



POSSIBLE BREAKTHROUGHS ROCKDUST AND BIO-FERTILIZERS

Rock dust is pulverized stone, often produced as a by-product of the mining industry. It has no large-scale application and consequently is stockpiled at mining sites. This dust is, however, able to deliver some crop nutrients, like potassium, magnesium and calcium. This allows farmers nearby these mining sites to substantially reduce fertilizer input costs and increase yields.



Description

Rock dust (or stone meal) gains momentum due its beneficial spin-offs compared to conventional marketed fertilizer. As a multifunctional fertilizer, it is able to supply, in addition to the macro-nutrients (N, P and K) required for optimal crop growth, a range of other micro-nutrients (e.g. S, Ca, Mg, B, Cl, Cu, Fe, Mn, Mo, Ni, Zn), while it also improves the physical, chemical and biological quality of the soil.¹ At the field level, these effects materialize in multiple profits for users, including an improved workability of the heavy clayey soils,² improved water retention and water holding capacity of the soil (sandy and clay soil),³ increased (quality of) yields of the cultivated crops, and higher farm benefit due to decreased application and purchase cost relative to conventional fertilizers. At the local and national level, the use of local available rock dust creates employment opportunities, increasing GDP while reducing import costs.

This shift in focus leads to less greenhouse gas emissions through lower demand for conventional fertilizer. Further climate change mitigation mechanisms reside in its capacity to directly sequester carbon and indirectly stimulate tree growth, thus leaving them to act as carbon sinks.

Global occurrence of rock dust usages

The origin of rock dust use dates back to more than three millennia ago, with South and Central America often cited as the regions of origin.⁴ This concerns especially Brazil, the region where terra preta soils are found, and Zacatecas, Mexico.⁵ In the latter state, the government is investigating the suitability of different rocks to restore grasslands.⁶ In Colombia, a movement is rising that supports the use of stone meal among small-scale coffee farmers in order to save their scarce financial resources.⁷ Other similar efforts have taken place in Panama and Costa Rica.

In Panama, experiments with basalt powder have shown significant increases in tree growth. In Costa Rica, yields of jatropha have increased with rock dust applications.⁸ Tanzania, too, has successfully tested the application of 30,000 tonnes of locally available rock phosphate on agriculture in 2008.⁹ Mali and Burkina Faso mines are smaller but still yield considerable amounts of rock dust that can be applied to local cropping systems. Chemical fertilizers are relatively expensive in many African countries due to the absence of local manufacturers. In Asia, the large-scale use of rock dust is taking place in Sri Lanka, where 45,000 tonnes/year are consumed by tea, coconut and rubber plantations; Indonesia and Malaysia import more than 2 million tonnes of phosphate rock per year for use in palm oil plantations; New Zealand imports 130 tonnes/year for application on vast pastures.

¹Straaten 2006, ²Ene and Okagbue 2009, ³Dumitru et al. 2001, ⁴e.g. Leonardos et al. 2000, ⁵Ibid, ⁶Rubio et al. 2009, ⁷Remineralize n.d., ⁸Ibid, ⁹Straaten 2006



In Europe, rock dust is applied at a large scale in forest soils (e.g. Black Forest, Baden-Württemberg and Odenwald) in order to increase the pH of acidified soils.¹⁰ It is estimated that for complete recovery, 600,000 hectares of forest in Baden-Württemberg need annual applications of 45 kg of dolomite for the coming twenty years.¹¹ Further applications of rock dust in Europe concern the addition of lime to acid-inclined soils, like peat soils in the North of the Netherlands. Similar practices with crushed shells are reported in Japan and along the West Coast of the United States, where shells are also added in forests. Examples of the use of rock dust for other purposes are of smaller scale but numerous. For instance, an Austrian study indicated that one-fourth of small-scale farmers and home gardeners in Tirol used alternative soil additives such as lime, stone meal or turban.¹² Numerous individual initiatives have been reported in Spain,¹³ the UK (e.g. SEER Centre) and Portugal.

In Portugal, a feasibility study was conducted by Fonseca et al.¹⁴ to assess the usability of dam sediments for the fertilization of food crops. Results of plot experiments proved the fertilizing effect of dam sediments, as yields increased. Based on these results, the authors recommend that dam owners initiate economic feasibility studies for the use of sediments in nearby agricultural sites.

Rock dust as fertilizer

Despite numerous positive references to the benefits of rock dust, the effect on yield still remains a controversial issue in the literature. Results of experiments with rock dust on crops range from no effect at all to yield increases of 50% (compared to plots where no fertilization at all was applied). These differences are related to the vast array of potential combinations of rock types, soil types and crop types. A further issue of discussion is the identification of the mechanisms responsible for the yield increase, as these are not always clearly mentioned in research reports.

Looking at the mineral composition of rocks, they are able to supply potassium, magnesium, calcium and a range of micronutrients like iron, copper and manganese.¹⁵ Rock types able to supply these and other beneficial nutrients include basalt, biotite, spilite, andesite, phonolite, anortosite, syenite, marl, limestone, serpentinite and micaschist.¹⁶ An early study by Arndt and McIntyre,¹⁷ in which they studied the impact of rock and super phosphate application on sorghum cultivated on clay loamy soil in Australia, shows that both fertilizer sources increased sorghum yield, with the yield response to rock fertilizer being somewhat slower compared to the readily available superphosphate. More recent research includes Goreau's five-year experiment¹⁸ in which basalt powder accelerated tree growth and biomass on impoverished tropical soils in Panama. A more elaborated list of the impact of rock dust on yields is provided in table 1.

¹⁰Sucker et al., 2009, ¹¹Ibid, ¹²Vogl and Vogl-Lukasser, 2003, ¹³One of two countries within EU that have outlined guidelines for organic agriculture at the national and district level.

¹⁴Fonseca et al. 2003, ¹⁵Nitrogen is not supplied by rocks, phosphorous can only be applied if there is enough water for it to be soluble, which is seldom the case.

¹⁶Leonardos et al., 2000, ¹⁷Arndt and McIntyre 1963, ¹⁸Goreau 2011



Table 1
Improved yields after rock dust application for various crops

Crop	Rock type	Application rate (t/ha)	Yield response	Source
Lettuce/wheat	W.M.F. fertilizer (rocks-microbes mixtures)	n/a	9.8% average higher yields	Western Mineral Fertilisers 2009
Birdwood grass and legume	Rock phosphate	5-10	Increased yield from 2.4 to 13.1 and 3.1 to 14.7 t/ha	Norman 1965
Clover	Granite powder	20g/kg soil	Increased resp. from 1,482, 2,280, 3,798 to 3,900, 3,682, 6,746 mg/pot	Coreonos et al. 1996
Clover	Basalt dust	0-40	Increased yield	Dumitru et al. 1999
Lettuce	Basalt dust and compost	n/a	Similar yield to completed organic fertilizer	Manning and Vetterlein 2004
Lupine	Granite	n/a	Increased yield with 1/20 of conventional fertilizer cost	Oldfield 1996
Maize	Rock dust	n/a	10% higher yield and 20-50% higher germination rate	Remineralize n.d.
Okra	Compost, feldspar and rock phosphate	N, K and P: 45, 143, 143 K ₂ O units/ha)	Rock fertilizer 6.9-7.9 t/ha; control and NPK resp. 3.6 and 6.7 t/ha	Abdel-Mouty and El-Greadl 2008
Olive and orchards	Basalt crusher dust	n/a	Increased tree growth and health	Manning and Vetterlein 2004
Onions	Feldspar (Ksp.)	114, 228 and 342 K ₂ O units/ha	Feldspar yields resp. 20.3, 22.5 and 27.8 t/ha Chemical yields resp. 18.5, 27.8 and 34.2 t/ha	Ali and Taalab 2008
Radish	Basalt rock	0-20 t/ha	Up to 50% increase in dry weight	Dumitru et al. 1999



Table 1
Improved yields after rock dust application for various crops (continued)

Crop	Rock type	Application rate (t/ha)	Yield response	Source
Rice	Phlogopite mica, feldspar	Resp. 0.2, 0.5 t/ha	Resp. 93.3 and 69.8 g/pot vs. 41.1 control pot	Weerasuriya et al. 1993
Ryegrass	Granite powder	20g/kg soil	Increased resp. from 2099, 3,749, 3,641 to 3,234, 4,894, 3,990 mg/pot	Coreonos et al. 1996
Sorghum	Rock phosphate	5, 10 and 25 t/ha	0.9, 1.3 and 1.4 t/ha vs. 0.7 t/ha control plot	Arndt and McIntyre 1963
Sugar cane	Basaltic rock	10-90 t/ha	Increased yield following years	D'Hotman de Villiers 1961
Tomatoes	Feldspar powder and compost (+bacteria)	0, 120, 240 and 360 kg K/ha	Yields 27.1, 42.3, 51.7, 58.8 t/ha vs. only compost yields of resp. 27.2, 30.9, 34.2 and 32.3 t/ha	Badr 2006
Tomatoes	Basalt	0-40 t/ha	Increased yield	Dumitru et al. 1999
Trees (not specified)	Granite	15-20 t/ha	Five times faster growth	Oldfield 1996
Tree growth	Basalt powder	n/a	Length 14m vs. 6 local soil; biomass 47 kg/tree vs. 6 kg/tree local soil	Goreau et al. 2011
Wheat	Stone meal, with lupine as green manure	7 years, 440 kg/ha	15% higher yield than conventional fertilizer, resp. 9,076 vs. 7,891 t/ha	Jost and Samobor 2008
Wheat	Rock dust	2 years, 250 kg/ha (lupine as green manure)	Wheat yield of 2.2 t/ha without pesticide and conventional fertilizer application	Oldfield 1996
Wheat	Volcano dust	After eruption	Increased yield	Fyfe et al. 2006



Energy

- › Production of conventional fertilizer requires 51-68 MJ/kg nitrogen (N); 6.82 MJ/kg phosphorous pentoxide (P_2O_5) and 2.88 MJ/kg potassium oxide (K_2O).¹⁹
- › Packaging and transport of conventional fertilizer is about 6-8 MJ/kg.²⁰
- › Application of fertilizer (conventional and rock dust) equals 51.62 MJ/kg.²¹
- › Rock dust is locally available as a by-product of mines and quarry sites. Therefore it does not consume energy for its production.
- › Rock dust need only be applied once every several years, while conventional fertilizer requires application at least once a season.



Water

- › Recent research in Germany does not provide evidence that stone meal improves the water retention capacity of the soil.²²
- › Yet Dumitru et al.²³ found increased soil water retention capacity with the application of basalt rock.

¹⁹Bhat et al. 1994, ²⁰Mudahar and Hignett 1987, ²¹Lobb 1989, ²²Pers. Comm. Bergsma 2011, ²³Dumitru et al. 2001



Productivity

- › Soil quality increases as rock dust micronutrients stimulate biota, biomass and organic matter content. This increases soil water retention and storage capacity.
- › Soil's nutrient delivery capacity is enhanced:
 - Basalt dust applications of 10 t/ha on clayey soils reduced phosphorous application requirements by 170 kg/ha super phosphate (US\$ 38/ha).²⁴



Climate change²⁵

- › Weathering of rock actually results in carbon sequestration. This process can be described by the following general equation:
fresh silicate rock + H₂O + CO₂ → soil + cations + HCO₃ (bicarbonate).
- › Serpentine and olivine are able to dispose of 0.5 and 0.67 t CO₂ per tonne weathered rock respectively.
- › All the CO₂ that is produced by burning 1 liter of oil can be sequestered by less than 1 liter of olivine.



Costs and benefits

- › Farmers are able to save up to 95% of the cost of conventional fertilizer.²⁶
 - Rock dust can be purchased at a low price; crushed dunite (olivine), for example, costs in the order of a few tens of US dollars per tonne in the Rotterdam harbor.²⁷
 - Prices for conventional fertilizers are high, in the order of US\$ 420/tonne for urea, US\$ 250/tonne for liquid nitrogen, US\$ 450/tonne for diammonium phosphate (DAP), and US\$ 500/tonne for potash.
- › The mining industry is open-minded for rock dust solutions, as it is currently only stockpiled.

²⁴Gillmann et al. 2002, ²⁵Schuiling and Krijgsman 2006, ²⁶Oldfield 1996, ²⁷Schuiling and Krijgsman 2006



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