pollution in the developing world (WHO 2019).

Flowers emit mixtures of scents that mediate plant-insect interactions, such as attracting insect pollinators. Certain air pollutants that are highly reactive in nature, such as ozone, degrade these volatile, plant-emitted hydrocarbons downwind of the source. Studies have shown that even moderate air pollutant levels, such as an ozone mixing ratio of 60 parts per billion on a per volume basis, (ppbv) substantially degrade floral volatiles and alter the chemical composition of released floral scents (Fuentes et al., 2016).

Honeybees can see ultraviolet light, which allows them to see patterns on flowers that are used as guides to find nectar and pollen but the problem with wood smoke is, it produces polycyclic aromatic hydrocarbons (PAHs) which are chemicals that form small PM, smaller than 2.4 microns. PAHs comprise more than 100 chemicals and come from coal, crude oil, gas, wood, tobacco and any burned rubbish(also synthetically made PAHs naphthalene etc). The honey bee olfactory system is disrupted by smoke. Smoke has been used since honey hunting and beekeeping began and we know that it is effective in calming bees during a hive inspection (Kirk Visscher P 1995*)*.

India is the world's largest fruit producer, second most populous country, and stands 9 of the world's 10 most polluted cities (Geetha G. T et al. 2020). Bangalore is the capital of the Indian state Karnataka and has an estimated (2014) population of 11,440,000 in the metro area. It is located in the south-eastern region on the state on the Deccan Plateau, and it is the third most populous city and the 5th most populous urban area. (Pallavi j, et al. 2024)and different Honeybee Flora (Venkatarameg-owda, S. 2021). A report released by Greenpeace Southeast Asia 2021estimated that Bangalore, which fared better than Delhi and Mumbai, still recorded an estimated 12,000 avoidable deaths owing to particulate matter concentration of air-born dust finer than 2.5 µm (PM) 2.5 air pollution. Among the six Indian cities featured in the global analysis, Bangalore is rated better than Delhi and Mumbai, but is worse off when compared with Chennai, Hyderabad, and Lucknow.Air Quality Index (AQI), 2023 – Bangalore. The air pollution data was compiled by the (Karnataka State Pollution Control Board) KSPCB, the pollutant concentration PM 2.5 was higher than the standard in all most all selected.

Persistent pollutant, air borne PM originate from both natural and artificial sources. Anthropogenic factors include burning fossil fuels (such as in vehicles and power plants), eroding pavement from vehicle traffic, abrasion from brakes and tires, and industrial operations (Rodica Margaoan et al., 2024). The practice of burning crop residue in the open field led to air quality impairment, smog, haze, heat waves, and different health problems (Raza, M.H et al., 2022). Smoke has been used since honey hunting and beekeeping began and we know that it is effective in calming bees during a hive inspection (Kirk Visscher P 1995*)*. This shows the effect of smoke on honey bees.The air quality in different cities and countries across the world is declining and since the cities are the main contributor to global air pollution (Minoo H L et al., 2022).

Erosion of natural habitats, urbanization, pollution and use of chemicals in agro- ecosystem manifold the intensity of environmental variations. Both a-biotic and biotic stresses significantly influence the insects and their population dynamics (Khaliq A et al., 2014).

Common air pollutants from both urban and rural environments may be reducing the pollinating abilities of insects by preventing them from sniffing out the crops and wildflowers that depend on them. (James M.W., 2022).

Millions of bee deaths per day not only by automobile pollution and also by Vehicles collusion (Jospeh S. W et al., 2024).Recent research addresses global loss of insect biodiversity. Artificial light at night (ALAN) causes insect declines due its affect on insect movement, foraging, reproduction, and predation. Pollinator insects pushed from agricultural fields to road verges by pesticides will be more exposed to streetlights and vehicle headlights (Owens C.S et al., 2019) therefore ALAN was palliated with better informed lighting practices in this study

This study aims to investigate the effects of Pesticide, vehicular smoke, Agricultural waste smoke and untreated (C) control influences the bees' ability to nectar foraging and lethality and assess the pollen types in the Honey samples.

2. Material and Methods

The study was conducted during February, 2023 to January, 2024. Survey studies were conducted in five places of Bangalore district of Karnataka State (Table-2). Information collected on various parameters and practices followed for *Apis cerana indica* rearing and management practices adopted by beekeepers for maintenance of bee colonies and honey storage practices.

2.1 Apis ceranaa indica

Newly emerged Healthy Honey bees colonies were collected from the local bee keepers and randomly assigned to six different groups (100 per cage), were kept in the selected experimental agriculture fields. Dead bees were counted and removed daily.

2.2 Sunflower (Helianthus annuus)

BSH-1variety (height 130 – 145 cm) seeds were collected from GKVK, Bangalore which are Sown January to February end in traditional area or during

September to November end and flowering in 58 to 60 days.Chandapuraagriculture field was selected for the semi field experiment among the five places.Four groups were made in experimental bed, in group 1 control (C), group 2 to treat Pesticide (P), group 3 to treat vehicular smoke (V), and group 4 to treat Agricultural waste smoke (A). 20 plants per group were raised individually.

2.3 Pesticide

Lambda - Cyhalothrin (Worrier with Zeon technology) a active Pyrethroid which controls broad spectrum of insects.As per the ICMR, directorate of oil seeds research, major insect pests are, sucking pests (leaf hoppers, thrips and white flies) leaf eating cater pillars (Tobacco cater pillars, Bihar hairy cater pillars, green semi looper) of Sunflower and controls capitulum borer yield loses 20 to 50%, was purchased from authorized dealers.

2.4 The experimental area

Plot of equal size (15X15 ft) and equal distance (200X 200 mtr) at four corners were made and no other plants species around the field was maintained with compound wall was selected (Fig-1). Seeds were sown manually during February with a row-to-row distance (3X3 ft) and plant-to-plant distance (3 X 3 ft). In each plot, the same agronomic procedures were used. Twenty plants were maintained (5X4) in each plot.

Each (plot) groups were treated individually with all the three selected pollutants, Pesticide (P) only once by sprayer, vehicular smoke (V) by 28 year old un maintained Hero Puch scooter daily one hour from 8 AM to 9 AM, and Agricultural waste smoke (A) by burning Agri waste daily one hour from 8 AM to 9 AM and another (plot) group was control (pollutants not treated).

Honeybee colony was kept between group 2 (P) and group 3 (V) to allow free visits of bees to the experimental area at two foot above the ground. The distance between each plot was 200 meters and the entire area was two Acre without any other plant species with 07 feet height compound wall. Figure -1.

2.5 CC TV

Cameras were installed to each plot facing (Sun flowers) west above 06 feet and recorded to make complete observation of bees foraging activity.

2.6 Honey samples

20 different honey samples were collected from 20 different regions and one from experimental fields of Bangalore district. Presence of different types of pollen was subjected to Melittopalynogical studies.

2.7 Seed collection

Seeds were harvested when it was ready. Seeds were manually removed from eachexperimental sunflowerplantshead for counting to ascertain and compare the impact of honeybees on seed settingand in time production.

2.8 Statistical Analysis

All data were subjected to statistical analysis wherever necessary using SPSS Package 11.5. 20 plus 02 samples were used in each of two replicates for each treatment and the experiment was repeated twice. A two-way analysis of variance was used to evaluate and the significance level was set at $P<0.05$.

3. Results

Semi field experiments were conducted at Chandapura , to investigate the forage behavior of *Apis cerana indica* , worker bees in relation to factors and assess the effectiveness of selected Pesticide (P) vehicular smoke (V) Agricultural waste smoke(A) and untreated (C) control.

Separate plots were allocated for the experiments, employing a randomized complete block design with two replications. The BSH-1varietyof sunflowerwas utilized in both experiments to ensure uniformity in the study.

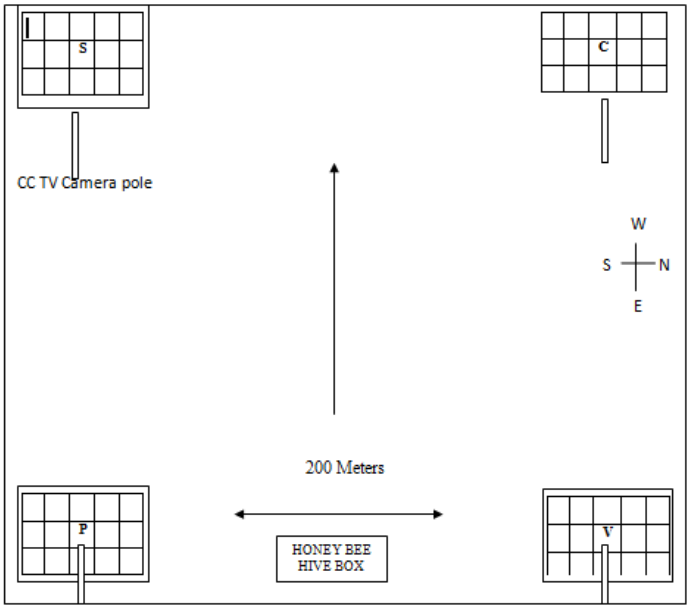
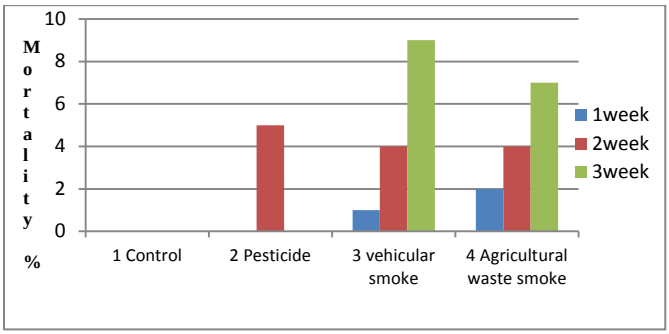


Fig. 1

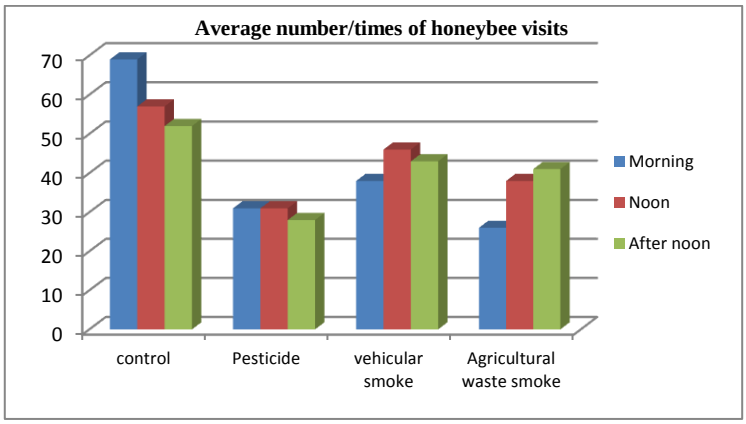
Mixed effects were observed in each pollutant treated plots. Bees reacts differently to poor air quality, where visit to flowers and percentage of death was more in the beginning in pesticide treated plot later its effect become very less and normal visit and forage was recorded and vice versa in vehicular smoke (V) Agricultural waste smoke (A) treated plots because the pesticide treatment was only once but was every day. Figure - 2 and 3.

Analysis of the honey samples Melittopalynological studies Figure 4 to ascertain and compare the experimental sample to find out the types of pollen grains in honey samples on a color scale graph which shows the foraging choice of bees within the quadrants regions and seasons (Fig. 4).



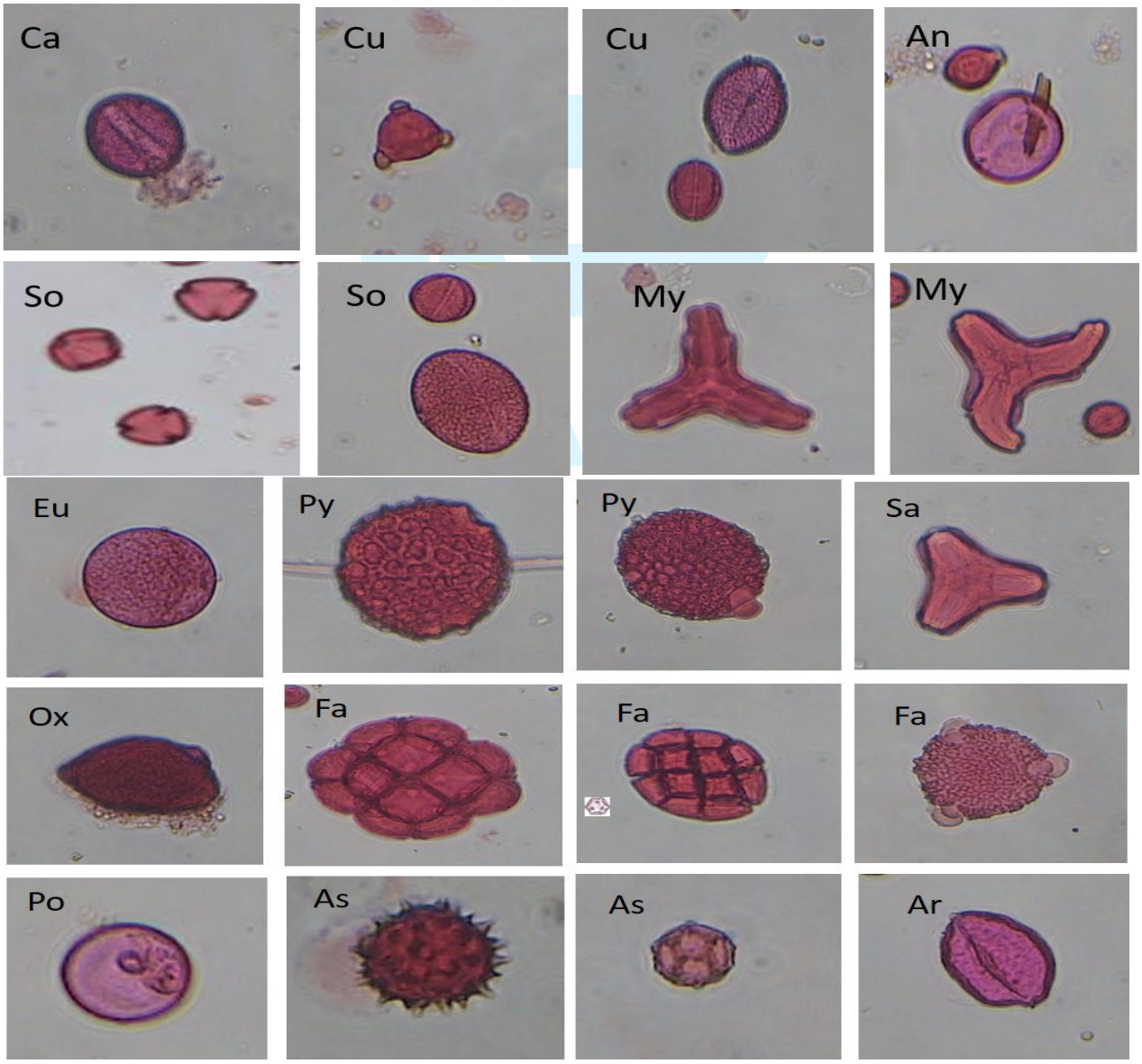
N= 100 average of 2 replicates

Fig. 2 Mortality percentages (%) of pollutants on *Apis cerana indica*



N= 100 average of 2 replicates

Fig. 3 Effect of pollutant exposed on *A.cerana indica*visits at different times of forage



Eu: *Euphorbiaceae* Po: *Polygonaceae* Sa: *Sapindaceae* Ox: *Oxalidaceae* Fa: *Fabaceae* Po*: PoaceaeA*s: *Asteraceae*
Ar: *Arecaceae* Ca: *Capparaceae* Cu: *Cucurbitaceae* An: *Anacardiaceae* So: *Solanaceae* My: *Myristicaceae*

Fig. 4 Photo micrographs of pollen types identified from samples (magnified to X1000)

Table 1 Colorscale graph showing the presence and absence of types of pollen in the samples

Region	Study period (2023-24)	Season	Cucurbitaceae	Solanaceae	Asteraceae	Anacardiaceae	Arecaceae	Oxalidaceae	Euphorbiaceae	Capparaceae	Fabaceae	Myrtaceae	Poaceae	Sapindaceae	Polygonaceae
DODDABALLAPUR	Aralumallige February	W	1	1	1		2	2	2	2	2	3	3	4	4
	Rajanukunte March	S	1	1		1		2	3		3	3		4	4
	Doddaballapura Town March	S	1	1	1			2	2	2		3	3	4	4
	Industrial area March -April	S	1	1	2	1	2	2	3	4	3			4	4
	Rajanukunte February	W	1	1	1			2	2	2		3		4	4
	Industrial Town February	W	1	1	1	1	1	2	2	2			3	4	4
BENGALURU NORTH	Yelahanka Feb	W	2	2	1	2	2	2	2	2	2	2			
	Byatarayanapura March	S	2	2		1		2	3	3	3	1	4	4	4
	Heggadenagar Feb	W	2	2	1		2	2	2	2	3	1	4	4	4
	GKVK Campus March	S	2	2		1	2	2	2	2	3	1	3	4	4
	Hebbal Feb	W	2	2	1	2	2		3		4	1	4	4	4
	R T Nagar Feb	W	2	2	1	1		2	2	2		1	3	4	4
BENGALURU SOUTH	Kengeri Feb	W	1	1	1	1	2	2	2	3	3	3	4	4	3
	Padmanabhanagar Vijayanagar March	S	1	1	1	2	2	2	2	2	2	3	4	4	4
	Chamarajapete Feb	W	1	1	1	1	1	2	2	3	3	4	4	4	4
	Nagarabhavi March	S	1	1	1	2	2	2	2	2	2	3	3	4	4
	Rajarajeswarinagar Feb	W	1	1	1	1		2	2	3	3	3	3	4	4
	Uttarahalli Feb	W	1	1	1	1	2	2		2	3		3	3	4
ANEKAL	Bannerghatta Feb	W	1	1	1	1	2	2	3	3	3	4	4	4	4
	Chandapura March	S	1	1	1	2	2	2	2	3	3	3	4	4	4
	Athibele Feb	W	1	1	2	2	2	2	3	3	3	4	4	4	4
	Anekal Town March	S	1	1	1		2	2	3	3		3	4	4	4
	Shivanahalli Feb	W	1	1	1	2	2	3	3	3	3	4	4	4	4
	Jigani Feb	W	1	1	1	1	2	2	2	2	3	3	2	4	4
NELAMANGALA	Nelamangala Town	S	1	1	1	1	2	2	2	1	3	3	3	3	4
	Arashinakunte	S	1	1	1	2	2	2	2	2	3	3	2	4	4

1: Predominant (>45%); 2: Secondary Pollen (16-45%); 3: Important Minor pollen (3-15%); 4: Minor pollen (<3%). S-Summer, W-Winter

4. Discussion

Honeybees have two large compound eyes and three smaller simple eyes. The compound eyes are made up of thousands of individual lenses, which allows them to see in different directions at the same time. The simple eyes are used to detect changes in light and dark, which helps the bees navigate. That honeybees tend to visit a similar proportion of plant species in communities where they are native, and in communities where they are introduced, is consistent with the opportunistic behavior of these social insects and their ability to exploit a wide range of novel flower types (Stanley, D. A et al., 2020)

It is known that the foraging activity of honey bees is initiated in early morning and finishes in the evening. The foraging activity fluctuates during the day from the morning until the evening found high pollen collection in the early morning while low amounts of pollen were collected in the afternoon (Abou-Shaara H.F. 2014).

Foraging model, one where initial decisions should be based on previous learning regardless of the foraging site or time and not differ between flower colors (Marisol A M et al., 2014).

Different locations are thus not considered as new problems, and the initial response is to base foraging on previously learned relationships until information to the contrary is obtained (Trimmer, P.C. 2911).

Other parameters related to foraging activity and the visiting of plants include, the number of foragers per flower and time spent per flower (Sushil et al., 2013). Foragers have the ability to remember the time of the day at which the higher food resources are available as found with Sysirinchium palmifolium plants (Silva et al., 2013)

Implication of the circadian clock in key aspects of honey bees foraging for flower rewards include anticipation, timing of visits to flowers at specified locations and time-compensated sun-compass orientation. Floral rhythms in traits such as petal opening, scent release and reward availability also show robust daily rhythms (Bloch G. 2017) a circadian clock may confer a selective advantage by allowing an organism to anticipate and prepare for predictable daily changes in its environment rather than reacting to changes. Moreover, the circadian system plays an important role in coordinating internal metabolic processes (Yerushalmi S, Green RM. 2009).

Effect of pesticides on bees and their products was noticed with affected Foraging behaviour (Kameela W S and Mohammed S M 2020; Morfin et al., 2019) leads to increase in mortality percent even though application was only once when compare to vehicular smoke and agri smoke which were given every day.

Acute ozone exposure impairs detection of floral odor, learning, and memory of honey bees, through olfactory generalization (Demares, F et al., 2022) environmental problems such as pesticides, chemical that used in agriculture (Varol, E. and Yucel, B 2019)
Not all plants are important for honeybees, and those plants that supply both nectar and pollen abundantly when in bloom known as honey bee plants. Honeybees visit native and introduced plant species with the opportunistic behavior and ability to exploit a wide range of novel flower types (Stanley, D. A et al., 2020).

The forager bees can be classified into two categories; scout bees which search for the best food resource and the reticent bees which wait in the beehive until the scout bees return and give them information about the food source by dancing.The mean of foraging distances was 6.1 km and the mean was5.5 km from the hive and decoded the waggle dance where and how far the bees foraged (Beekman et al., 2004). In this experiment noticed the forage from far place where pollution is less and other plant species pollens gives the evidence.

Honeybees are social insects that exhibit striking caste-specific differences in longevity. While honeybee queens can live up to 5 years, workers usually only live two to six weeks in the summer and about 20 weeks in the winter (Prado A et al., 2020) and sunflower life cycle is 58 to 60 days therefore experimental data collection was calculated only for 3 weeks.

The highest number of honeybee visits, 85%, was observed on the control sunflowers, with the longest average time spent by the honeybees being 58 minutes. In contrast, the pesticide-treated sunflowers had the fewest honeybee visits,31% with a maximum average time of 40 minutes. Sunflowers exposed to vehicular smoke pollution saw a maximum average time spent of 36 minutes by the honeybees. Analysis revealed a significant correlation between head diameter, seed setting, and the number of honeybee visits across all three polluted sunflower plots.

5. Conclusion

20th May, World Bee Day raises awareness of the essential role of bees, and other pollinators which plays in keeping people and the planet healthy. Air pollution and the decline in bee abundance are both global issues. It seeks to assess the effectiveness of selected insecticides and botanical oils, contributing to the development of sustainable and cost-effective pest management strategies of bioremediation.It is concluded that farmers should maintain honeybee colonies close to the desired crop to increase pollination and increase output

Conflict of Interest

Authors declare that there is No conflict of interest.

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