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IMPACT OF STONE QUARRYING ON THE PIGMENT CONCENTRATION AND PRODUCTIVITY OF PADDY (*ORYZA SATIVA, L*)

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ABSTRACT

The response of plants to air pollutants in stone quarrying industry is variable and depends on the individual genotype, age, state of growth, concentration of pollutants and duration of the onslaught. It affects the opening of stomata resulting in reduction in photosynthesis which in turn leads to reduction in growth, development and finally influences adversely the productivity and yield of crop plants. A study carried out in selected quarry locations revealed the effect of dust pollution on the growth, yield, pigment concentration and various other grain characteristics in paddy plants.

INTRODUCTION

Quarrying activities are accompanied by a variety of environmental problems. The process of environmental degradation starts with the extraction of minerals resulting in land degradation and vegetation cover. Unplanned quarrying activity without reclamation causes irreparable damage to the equilibrium and hence disturbs the environment. More over as land is a non-renewable asset, quarrying should not be considered as the final use of agricultural land. It becomes the duty of the concerned authorities to decide the best final use of the land where quarrying is carried out. This calls for the assessment of the effect of quarrying on the surrounding agricultural land utilization and on other environmental attributes. In order to highlight the significance of these factors, a study on the agricultural crop (*Oryza sativa*) growing in the stone quarry area has been considered in few of the selected quarry locations.

Paddy is the main agricultural crop in the study area. Field studies were made in the quarry environs in selected quarry sites to understand the pigment concentration, growth and productivity of local paddy plants and compared with control plants. Similar studies on coal smoke SO_2 pollution on wheat was undertaken by Pandey and Rao (1978). They reported no symptoms of chlorosis or necrosis in the leaves at any stage of their growth. The reduction in root and shoot length, biomass, productivity, number of grains per spike, weight of 1000 grains, shortened life cycle were some of the indicators of growth suppression of wheat plants in SO_2 polluted environment. Rajendra Prasad (1990), reported decrease in pigment concentration in the plants growing near the stone crushers. Sarangi *et al.* (1997) assessed the dust pollution on plant physiology and bio-chemistry in the study of fly ash.

Study area

Study sites were selected based on the preliminary observations made in stone quarry sites in Bangalore and Kolar Districts during the periods 2003-2004 comprising of polluted, unpolluted and control sites to make a comprehensive study and to discern variations if any.

1. SQ-I- Paddy field near Bettahalsur quarry surrounded by many working quarries.
2. SQ-II-Paddy field near Kallugopanahalli quarry surrounded by many working quarries.
3. SQ-III - Paddy field near Kogilu stone quarry area.
4. SQ-IV- Paddy field near Narasapura stone quarry area.
5. SQ-V - Paddy field near a less polluted area.
6. Control- away from the stone quarry area.

Table 1

Concentration of chlorophyll (Chl a, Chl b, carotinoids and total chlorophyll) of *Oryza sativa* at different stages of growth in stone quarry area

Parameters	SQ-I	SQ-II	SQ-III	SQ-IV	SQ-V	Control
30 days						
chl a	0.44±0.04	0.39±0.05	0.51±0.05	0.45±0.05	0.56±0.04	0.72±0.06
Chl b	0.23±0.02	0.26±0.02	0.32±0.04	0.29±0.01	0.35±0.05	0.36±0.05
Tol-chl	0.67±0.06	0.64±0.07	0.83±0.09	0.74±0.06	0.91±0.09	1.08±0.11
Carotinoids		0.53±0.02	0.39±0.05	0.39±0.05	0.30±0.03	0.51±0.02
0.52±0.03	Chl-a/b	1.91	1.5	1.59	1.55	1.6
2.0						
50 days						
chl a	0.92±0.08	0.64±0.05	0.62±0.14	0.46±0.06	0.65±0.05	1.32±0.15
Chl b	0.41±0.05	0.34±0.02	0.39±0.09	0.20±0.03	0.31±0.06	0.46±0.06
Tol.chl	1.33±0.13	0.98±0.07	1.01±0.23	0.66±0.09	0.96±0.11	1.78±0.21
Carotinoids	0.60±0.04	0.48±0.03	0.55±0.11	0.40±0.04	0.36±0.05	0.62±0.08
Chl a/b	2.2	1.88	1.58	2.30	2.0	2.80
70 days						
Chl a	1.49±0.12	0.89±0.04	0.68±0.11	0.52±0.04	0.70±0.06	1.49±0.06
Chl b	0.55±0.05	0.30±0.03	0.34±0.07	0.24±0.02	0.33±0.04	0.40±0.05
Tol.chl	2.04±0.17	1.19±0.07	1.02±0.18	0.76±0.06	1.03±0.10	1.89±0.11
Carotinoids	0.59±0.05	0.51±0.05	0.53±0.05	0.45±0.03	0.42±0.02	0.60±0.08
Chl a/b	2.70	2.96	2.0	2.16	2.12	3.72
90 days						
Chl a	0.41±0.05	0.38±0.03	0.52±0.06	0.33±0.05	0.35±0.05	0.52±0.05
Chl b	0.21±0.02	0.21±0.02	0.29±0.05	0.18±0.03	0.20±0.02	0.30±0.04
Tol.chl	0.62±0.07	0.59±0.05	0.81±0.08	0.49±0.01	0.55±0.07	0.82±0.09
Carotinoids	0.58±0.04	0.38±0.07	0.29±0.02	0.26±0.02	0.21±0.02	0.39±0.05
Chl a/b	1.95	2.0	1.79	1.83	1.75	1.73

Table 2

Root length, shoot length, Biomass and Net primary production of paddy plants at different study sites

Parameters	SQ-I	SQ-II	SQ-III	SQ-IV	SQ-V	Control
Vegetative stage						
Root length (cm)	7.8±1.4	6.9±1.0	7.8±0.2	7.2±0.8	8.0±0.6	8.2±1.2
Shoot length(cm)	30±1.8	31.0±1.6	36.0±3.2	32.4±1.8	40.3±3.3	44.5±3.6
Root weight(g/m²)	10.5±0.09	11.4±1.2	9.9±0.5	10.6±1.5	10.6±0.7	12.4±1.2
Shoot weight (g/m²)	63.0±2.5	55.3±3.9	82.6±3.3	59.6±4.9	84.7±4.1	89.5±2.8
Standing dead (g/m²)	9.0±1.0	7.4±0.2	5.4±0.5	10.4±1.8	6.0±0.3	11.5±0.8
Biomass (g/m²)	82.5	74.1	97.9	80.6	101.3	113.4
Rate of production (g/m²/d)	1.65	1.49	1.96	1.6	2.02	2.27
Ear formation stage						
Root length (cm)	9.0±1.0	7.4±2.6	8.4±0.3	6.8±1.2	8.6±0.9	9.1±0.8
Shoot length (cm)	41.0±2.8	52.6±3.8	58.4±1.8	64.6±4.8	69.8±5.7	59.0±4.2
Root weight (g/m²)	34.5±1.9	37.5±4.6	23.2±1.3	49.5±3.6	61.7±3.9	42.6±3.6
Shoot weight (g/m²)	226.5±6.5	178.6±6.2	292.8±5.8	166.7±7.6	304.6±10.6	346.5±11.6
Standing dead (g/m²)	34.2±2.2	28.6±1.5	21.71±3.5	25.5±4.0	32.5±1.8	29.6±1.8
Total weight	295.2	244.0	337.7	241.7	338.8	418.7
Rate of production (g/m²/d)	4.22	3.5	4.82	3.45	4.84	6.0
Senescence stage						
Root length (cm)	10.1±0.7	8.9±0.5	9.2±0.4	7.4±2.1	9.2±1.2	9.4±1.6
Shoot length(cm)	65.0±3.8	60.7±4.2	72.6±2.4	77.5±3.6	81.4±6.2	85.2±5.4
Root weight (g/m²)	42.5±2.3	43.6±5.7	33.7±2.8	57.5±4.2	62.8±4.2	54.7±4.2
Shoot weight (g/m²)	267.2±6.9	212.7±7.4	295.7±6.7	218.6±6.4	312.8±11.7	486.7±9.7
Weight of ear(g/m²)	159.0±7.1	136.4±2.6	28.6±5.7	118.5±3.8	121.7±2.4	139.4±2.6
Biomass(g/m²)	468.3	422.7	458.0	394.5	505.3	680.8
Rate of production (g/m²/d)	3.12	2.81	3.05	2.63	3.36	4.53

MATERIALS AND METHODS

The amount of chlorophyll a, chlorophyll b, total chlorophyll were calculated and expressed in mg/g fresh leaves, using the formula of Mac Lachlan and Zalik 1963. For biomass estimation sampling was done at vegetative stage, ear formation stage and senescence stage. Paddy plants were taken from a quadrant of 50cmx50cm in five replicates from each study sites. Roots were dug out from soil by monoliths of 25cmx25cm. Roots were washed in the field and thoroughly washed in laboratory under running tap water to get roots completely free from soil. Length of shoots and height of shoots were determined. Standing dead roots and shoots are oven dried at 80°C for 48 hrs and the biomass of each replicate was taken. At senescence stage average length of spike (cm), number of starchy and non-starchy grain per spike was

Table 3
Quantitative characteristics of paddy grains collected from different sites

Grain characteristics	SQ-I	SQ-II	SQ-III	SQ-IV	SQ-V	Control
Avg.length of spike(cm)	12.1±0.7	13.8±0.9	11.6±0.7	13.5±1.0	12.7±1.0	14.7±1.7
Avg no.of starchy grain/(no) spike	30.2±4.8	28.4±2.4	27.5±3.6	29.0±3.2	31.6±4.1	54.3±5.5
Avg no.of non starchy grain/(no) spike	12.5±1.0	10.2±0.5	7.8±0.9	9.4±0.7	7.6±0.8	6.8±0.5
Avg wt. of 1000 grains(g)	26.7±2.4	25.3±1.9	27.6±1.3	26.8±2.1	30.6±0.7	32.2±0.5
Avg wt.of 1000 rice(g)	17.9±1.3	20.6±1.7	22.8±1.0	19.6±1.8	26.5±1.2	27.6±0.7
Avg wt. of 1000 non starchygrain/spike(g)	4.2±0.4	4.9±0.6	4.5±0.6	4.6±0.5	4.1±1.3	3.9±0.6
Avg vol of 1000 grains (mL)	21.5±1.5	19.8±1.5	22.6±1.6	20.9±1.4	21.0±1.0	21.9±0.9
Avg. vol of 1000 rice	14.6±1.0	14.6±1.6	18.7±1.4	15.9±1.2	19.2±1.2	21.6±1.6
Avg. wt. of starch grains(g/m²)	159.2±13.0	147.5±9.6	195.7±7.8	163.6±6.2	206.5±5.4	8.6±12.5
Avg.wt of non starchy grains (g/m²)	6.8±0.7	7.5±0.9	4.9±0.6	7.6±0.5	6.8±0.9	8.6±0.6
Avg.wt of rachis (g/m²)	10.2±1.2	9.8±1.4	12.8±1.0	11.6±0.7	12.6±1.6	17.2±1.4
Total wt. of ear (g/m²)	176.2	164.8	213.4	182.8	225.9	294.4

taken. Volume of 1000 grains (mL) were taken by water displacement method. Weight of starchy grains (g/m^2), non-starchy grains (g/m^2) and rachis (g/m^2) were also determined. The visible foliar injuries like chlorosis and necrosis were analyzed on the basis of typical injury as described by Jacobson *et al.* (1971). The results obtained are represented in Table 1 to 3.

RESULTS

It is observed from the results that paddy plants growing in different study sites (control and polluted) did not show any symptoms of chlorosis or necrosis in their leaves at any stage of their growth. Maximum amount of chlorophyll a, and Chlorophyll b, carotinoids and chlorophyll a/b ratio were found in SQ-5 and minimum in SQ-1. Maximum amount of pigments were found in 70 days sample and minimum in 90 days sample (Table 1).

A considerable reduction in shoot length have been observed in SQ-I, SQ II and SQ-III samples. Overall growth, reduction in root length, shoot length, root weight, shoot weight, standing dead, total biomass and rate of production in decreasing order may be represented as SQ-V, SQ- III ,SQ-I , SQ-II , SQ-IV (Table 2).

Similar trend have also been observed in various grain characteristics of paddy plants collected at senescence stage from the different study sites, represented in Table 3.

CONCLUSION

The paddy plants collected at different polluted and unpolluted sites did not show any symptoms of acute or chronic injury. However their physiological processes were seriously affected as indicated by the productivity and other parameters of their growth. From the results (Table 1), it is evident that the chlorophyll contents were reduced in polluted sites. The dust and particulate pollutants covers the leaf surface which may clog stomatal pores and alters light penetration thereby interfering in the exchange of gases and disturbing photosynthetic activity. Similar observations were made by Gupta *et al.* (1994). The decrease in chlorophyll a, chlorophyll b, chlorophyll a/b ratio in the polluted sites also represents less synthesis and more destruction of chlorophyll a than chlorophyll b under the influence of pollutants.

There was overall reduction in plant growth in different polluted sites compared to control values. Reduction in the production of paddy plants may also be due to gaseous, particulate and other soil pollutants. In similar studies Pandey and Rao (1978) observed a measurable interference of coal smoke or its oxidation products with plant growth. The biomass value for the polluted sites is less than the control site of the same age which could be attributed to pollutants. There is also a considerable reduction in grain setting of paddy plants at all polluted sites (SQ-I - SQ-V) as compared to control plants. The reduction in the number of grains per spike and other characteristics could be due to dust coated stigmas which did not allow pollen grains to germinate and consequently lowered the grain setting. The weight and volume of grains produced by paddy plants at all polluted sites were also reduced with respect to control. The level of deterioration in grain quality of affected plants varied at different sites. It is also evident that, in comparison to the control value the net primary production in polluted sites were reduced. The maximum reduction in the rate of production was in Q-II at all stages of growth. This indicates the severe damage of crops due to particulate pollutants coming from the stone quarrying industry and also due to the extensive quarrying activity. Thus under ambient field condition stone quarrying industry may not cause acute or chronic injury symptoms but it seriously interferes with the physiological processes of paddy plants over a long period, especially the production process, as it is evident from the present study. Hence it is suggested that stringent and mandatory legislative measures should be adopted to avoid the physiological disturbance and stress caused by stone quarrying activity. In addition effective mitigatory measures should be practiced to combat the situation which needs detailed investigation.

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