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## Foliar Application of Fly Ash on Wheat Crop

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### ABSTRACT

Fly ash is a major particulate type of air pollutant affected the opening and closing of stomata by blocking the stomatal aperture and thereby allowed increased transpiration. Low dusting rate of fly ash increased chlorophyll contents significantly, while high dusting rate of fly ash reduced the chlorophyllase enzyme due to the alkalinity caused by excessive soluble salts on the leaf surface and also due to increase of foliar temperature which retarded chlorophylls or breakdown of chlorophyll to form pheophytin. Due to which photosynthesis in leaves also retarded. In present lower dose of fly ash dust was found beneficial for all plant growth (Length, fresh and dry weight of shoot and root and tillers no. leaf area); yield (Ear length, no. of grains/ear and weight of 100 grains) compared to control. While, both another doses (2.5 and 5.0 g m<sup>-2</sup>) caused reduction in all above parameters and reduction were higher in 5.0 g m<sup>-2</sup> treatments. Similarly, all biochemicals (Photosynthetic pigments, seed protein and seed carbohydrates) were also increased at 1.25 g m<sup>-2</sup> treated sets. Lower dose of fly ash was also found beneficial to all leaf epidermal characteristics (No. of adaxial and abaxial surface of stomata, length and width of stomatal aperture and no. and length of trichomes). All these parameters were increased significantly. After that there was gradual decrease in all these parameters at both doses (2.5 and 5.0 g m<sup>-2</sup>).

**Key words:** Fly ash, foliar application, leaf epidermal characteristics, plant growth, photosynthetic pigments, yield

### INTRODUCTION

Fly ash is a major particulate type of air pollutant generated by the combustion of coal in coal fired thermal power plants. The Indian coal constitutes about 30-40% fly ash after complete burning (Kumar *et al.*, 2000). About 90 million t fly ash was produced during year 2000 and at present about 100 million t is being produced throughout the country. It will likely to cross about 140 million t by the year 2020 AD. It consist minute, glass like particles of 0.01-100 mm having specific gravity 2.1-2.6 (Davison *et al.*, 1974).

Although, fly ash is trapped as fine dust in cyclonic and electrostatic precipitators during combustion of coal, but a considerable amount is escaped and emitted into atmosphere and deposited on soil and vegetation around emission sources. In humid condition fly ash sticks on the leaves or fruits and causes small necrotic dark brown spot on the leaves due to killing of the tissues. Fluckiger *et al.* (1979) and Krajickova and Mejstrik (1984) reported that fly ash particles affected the opening and closing of stomata by blocking the stomatal aperture and thereby allowed increased transpiration. Dubey *et al.* (1982) observed that low dusting rate of fly ash increased chlorophyll contents significantly. While high dusting rate of fly ash reduced the chlorophyll contents due to the alkalinity caused by excessive soluble salts on the leaf surface

(Elsewi *et al.*, 1980) and also due to increase of foliar temperature which retarded chlorophyllase or breakdown of chlorophyll to form pheophytin (Mudd and Kozlowski, 1975). Mishra and Shukla (1986) reported that fly ash deposition on leaves also retarded the photosynthesis. Recently, Raghav (2006) has obtained the similar results on photosynthetic pigments by dusting of fly ash on potato leaves.

Therefore, present study was carried out to evaluate the beneficial dose of fly ash that will helpful to increases crop productivity without any loss.

## MATERIALS AND METHODS

**Plant culture and treatments:** For this experiment, seeds of wheat were surface sterilized (dipped in 0.01% HgCl<sub>2</sub> solution) for 15 min. Sterilized seeds were sown in each autoclaved pots. After germination, seedlings were thinned to maintain single seedling per pot. Each treatment was replicated three times along with a control set. After 15 days of germination, plants were exposed to different of fly ash (1.25, 2.5 and 5.0 g m<sup>-2</sup>) as foliar application. The fine particles of fly ash were dusted by a plastic duster, which delivered the particles uniformly over the aerial part of plant. Dusting was done twice in a week till 100 days. After each exposure all pots were kept on glass house benches in a randomized block design at 27/23°C day/night temperature. Photosynthetic active radiation was PAR>750 μmol m<sup>-2</sup> sec<sup>-1</sup> between 1100 and 1200 h and humidity was 67±5%. The experiment was terminated after 120 days and plants were uprooted carefully. Roots were washed thoroughly under tap water to avoid soil particles and debris. Plant growth, yield, photosynthetic pigments (chl a, chl b, total chl a+b and carotenoids), seed protein (soluble and insoluble) and seed carbohydrate (soluble and insoluble) contents were estimated, the photosynthetic pigments and leaf epidermal characters were examined before maturation of crop.

**Statistical analysis:** The data was analyzed using analysis of variance for single factor (ANOVA) and L.S.D. were calculated at p<0.05 and p<0.01 for significance (Gomez and Gomez, 1984). The standard deviation and percent increase (+) or decrease (-) over control were also calculated.

## RESULTS

Lower dose (1.25 g m<sup>-2</sup>) of fly ash as foliar application was found beneficial for plant growth and yield of wheat. All parameters were increased significantly (p = 0.05 and p = 0.01). After that there were reductions occurred in all parameters. However, decrease in all parameters was non-significant (p = 0.05 and p = 0.01) in 2.5 g m<sup>-2</sup> dose, while there was significant decrease in 5.0 g m<sup>-2</sup> dose as compared to control. Thus all doses of fly ash showed varied responses (Table 1, Fig. 1).

Table 1: Effect of foliar application of different doses of fly ash on plant growth and yield of wheat

Treatments (g m <sup>-2</sup> )	Plant growths						Yields				
	Length (cm)		Fresh weight (g)		Dry weight (g)		Tillers no.	Leaf area (cm <sup>2</sup> )	Ear length (cm)	No. of grains/ear	weight of 100 grains (g)
	Shoot	Root	Shoot	Root	Shoot	Root					
Control	65.3	19.6	20.7	1.81	4.82	0.401	3.7	34.2	11.6	35	4.50
1.25	68.3 (+4.59)	21.5 (+9.69)	22.9 (+10.6)	2.18 (+20.4)	5.28 (+19.5)	0.483 (+20.4)	4.0 (+8.11)	37.8 (+10.5)	12.2 (+5.17)	38 (+8.57)	4.85 (+7.78)
2.5	64.2 (-1.68)	19.3 (-1.53)	20.5 (- 0.82)	1.78 (-1.65)	4.76 (-1.24)	0.400 (- 0.25)	3.6 (- 2.70)	33.4 (- 2.33)	11.4 (-1.72)	34 (-2.85)	4.49 (- 0.22)
5.0	60.4 (-7.50)	17.3 (-11.7)	17.2 (-16.8)	1.55 (-14.4)	3.24 (- 32.8)	0.350 (-12.7)	3.0 (- 18.0)	29.4 (-14.0)	10.5 (- 9.48)	29 (-17.1)	3.72 (-17.3)
p = 0.05	1.93	1.21	1.30	0.17	0.27	0.032	0.16	2.15	0.34	1.49	0.20
p = 0.01	2.93	1.84	1.97	0.25	0.41	0.048	0.22	3.26	0.52	2.25	0.31

Each value is a mean of three replicates. Figures in parentheses are percent increase (+) or decrease (-) over control

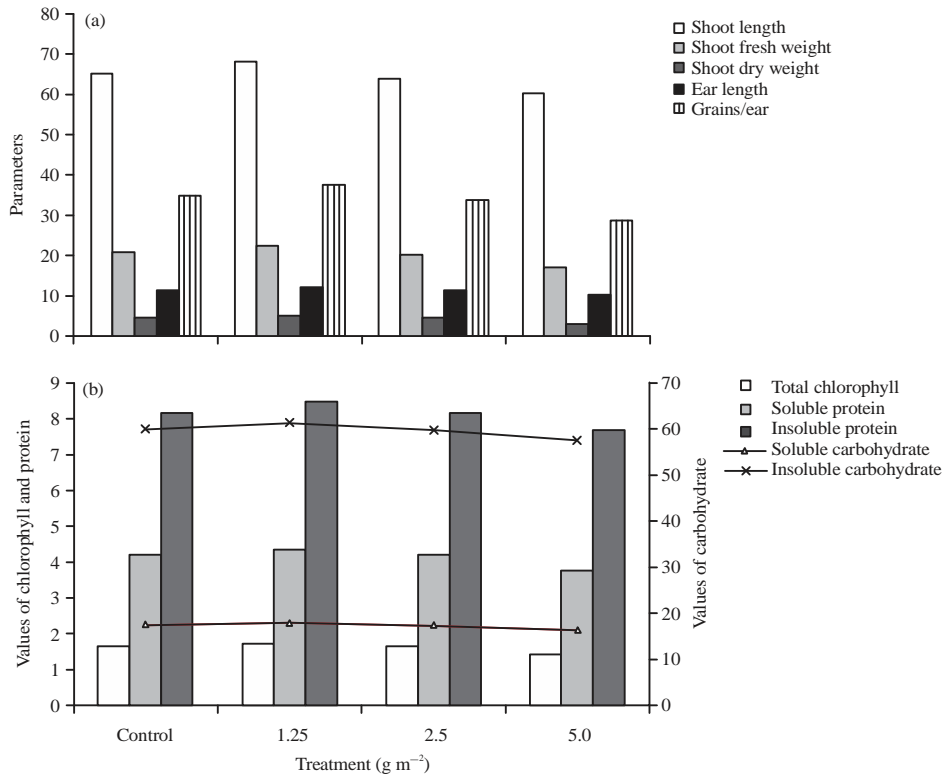


Fig. 1(a-b): Effect of foliar application of fly ash on (a) Plant growth and yield and (b) Biochemical parameters of wheat

Table 2: Effect of foliar application of different doses of fly ash on biochemical properties of wheat

Treatments (g m <sup>-2</sup> )	Photosynthetic pigments (mg g <sup>-1</sup> leaf fresh weight)				Carbohydrate (%)		Protein (%)	
	Chl a	Chl b	Total chl(a+b)	Carotenoids	Soluble	Insoluble	Soluble	Insoluble
Control	1.107	0.549	1.656	0.560	17.63	60.18	4.24	8.22
1.25	1.156(+4.43)	0.573(+4.37)	1.729(+4.41)	0.570(+1.79)	18.02(+2.21)	61.54(+2.26)	4.38(+3.32)	8.51(+3.51)
2.5	1.097(-0.90)	0.540(-1.64)	1.637(-1.15)	0.550(-1.79)	17.39(-1.38)	59.93(-0.42)	4.17(-1.65)	8.15(-0.87)
5.0	0.930(-16.0)	0.488(-11.1)	1.418(-14.4)	0.471(-15.9)	16.44(-6.75)	57.60(-4.28)	3.78(-10.92)	7.69(-6.46)
p = 0.05	0.031	0.015	0.047	0.016	0.27	0.96	0.100	0.22
p = 0.01	0.047	0.022	0.071	0.024	0.42	1.45	0.152	0.33

Each value is a mean of three replicates. Figures in parentheses are percent increase (+) or decrease (-) over control

The data presented in Table 2 also indicate that the lower dose (1.25 g m<sup>-2</sup>) of fly ash dust was beneficial for all photosynthetic pigments, carbohydrate and protein contents. The increment in all parameters was statistically significant (p = 0.05 and p = 0.01) compared to control, except carotenoids. But at 2.5 g m<sup>-2</sup> the parameters were statistically similar to control, while at 5.0 g m<sup>-2</sup> dose, there were significant reductions in all above parameters (Fig. 2).

Table 3 reveals that 1.25 g m<sup>-2</sup>, dose of fly ash was also found beneficial to all leaf epidermal characters of upper and lower surfaces of wheat. Number, length and width of stomata; length and width of stomatal aperture and number and length of trichomes were increased significantly (p = 0.05), except number and width of stomata and aperture length of abaxial surface compared to control. After that there was gradual and significant decrease in all parameters, except the aperture width and trichome length (in 2.5 g m<sup>-2</sup>) and trichome number (in 2.5 and 5.0 g m<sup>-2</sup>).

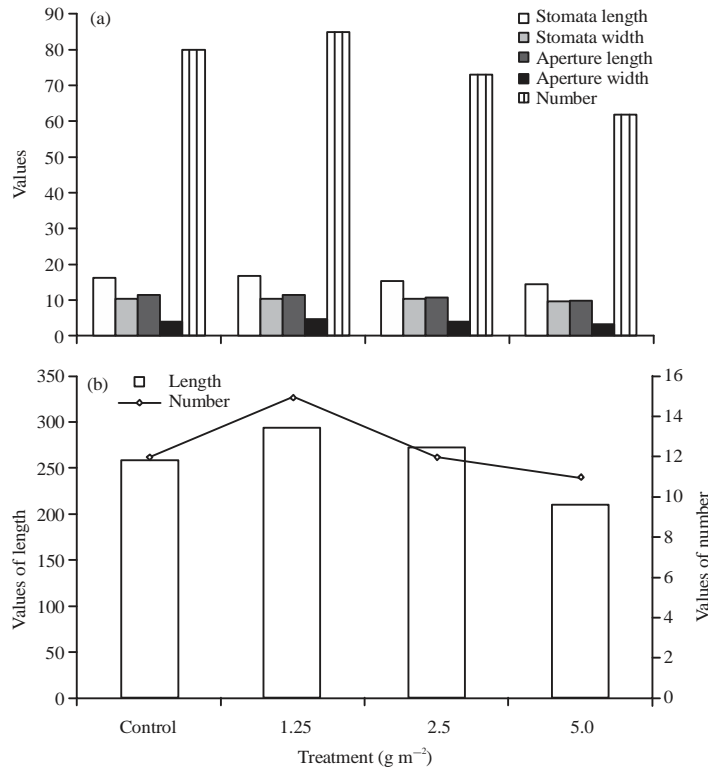


Fig. 2(a-b): Effect of foliar application of fly ash on leaf epidermal characters of wheat, (a) Stomata and (b) Trichome

Table 3: Effect of foliar application of different doses of fly ash on leaf epidermal characters of wheat

		Stomata				Trichome		
		Size of stomata (µm)		Size of stomatal aperture (µm)				
Treatment (g m <sup>-2</sup> )	Leaf surface	Number (mm <sup>-2</sup> )	Length	Width	Length	Width	Number (mm <sup>-2</sup> )	Length (µm)
Control	Abaxial	80±2.00	16.3±0.03	10.30±0.04	11.5±0.17	3.98±0.03	12±0.58	260±1.9
	Adaxial	70±2.08	16.2±0.02	10.22±0.02	11.3±0.20	3.87±0.44	9±1.00	214±1.5
1.25	Abaxial	85±1.53	16.8±0.15	10.38±0.03	11.7±0.12	4.62±0.05	15±1.16	295±3.1
	Adaxial	72±2.00	16.6±0.17	10.26±0.04	11.5±0.27	4.54±1.16	12±1.00	264±2.0
2.5	Abaxial	73±0.52	15.3±0.21	10.09±0.02	10.7±0.21	3.56±0.04	12±2.08	273±2.1
	Adaxial	64±1.00	15.1±0.17	9.92±0.02	10.6±0.17	3.44±0.04	9±0.58	230±3.0
5.0	Abaxial	62±2.00	14.2±0.23	9.70±0.02	9.9±0.12	3.27±0.03	11±2.65	211±1.6
	Adaxial	55±2.08	13.9±0.15	9.65±0.03	9.8±0.20	3.24±0.03	8±1.16	183±2.2
p = 0.05	Abaxial	4.3	0.43	0.07	0.14	0.61	2.1	27
p = 0.05	Adaxial	3.5	0.37	0.05	0.16	0.62	2.2	30

Each value is a mean of three replicates, ±Standard deviation

## DISCUSSION

Although, fly ash is a particulate air pollutants but it contains various utilizable plant nutrient elements such as Ca, Mg, Fe, Cu, Zn, K, Mn, B, S and P along with appreciable amounts of heavy metals (Adriano *et al.*, 1980). The response of plants to micro and macro-nutrients in fly ash may vary from beneficial effects of small concentrations of nutrient element to toxic effects of high concentrations of many elements (Chang *et al.*, 1977).

Wheat plant dusted with different doses of fly ash did not show any visible injury. Interestingly, the lower dose (1.25 g m<sup>-2</sup>) was found beneficial to plant growth, yield, photosynthetic pigments, carbohydrate and protein contents of wheat. It was due to availability of more than 10% water

soluble components like S, Ca, Mg especially boron through leaf surface (Elsewi *et al.*, 1980). The absorption of water soluble salts has also been observed by Rohrman (1971). The transport of the elements through intact cuticles and stomata has been reported by Murray (1984). The absorbed elements actually improved the plant growth. Other side photosynthetic pigments were also increased which led to increase the photosynthetic rate. Thus, the cumulative effects caused increment in all the considered parameters of wheat. Present findings also confirm the results of Mishra and Shukla (1986) on maize and Siddiqui and Singh (2005) on wheat at lower dusting rate. However, higher dusting rate of fly ash adversely affected the wheat plant. Actually fly ash formed a thick layer on the surface of leaves and stem. Thick layer interferes with incidence of light and thus retards the photosynthesis (Mishra and Shukla, 1986). Reduction in chlorophyll content at high dusting rate is attributed to the alkalinity caused by excessive soluble salts on the leaf surfaces (Elsewi *et al.*, 1980) and also due to increase foliar temperature, which retards chlorophyll synthesis (Tomes, 1963). Reduced photosynthetic pigments perhaps caused less production of food in leaves and insufficient supply of food material to plants, which led to reduction in all the growth parameters. Ultimately, all other parameters like yield, carbohydrate and protein contents were reduced. Similar results have also been observed with high dusting rates of fly ash on maize (Mishra and Shukla, 1986), wheat (Siddiqui and Singh, 2005) and potato (Raghav, 2006). Similar results with cement dust were also found earlier on bean by Darley (1966), at  $3.8 \text{ g m}^{-3}$  and on *Vigna mungo* by Prasad and Inamdar (1990).

All stomatal parameters were increased at  $1.25 \text{ g m}^{-2}$  foliar application, while width of aperture was widened. It was due to the deposition of fly ash particles on the leaf surface of guard cells (Mishra and Shukla, 1986), stimulated the mechanism of regulating the opening and closing of the stomata and prevents them from being closed (Fluckiger *et al.*, 1979; Krajickova and Mejstrik, 1984). While, in heavily dusted leaves ( $2.5$  and  $5.0 \text{ g m}^{-2}$ ) a thick layer of dust was formed, which checked the opening and closing mechanism by plugging the stomata and also caused reduction in their numbers. However, the number and length of trichomes were increased at  $1.25 \text{ g m}^{-2}$  fly ash dust. The stimulation of trichome number and increment of length might be a morphological adaptation of wheat plant against the dust particles to prevent on leaf surface, in order to provide physical defense against toxic gases and particulate matter (Levin, 1973). Raghav (2006) also reported similar results on potato plant. However, at higher dose ( $5.0 \text{ g m}^{-2}$ ) the length and number of trichomes were suppressed significantly. It might be due to failure of adaptive response of plant because of high dust fall. Interestingly, the fly ash was found beneficial to wheat at lower dose ( $1.25 \text{ g m}^{-2}$ ) of foliar application.

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