Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2016; 4(4): 1185-1191

Received: 01-05-2016
Accepted: 02-06-2016

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Relationship of urban dust precipitation on pollination and fruit falling of *Mangifera indica* and *Litchi chinensis* in Dhaka District, Bangladesh

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Abstract

A study was conducted on the relationship of road-side dust on pollination and fruit falling of Mango (*Mangifera indica*) *and* Litchi (*Litchi chinensis*) from February to May, 2014. Trees were selected based on three different exposures- high, dusty (roadside), Medium dusty (100m from the road) and low dusty (200 m from the road). Number of flowers, percentage of successfully pollinated flower, rate of fruit falling at initial stage and dust precipitation per day per leaf was 940.27±122.01, 1.55%, 62.94% and 4.18 mg in mango and 408.03±77.51, 3.74%, 74.52% and 3.16 mg, respectively in litchi was found. There was, in fact no correlation between dust precipitation and rate of successful pollination (r= -0.096, df=36 for mango and r= - 0.02, df= 22 for litchi). The correlation was weak and positive between dust weight and fruit falling rate (r=0. 22, df=36 for mango and r= 0.4, df=22 for litchi) at the initial stage. Mechanical factors cause fruit falling after its formation, not the dust, up to the recorded level of precipitation. 23 pollinator insect species were recorded randomly. No Significant variation was found (α= 0.05) among dust precipitation and successful pollination rates at different dust exposure. But in fruit falling after formation, variations have been noticed.

Keywords: Mango, Litchi, successful pollination rates, dust precipitation, fruit falling rates

Introduction

Effective pollination is extremely important for ecosystem services e.g., food production, medicine and for conservation of global biodiversity [1-6] most plant species depend on animal-mediated pollen flow [7] in order to enhance the directedness of pollen transfer among flowers. [8] Dust is a general name for solid particles having diameters of (>500) µm, [9, 10] arise from natural sources such as soil dust lifted up by wind and volcanic eruption. [11] In addition, agricultural and developing activities also generate high dust concentrations. [12]

Dust can affect the plants either directly or indirectly. Generally exposed areas of a plant especially leaves, act as constant absorbers for particulate matters. [13] Coating of dust to 1 mm thick on a leaf surface may reduce its photosynthesis by 25-30 percent. [14] The dust directly affects fruit production in three ways: first by a reduction in the number of buds formed, resulting in lower flower initiation and hence, lower fruit setting; second by reducing the fruit size due to an inadequate supply of carbohydrates and finally by lowering the sugar content of fruits (Jackson, 1983).

In Bangladesh, Dhaka-Aricha highway is one of the most important and busy highway of Bangladesh. The density of motorized and non-motorized vehicles on this road is high, producing a high concentration of dust on the top of the roadside house buildings and leaf surface of plants. The studying site at Savar radio colony is situated at the roadside while in the Jahangirnagar University is situated in the range between 100 and 200 meters and in Savar Military Farm more than 200 meters.

Although it was too complex to isolate and quantify each effect caused by reducing photosynthesis, an attempt has been made to predict the co-relation between dust and pollination rate and dust and fruiting rate in three different areas of Dhaka. The present study was conducted to find out the effect of dust on pollination and its rate from three different areas, a high dusty area (Savar radio Colony), a medium dusty area (Jahangirnagar University Campus) with the low dusty area (Savar Military Farm).

Aims and Objectives

The aims of this study were to investigate, how dust affects pollination of Mango (*Mangifera indica*) and Litchi (*Litchi chinensis*) plants with the following objectives: to count the number of flowers in a whole flower bud (including all sub-buds); to assess the dust precipitation rate (in mg) per day per leave, in both fruiting plant species; to count the number of fruits at the very initial stage (percentage of total flowers pollinated) and to assess the rate of fruit falling.

Method and Materials

Study Area

The study areas were selected based on the rate of pollution mainly by dust. The three main study areas were Savar radio Colony, Savar Military Farm and Jahangirnagar University Campus.

Savar is an Upazila of Dhaka District in the Division of Dhaka, Bangladesh. It is located at a distance of about 24 kilometres to the northwest of Dhaka city and a total area of 280.13 square kilometres. The land of the upazila is composed of alluvium soil of the Pleistocene period. The altitude gradually increases from the east to the west. The southern part of the upazila is composed of the alluvium soil of the Bangshi and Dhaleshwari rivers. Main rivers are Bangshi, Turag, Buriganga and Karnatali. The Bangshi River has become polluted due to industrial waste. As of the 2011 Bangladesh census, Savar Upazila had a population of 1,387,426. Savar is one of the highest profile industrial area causing serious pollution to the environment as well as water body.

The Jahangirnagar University Campus stands on the west side of the Asian Highway, popularly known as the Dhaka-Aricha Road, and is 32 kilometers away from the capital. Spread over a land area of 697.56 acres (2.8 km²). The topography of the land with its gentle rise & plains is shooting to the eye.

Savar Radio Colony and Military farm, savar also stand on the side of the Asian Highway, in the centre of savar upazila. Savar Radio Colony stands along with Military Farm, Savar. Ecological condition of these two places as like the Jahangirnagar University on the basis of same geographical region. Plants and Animals species found more or less, as same as the university campus.

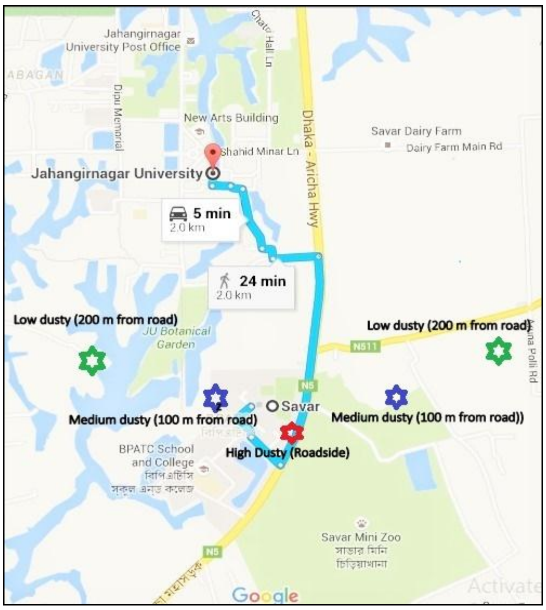

Fig 1: Map of study areas: Red point- High dusty (Roadside), Blue Point- Medium dusty (100 m from road) and Green Point- Low dusty (200 m from road)

Materials

During the beginning of each survey the buds of the tree (Mango, *Mangifera indica;* liche**,** *Litchi chinensis)* were selected. The length of buds using thread, scale and point compass were measured, also the number of buds by the counter were counted. Then the data in the data sheet using pencil were recorded. For further observation the buds were marked with tape and marker pen and also took some snaps by using camera (Canon-1100D). For the collection of leaves, at first the leaf was selected and cut it with scissor then wrapped it with tissue and carefully put it in the plastic box. In order to measure the amount of dust, electric balancer was used in the laboratory and collected the data on data sheet and also used a binocular to identify the pollinator.

Methods

Due to the shortage of suitable information regarding the effects of road dust on rural production, this study entailed a search for raw data, both objective and subjective, which was adapted, integrated and extrapolated to provide a basis for making assumptions and for conducting sensitivity analyses of possible effects. The general procedure of the study is as follows.

1. Selection of possible study sites
2. Measuring and counting of bud
3. Measuring the amount of dust.

Working Procedure

The study sites were selected based on the rate of dust precipitation. The three main study areas were Savar radio Colony, Savar Military Farm and Jahangirnagar University Campus. For both mango and litchi, three different spots were selected for the study-a spot nearest to the road where dust density in the air is much rich. Second one was**,** anyway, 100m away from the road sides where dust is relatively low. The last site was at least 200m far from the road, and in calm and forested areas where there were minimum chances for the roadside dust to reach.

In the research, the procedure maintained was as per the following sequence, both for mango and litchi-

- Twenty (mango) and three (litchi) trees were selected randomly at three study sites; varieties of the plant was not taken in count;
- At each tree, some leaves and buds were selected and marked;
- The selected leaves were properly cleared so that no unwanted dust remained attached to them, thus, all dusts were wiped out using tissue, and water, wherever necessary.
- The measurements regarding the bud and sub-bud lengths were taken using normal scale and compass.
- The number of unit flowers was counted, for each bud.
- After a few (7-10) days, the previously selected and cleared plant leaves were collected, wrapped with a tissue paper of a particular size and brand. Rainfall was a factor during the study time and it was noticed that, the exact time of dust precipitation could be recorded. Measurement of the weight of a single leaf with dust and tissue paper and then the leaf it was taken at the Laboratory of the Department of Chemistry, Jagannath University, Dhaka uses a sensitive Electric Balance. Deducting the weight of tissue and cleared leaf, dust weight was calculated.
- When the fruits arrived, their number at each bud was taken in count.
- After a few days, a second count was taken to determine the falling by that time.

(A) (B)

Plate 1: Flowering in Mango (A) and Litchi (B)

(A) (B)

Plate 2: Initial Fruiting in Mango (A) and Litchi (B)

Results and Discussions

Results

Length of Ovule Bud

In Mango, the average length of the whole ovule bud was 18.94±0.74 cm with maximum 31.4 cm and minimum 10.0 cm. Among them, in high dusty area it was 18.97 cm; in medium dusty area 19.67 cm and in low-dusty area 18.19 cm on average. In litchi, the length of whole ovule bud was 18.57±4.46 cm with maximum 27.1 cm and minimum 9.5 cm where the average whole ovule bud length of high dusty area was 18.48 cm, medium dusty area was 14.15 cm and low-dusty area was 23.08 cm.

Number of Ovule in a whole Bud

In mango, the average number of flower in whole bud was 940.27±122.01, where the average number of flowers of dusty, medium and non-dusty areas was 1077.23, 900.37 and 843.2 respectively.

In litchi, the average number of flower in whole bud was 408.03±77.51, where the average number of flowers of dusty, medium and non-dusty areas was 328.5, 483.35 and 412.25 respectively.

Number of Fruit in Whole Bud`

Observation of first week after pollination, in mango, the average number of fruit in whole bud was 12.03±1.47, where the average number of fruit in whole bud of high dusty area was 11.23, medium dusty area 13.73 and low-dusty area 11.13.

In litchi, the average number of fruit in whole bud was 13.32±1.05, where the average number of fruit in whole bud of high dusty area was 12.10, medium dusty area 19.95 and low-dusty area 13.90.

Observation of third week after pollination, in mango, the average number of fruit in whole bud was 4.6±1.70, where the average number of fruit in whole bud of high dusty area was 2.63, medium dusty area 5.6 and low-dusty area 5.56.

In litchi, the average number of fruit in whole bud was 3.0±1.09, where the average number of fruit in whole bud of high dusty area was 2.55, medium dusty area 2.2 and low-dusty area 4.25.

In mango, 1.55% and in Litchi, 3.75% of total ovules were observed to form fruit

Table 1: Different parameters of Mango (*M. indica*) and Litchi (*L. chinensis*) fruiting in relation to different rate of dust precipitation at different sites

Tree name	Area Type	Stalk bud					% fruit available observation-I	% fruit available observation-II	Falling rate (%)
		Avg. Length (cm)	Avg. number of sub-buds	Avg. length of sub buds(cm)	average number of flowers in sub buds	Avg. number of flowers in a whole bud			
Mango	High	18.97	35.53	5.09	27.90	1077.23	1.36	0.37	79.41
	Medium	18.19	36.43	5.08	22.63	843.20	1.65	0.79	50.26
	Low	19.67	32.30	5.93	27.47	900.37	1.65	0.73	59.16
	AVG	18.94	34.76	5.37	26.00	940.27	1.55	0.63	62.94
	STDEV	0.74	2.17	0.49	2.92	122.01	0.17	0.23	14.94
Litchi	High	18.48	16.20	3.76	19.95	328.50	3.83	0.92	77.93
	Medium	14.16	13.00	2.94	31.70	412.25	3.92	1.22	70.21
	Low	23.08	15.20	4.99	31.10	483.35	3.50	0.60	75.44
	AVG	18.57	14.80	3.90	27.58	408.03	3.75	0.91	74.52
	STDEV	4.46	1.64	1.03	6.62	77.51	0.22	0.31	3.94

With dust precipitated on leaves per day per leaf fruiting (the percentage of total flowers of a bud successfully pollinated and fruits were appeared) rate was correlated weakly and the relationship was negative (r_s=-0.096 for mango and r_s=- 0.02 for litchi).

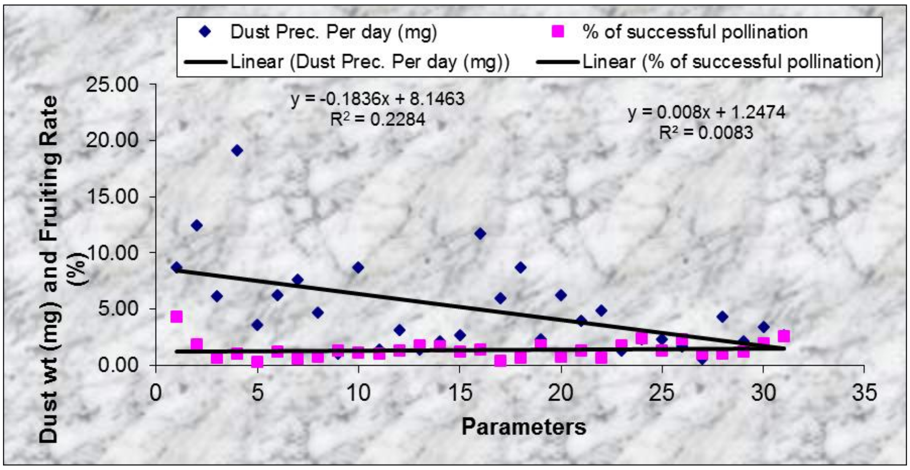

Fig 3.1: Scattered diagram showing the relationship between Dust precipitation (mg) and successful pollination (% of flowers yielding fruit) in *Mangifera indica*

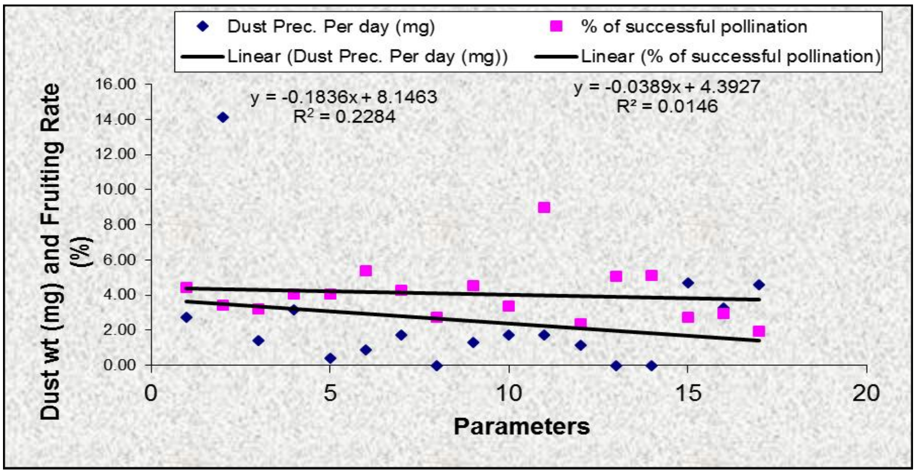

Fig 3.2: Scattered diagram showing the relationship between Dust precipitation (mg) and successful pollination (% of flowers yielding fruit) in *Litchi chinensis*

Rate of Fruit Falling

In mango, the average rate of fruit falling was 62.94±14.94%, where the average rate of fruit falling off high dusty, medium and low-dusty area was 79.40%, 59.15% and 50.26% respectively.

In litchi, the average rate of fruit falling was 74.52±3.94%, where the average rate of fruit falling off high dusty, medium and low-dusty areas was 77.93%, 75.21% and 70.21% respectively.

Dust precipitate on leaves per day per leaf was correlated weakly with a falling rate after 7 days (the percentage of total fruits of a bud fallen) and the relationship was positive (r_s=0.22 for mango and r_s= 0.4 for litchi).

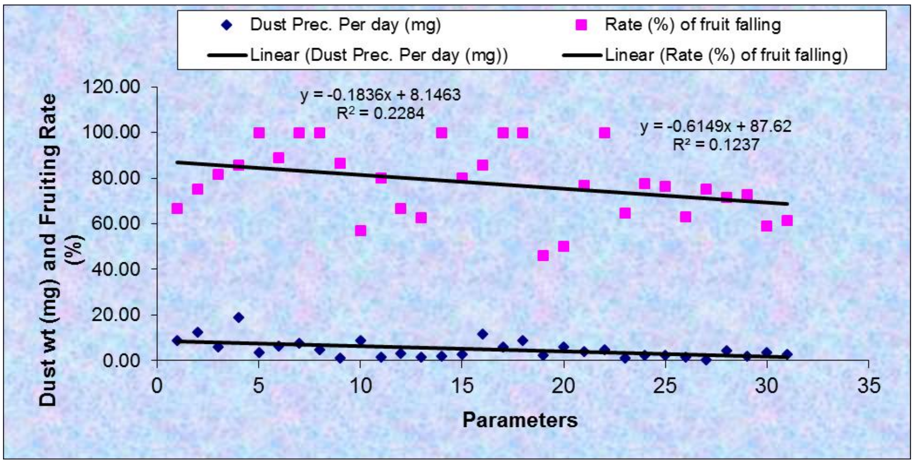

Fig 3.3: Scattered diagram showing the relationship between Dust precipitation (mg) and percentage of Fruit fallen at an early stage in *Mangifera indica*

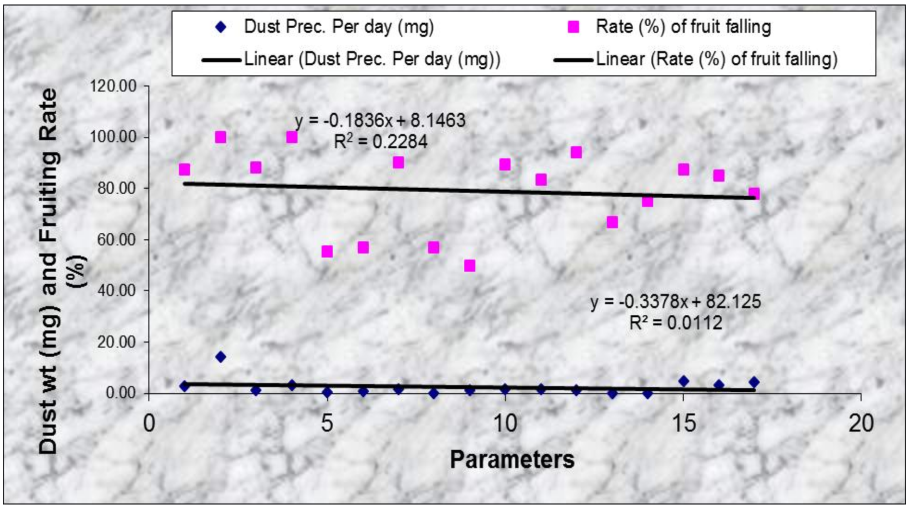

Fig 3.4: Scattered diagram showing the relationship between Dust precipitation (mg) and successful pollination (% of flowers yielding fruit) in *Litchi chinensis*

Dust Precipitation

In mango, the average dust precipitation was 3.90±1.99 mg/leaf/day, where the average dust precipitation of high dusty, medium and low-dusty area was 6.2 mg/leaf/day, 2.69 mg/leaf/day and 2.82 mg/leaf/day respectively.

In litchi, the average dust precipitation was 2.61±0.715 mg/leaf/day, where the average dust precipitation of high dusty, medium and low-dusty area was 2.86 mg/leaf/day, 1.8 mg/leaf/day and 3.16 mg/leaf/day respectively.

Table 2: Dust precipitation on Mango and Litchi leaves in different places.

Tree Name	Area Type	Leaf Weight (g)	Dust Weight (g)	Dust Weight (mg)	Dust pp. per day per leaf
Mango	High	0.85	0.043	43.42	6.2
	Medium	0.7031	0.0188	18.8	2.69
	Low	0.62	0.02	19.75	2.82
	AVG	0.7244	0.0273	27.323	3.903
	STDEV	0.1165	0.0136	13.9482	1.99
Litchi	High	0.627	0.02	20	2.86
	Medium	0.62	0.013	12.57	1.8
	Low	0.517	0.022	22.14	3.16
	AVG	0.588	0.0183	18.2367	2.6067
	STDEV	0.0616	0.0047	5.0228	0.7145

Insect Pollinators of Mango and Litchi

Though only effect of roadside dust were the main objective, we had noticed some insect pollinators on these plants. No differentiation was made for Mango and Litchi, just a note was taken for insect found on plants.

During the period, the study was done on the pollinators, mainly insects which pollinate the mango and litchi trees of the study sites. The major pollinating species was found to be Syrphid flies followed by *Apis mellifera* and *Apis florae*. The other pollinating species having the major role in pollination were Asian lady beetle, Rock bee, housefly and members of Lepidoptera

The pollination efficiency of the bees is more than flies, due to the presence of hairs on the body, pollen comb, pollen basket presents in the legs of the bees. For pollinator diversity, a smooth assessment of at least 16 months is required to make a good assessment. Due to the shortage of suitable time during the study period, the observation of pollinators was performed only 6 months.

Table 3: List of pollinator species associated with Mango and Litchi trees

Sl. no.	Common name	Scientific name	Order
1	Tachinid fly	*Hystricia abrupta*	Diptera
2	Green bottle fly	*Lucilia sericata*	Diptera
3	March fly	*Scaptia sp.*	Diptera
4	Housefly	*Musca domestica*	Diptera
5	Drone fly	*Eristalis tenax*	Diptera
6	Flesh fly	*Sarcophaga spp.*	Diptera
7	Lesser house fly	*Fannia canicularis*	Diptera
8	Syrphid flies	*Simosyrphus grandicornis*	Diptera
9	European bee	*Apis mellifera*	Hymenoptera
10	Rock bee	*Apis dorsata*	Hymenoptera
11	Dwarf bee	*Apis florea*	Hymenoptera
12	Wasp	*Polistes sp.*	Hymenoptera
13	Ant	*Camponotus spp.*	Hymenoptera
14	Asian lady beetle	*Harmonia axyridis*	Coleoptera
15	*Altica* (blue beetle)	*Montipora spp.*	Coleoptera
16	Orange beetle	*Ischyrus quadripunctatus*	Coleoptera
17	Red cotton bug	*Dysdercus koenigii*	Hemiptera
18	Cabbage white	*Pieris brassicae*	Lepidoptera
19	Mottled emigrant	*Catopsilia pyranthe*	Lepidoptera
20	Grass yellow	*Eurema daira*	Lepidoptera
21	Blue Glassy Tiger	*Tirumala limniace*	Lepidoptera
22	Common Palmfly	*Elymnias hypermnestra*	Lepidoptera
23	Common Jezebel	*Delias eucharis*	Lepidoptera

Discussion

The study reveals that small to moderate amount of roadside urban dust precipitation have no adverse effect on pollination and primary fruit formation in both mango and litchi but the impacts are fruit falling after fruit formation. Though it is reported that significant reduction occurs in plant length, cover, number of leaves and total chlorophyll contents; (*Vitis vinifera* L.) (*Grape*) [15] the percentage of flower of both mango and litchi turned into fruits depend on dust precipitation on it rather in some cases the plants of dusty areas showed higher successful pollination rate. Thus dust precipitation is not a key factor to pollination up to a tolerable extent. Though the level of tolerance beyond which pollinators activities is detected. It can be commented that (19.1 4mg/day/leaf) precipitation level does not harm pollinators activities in both mango and litchi. Fruit fall was higher in successive weeks at dusty areas. Here dust can only be a factor but never the key factor of this. Because roadside areas are crowded, plants come in human interference and the plants get less nutrition and becomes weaker than those at less dusty areas. So the causes are more nutritional or mechanical rather than dust precipitation.

The researchers mainly conducted their research on the effects of road dusts on plant respiration, photosynthesis processes and transpiration; [16-22] Insect populations [23-26] and animal physiological processes [27-28]. McCrea (1984) [29-31] reported on his work an assessment of the effect of road dust on agricultural systems that high value, intensively grown horticultural crops suffer the greatest costs from road dust and that road dust damage through such areas may, in part at least, justify road sealing programs. Leghari *et al*., (2013) [15] worked on the effect of roadside dust pollution on the growth and total chlorophyll content in *Vitis vinifera* L. (grape), the result reveal that there is a negative correlation between dust amount and plant growth parameters, if the amount of dust increased plant growth decreased, respectively. But there is no known attempt to place a value on the costs of roadside dust to pollination. Certainly, further research into the subject is warranted.

The air somehow, full of fine dust which generally precipitates during clement weather on plants and its rate is not at all less than that of the wayside precipitation. So, we can conclude that dust precipitation is not a key factor to pollination up to a tolerable extent.

ANOVA was performed based on three categories for both Mango and Litchi; dust precipitation per leaf per day; rate of successful pollination and fruit falling. Significant variation was not found on rate of successful pollination and fruit falling in both mango and litchi but were found in dust precipitation per leaf per day.

Table 4: Summary of ANOVA (α= 0.05) for different factors

Factors	df	F	F-crit	P-value
Successful pollination in Mango	2	1.23800857	3.101295757	0.295017972
Successful pollination in Litchi	2	0.323589849	3.158842719	0.724867346
Fruit falling in Mango	2	21.32251548	3.101295757	2.9121E-08
Fruit falling in Litchi	2	0.492263132	3.158842719	0.613815933
Dust precipitation in Mango	2	1.043813289	3.267423525	0.362812757
Dust precipitation in Litchi	2	0.322799412	3.492828477	0.727821894

Based on the ANOVA Test, the t-tests were performed between Dusty-Medium dusty; Medium Dusty-Low dusty and Dusty-Low dusty areas.

Table 5: Summary of t-test Results

Factor	df	t-stat	t-crit	P-value
Dusty- Medium Dusty	58	4.512556	1.671553	1.59E-05
Medium dusty- Low Dusty	58	1.887441	1.671553	0.032054
Dusty-Low dusty	58	6.445659	1.671553	1.24E-08

A coal based power station in progress at the lap of the Sundarban. The fly ashes emitted by such station may harm to pollination of the surrounding plantation is a debate in Bangladesh. Dust and fly ashes are though not similar; level of precipitation must become a key factor in those areas.

Pollination is the most important fusion in nature. It mainly depends on pollinators' availability. Excessive amount of pollination and dust precipitation, if prevent pollinators doing their natural foraging to flowers, disaster may occur in natural production.

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