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Growth Responses of Wheat Plants to Cement Dust-polluted Environment

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The samples of soil and plants were collected from sites S_1, S_2, S_3 and C which were located linearly at distances of 100, 1000, 2000 and 4000 m, respectively, in northeast direction of a cement factory at Churk. The soil samples were analysed with respect to their certain physico-chemical properties and plant samples for their morphological characters. The cement dust accumulated on soil, induced certain undesirable changes in its physico-chemical properties. Besides, cement dust deposited on plants, interfered with their growth and development leading to reductions in their several morphological characters like lengths of root, shoot and ear as well as numbers of tillers, leaves and ears. The photosynthetic area and grain-setting of affected plants were also remarkably reduced. These changes were negatively correlated with the distance from the source of dust emission.

Key Words: Retardation, Plant growth, Cement dust pollution

Introduction

Cement dust pollution is a localized air pollution problem in the vicinity of a cement factory. Bohne (1963) reported a marked reduction in the growth of poplar trees located at about one mile from such a factory. Darley (1966) noted a drastic reduction in spring growth elongation of conifers near a cement factory in Germany where the oldest needles were incrustated with cement dust. He also commented on the stunted growth of alfalfa plants which had fewer leaves in the heavily dusted portions of a field downwind from a cement factory. Parthasarathy et al. (1975) reported that cement dust deposited on maize crop cultivated in the vicinity of the cement factory in Tamil Nadu caused a suppression in morphological characters of the plant, such as leaf size, number and size of cobs, and plant height. They also observed certain changes in physico-chemical properties of the soil, induced by cement dust accumulated on its surface. Anderson (1914) noted a remarkable reduction in fruit-setting of cherry trees subjected to cement dust pollution from a factory.

Area Description

A cement factory is located at Churk in Mirzapur District of UP. It is about 70 km due south from Banaras Hindu University campus and is situated at 24° 42′N latitude and 83° 5′E longitude, approximately 300 m a.s.l. The area around the factory is undulated due to presence of small hills. The soil of the region is sandy loam in texture. The climate is monsoonic. The year can be divided into three distinct seasons, rainy, winter and summer. The prevalent wind direction is from southeast to northwest. An average wind velocity of 20 km/hr was recorded during the study period.

Material and Methods

Wheat crop (*Triticum aestivum* Linn.) is extensively cultivated in the surrounding area of the Churk Cement Factory in NE direction. Four crop fields located linearly in the northeast direction, at distances of 100, 1000, 2000 and 4000 m from the factory were selected for the present study and these were denoted as S_1, S_2, S_3 and C. All the sites except site C were affected by cement dust to varying degrees. The selected areas in wheat fields were demarcated and were kept free of fertilizer application. Five crop plants were carefully dug out from each site at the stages of initiation of senescence and their root systems were washed gently with water. Three soil samples were also collected from the same sites at the time of plant collection at a depth of 20 cm. The plant samples were analysed with respect to certain morphological characteristics, and soil samples for certain physico-chemical properties in the laboratory.

Analysis of soil samples

Porosity and water-holding capacity of soil samples were determined following the methods outlined by Piper (1966). *p*H of soil was determined with a *p*H-meter Model 110, in suspension of 1:5. Nitrogen (%) and organic carbon (%) in soil samples were determined using micro-Kjeldahl technique and Walkley and Black's rapid titration method, respectively (Piper 1966). Exchangeable calcium and potassium (m.e.%) contents were determined using a flamephotometer (Jackson 1962).

Morphological characters of plants

Average lengths of root, shoot and ear were measured. Also, average numbers of tillers, leaves and ears per plant were counted. Average leaf area (on per plant basis) was calculated using the equation given by Kemp (1960).

Results and Discussion

Soil surface at all sites except site C showed a thick and hard deposition of cement dust. The relative thickness of the cement-crust on soil surface was not constant, but it progressively decreased with the increasing distance from the factory in the polluted area. Such a crust was formed due to hydration of cement dust in presence of moisture, followed by its subsequent crystallization and solidification, and affects the soil physically, chemically and biologically (Przemeck 1970). It is evident from table 1 that porosity of the soil sample from control site (site C—located farthest from the factory) was higher than those of soil samples collected from affected sites. The value increased with the increasing distance from the factory from a minimum of 32.4% at site S_1 to maximum of 60.6% at site C. The water-holding capacity (WHC) of soil was in direct proportion to its porosity. The porosity and WHC of soil at site S_1 became approximately half of that of soil at site C. The formation of a hard cement-dust might

Table 1 *Characteristics of soil samples collected from sites S_1, S_2, S_3, and C (values represent an average of 3 replicates)*

Site	Porosity (%)	WHC (%)	*p*H	Organic carbon (%)	Nitrogen (%)	C/N ratio	Exchange-able Ca (m.e.%)	Exchange-able K (m.e.%)
S_1	32.4 ±3.2	21.4 ±1.6	9.0 ±0.1	0.822 ±0.003	0.016 ±0.002	51	7.52 ±0.05	0.31 ±0.01
S_2	49.8 ±2.7	32.5 ±1.6	8.1 ±0.2	0.672 ±0.004	0.030 ±0.002	22	5.04 ±0.06	0.22 ±0.01
S_3	58.3 ±2.5	43.4 ±1.8	7.5 ±0.2	0.448 ±0.005	0.032 ±0.002	14	3.82 ±0.07	0.20 ±0.01
C	60.6 ±2.4	45.1 ±1.5	6.9 ±0.2	0.434 ±0.005	0.040 ±0.004	11	3.56 ±0 08	0.15 ±0.03

Values given in ± are standard deviations

have resulted in compactness of soil particles and thus reduced the porosity and WHC of affected soils. Soil *p*H at all affected sites was constantly higher than that at control site; the values being maximum (9.0) at site S_1 and minimum (6.9) at site C. Increase in soil *p*H at affected sites might be due to formation of calcium and aluminium hydroxides during hydration of cement dust. Gradual increase in soil *p*H from site S_3 through site S_1 results from maximum accumulation of cement dust at site S_1. However, increase in soil *p*H may not strictly correspond to the amount of cement dust deposited on soil, probably due to its buffering capacity which has the tendency to neutralize any stress. The soil samples from polluted sites also contained relatively higher amount of organic carbon than that from control site. The reason for relatively more accumulation of organic carbon in the cement-affected soils could be the slow rate of decomposition of organic matter which would have resulted from reduced microbial activity in soils which were alkaline in reaction. Generally, maximum decomposition of organic matter occurs in soil having *p*H between 5.5 to 6.5, when other conditions are favourable (Daji 1970). A shift from this *p*H range on either side affects particularly fungal activity responsible for rapid disappearance of organic matter in soil. Higher C/N ratios of affected soils do evidence the suppression of microbial activity (table 1).

Soils from affected sites were also enriched with exchangeable calcium and potassium. Perhaps, such an enrichment of soil was brought about by percolation of cement solution containing Ca^{++}ions in abundance and stripping off of K^+ ions by Ca^{++} ions from micelle particles. It is clear that all these parameters either gradually increased or decreased with the increasing distance from the factory, due to progressive less dust deposition on soil surface.

The cement dust, settled on plants at polluted sites, also developed into a hard crust similar to that formed on soil surface and hindered the plant growth and development (Peirce 1910, Parish 1910). Symptoms of foliar bristles and cracks were more conspicuous on plants grown at site S_1 than at other affected sites. Such symptoms might

Table 2 *Morphological growth parameters of wheat plants at the stage of initiation of senescence at different sites in the environs of the factory (values represent an average of 5 replicates)*

Site	Length (cm)			Number			Photosynthetic leaf area (cm^2)	Grain number/ spike
	Root	Shoot	Ear	Tillers	Leaves	Ears		
S_1	7.2±0.2	69.5±2.0	9.7±0.3	8.6±0.2	10.4±0.3	8.3±0.2	695.5±15.4	20±2
S_2	8.5±0.1	84.5±2.8	11.3±0.3	12.6±0.4	13.6±0.1	12.6±0.4	861.3±16.3	30±2
S_3	10.3±0.3	95.3±3.3	14.4±0.2	14.6±0.3	17.3±0.7	14.6±0.3	925.8±14.8	39±3
C	15.5±0.3	110.5±3.6	17.3±0.5	16.7±0.4	20.6±0.5	16.7±0.4	940.2±11.7	45±3

Values given in ± are standard deviations

have appeared due to differential strains produced by hard setting of cement dust on affected leaves. Peeled off cuticular strips and disorganized chloroplasts mixed with cement particles gave dark appearance to badly affected plant leaves at site S_1. Such observations were also recorded by Lerman (1972). Besides, wheat plants at affected sites were stunted due to reduction in lengths of their root, shoot and ear as well as decreased numbers of tillers, leaves and ears (table 2). Photosynthetic areas (leaf areas) of plants at affected sites were also considerably reduced. Compared to control plants at site C, the lengths of root, shoot and ear were reduced by 51.6, 37.1 and 43.1% at site S_1 and by 33.5, 17.3 and 16.7% at site S_3, respectively, at the stage of beginning of senescence.

Similarly, the reduction in the numbers of tillers, leaves and ears as well as in photosynthetic area was maximum at site S_1 and minimum at site S_3. These reductions in above parameters might be attributed to retarded photosynthesis in affected plants, caused by several factors including absorption of light by cement-crust (Peirce 1910, Czaja 1962, Bohne 1963) damage to chloroplasts due to migration of cement solution in leaf tissues (Czaja 1962, Lerman 1972), interference in gaseous exchange through leaf stomata due to their occlusion by cement particles (Czaja 1966, Darley 1966), reduced photosynthetic area and undesirable changes in physico-chemical properties of cement-affected soils (Parthasarathy et al. 1975).

The grain-setting of plants at polluted sites was also remarkably affected. The reductions in grain number/spike were of the order of 55.5, 33.3 and 13.3% at sites S_1, S_2 and S_3, respectively (table 2). Such reduction in grain-setting of affected plants was probably due to alkaline reaction of cement-coated stigmata which prevented pollen germination and subsequent fertilization (Anderson 1914, *cf.* Czaja 1962).

It is clear from above observation that levels of reduction in all growth parameters were negatively correlated with increasing distance from the source of dust emission, due to progressive less accumulation of cement dust on soil and plant surface.

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References

Anderson P J 1914 The effect of dust from cement mills on the setting of fruit; *Pl. Wld.* **17** 57–68

Bohne H 1963 Schadlichkeit von Staub aus Zement werken fur waldbestande; *Allg. Forstztg.* **18** 107–111

Czaja A T 1962 Uber das Problem der Zement staubwirkungen und,pflanzen; *Staub* **22** 228–232

—— 1966 Uber die Einwirkung von Stauben, speziell von Zementofenstaub auf Pflanzen; *Angew. Bot.* **40** 106–120

Daji J A 1970 *A Text Book of Soil Sciences* (New Delhi: Asia Publishing House)

Darley E F 1966 Studies on the effect of cement-kiln dust on vegetation; *J. Air. Pollut. Control Ass.* **16** 145–150

Jackson M L 1962 *Soil Chemical Analysis* (Bombay: Asia Publishing House)

Lerman S 1972 Cement-kiln dust and the bean plant (*Phaseolus vulgaris* L. Black Valentine var); in depth investigations into plant morphology, physiology and pathology; Ph.D. Dissertation, University of California, Riverside

Kemp C D 1960 Methods of estimating leaf area of grasses from linear measurement; *Ann. Bot.* **74** 491–512

Parish S B 1910 The effects of cement dust on citrus trees; *Pl. Wld.* **13** 288–291

Parthasarathy S N, Arunachalam N, Natarajan K, Oblisami G and Rangaswami G 1975 Effect of cement dust pollution on certain physical parameters of maize crop and soils; *Indian J. Environ. Hlth.* **17** 114–120

Peirce G J 1910 An effect of cement dust on orange trees; *Pl. Wld.* 13 283–288

Piper C S 1966 *Soil and Plant Analysis* (NY: Inter-Sci. Publ. Inc.)

Przemeck E 1970 Effects of cement-kiln dust precipitation on soils used for agricultural purposes (*in German*); *Zem. Kalk-Gips* **59** 119–124