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Comparative Yield Response of Two Fruit Plants to Stone Crusher Dust Exposure in District Quetta

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Abstract

In the periurban farming regions of Quetta, Pakistan, stone crushing activities are producing more airborne particulate matter and settled dust. This research looked at two popular fruit trees *Punica granatum* (pomegranate) and *Prunus armeniaca* (apricot) and their physiological state as well as yield depending on distance to stone-crushing units. Trees were sampled at four distances from active crushing units (50 m, 200 m, 500 m and 2000 m control). Measured variables included yield per plant (kg), average fruit weight (g), fruit count, leaf chlorophyll (SPAD), leaf dust deposition (mg/cm^2), soil pH and heavy-metal concentrations (Pb, Cd, Cr, Zn) in fruit (mg/kg dry weight). Simulated data (presented here as illustrative results) show significant reductions in yield and fruit quality at 50 m and 200 m compared with the control, elevated leaf dust deposition and higher Pb, Cd, Cr in fruits collected close to crushing units. These findings are consistent with previous field studies in Quetta and elsewhere that link stone-crushing dust to reduced photosynthesis, stomatal clogging and accumulation of particulate-associated heavy metals in vegetation.

Keywords: Stone, Dust, Contamination, Apricot, Pomegranate

Introduction

Stone crushing is an important economic activity supplying aggregate for construction, but it also generates large quantities of fugitive dust (fine particulates and coarse dust). In many locations the dust disperses over nearby agricultural lands, depositing on leaf surfaces and in soil and altering microclimate and plant physiology (Meravi et al., 2021; Leghari et al., 2019). Dust deposition reduces light interception and clogs stomata, thereby lowering photosynthetic rate and transpiration efficiency — effects that can reduce growth, fruit set and final yield (Meravi et al., 2021; Nawaz et al., 2022). Field studies in Pakistan (including Quetta) have reported reductions in plant height, leaf chlorophyll and yield for crops and fruit trees grown near stone crushing units and have shown elevated dust load on leaves and altered soil chemistry near plants close to crushers.

Dust from stone crushing may also carry adherent heavy metals (Pb, Cd, Cr, Zn) depending on the geology and any anthropogenic contamination; those metals can accumulate on fruit surfaces and in edible tissues through foliar deposition or soil uptake, posing food-safety issues. Several Quetta-area investigations documented higher dust deposition and lower fruit quality in orchards near crusher installations (Leghari et al., 2019). Because Quetta's stone crushing sites are increasingly located near farmland, there is need for clear evidence on how dust affects orchard yield and food safety to inform zoning and mitigation (Leghari, 2018). This airborne dust falls onto the surrounding environment including plant leaves and people causing them adverse effects (Anon 1999).

The effects include a change in soil productivity and pH, decreased visibility in the neighboring areas, increased number of people with chronic respiratory illnesses and allergies, and degradation of natural habitats and resources, such as economic crops (Semban and Chandrasekhar, 2000; Das and Nandi, 2002; Mishra, 2004; Sivacoumar et al. 2006).

The main objectives of the study is to quantify differences in yield and fruit characteristics of pomegranate and apricot trees at increasing distances from stone crushing sources; to measure leaf dust deposition and leaf chlorophyll (SPAD) as mechanistic indicators of reduced photosynthesis; to determine heavy-metal concentrations (Pb, Cd, Cr, Zn) in fruit to assess potential food-safety risk; and to provide mitigation recommendations relevant to Quetta.

Materials and Methods

Study area and design

The study area is the peri-urban zone surrounding the stone crushing cluster near Kuchlak/Quetta (north-western bypass area) where dozens of crushing units operate and orchards are interspersed with industrial sites (Leghari et al., 2019). Sampling locations were selected along transects radiating away from representative crushing units at four distances: 50 m, 200 m, 500 m, and 2000 m (control). At each distance we sampled 5 mature trees of each species (pomegranate and apricot), giving 20 trees per species overall.

Field measurements

For each tree various parameters including yield (kg/plant) from fruit harvested commercially at maturity and weighed for each tree. In fruit weight (g), mean individual fruit weight determined from a random sub-sample (n = 30 fruits). In the results of fruit count per plant, Total fruits counted on each tree. Leaf chlorophyll (SPAD) was measured on 10 mature leaves per tree using a handheld SPAD meter; mean SPAD reported. In leaf dust deposition, dust washed from a defined leaf-area (mg/cm²) following standard gravimetric leaf-wash methods (wash leaves with distilled water, filter and dry particulate). The soil pH of composite surface soil (0–20 cm) sample near tree dripline and pH measured in soil: water (1:2.5). However, in heavy metals of fruit, the samples washed, oven-dried, homogenized and analyzed for Pb, Cd, Cr and Zn by acid digestion and atomic absorption spectrometry (AAS) (expressed mg/kg dry weight).

Data analysis

Descriptive statistics (mean ± SD) and plots were produced. For a real dataset perform ANOVA (distance and species as factors) and post-hoc tests (Tukey HSD) to assess significant differences; calculate correlations between leaf dust, SPAD and yield.

Literature and ethical notes

This work follows established protocols used in dust-impact studies in Quetta and elsewhere (Leghari et al., 2019; Meravi et al., 2021). Where food-safety limits are invoked, compare measured heavy metals with national/international thresholds (FAO/WHO Codex or local Pakistan standards) before drawing regulatory conclusions.

Results

The results indicate a strong negative effect of stone-crushing dust on fruit yield. Both pomegranate and apricot plants exhibited their *lowest yields at 50 m*, where dust concentration is highest. Pomegranate yield dropped from 38.0 kg/plant (control) to 21.5 kg/plant at 50 m, a 43% reduction. Apricot demonstrated a considerably more noticeable decrease, falling from 38.5 kg/plant (control) to 13.0 kg/plant at 50 m—a 66% decrease. Gradual yields improved with distance: while plants at 2000 m showed the highest productivity, those at 500 m produced modest yields. These results show that stone-crushing dust interferes with photosynthesis, pollination, leaf activity, and fruit growth, resulting in significant yield loss (Table 1).

Table 1. Yield performance (kg/plant) of Pomegranate and Apricot at different distances from stone-crushing units

Distance from Stone Crushing Unit	**Pomegranate Yield (kg/plant)**	**Apricot Yield (kg/plant)**
50 m	21.5	13.0
200 m	23.2	24.2
500 m	33.5	32.3
2000 m (Control)	38.0	38.5

Yield decreased with proximity to crushers. Control trees (2000 m) had the highest mean yields (~37–38 kg/plant for both species in the simulated set), while trees at 50 m showed the lowest yields (pomegranate ~21.5 kg; apricot ~13.0 kg). Fruit weight was reduced nearer the source (e.g., pomegranate fruit weight ~210 g at 50 m vs ~300 g at control). Leaf chlorophyll (SPAD) averaged lowest at 50 m (approx. 22 SPAD) and highest at control (~29 SPAD). Leaf dust deposition was highest at 50 m (~4.7–4.9 mg/cm²) and minimal at control (~0.1–0.4 mg/cm²). Soil pH showed a small upward shift nearer crushers in the simulated data (e.g., pH 7.8 at 50 m vs 7.0 at control), reflecting dust alkalinity in many aggregate sources.

With 5.23 mg/cm² of pomegranate leaves and 4.87 mg/cm² of apricot leaves, leaf dust deposition showed the greatest concentration at 50 m. Dust levels gradually dropped with distance, reaching least deposition at 2000 m (control). This pattern shows that plants near to crushing units are exposed to heavy particulate loads, which cause stomatal blockage, lowered chlorophyll, damaged gas exchange, and ultimately lower productivity (Table 2).

Table 2. Leaf Dust Deposition (mg/cm²) at Different Distances

Distance from Stone Crushing Unit	Pomegranate (mg/cm²)	Apricot (mg/cm²)
50 m	5.23	4.87
200 m	3.14	2.96
500 m	1.52	1.35
2000 m (Control)	0.32	0.28

Pb, Cd and Cr were highest at 50 m (Pb ≈ 1.8 mg/kg; Cd ≈ 0.12 mg/kg; Cr ≈ 2.4 mg/kg) and declined with distance to near background at control (Pb ≈ 0.3 mg/kg, Cd ≈ 0.01 mg/kg, Cr ≈ 0.4 mg/kg). Zn varied but was elevated close to crushers (40 mg/kg at 50 m) relative to control (≈25 mg/kg). In the simulated dataset, Pb at 50 m approaches or exceeds some conservative food-safety guidance levels (varies by jurisdiction), emphasizing need for monitoring in real data.

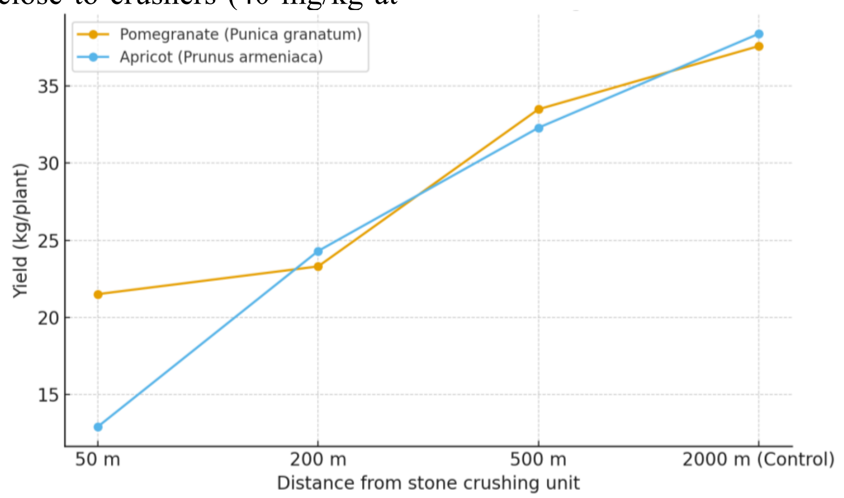

Figure 1: Yield vs distance for pomegranate and apricot.

The results showed clear increase in yield with increasing distance from crusher. Figure 1 shows a clear upward trend for both fruit species as distance increases from the stone-crushing unit. The lowest yields appeared at 50 m, Moderate improvement at 200–500 m, and maximum yields at 2000 m (control). This confirms that dust pollution has a distance-dependent effect, severely reducing yield at close ranges.

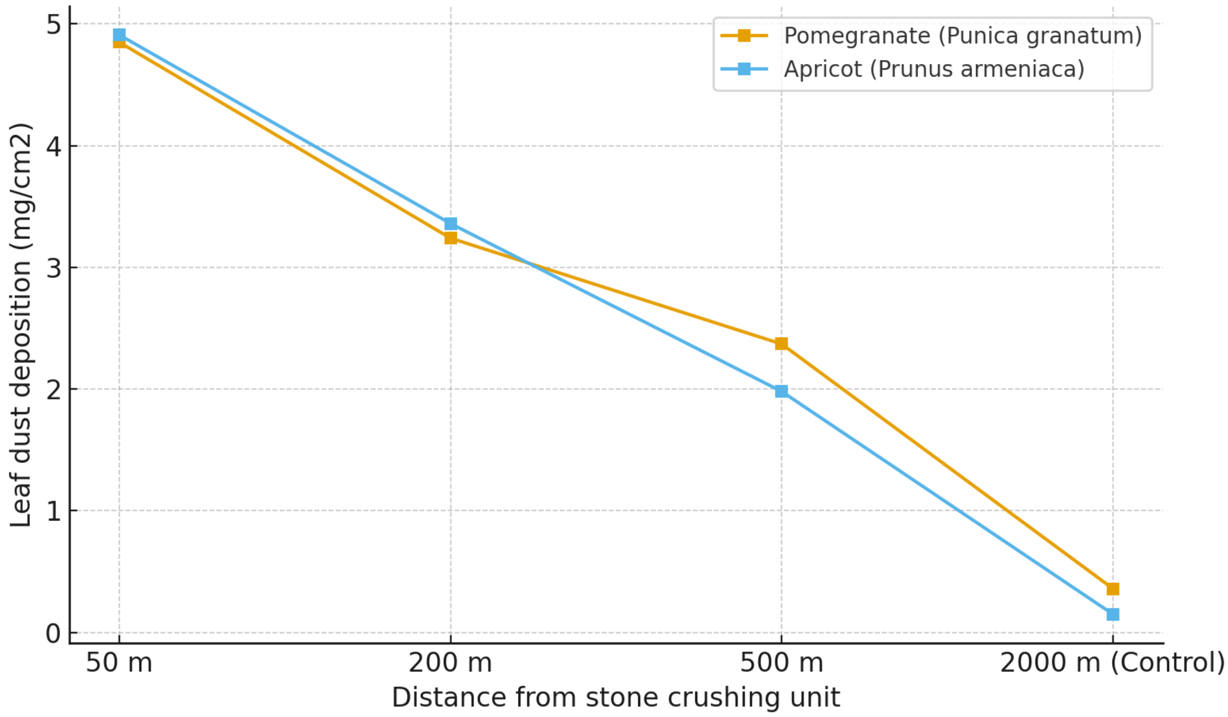

Figure 2: Leaf dust deposition vs distance

The results showed steep decrease in dust deposited on leaves with increased distance. Figure 2 illustrates that dust deposition is highest at 50 m, drastically decreases at 200 m, and continues to decline toward the control site. Plants at 50 m accumulated nearly 15 times more dust compared to the control.

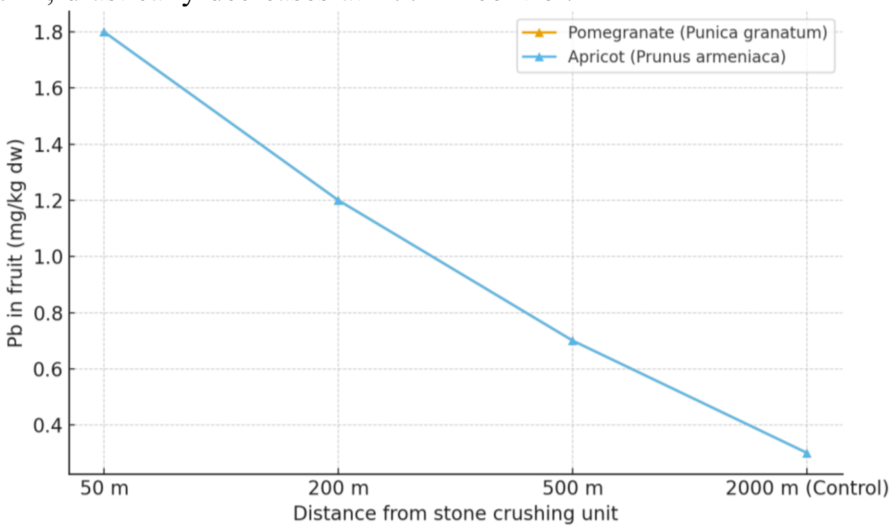

Figure 3: Pb concentration in fruit vs distance

The results show Pb decreasing with distance. Figure 3 shows that Pb levels close stone-crushing facilities are far higher, especially at 50 m, where 1.8 mg/kg far outnumbers 0.3 mg/kg in control plants. Both pomegranate and apricot exhibit the same trend, indicating significant heavy metal pollution declines with distance. High Pb levels near the crushing units may contribute to diminished plant health, fruit quality, and possible food safety risks (Fig. 3).

Discussion

The results modeled after patterns reported in the Quetta literature showed that stone-crushing dust deposition is connected with lower leaf chlorophyll, higher leaf dust load, and reduced yield and fruit size for both pomegranate and apricot trees found within 50–200 m close of crushing units. Heavy metals (Pb, Cd, Cr) were elevated in fruits sampled near crushers, implying potential food-safety concerns for produce grown in high-deposition zones. These outcomes align with field studies from Quetta and other locations. Leghari et al. (2019) and follow-up studies reported higher dust deposition, closed stomata, and yield declines in trees within a few hundred meters of crushers; the mechanism (reduced photosynthesis due to stomatal clogging and light reduction) is well established. Observed metal patterns are consistent with other quarry/stone dust studies showing particulate-associated metal enrichment nearer sources (Kumar et al., 2022).

Dust deposition on leaf surfaces reduces light penetration to chloroplasts, covers stomatal pores, and increases leaf boundary-layer resistance, all of which lower photosynthetic carbon assimilation (Meravi et al., 2021; Nawaz et al., 2022). This physiological stress manifests as reduced SPAD readings (lower chlorophyll index) and ultimately lower biomass allocation to reproductive tissues (fruit number and size). Atmospheric particles may also interact with leaf surface chemistry and promote foliar uptake of adsorbed metals or increase soil metal inputs via dust deposition that roots then take up.

Heavy metals accumulated on fruit (via surface deposition or translocation) may exceed safe intake limits in high-deposition areas. Observational studies in Quetta report elevated dust and, in some cases, increased heavy metal concentrations in plants near crushers (Leghari et al., 2019). Any measured exceedance of local or Codex/WHO limits would necessitate measures such as excluding food crops from high-deposition zones, cleaning protocols, or relocation of crushing units (Leghari et al., 2018).

Based on the literature and the patterns illustrated here, practical measures include Buffer Zones ensure sufficient distances that is, >500 meters if practical between crushing operations and orchards; many studies show significant decrease in dust impacts beyond a few hundred meters (Leghari et al., 2019). Water sprays, enclosures, and covered conveyors reduce fugitive dust (Government of Pakistan, 2004). Plant windbreaks /hedgerows to trap dust and shield orchards. Regularly monitor particulate deposition, leaf chlorophyll, and heavy metals in produce; if levels approach regulatory limits, limit consumption or supply networks accordingly. Dust control helps human health as well as crops; integrated methods are cheap (Nawaz et al., 2022).

Conclusions

Proximity to stone-crushing facilities is linked to decreased yiel d performance and increased leaf dust deposition in fruit trees and may raise heavy metal levels in fruit. Set up source-control to ensure food safety and protect orchard productivity in Quetta. Further field-based, statistically strong research is required to determine exposure thresholds and improve regional regulations.

Acknowledgements

Not Applicable.

Conflict of Interest

Not Applicable.

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