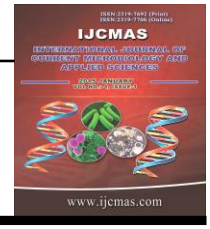

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Original Research Article

Effects of Stone Crusher Dust Pollution on Growth Performance and Yield Status of Gram (*Cicer arietinum L.*)

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A B S T R A C T

Keywords

Stone crusher dust, *Cicer arietinum*, Seedling growth, Chlorophyll, Protein, Carbohydrate

The effect of stone crushing dust pollution on the growth performance and yield status of Gram (*Cicer arietinum* L.) was studied in specified land areas of village Arap, Patna. The results indicated that the germination frequency of seeds, shoot length, root length, chlorophyll content, total carbohydrate and protein contents, and grain yield of Gram (*Cicer arietinum*) were severely affected by stone dust pollution. The plants that grown in control land area were healthy as compared to plants grown in the stone dust treated land areas. A loss in chlorophyll-a and chlorophyll-b content in leaves of plants treated with stone dust supported the argument that the chloroplast is the primary site of attack by stone crushing dust pollutants. The present results clearly indicate that the stone crushing dust adversely affect the growth and yield status of Gram (*Cicer arietinum*).

Introduction

There are three main categories of stones, siliceous, argillaceous and calcareous. The siliceous stone is made up of silica or silicon dioxide (SiO_2). This type of stone also includes compressed sediments like sandstones viz. quartz (pressurized sand stone), mica, feldspar etc. The average density of granite is between 2.65 and 2.75g/cm^3, its compressive strength lies above 200Mpa, and its viscosity near STP is 3-6.10^{19}paS (Kumagai et al., 1978). Its melting temperature is 1215-1260^{0}C (American Mineralogist, 1929). The argillaceous stone is basically composed of alumina (Al_2O_3). Calcareous stone is made up mostly of calcium carbonate ($CaCO_3$) or lime which comes from the bodies of sea creatures.

The world wide average chemical composition of stone/granite by weight percent, based on analysis of Harvey Blatt and Robert J. Tracy, 1997 is as follows:

SiO_2-72.04; Al_2O_3-14.42; K_2O-4.12; Na_2O-3.69; CaO-1.82; FeO_3-1.22; MgO-0.71; TiO_2-0.30; P_2O_5-0.12 and MnO_2-0.05

There are over 12000 stone crusher units operating in India (Patil, 2001). Clusters of stone crushing and sizing units are located at Pakur district, Jharkhand. The stone crushing industry and the associated traffic in this area generate a number of air pollutants which exceed the air quality standards, particularly during day time. The stone crushing industry at Pakur District includes two main operations: quarrying or mining operations and crushing operations. But, there is a lack of environmental governance in both quarries and the crushers which has resulted in considerable degradation of the environment surrounding the locations where stone crushing industry is established (ES, 1998).

The suspended particulate matter (SPM) released due to stone crushing, remain in the air for varying length of time. Those larger than 10µm in size settle under the force of gravity on the vegetations and soil but the smaller ones remain suspended in air for longer periods of time, get dispersed and diffused by wind, and eventually deposited on various surfaces including foliar ones (Rao, 1971; Rao, 1985).

Stone dust is a primary aerosol and it is released directly from the source. This primary aerosol has a detrimental effect on people and environment including flora and fauna, for example changed soil pH and productivity, formation of haze reducing visibility in the surrounding areas, destruction of habitat, damage of natural resources like valuable vegetations and wild lives, promotion of spreading many diseases etc. (Semban and Chandrashekhar, 2000; Das and Nandi, 2002; Mishra, 2004; Siva coumar et al., 2006).

Effects of cement, petroleum- cake dust, flyash, coal dust, automobile exhaust and other air borne particulates on various morphological and physiological parameters in different plants were studied by many workers viz. Singh and Rao, 1980; Prasad and Rao, 1981; Ambrust, 1986; Agrawal and Agrawal, 1989; Pyatt and Haywood, 1989; Naidu and Chirkut, 2004; Verma and Singh, 2006; Prajapati and Tripathi, 2008; Pandey and Kumar, 1996; Pandey and Sinha, 2000; Grewal et al., 2001; Pandey and Kumar, 2004; Mishra, 2008; Mishra and Kumari, 2008; Pandey et al., 2008; Pandey et al., 2009; Pandey and Prasad, 2010; Prasad et al., 2010; Pandey and Pandey, 2010; Kumari and Pandey, 2011; Saha and Pandey, 2011 etc.

Agricultural crops have long been act as a sink for air pollutants and to suffer from the harmful consequences. Reduction of ascorbic acid, protein, carbohydrate and pigments was noticed by Prasad and Rao (1981) in petroleum- coke treated plants, *Phaseolus aureus*. Reduction of dry weight in *Gossypium hirsutum* due to reduced photosynthesis as a result of dust deposition was studied by Ambrust (1996). The growth and development aspects of plants are adversely affected by air- borne particulates, depending on their physical and chemical nature. John and Iqbal (1992) observed reduction in the leaf blade area of five tree species as a result of extensive dust and SO_2 pollution. Most of the plants experience physiological alterations before morphological injury symptoms become visible on their leaves (Liu and Ding, 2008). Prajapati and Tripathi (2008) studied species- wise and season- wise dust deposition pattern on six selected tree species and their effects on chlorophyll and ascorbic acid content in foliar tissues. Dulalchandra Saha and Pratap Kumar Padhy (2011) have studied the effects of stone crushing industry on *Shorea robusta* and *Madhuca indica* foliage. Investigations on ten annual plant species by Rai et al., (2010) reveals that the foliar surface was an excellent receptor of atmospheric pollutants leading to a number of structural and functional changes.

Cicer arietinum L. (Gram or Chick- pea) is a much branched erect or spreading annual herb. It is grown as a *rabi* crop in the middle of October after the monsoon rains are over.

It is well adapted to arid and semi- arid regions with low to moderate rainfall and a cool and dry climate. Heavy rain after sowing or at flowering and fruiting stage is injurious. The crop cannot tolerate frost at any stage of growth.

Like other crops *Cicer arietinum* is also highly vulnerable to atmospheric pollutants attack. The effects of stone crushing dust pollutants on growth performance and yield status of this crop has not been studied so far. Stone crushing dust pollutant treated growth of Chick pea might prove to be an effective management practices for the growth and yield status of this crop in different agro climatic conditions. Therefore an attempt has been made to study the effects of stone crushing dust pollutants on growth performance of *Cicer arietinum*.

Materials and Methods

Patna is the capital of Indian state Bihar. Its total area is approximately 3202 km² and is situated at altitude 53m, 25°36´40″North latitude, 85˚08´38″East longitudes. The climate is generally dry and humid with four distinct seasons, viz. summer, rainy, winter and spring. The maximum and minimum temperatures recorded during summer and winter respectively are 42^0C and 5^0C. The annual rainfall is about 1450mm and the maximum relative humidity is 90% during rainy season.

The present work was carried out in the Biochemistry research laboratory, Dept. of Biotechnology, College of Commerce, Patna from November 2014 to December 2014 and in field from October 2014 to January 2015.

The field work was carried out on agriculturally fertile soil of village Arap, District Patna. Six specified land area, each of an area of about $5m^2$ were selected (one for control and five for treatment) as follows:

Control: Area not treated with stone crushing dust

SA1: Area where pulses crops are being grown

SA2: Area where cereal crops are being grown

SA3: Area where both cereal and pulses crops are being grown

SA4: Area where vegetable crops are being grown

SA5: Area where oil yielding crops are being grown

Seeds (about 200g) of chick pea (*Cicer arietinum* L) were sown separately in each of the specified land area. Stone crushing dust (about 100g) collected in polythene bag in the vicinity of stone crusher mills of Pakur District Jharkhand was dusted on the plantation fields at the time of sowing seeds. One of the six fields was treated as control. The percentage of germination of seeds was recorded in all fields. Similarly growth of the seedlings one week after seed germination in each specified land area was recorded in terms of root and shoot lengths.

One month after germination ten fresh leaves were collected from each specified land area and subjected to biochemical analysis in laboratory. The chlorophyll was extracted in 80% (v/v) aqueous acetone. The extract was centrifuged at 2000rpm. The absorbance was recorded at 645 and 663nm using a spectrophotometer. Chlorophyll-a and chlorophyll-b were assayed by the method suggested by Arnon (1949) and expressed in mg/g of leaf tissue. The total carbohydrate was measured following Anthrone method suggested by Hedge and Hofreiter (1962) and was expressed in µg/100mg leaf tissue. The foliar protein content was expressed by method suggested by Lowry et al. (1951) and expressed in mg/g of leaf tissue. The yield was measured in terms of gm of grain/plant in fields after 100 days of cultivation and the results were analyzed statistically by one way analysis of variance (ANOVA). The results obtained have been presented in Table-1, 2, 3 and 4.

Result and Discussion

The germination behavior of seeds of gram (*Cicer arietinum*) was analyzed at five different specified land areas of Arap village, Patna when sols of each land area were previously treated with 100gm of stone dust. The results showed that the germination percentage of gram favoured 85% germination. Among stone dust treated soils the percentage of germination was maximum in SA1, followed by SA5, SA2, SA3 and SA4 (Table-1).

The seedling growth of gram was also lower in all the specified land areas as compared to control field (Table-2). In control field the shoot and root lengths were found to be 15.7cm and 12.5cm respectively one month after germination. In all the five stone dust treated areas seedling growth was relatively low, in the range of 13.0 to 13.6cm shoot length and 9.5 to 10.5cm root lengths. The present findings gain support from the work of Sadhana Chaurasia et al., (2014) who also observed a decrease in shoot and root lengths in Wheat (Triticum species) in response to particulate pollutants released near the Cement industry of Kodinagar, Gujarat. Chouhan and Joshi (2010) found that the plants growing at 0.5km distance from Cement industry have lesser growth (root and shoot length) and as the distance increases from the industry the shoot length and root length also increases. Decrease in plant height of Cow pea was also recorded along the gradient of air pollution by Addo et al.(2013).

The plants grown in all the stone dust treated land areas showed thick root systems, stunted growth with stubby and brittle branches as compared to control plants. These symptoms might be due to toxic effects of aluminium which is present in the form of alumina (Al_2O_3) in 14.42 percent. Therefore in view of the environmentally prevalent nature of aluminium compounds its levels should be regularly monitored to avoid toxicity caused by this soil pollutant.

Results of the present investigation showed reduction in foliar chlorophyll, total carbohydrate and protein content in the stone dust treated land areas which indicated that the process of manufacturing food by *Cicer arietinum* was reduced as a result of stone dust pollution (Table-3). In control field the foliar chlorophyll-a and chlorophyll-b were 90.75mg/g and 25.22mg/g of total leaf tissue respectively. Among stone dust treated specified land areas the foliar chlorophyll-a was maximum in SA2 and SA5 (75.15mg/g), followed by SA3 (70.35mg/g) and minimum in SA4 (64.30mg/g) and SA1 (65.50mg/g). The chlorophyll-b content was minimum in SA2 (15.18mg/g) and SA1 (16.75mg/g). In SA3, SA4 and SA5 the chlorophyll-b content was more or less similar, in the range of 20.25 to 20.92mg/g of foliar tissue.

In all the stone dust treated specified land areas the foliar protein and carbohydrate contents were also found to be low as compared to the control. The total foliar protein content was in the range of 93.75 to 97.16mg/g of leaf tissue in the stone dust treated plants as compared to control

(103.50mg/g of leaf tissue). Similarly the total foliar carbohydrate in treated plants was in the range of 114.75 to 120.75/100µg of leaf tissue in comparison to control (126.15µg/100mg of leaf tissue). The present findings are in accordance with DulalChandra Saha and Pratap Kumar Padhy (2011) who also observed the decline in chlorophyll-a, chlorophyll-b, total carbohydrate and protein contents in *Shorea robusta* and *Madhuca indica* when their foliages were treated with stone crushing dust pollutants. Singh and Rao (1980) found incidence of foliar injury symptoms and decrease in concentration of chlorophyll in plants in the vicinity of Cement factories. Prasad and Rao (1981) found decrease in protein and carbohydrate content in petroleum coke treated plants. Agarwal and Agarwal (1989) found reduction in photosynthetic pigment in *Mangifera indica* around a thermal power plant. Pandey and Nand (1995) assessed the effect of stone crusher dust on grain characteristics of Maize and found lower values of protein as compared to control. Trivedi and Singh (1995) noticed significant reduction in protein content in few plants as a result of fly ash particulates. Williams and Banerjee (1995) found considerable reduction in chlorophyll and protein in leaves of *Mangifera indica* and *Shorea robusta* affected by emissions from a nearby thermal power plant. Marked alterations in photosynthetic pigments and protein content in foliar tissues as a result of auto exhaust pollution were noticed by Verma and Singh (2005). Similarly, decrease in chlorophyll content as a result of increased dust deposition was noticed by Prajapati and Tripathi (2008).

Table.1 Showing percentage germination of seeds of gram (*Cicer arietinum*) after treatment of stone dust

Treatment	Percentage germination
Control land area	85
SA1	75
SA2	72
SA3	71
SA4	68
SA5	73

Table.2 Seedling growth of gram (*Cicer arietinum*) one month after treatment with stone dust

Treatment	Root length in cm[a]	Shoot length in cm[a]
Control land area	12.5±0.13	15.7±0.14
SA1	10.2±0.14	13.6±0.81
SA2	10.5±0.16	13.2±0.07
SA3	11.6±0.06	13.5±0.13
SA4	9.5±0.08	13.4±0.16
SA5	9.8±0.11	13.0±0.15

a=average of 10 replicates: p at 0.05 level

Table.3 Showing biochemical characteristics of foliage of gram (*Cicer arietinum*) after treatment with stone dust

Biochemica parameters	Control	SA1	SA2	SA3	SA4	SA5
Chl-a	90.75	65.50	75.15	70.35	64.30	75.15
Chl-b	25.22	16.75	15.18	20.36	20.25	20.92
Total carbol	126.15	118.16	115.35	121.45	120.75	114.75
Protein	103.50	94.15	93.75	96.15	97.16	96.50

Chl-a and chl-b in mg/g of leaf tissue; carbohydrate in µg/100mg of leaf tissue; total protein mg/g of leaf tissue

Table.4 Showing grain yield in g/plant of gram (*Cicer arietinum*) after three months

Treatment	Grain yield[a] in gm/plant
Control	125.50±1.25
SA1	121.75±0.16
SA2	120.55±0.11
SA3	118.50±0.13
SA4	120.65±0.14
SA5	117.45±0.15

a= average of 10 replicates; p at 0.05 level

After 100 days of plantation plants were harvested from all the treated and control land areas separately and grain yield per plant was statistically analyzed. The result showed that there was a marked reduction in the grain yield in stone dust treated land areas (117.45 to 121.75g/plant) as compared to control in which grain yield per plant was recorded to 125.50g/plant (Table-4). The present finding gains support from the work of Sadhana Chaurasia et al. (2014) who also found a marked reduction in the grain yield and grain weight in *Triticum* species on account of the impact of cement industry pollution. All the statistically data show that the result was significant at 95% level.

The results obtained in the present investigation indicate that the shoot length, root length, chlorophyll content, total carbohydrate and protein contents, and grain yield of Gram (*Cicer arietinum*) were severely affected by stone dust pollution. The plants growing in control land area were healthy than the plants growing in the stone dust treated land areas. A loss in chlorophyll-a and chlorophyll-b content in leaves of plants treated with stone dust supports the argument that the chloroplast is the primary site of attack by stone crushing dust pollutants. The present results clearly indicate that the stone crushing dust adversely affect the growth and yield status of Gram (*Cicer arietinum*).

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References

Addo, M. A, Darko e. O, Gordon, C and Nyarko, B. J. B (2013): Contribution of soils and loss of productivity of

Cowpea (Vigna unguiculata L.) caused by cement dust pollution, Inter. J. Res. In *Chem. And Env*. 3(1): 272- 282.

Agrawal, M and Agrawal, S. B (1989): Phytomonitoring of air pollution around thermal power plant, *Atmospheric Environment*, 23, 263- 769.

Arnon, D. I (1949): Copper enzyme in isolated chloroplasts polyphenol oxidase in *Beta vulgaris*, Plant *Physiology*, 24, 1- 15.

Ambrust, D. V (1986): Effect of particulate dusts on cotton growth, photosynthesis and respiration, *Agronomy Journal*, 78, 1078- 1081.

Chauhan, A and Joshi, P. C. (2010): Effect of ambient air pollutants on wheat and mustard crops growing in the vicinity of urban and industrial areas, New York, *Science J*. 3(2): 52- 60.

Das, D. K and Nandi, A (2002): Health hazard in stone quarries and crushers. *Science and Technology project*, Government if India, NISM, Kolkata.

Dulal Chandra Saha and Pratap Kumar Padhy (2011): Effects of stone crushing industry on *Shorea robusta* and *Madhuca indica* foliage in Lalpahari forest, *Atmospheric pollution Research*, 2, 463- 476.

E S (1998): Excutive summary of the Report on the state Environment, " Status of environment in West Bengal", PartII. Vectors of Environmental Impacts, The Department of environment Government of West Bengal in September, 1998.

Grewal, K. S, Yadava, P. S, Mehta, S. C. and Oswal, M. C. (2001): Direct and residual effect of fly ash application to soil on crop yield and soil properties. *Crop. Res*. 21: 60- 65

Harvey Blatt and Robert J. Tracy (1997): Petrology (2nd ed.). New York Freeman P. 66.

Hedge, J. E and Hofreiter, B. t (1962): In: Carbohydrate chemistry 17 (Eds Whistler, R. L. and Be Miller, J. N), Academic Press, New York.

John, S and Iqbal, M. Z (1992): Morphological and anatomical studies on leaves of different plants affected by motor vehicle exhaust. *Journal of Islamic Academy of Sciences*, 5, 21- 23.

Kumagai, Naoichi, Sodao Sasajima, HidebumiIto (1978): "Long- term creep of Rocks; Results with Large specimens obtained in about 20 years and Those with small specimens in about 3 years". *Journal of the Society of Materials Science*, Japan (Japan Energy Society) 27 (293): 157- 161.

Liu, Y. J and Ding, H (2008): Variation in air pollution tolerance index of plants near a steel factory; implication for landscape- plant species selection for industrial areas. WSEAS *Transactions on Environment and Development*, 4, 24- 32.

Lowry, O. H, Rosenbrough, N. J, Farr, A. L, Randall, R. J (1951): Protein measurement with the folin phenol reagent. *Journal of Biological Chemistry*, 193, 265- 275.

Minsocam. Org. American Minerologist (1929): volume 14, pages 81-94. The temperatures of magmas, Espers, Larsen, Harvard University.

Mishra, C. P, Pandey, Kiran and Pandey, D. D. (2008): Effect of cement dust pollution on Safflower (Carthamus tinctorious L.). *Modern J.Life Science*. Vol.6&7 (1-2): 10-30

Mishra, R.D. and Kumari, P. (2008): Effect of dust pollution on chlorophyll and characteristics of maize. *Adv. Biol. Res.* Vol. 26(1&2):62-67

Mishra, M (20014): Project achievement reports; update, Nov. 2004 on demonstration of dust suppression Technology to reduce occupational and Environmental health hazards in stone crusher industries, a project study in Khurda Orissa, India by JrP, CISS (India) and PKI (USA).

Naidoo, G and Chirkoot, D (2004): The effects of coal dust on photosynthetic performance of mangrove, Avicennia marina in Richards Bay, South Africa, *Environmental pollution*, 127, 359- 366.

Patil, M. A (2001): Environmental management scenario in stone crusher industry sector and cleaner production possibilities, *TERI Information Monitor on Environment Science* 6, 83- 92.

Pandey, D.D and Nand, S (1995): Effects of stone crusher dust pollution on grain characteristics of maize. *Environment and Ecology*, 13, 901-903.

Pandey, A.; Tiwari, K. and Pandey, J. 2009. Atmospheric deposition of nutrients in a dry tropical urben environment of Varanasi. Proc. Of National Symposium on Environmental threat to human health in 21st century. B. H.U., Varansi, Page53.

Pandey, D.D. and kumar, K. 1996. Impact of cement dust pollution on biomass, chlorophyll, nutrient and grain characteristics of wheat, *Environment & Ecology*, 10(4): 872-875.

Pandey, D.D and Kumar, K. 2004. Effect of dust pollution on nutritional

Quality of Cynodon dactylon. *Environmental & Ecology* 22 (spl. 4) ; 775-777.

Pandey, D.D. and Pandey, Kiran 2010. Effect of particulate pollutant on chlorophyll of rice leaf. *Adv. Biol. Reg.* 28(1): 167-168.

Pandey, D.D. and Prasad, Raghunath (2010): Effect of cement dust pollution of Zea mays. In Proceeding of Environmental pollution : A threat to living world. Edited by D.D. Pandey, Jaspal Prakashan, Patna, page 20.

Pandey, D.D. and Sinha, M. (2000): Effect of fly ash pollution on biomass, primary productivity and characteristics of grains of Maize. *Environmental &Ecology* 18(3):738-741.

Pandey, G., Kumar, Bhola and Pandey, D.D.2008. Effect of stone crusher dust pollution on biomass and productivity of *Sesamum indicum*. *Environmental & Ecology* Vol.20(1):230-231.

Prasad, S.N. Mishra, C.P. and Sinha , A.P.(2010): Effect of cement dust pollution on nutritional quality of *Dichanthium annulatum*. In Proc. Of National Seminar on Environmental pollution. A threat to living world. Organized by P.G. Dept. of Botony, Nalanda College, Biharsharif held on 27-28 March, 2010, Page 19.

Prajapati, S. K and Tripathi, B. D (2008): Seasonal variation of leaf dust accumulation and pigment content in plant species exposed to urban particulates pollution, *Journal of Environmental Quality*. 37, 865-870.

Prasad, B. J and Rao, D. N (1981): Growth response of Phaseolus aureus plants to petro- coke pollution, *Journal of Experimental Botany*, 32, 1343-1350.

Pyatt, F. B and Haywood, W. J (1989): Air borne particulate distributions and their accumulation in tree canopies, Nottingham, UK. *The Environmentalist* 30, 18- 23.

Rai, A, Kulshreshtha, K, Srivastava, P. K and Mohanty, C. S (2010): Leaf surface structure alterations due to particulate pollution in some common plants. *Environmentalist*, 30, 18- 23.

Rao, D. N (1985): Plants and Particulate pollutants. Air pollution and plants: A state of Art Report, Ministry of Environment and Forest; Department of Environment, Govt. of India, new Delhi, India.

Rao, D. N. (1971): A study of air pollution problem made to coal unloading in Varanasi, India. Academic Press of 2nd International Clean Air Congress, 235- 276.

Rao, D. N (1981): A study of air pollution problem due to coal unloading in Varanasi, India. Proceeding of International Clean Air Congress, 273- 276.

Sadhana Chaurasia, Ashwani Karwariya and Anand Dev Gupta (2014): Impact of Cement Industry Pollution on Morphological Attributes of Wheat (Triticum species) Kodinar, Gujarat, India, *Journal of Environmental Science, Toxicology and Food Technology*, 8(7), 84- 89.

Sadhana Chaurasia, Ashwani Karwariya and Anand Dev Gupta (2013): Effedt of cement industry pollution on chlorophyll content of some crops at Kodinar, Gujarat, India, *Proceedings of the International Academy of Ecology and Environmental Science*, 3(4): 288- 295

Saha, D L and Padhy, P. K (2011): Effects of stone crushing industry on *Shorea robusta* and *Madhuca indica* foliage in Lalpahari forest. *Atmospheric Pollution Research*, 2, 463-476.

Shivcoumar, R, Jayabalou, R, Swarnalatha, S, Balakrishnan, K (2006): Particulate matter from stone crushing industry: Size distribution and health effects. *Journal of Environmental Engineering- ASCF*, 132, 405- 414.

Semban, T and Chandrashekhar, S (2000): Impact of crusher pollution on workers in tricky. Environment and People 7, publication society for Environment and Education.

Singh, S. N and Rao, D. N (1980): Growth on Wheat plants exposed to cement dust pollution, *Water, Air and Soil pollution*, 14, 241- 249.

Trivedi, M. L and Singh, R. S (1995): Reduction in protein contents in a few plants as indicators of air pollution. *Pollution Research* 14, 269- 273.

Verma, and Singh, S. N (2006): Biochemical and ultrastructural changes in plant foliage exposed to auto- pollution, *Environmental Monitoring and Assessment*, 120, 585-602.

Williams, A. J and Banerjee, S. K(1995): Effect of thermal power plant emission on the metabolic activities of *Mangifera indica* and *Shorea robusta*. *Environment and Ecology* 13, 914- 919.