Significant positive association among the characters except maturity period suggests the possibility of yield improvement in Chickpea by similtaneous selection for these characters. Maturity period did not show significant positive association with any of these characters indicating that higher biological yield and grain yield can be combined with optimum duration in chickpea.

Considering both the analyses, graphic and component, it is concluded that both additive as well as non-additive (including epistasis) genetic variances were important for all the characters. Non-additive component was more important in the inheritance of biological yield and number of branches per plant. Considering the importance of these two characters for yield improvement in Chickpea, breeding a homozygous stable line by pedigree method would mean only a partial exploitation even of the additive genetic variance. Under such a situation for exploitation of both, additive and non-additive genetic variances and also for the breeding of broad based widely adopted varieties in certain elite crosses as indicated by Deshmukh (1980), population breeding approach in the form of biparental mating between selected recombinants as well as mating of selected segregants between crosses in early segregating generations should be practiced.

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EFFECT OF CEMENT KILN DUST POLLUTION ON SOIL PROPERTIES AND ON SORGHUM PLANTS

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ABSTRACT

The effects of cement kiln pollution on *sorghum bicolor* has been studied. Simulated pollution by dusting on experimental plants in different quantities was compared with non-dusted control plants. The dusted plants showed a reduction in leaf area index, plant height, stem girth, grain yield and dry matter production. These parameters of the lowest dose of dust (2.5 g m^{-2}) were almost comparable with that of the control plots. Further increase in the dosage showed an adverse effect on crop growth and yield. The amount of total chlorophyll, chlorophyll 'a' and 'b' and soluble protein was found to derease on dusting. However, dose of 2.5 g m^{-2} was comparable with control plot in all the cases. The dusted plants showed a decrease in N and P content and an increase in K, Ca and Na. In the soil, available N and P contents reduced, while available K content increased in the dusted plots when compared to that of the control plots. The dose of 2.5 g m^{-2} did not show any significant change in the contents. Therefore, it was concluded that upto 2.5 g m^{-2} dose of cement kiln dust, there is no significant effect on the crop, beyond which there is an adverse effect on crop growth and yield.

KEY WORDS : Pollution, cement kiln dust, sorghum, soil

Air pollution due to rapid industrial expansion is becoming a cause of public concern in developing countries. Cement kiln dust contained in the waste gases from the kilns form the primary pollutants of atmosphere in the vicinity of the cement factory. The cement dust is reported to be harmful to vegetation, causing considerable reduction in agricultural production (Darley, 1966). The particulate material (dust) falling on the leaves may cause foliar injuries, reduction in yield changes in photosynthesis, transpiration and uptake as well as accumulation of mineral elements from soil. The harmful effects of cement exhausts on soil physico-chemical properties and plant growth are not fully substantiated hitherto and have been questioned by investigators (Lerman and Darley, 1975 ; Madhoolika Agrawal and Najma Khanam, 1989 ; Saralabai and Vivekanandan, 1992). The present paper reports on cement kiln dust pollution on growth and metabolism of sorghum plants as well as on the soil available nutrient status.

MATERIALS AND METHODS

A field experiment was conducted at the Agricultural College and Research Institute, Killikulam to assess the impact of cement klin dust on sorghum crop *Sorghum bicolor* (L.) Moench from November 1995 to February 1996. Klin dust collected from the Sankar Cement Factory in the Talayuthu area 6 km away from Tirunelveli Town was dusted artificially with the help of a duster at different quantities on the crop.

A field of about half an acre was selected in the College premises for the study. The land was thoroughly deep ploughed to have fine tilth. Beds and channels were opened to divide the area into 20 plots each having a size of 5 x 4 m^2. Seeds of Co 26 sorghum were sown in the beds. 30 days after sowing dusting was started. For this, cloth was tied on all the four sides of individual plots To prevent the escape of dust to the adjacent plots. The required quantity of dust was taken in the duster and dusted over the foliage at weekly intervals upto harvest. The details of the treatments are as follows: T_1 - Control ; T_2 - 2.5 g m^{-2} ; T_3 - 5.0 g m^{-2} ; T_4 - 7.5 g m^{-2}, and T_5 - 10.0 g m^{-2}.

Soil samples were collected at 50 and 80 days after sowing (DAS) and at post harvest stage of the crop growth. The soil samples were air dried in the shade, powdered with a wooden mallet to pass through a 2 mm sieve and stored in polythene bags for further analysis. From each indidual plot, 5 plants were selected at random and their height, number of leaves and leaf area index (LAI) were observed in three stages *Viz.*, active vegetative stage (50 DAS), peak flowering stage (80 DAS) and at harvest stage. Stem girth was measured with vernier calipers during the harvest stage. After recording the yield of grain and straw from individual plots, samples of straw were collected separately from all the plots. Whole plant samples were also collected at 50 and 80 DAS The samples were air dried initially and then in an electric hot air oven at 60°C. The samples were powdered and used for estimations of total N, P, K, Na, Ca and Mg. Fresh leaf samples were used for the estimation of chlorophyll 'a' and 'b' and total chlorophyll for soluble protein. These analyses were done at active vegetative stage and peak flowering stage. Initial soil analysis of the field was estimated and given in Table 1. From each

Table 1. Initial soil analysis

Parameters	Content
Texture	
1. Clay	34.70
2. Silt	2.50
3. Fine sand	42.72
4. Course sand	20.70
5. Texture	Sandy clay
Physical properties	
B.D. (g cm^{-3})	1.21
P.D. (g cm^{-3})	2.27
Porosity (%)	29.53
Maximum water holding capacity (%)	35.20
Volume expansion (%)	5.42
Physico-chemical properties	
pH	7.22
EC (d S m^{-1})	0.29
Free CaCO (%)	3.40
CEC (me 100 g^{-1})	15.74
Organic carbon (%)	0.53
Available N (kg ha^{-1})	287
Available P (kg ha^{-1})	29
Available K (kg ha^{-1})	487
Available Fe (kg ha^{-1})	16.0
Available Mg (ppm)	17.92
Available Zn (ppm)	4.67
Available Cu (ppm)	2.53

Table 2. Effect of cement kiln dust on growth parameters and yield of sorghum crop

Treatment Cement dust	Leaf area index	Plant height (cm)	Stem girth (cm)	Grain yield (kg ha^{-1})	Dry matter production (kg ha^{-1})
Control	6.02	167	1.93	886	2215
2.5 g m^{-2}	5.29	160	1.95	879	2198
5.0 g m^{-2}	5.13	165	1.86	860	2150
7.5 g m^{-2}	4.69	150	1.73	837	2093
10 g m^{-2}	4.1	145	1.7	803	2008
SED	0.12	0.63	0.01	4.9	8.69
CD (0.05)	0.24**	1.27**	0.03**	10.7**	18.9**

individual, soil samples were collected randomly at 5 locations making a V cut in the soil. The soil samples were estimated for available N, P and K using standard procedures.

RESULTS AND DISCUSSIONS

The plants treated with cement kiln dust developed a thin hard crust on their exposed surfaces. The cumulative dose of dust applied on the crop, had some adverse effect on the crop growth. As the quantity of dust applied increased, the reduction in leaf area index, plant height and stem girth also increased at all stages of the crop growth. The effect of cement kiln dust was not only a reduction in the size of vegetative parts, but also formation of reproductive organs, fertilization and yield (Table 2). The grain yield and dry matter production (DMP) of dusted plants were lower than those of control plants due to reduced rate of photosynthesis, which is attributed to the cumulative effects of reduction in the incident radiation on leaf surface, obstructions in stomata, shrinkage of guard cells and subsidiary cells; prevention of gas exchange and reduced chlorophyll content as given by Prasad *et al* (1991). The highest dose of 10.0 g m^{-2} recorded the least grain yield (803 kg ha^{-1}) and dry matter production (2008 kg ha^{-1}) as against the control plot values of 886 kg ha^{-1} and 2215 kg ha^{-1} respectively. Cement kiln dust at 5.0 g m^{-2} and above markedly reduced the dry matter production and grain yield compared to 2.5 g m^{2} and the check. A successive decrease of growth parameters was observed from 5.0 g m^{-2} to 10.0 g m^{-2}.

The amount of chlorophyll 'a', 'b' and total chlorophyll in dusted leaves were always found lower than that of control leaves of the same age (Table 3). Pawar *et al* (1982) reported the reduction in chlorophyll 'a' content in the dusted leaves. The reduction in chlorophyll content might be due to the inhibition of chlorophyll formation by the pollutants (Chang, 1975). Soluble protein showed a decline in quantity in dusted plants probably due to decrease in chlorophyll content.

With respect to the nutrient concentration in the leaf, an increase in Ca, Na and K was observed in the dusted plants when compared to that of the control plants (Table 4). A marked decline in N and P content at all stages of observation was also registed. Similar results were studied by Singh and Rao (1978). There was no remarkable change in the Mg content due to the cement kiln dust. The

Table 3. Effect of cement kiln dust of physiological parameters of Sorghum

Treatment	Chlorophyll 'a' mg/g		Chlorophyll 'b' mg/g		Total Chlorophyll mg/g		Soluble Protein mg/g	
	S1	S2	S1	S2	S1	S2	S1	S2
T1	3.0964	3.1235	1.3663	1.4841	4.4868	4.6209	20.0275	19.8667
T2	2.8923	2.8925	1.0105	1.1937	3.9270	4.1231	19.5055	19.4826
T3	2.5874	2.6656	0.9408	0.9762	3.5100	3.8448	18.5880	18.8221
T4	2.4815	2.5134	0.8188	1.0292	3.3255	3.5690	17.8059	17.0777
T5	1.9504	1.5930	0.7357	0.6790	2.2655	2.1558	15.9649	15.8000
SED	0.304	0.186	0.164	0.265	0.31	0.808	0.358	0.342
CD (0.05)	0.66**	0.41**	0.36**	NS	0.68**	NS	0.87**	0.75**

T1 : Control ; T2 : 2.5 g m^{-2} ; T3 : 5.0 g m^{-2} ; T4 : 7.5 g m^{-2} ; T5 : 10.0 g m^{-2}

Table 4. **Effect of cement kiln dust on the nutrient content of sorghum**

Treatment	N%	P%	K%	Ca%	Mg%	Na%
T1	3.100	0.514	0.843	0.493	0.294	0.125
T2	2.980	0.530	0.857	0.523	0.324	0.132
T3	2.800	0.481	0.877	0.647	0.388	0.139
T4	2.700	0.446	1.107	0.683	0.418	0.151
T5	2.570	0.425	1.210	0.730	0.440	0.166
SED	0.036	0.01	0.026	0.02	0.199	0.006
CD (0.05)	0.07**	0.02**	0.05*	0.04**	NS	0.01**

T1 . Control ; T2 : 2.5 g m^{-2} ; T3 : 5.0 g m^{-2} ; T4 : 7.5 g m^{-2} ; T5 : 10.0 g m^{-2}

Table 5. **Effect of cement kiln dust on available nutrients in soil during the growth of sorghum crop**

Treatment	N kg ha^{-1}	P kg ha^{-1}	K kg ha^{-1}
T1	362	28.5	229
T2	352	27.1	241
T3	344	25.7	251
T4	340	23.3	262
T5	333	21.9	272
SED	1.67	1.09	4.35
CD (0.05)	3.38**	2.20**	8.78**

T1 : Control ; T2 : 2.5 g m^{-2} ; T3 : 5.0 g m^{-2} ; T4 : 7.5 g m^{-2} ; T5 : 10.0 g m^{-2}

reduction in N and P uptake might have reduced the chlorophyll content and soluble protein content.

Cement kiln dust causes certain changes in the available nutrient status of the soil (Table 5). The dusted plots showed a higher value for available K content than that of the control plots. This is due to the presence of traces of potassium compound in the cement kiln dust. A marked decline was observed in available N and P content in the surface at all stages of observation in the investigation. This is in agreement with the reports of several scientists (Mukunda Rao, 1993). This results could be attributed to the reduction in the microbial activity due to high pH in the polluted soil by which the decomposition rate of organic matter is lowered as was reported by Singh and Rao (1978) and Vyas *et al.* (1985).

It was concluded that upto 2.5 g m-2 of cement kiln dust, there was no significant effect on sorghum crop above which there is a successive decrease in nutrient concentration, physiological and growth paramters, DMP and grain yield.

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