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Investigating the Dust Deposition on Some Physiological Characteristics of Soybean

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ABSTRACT

Dust from cement factories and sand crushers can cause stress by depositing on the leaves. Accordingly, in areas that are often exposed to such problems, it is important to investigate its effect on plant growth and physiology. This experiment was simulated to investigate dust deposition on soybean leaves and their physiological characteristics. The experiment was carried out on soybean [*Glycine max* (L.) Merr. Var. Hobbit] via factorial in the form of randomized complete block design (RCBD) with three replications in 2016 and 2017. The factors included the type of dust (cement, clay, and sand), each of them 20 g m^{-2} at different stages of soybean growth (V3 (third-node), R1 (beginning bloom), R3 (beginning pod) and R5 (beginning seed)). Plant traits measurements included chlorophyll content, stomatal conductance, catalase activity, soluble sugar, chlorophyll fluorescence (F_v/F_m), and seed yield. The results proved that dust deposition had significant effects on reducing stomatal conductance, photosynthetic pigments, F_v/F_m, and soybean yield. Finally, the use of cement dust from stage V3 led to a significant reduction in some traits. In this treatment, the amount of damage was higher with the increase of dust deposition period.

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1. Introduction

Soybean (*Glycine max* L.) is one of the important industrial crops and has many uses (Gawęda *et al.*, 2020). This crop has a high grain yield and the seeds of this plant have large amounts of oil and protein, which has led to a high demand for soybeans around the world (Zhou *et al.*, 2020). Despite advances in agricultural practices that have increased productivity, environmental factors can greatly affect crop yields (Suchkov *et al.*, 2022). One of these environmental factors is the presence of fine dust, which is increasing today with industrialization. The dust deposition on the surface of the leaf causes a disturbance in the plant growth system and acts as an abiotic stress. The dust has a long history in the Middle East. In recent years, climate change, intensification of desertification, and wind erosion even worsened the situation (AbdelRahman, 2023). In Iran, the dust has had destructive effects on agricultural lands and areas around industrial towns (Velayatzadeh, 2020).

Reports show that even roadside dust hurts human health, livestock, animals, and even plants. A total of 1186 articles have been published about its impact, most of which were in China and the least studied were in Africa and the Middle East (Semerjian *et al.*, 2020).

Most of the research on dust has been done on the morph physiological effects of cement dust (Al Faifi and El-Shabasy, 2021; Drack and Vázquez, 2018). The deposition of dust around the cement factories has affected the physical and chemical characteristics of the soil around the factories. This has caused alkalization, increasing electrical conductivity and apparent density, reducing the storage capacity of nitrogen and soil organic carbon, and also increasing the amount of phosphorus and heavy metals in the soil (Lamare and Singh, 2020; Gross *et al.*, 2021; Li *et al.*, 2022; Singh *et al.*, 2018).

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Previous research has determined that in dusty leaves, the stomata are closed and the photosynthetic system has been damaged through changes in the structure and function of the thylakoids of chloroplasts (Lhotská *et al*., 2022). In addition, there has been a decrease in the amount of protein content, total chlorophyll, and soluble carbohydrates (Sharifi Kaliani *et al*., 2021). Cotton has increased the number of closed stomata on dusted leaves (Zia-Khan *et al*., 2015).

A study of the effect of dust deposition on plants has found that the leaves of plants and trees can absorb a large amount of fine dust around the roads and air. Therefore, many plants have been proposed as a green belt to reduce the amount of fine dust (Zhang *et al*., 2020) or to use some plants as a sink for particulate pollutants in the atmosphere in the form of air pollution biomonitors (Fusaro *et al*., 2021).

According to what was mentioned, dust affects the yield and physiological characteristics of crops. Due to the importance of the subject, so far, few experiments have been done on the evaluation of soybean physiology and yield under the influence of different types of dust applied at different growth stages in field conditions. The purpose of this study was to investigate the effect of cement, clay, and sand dust on some physiological characteristics of soybean in different stages of growth.

2. Materials and methods

2.1. Site description

This experiment was conducted in the research farm of the Campus of Agriculture and Natural Resources, Razi University, Kermanshah City, in 2017 and 2018.

2.2. Weather conditions

Considering weather conditions (Fig. 1), rainfall and wind speed are the important factors responsible for dust emission, transport, and deposition. In 2017, there was the most dust in the last stages of growth, while in 2018, the most dust in the early stages of growth of soybean.

Moreover, we had 0.21, 71.46, and 126.33 mm of precipitation in Sep, Oct, and Nov of the second year of the experiment, respectively, which was significantly higher than that recorded for the first year (0, 0.2, and 39.73, respectively (Fig. 1). The wind speed was also almost the same during the growth period in both years. Relative humidity was relatively higher in 2018 due to more rainfall.

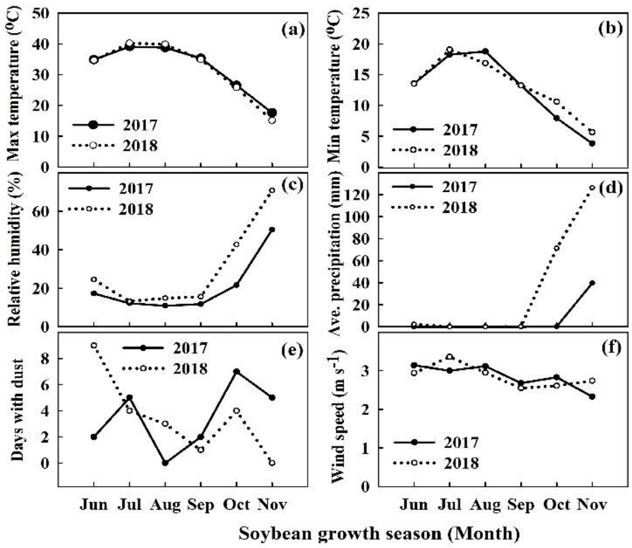

Figure 1. Weather characteristics during 2017 and 2018. Maximum temperature (a), Minimum temperature (b), Relative humidity (c), Average precipitation (d), Days with dust (e), Wind speed (f)

2.3. Soil characteristics

Soil sampling was done from the depth of 0 - 30 cm to distinguish the physicochemical characteristics and the results are shown in Table 1. Based on the soil test, was used 150 kg ha^{-1} of triple superphosphate at the time of planting and 100 kg ha^{-1} nitrogen fertilizer (from a urea source) at the emergence and flowering stages (1:1).

Table 1. Soil physicochemical specifications of the farm during the two years of the experiment at the depth of 0-30 cm

Year	Soil texture	Clay	Silt	Sand	Organic carbon	Organic matter	N	Lime	P	K	EC	pH
			(%)			(%)			(ppm)		(ds m^{-1})	
2017	Silty clay	50	46	4	0.9	0.93	0.1	29	7.9	375	1.12	7.4
2018	Silty clay	55	40	5	1.1	0.87	0.13	34	8.1	405	1.07	7.8

2.4. Experimental Design

The experiment was carried out as factorial based on a randomized complete block design (RCBD) with three replications. There were 60 plots in the whole trial (20 plots in each replication). Each experimental plot included 5 planting lines with 4 m long and 0.5 m distant. In this experiment, soybean cultivar Hobbit, [*Glycine max* (L.) Merr. Var Hobbit], from maturity group III and with determinate growth, inoculated with *Rhizobium japonicum* were planted at a depth of 5 cm on a planting pattern 8×50 cm (Fig. 2). Plants were irrigated by a surface method.

2.5. Dusting procedure

The experimental treatments included the type of dust deposition on soybean foliage (control (no dust), cement dust, clay dust, and sand dust) at different time intervals (from V3 (third node stage), R1 (initiation of flowering), R3 (initiation of pods) and R5 (initial seed formation) and C were the control plots in two years. Growth stages were selected based on the code of Purcell et al. (2014) Code. In this experiment, in the treatment without dust or the control, the plants were washed with a manual water sprayer (Fig. 3).

Cement dust was obtained from a cement factory. The diameter of cement dust particles is between 0.1 and 100 micrometers (factory report). The clay dust used in this experiment was of natural origin and was collected from the dust on the side of the dirt road and on-site. Half square meter trays were used to collect roadside dust. These particles had a diameter of 0.1 to 54 micrometers. The dust particles of sand were 50 to 80 micrometers in size and were obtained from sand-crushing factories. The plan of the experimental design and each plot is shown in Fig. 1.

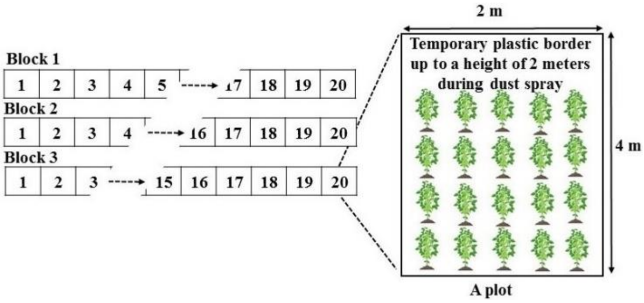

Figure 2. The plan of the experimental design and the plots during the implementation of dust treatment

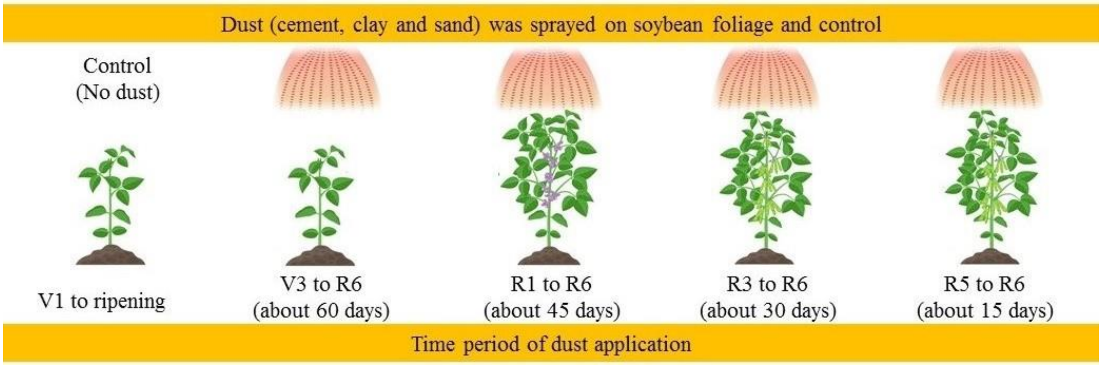

Figure 3. How to apply dust on soybean plants at different growth stages

2.6. Measurements

Physiological traits were measured each year at the end of the R6 stage, at which time the soybean plant has maximum leaf area and height. These physiological traits are:

2.6.1. Chlorophyll a, b, and total

Chlorophyll *a* and *b* content were determined by 80% acetone. According to this method, 0.25 g of the leaves were thoroughly homogenized in a Chinese mortar containing 5 ml of 80% acetone. The resulting solution absorption was then read by spectrophotometer at wavelengths 664.5, 647, and 664 nm. Chlorophyll a and b and total were determined using the following equations (Inskeep and Bloom, 1985):

$$\text{Chlorophyll a} = 12.63\ A_{664.5} - 2.52\ A_{647} \quad (1)$$

$$\text{Chlorophyll b} = 20.47\ A_{647} - 4.73\ A_{664.5} \quad (2)$$

$$\text{Total chlorophyll} = 7.90A_{664} + 18.95A_{647} \quad (3)$$

2.6.2. Chlorophyll fluorescence

The efficiency of photosystem II was studied using a chlorophyll fluorescence analyzer (Handy-PEA, Hansatech, USA). The efficiency of Photosystem II was measured randomly from 10 am to 12 am. The stress meter clamps were attached to the leaves. The clamps have valves that close the desired part of the leaf in the dark. After twenty minutes of leaf acclimation to the dark, the sensor was connected and read the fluorescence parameters.

2.6.3. Stomatal conductance

Stomatal conductance (mmol H_2O $m^{-2}s^{-1}$) was measured with a leaf porometer (SC-1 Decagon Devices, Inc., USA) between 9 -12 A.M., from fully expanded leaves (more than ten leaves randomly selected from each plot).

2.6.4. Catalase activity

Catalase activity was measured by the method of Sinha (1972). In this method, phosphate buffer, hydrogen peroxide, enzyme extract, and spectrophotometer were used at a wavelength of 240 nm.

2.6.5. Soluble sugar

Soluble sugar was obtained by the method of Wehner et al. (2016). In this method were used anthrone reagent, water bath, and spectrophotometer at 620 nm wavelength. A glucose solution was used also to draw the standard curve.

2.6.6. Seed yield

At the time of ripening, one square meter was harvested from each plot and the amount of seed was calculated by kilograms per hectare.

2.7. Statistical analysis

Data were analyzed using SAS, version 9.1 software. Means were compared using Tukey's method or honestly significant difference (HSD) at a probability level of 0.05. All data collected in two years were evaluated in the form of composite analysis.

3. Results and discussion

The combined analysis of variance showed that dust treatment levels had significant effects on all studied traits (Tables 2 and 3). The interaction of dust by different growth stages was significant ($p<0.01$), in the sense that depending on the growth stage, soybean response to the dust treatment levels was significantly different.

3.1. Photosynthetic pigments

The dust treatment affected chlorophylls a, b, and total (Table 2). Averaged over the two years, the chlorophyll a content varied from 13.15 to 27.74 mg g^{-1} FW, chlorophyll b from 5.55 to 18.41 mg g^{-1} FW, and total chlorophyll from 18.71 to 46.15 mg g^{-1} FW (Fig. 4). At each time range, dusting led to a decrease in chlorophyll content compared with control. Besides, cement dust resulted in the highest reduction in chlorophyll *a*, compared to the other two kinds of dust (i.e., clay dust and sand dust). The lowest chlorophyll *a* (13.15±0.577) had found for those plants dusted by the cement dust from the V3 stage, which was equal to a 52.59% reduction as compared with the control. On the other hand, chlorophyll *a* was 26.17±0.077 when plants from the R5 stage were treated with clay dust. Therefore, the minimal drop in chlorophyll *a* content was achieved when the soybean plants were sprayed with clay dust from the R5 stage (Fig. 4a).

Applying any of the three types of dust from the V3 stage resulted in a drastic reduction in chlorophyll *b*, compared with the control. Despite this, the highest decline was found when soybean plants were settled to the cement dusting from the V3 stage. Moreover, for each type of dust, the lowest drop in chlorophyll *b* content was found when the dusting was started from the R5 stage (Fig. 4b).

Likewise, plots sprayed with cement dust from the V3 stage were found to have the lowest total chlorophyll content (18.71±0.542). The data in Fig. 4c show that for each type of dust, the lowest drop in total chlorophyll content was produced when the dust treatment was used from the R5 stage compared to other time ranges.

Table 2. Analysis of variance in the types of dust deposition on chlorophyll a, b, total and soluble sugar at different growth stages of soybean (Mean squares)

Source of variance	df	Chlorophyll a	Chlorophyll b	Total chlorophyll	Soluble Sugar
Year (Y)	1	0.33^{ns}	0.31^{ns}	0.0001^{ns}	0.00003^{ns}
Rep/Year	4	6.66**	2.58**	5.13^{ns}	0.17^{ns}
Growth Stage (S)	3	310.37**	122.3**	815.9**	6.83**
Dust (D)	3	397.02**	535.2**	1852.1**	17.33**
Y × S	3	0.04^{ns}	0.01^{ns}	0.04^{ns}	0.000004^{ns}
Y × D	3	0.04^{ns}	0.32**	0.46**	0.000015^{ns}
S × D	9	35.58**	13.83**	91.92**	0.77**
Y × S × D	9	0.06^{ns}	0.004^{ns}	0.06^{ns}	0.00001^{ns}
Error	60	1.55	0.56	2.04	0.17

*, ** and, ns are significant at the probability level of 5 and 1 percent and non-significant, respectively

3.2. Soluble sugar

The presented data (Table 2) show that the consumption of fine dust caused a significant increase in soluble sugar in all time ranges of application, compared to the control. On average, over the two years, the soluble sugar changed from 10.91 to 13.71

mg g^{-1} FW (Fig. 5). Overall, the highest significant increase was found for those treated with cement dust followed by clay dust and sand dust, respectively. Despite this, the plots exposed to the cement dust from the V3 stage were found to have the highest rate of soluble sugar, which was equal to a 25.6% increase as compared to the control. Usage of the cement dust from the R1, R3, and R5 developmental stages resulted in a 17.9%, 12.8%, and 11.0% increase in soluble sugar, respectively, as compared with the control. Therefore, dust-affected plants from the vegetative stage had more soluble sugar in their leaves. In contrast, the lowest increase (9.1%) was obtained for those treated with sand dust from the R5 stage. These results showed that the occurrence of dust at pod development (R3) or seed filling (R5) stages had fewer impacts on soluble sugar (Fig. 5).

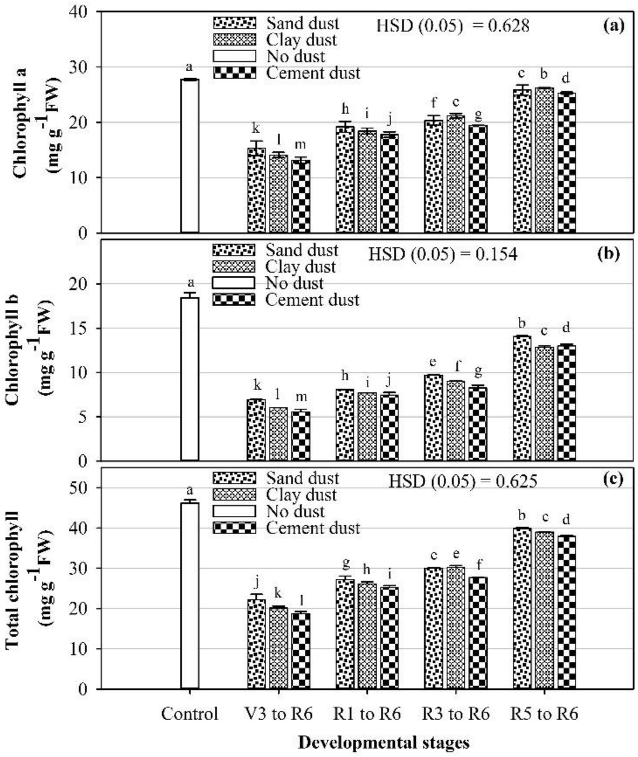

Figure 4. Effect type of dust deposition on chlorophyll a (a), chlorophyll b (b), and total chlorophyll (c) at various growth stages of soybean

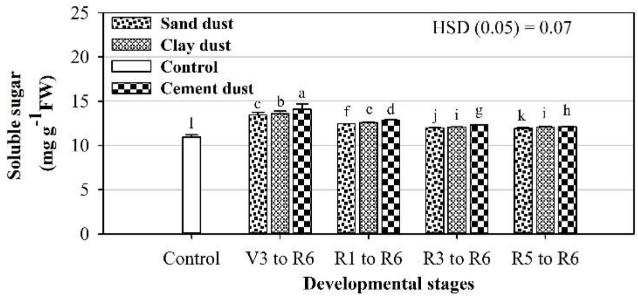

Figure 5. Effect type of dust deposition on soluble sugar at different growth stages of soybean

3.3. Stomatal conductance

The interaction effect of plant growth stages and the type of dust applied was significant on stomatal conductance (Table 3). Generally, during the two years, the stomatal conductance fluctuation from 8.50 to 26.22 mmol H_2O $m^{-2}s^{-1}$. Dust resulted in a significant loss of stomatal conductance compared to the control plants (Fig. 6). Moreover, at each time range, the highest significant decrease in stomatal conductance was observed for treated with cement dust followed by clay and sand dust, respectively. In this experiment, the plots exposed to the cement dust from the V3 stage were found to have the lowermost stomatal conductance (about -67.59% decrease, compared with the control). The usage of cement dust from the R1, R3, and R5 stages resulted in 49.95%, -30.47%, and -17.18% decrease in stomatal conductance, respectively, compare to control. Therefore, stomatal conductance was significantly higher for dusted from the R5 stage. As predicted, the lowest decrease (-10.3%) was remarked for those treated with sand dust from the R5 stage.

Table 3. Analysis of variance of the kinds of dust deposition on stomatal conductance, F_V/F_m, catalase, and seed yield at different growth stages of soybean (Means squares)

Source of variance	df	Stomatal conductance	F_V/F_M	Catalase activity	Seed yield
Year (Y)	1	0.11^{ns}	0.000004^{ns}	0.004^{ns}	1335604*
Rep/Year	4	2.21**	0.0004**	0.03^{ns}	39302*
Growth Stage (S)	3	448.7**	0.01**	22.21**	2852692*
Dust (D)	3	606.9**	0.03**	30.37**	3498476**
Y × S	3	0.07^{ns}	0.000001^{ns}	0.003^{ns}	140797*
Y × D	3	0.03^{ns}	0.000001^{ns}	0.003^{ns}	18391^{ns}
S × D	9	50.02**	0.001**	3.8**	319976**
Y × S × D	9	0.02^{ns}	0.000006^{ns}	0.01^{ns}	22295.2^{ns}
Error	60	0.46	0.00008	0.04	11427.9

*, **, and ns are significant at the probability level of 5 and 1 percent and non-significant, respectively

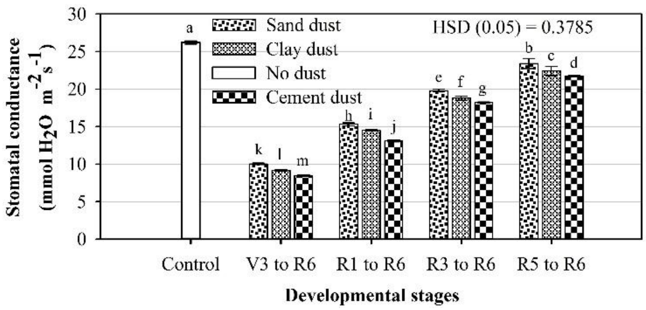

Figure 6. Effect type of dust on stomatal conductance at different growth stages of soybean

3.4. Chlorophyll fluorescence (F_v/F_m)

The interaction effect of plant growth stages and type of dust deposition was significant on chlorophyll fluorescence (Table 3). Over the two years, the highest value of the ratio of variable to chlorophyll fluorescence (F_v/F_m) was found for the control, while dust-covered plots were obtained to have significantly reduced F_v/F_m (Fig. 7). The lowest F_v/F_m was found for plots dusted with the cement dust or clay dust from the V3 stage. Compared to other time ranges, the reduction in the F_v/F_m was lower when the dust treatments were applied from the R5 stage (Fig. 7). Therefore, the highest and lowest drop in the F_v/F_m belonged to dusted treatments from the V3, and R5 stages, respectively. Hence, dust incidence at the vegetative growth stage strongly affected the plants tested. In contrast, dust occurrence during the reproductive stage caused relatively less stress.

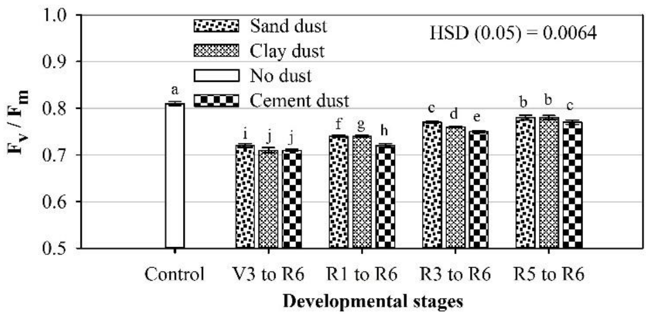

Figure 7. The interaction effect of different kinds of dust deposition applied at different growth stages on chlorophyll fluorescence or F_v/F_m of soybean

3.5. Catalase activity

Dusting treatments significantly increased catalase enzyme activity (Fig. 8). The enzyme's activity was almost three-fold higher than the control for cement-dusted plots from the V3 stage. Likewise, catalase showed high activity for plots treated with cement dust from R1, R3, and R5. Therefore, cement dust ranked one to increase catalase activity compared to the other two types of dust. After the cement dust, clay dust, and sand dust from the V3 stage showed the highest catalase activity 4.79, and 3.87 U mg^{-1} protein min^{-1}, respectively). Therefore, Fig. 8 shows that plants affected by dust treatment from the V3 and R5 stages had the highest and lowest catalase activity, respectively.

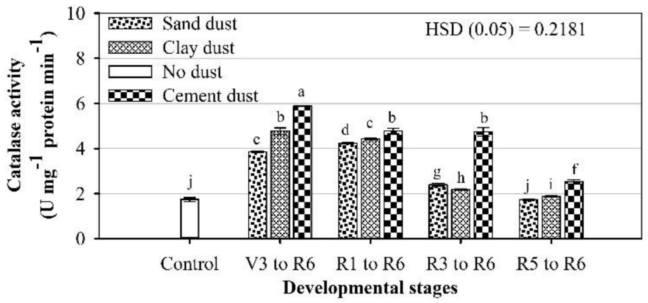

Figure 8. The interaction effect of different kinds of dust deposition and theirs applied at different growth stages on catalase activity of soybean

3.6. Seed yield

Different levels of dust treatment affected soybean seed yield (Table 3). In these two years, the highest grain yield 1789.18 kg ha^{-1} was achieved for dust-free treatment indicating the most favorable growing conditions. As shown in Fig. 9, dusted plants had significantly lower seed yields. Cement dust from the V3 stage had the lowest seed yield, which was equal to -81.08% loss, compared with the control indicating severe stress conditions due to the dust (Fig. 9). On the contrary, the least yield loss (-7.96%) was found for those plants dusted with the sand dust from the R5 stage (Fig. 9). These results revealed that the incident of dust (especially cement dust) at the vegetative and seed filling stages led to the highest and lowest impact on soybean yield, respectively.

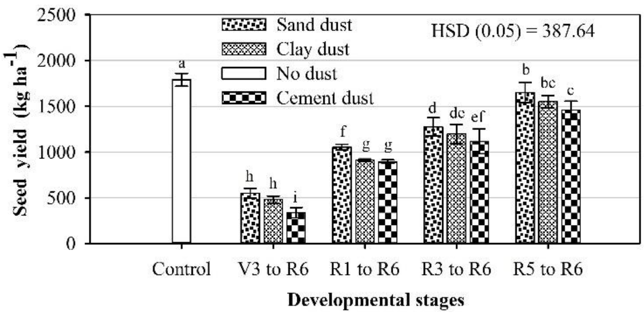

Figure 9. The interaction effect of different kinds of dust deposition applied at different growth stages on the seed yield of soybean

The results of this work showed that dust deposition on soybean leaves significantly reduced the stomatal conductance compared to the control treatment. The deposition of dust particles has affected the amount of opening rate of the stomata and as a result, has reduced the gas exchange to a significant extent. Stomatal conductance reduction due to dust is also reported by Chaurasia et al. (2022). In another study, the effects of cement dust on peach (*Prunus persica*) leaf in the Mediterranean region reduced stomatal conductance, photosynthesis rate, transpiration, and water use efficiency compared to the control (Maletsika *et al.,* 2015). One of the most important problems of fine dust deposition is the interference of air entering the leaves. This reduces the entry of carbon dioxide for photosynthesis in the leaf and thus reduces the photosynthetic performance (Hariram *et al.,* 2018).

Pigments content has an important role in plant metabolism and Chlorophyll evaluation is essential to study the effects of dust on plants. According to this, any reduction in the content of pigments directly affects the growth of the plant. The results of this work showed that the dust resulted in a significant decrease in leaf pigment content. The amount of pigments depends on many genetic and environmental factors, including species, leaf age, leaf thickness, drought stress, dust deposition thickness, etc. (Achakzai *et al.,* 2017; Shah *et al.,* 2018). Obviously, dusty leaves receive less light due to the shading effects caused by the deposition of particles on the leaf surface. Therefore, dusted plants had lower pigment content due to stomatal blockage stresses, reduced leaf area, and less light (Alonso-Montesinos *et al.,* 2020). Dust may also enter the leaf tissues through the stomata and causes partial denaturation of chloroplasts and reduction of pigment content. According to these results, a decrease in the content of pigments caused by dust has also been reported in grapes (Behrouzi *et al.,* 2022), *Robinia pseudoacacia* L. (De Micco *et al.,* 2023), *Ficus benjamina* (Shah *et al.,* 2017) and chickpea (Ranjbar *et al.,* 2021). Contrary to the results of the present work, Gnoinsky et al. (2019) believe that road dust had no significant effect on soybean leaf chlorophyll content. They explained that the lack of significant differences might be due to the nature of applied dust. Therefore, it is essential to be stated that different types of dust may have different effects on plant physiology and function due to different types and amounts of harmful elements.

In the present work, dust-deposited treatments were found to have significantly reduced F_v/F_m. Measurement of F_v/F_m after a period of darkness indicates whether photosystem II is under stress or not. The value of F_v/F_m in many species is in the range of 0.79 to 0.84 under stress-free conditions. If the values are lower than this range, it indicates the stress on the plant (Maxwell and Johnson, 2000). In this study, the F_v/F_m value reached 0.7 in leaves treated with cement dust, while it was 0.81 in the control plans, which indicates that the dust created a stressful environment for plants. Meravi et al. (2021) found a negative relation between F_v/F_m (photochemical efficiency of PS II) and dust deposition in some plants.

The results showed that dust treatment resulted in a significant increase in soluble sugar, compared with the control. Increasing the soluble sugar is a protective process of the leaf. Studies have shown that resistant plant species to environmental stresses generally have more soluble sugar in their leaves than susceptible species (Bahadoran *et al.,* 2019). Therefore, the content of soluble sugars is one of the physiological mechanisms of a plant. This can indicate plant sensitivity to environmental pressures such as dust pollution. Therefore, a significant increase in soluble sugar levels means stressful conditions for plants due to the use of dust. Naturally, the higher the concentration of soluble sugar, the greater the stress imposed on the plant (Najafi Zilaie *et al.,* 2022).

In this study, the dusty environment induced catalase activity. Hydrogen peroxide is converted to molecular oxygen and water by the catalase enzyme to counteract oxidative stress (Erol *et al.,* 2019). In this study, increased catalase activity suggests an increase in hydrogen peroxide production, confirming the occurrence of dust stress. This conclusion is confirmed by previous experiments, which showed that catalase activity increased for plants that were in areas with dust (Shah *et al.,* 2020).

In the present study, applying dust reduced the soybean mean seed yield significantly compared to the control plants. Although dust-infested plants showed no visible symptoms, they showed reduced amounts of chlorophyll, reduced stomatal conductance, and reduced efficiency of photosystem II. All these physiological traits are directly related to yield, and naturally, the observed decline in yield was due to a decrease in these physiological characteristics. Dust pollution has also reduced cotton yield (Abdullaev and Sokolik, 2020), potato (Tomar *et al.,* 2018), and black gram (*Phaseolus mungo* L.) (Babu *et al.,* 2018). Hatami et al. (2018) in an experiment studied the negative effects of desert dust on the performance of cowpea (*Vigna unguiculata* L.). They found that desert dust significantly reduced biomass and grain by 28.3% and 25.6%, respectively, compared to conditions without dust. In another study, cement dust reduced aerial, and underground length, leaf area, leaf thickness and thousand seed weight of *Arachis Hypogaea* L. (Shah *et al.*, 2019).

Moreover, the results of this research can be interpreted from two main perspectives. First, the physiology and yield of soybean were most affected by cement dust compared to clay and sand, and second, plants were much influenced by dust sprayed from the vegetative stage compared to other application time intervals. The highest reduction in physiological traits occurred when the cement dust was sprinkled on the leaves. This result can be attributed to two main reasons, the diameter, and the harmful nature of cement dust. The diameter of the cement dust particle ranges from 0.1 to 100 µm, clay dust from 1 to 54 µm, and sand dust from 50 to 80 µm. Therefore, compared to the other two types of dust, jots with a thickness of less than 5 µm has more frequent in cement dust. Therefore, the size of dust particles is a major factor in infiltration into leaves. The smaller the breadth of the dust particles, the higher the effect on the reduction of stomatal conductance. Consequently, due to the smaller particle width, cement dust had a more reducing effect on stomatal conductance than clay and sand dust. Clogging of leaf stomatal openings reduces the rate of transpiration and carbon absorption. This reduction ultimately leads to a significant reduction in the rate of photosynthesis.

Thus, the highly alkaline nature of cement dust causes damage to plant tissues, including stomata cells. As a result, the activity of the stomata is disrupted, leading to a decrease in stomatal conductance (Drack and Vázquez, 2018). The shape and surface of the leaves of plant species (thick cuticular waxes on the leaf epidermis) affect the deposited particles, but the season and age of the leaves have less effect (Perini *et al.*, 2017). There are species sensitive to tolerant to air pollution (Bharti *et al.*, 2018). The effects of dust on plants are investigated from three aspects: morphological aspects (including effects on stomata, and epidermal cells), physiological aspects (including effects on acidity and relative water content of leaves), and biochemical aspects including the effect on photosynthetic pigments, ascorbic acid, enzymes, sugars and protein (Banerjee *et al.*, 2022; Nawaz *et al.*, 2022).

4. Conclusion

The result of this experiment showed that the amount of dust damage to soybean depends on the amount of dust, the type of dust and the length of time the dust remains on the leaf. The presence of dust in any stage of development declines soybean plant growth. It is recommended not to cultivate soybean in the vicinity of stone crusher factories and cement factories that have dust. Irrigation regularly with sprinklers can reduce the amount of dust damage by washing the leaves.

Conflict of Interests

All authors declare no conflict of interest.

Ethics approval and consent to participate

No human or animals were used in the present research.

Consent for publications

All authors read and approved the final manuscript for publication.

Availability of data and material

All the data are embedded in the manuscript.

Authors' contributions

All authors had an equal role in study design, work, statistical analysis and manuscript writing.

Informed Consent

The authors declare not to use any patients in this research.

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