NON-ORGANIC SUBSTRATES - ROCK AND MINERAL WOOLS REVISITED

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Introduction

Mineralwool is a term for man-made fibrous inorganic substrate that can be used alone or in combination with other materials as a substrate for plant production.

There are different kinds of mineralwools available and named on the basis of their starting components. *Rockwool* is made from basaltic rock melted at a temperature in excess of 1500° C. Slagwool is made from melted blast furnace slag. There can be hybrid wools made from a combination of basaltic rock and slag. Mineralwools are alumina-silicates that are spun into fibers and contain some calcium and magnesium. The wools greatly affect physical properties of substrates, but usually have a much smaller impact on chemical properties. The fibrous wools are manufactured when the molten mixture of rock or slag, coke, carbonate of lime and other ingredients is fed onto a rotating drum which spins the molten mass into fibers. Additives can create mineralwool that is either water absorbent or water repellent (Smith, 1987).

Rockwool is the mineralwool that has been used in floriculture for the longest period of time. It is available as a slab for the culture of greenhouse vegetables, cut flowers and stock plants. The fibers can also be granulated as a loose material suitable for use alone or combining with other components to create a substrate for potted plants. The rockwool slab is manufactured by adding binders to the fibrous wool then shaping in to a rectangle that is about 3.5 to 4 inches deep. The primary function of the rockwool is to support the plant in an upright position but also has an important influence on the air-water balance in the substrate. Generally rockwool is inert and provides little nutritional value to the plant. Also, rockwool does not swell when wet or shrink when dry thus forming a stable substrate for plant production.

Plant Properties

The physical properties of mineralwools make them a very useful component for container substrates. The bulk density ranged from 0.11 for mineralwool to 0.20 $g{\cdot}cm^{-3}$ for water repellant rockwool (Table 1). Bunt (1988) reported a bulk density for mineralwool that is one-half that of peat moss while Constrisciano (1993) reported the bulk density of mineralwool and peat to be similar. Mineralwool can be easily compressed and the amount of compression will greatly affect the bulk density reported. Mineralwool is not as light as styrofoam but is similar to the weight of peat moss or perlite.

The relatively low bulk density of mineralwool indicates that its total pore space is rather large. Smith (1987) reported that the pore space in rockwool slabs was 95% meaning that the rockwool fibers only accounted for 5% of the volume of the slab. Rockwool slabs then, are very light and contain mostly air and water when used in plant production. Loose rockwool also has about 95% pore space (Table 1)

The most critical physical property of mineralwool is its air-water balance. Tonteno and Nelson (1990) determined the water retention curve of several substrates including rockwool. It is evident from the data that rockwool has a very high water holding capacity, holding more water than peat moss.

In other studies container capacity of rockwool was 74% which is higher than the 54% for mineralwool (Table 1). Increased compression will increase container capacity and that will explain the difference between rockwool and mineralwool. If the rockwool is lightly compacted its bulk density will be very low and container capacity will be lower, than if the rockwool is compacted more firmly. What is clear from these studies is that mineralwools do have important water holding capacities buy not as high as some other components, for example peat moss.

Rockwool also gives up the water very readily giving up its available water by the time that the water tension reaches 100 cm water tension. To gibe you an idea what 100 cm tension is, if you were to irrigate your crop at 100 cm of tension, the growing media would not be very dry when irrigated. In crop production the large water holding capacity of rockwool means less frequent irrigations, and more of the held water is easily removed and is available for plant growth. Mineralwool provides these advantages whether used alone or with peat (Table 2)

The aeration in unamended mineralwool is very high (Table 1). Figure 1 would also lead to a similar conclusion; however, the water is lost rapidly from the rockwool so over watering may only be a problem with very small plants or conditions of low transpiration. When mineralwool is added to peat moss the aeration of the mix is very good (Table 2)

One very important factor affecting measured aeration is whether or not the components to be mixed are wet or dry. When dry peat, vermiculite and a small percentage of water resistant rockwool were mixed, the aeration increased with the percent of rockwool incorporated (Table 3).

When the components were moistened before mixing the aeration was higher than when mixed dry and rockwool additions had little effect on aeration. Thus a general recommendation would be to moisten the rockwool and peat separately then combine them to make the peat-wool blends. This will not be possible for the commercial mix manufacturers, but for growers mixing their own substrates, moistening components prior to blending should provide substrates with better aeration.

Table 1
Physical properties of water absorbing and water repelling mineralwools.

Substrate	Bulk density ($g \cdot cm^{-3}$)	Total Porosity (%)	Container capacity (%)	Aeration porosity (%)	Unavailable water (%)
Rockwool	0.18	94	74	20	1.1
Slagwool	0.1	13	97	54	43
Combination	0.20	94	71	23	3.0
Water Repellant	0.20	94	8	86	3.0

Chemical Properties

The chemical composition of mineralwool suggests that there are few plant nutrients available. Smith (1087) stated that there were no plant nutrients in rockwool. Contrisciano (1993), however, reported that potassium, magnesium, and calcium were high enough to be considered when planning a fertilization program, but amounts of other plant nutrients in rockwool were too low to be considered when planning a fertilization program.

The minerals that are available in rockwool tend to react as bases, so one might assume that the pH of unamended mineralwool to be about 8.0. Fonteno and Nelson (1990) reported that the pH values of their rockwool amended substrates were between 6 and 7. It seems that the only time when the pH of rockwool may be of concern is when unamended mineralwool or rockwool is used as a substrate. It should be pointed out however, that the exchange capacity of mineralwool is rather low so changing the pH should be very easy by adding an acidified nutrients solution.

It is important to note that there is little, if any, exchange capacity in mineralwool, so mineralwool will not store plant nutrients for uptake by the plants at a latter time. Plants grown in rockwool should be fertilized at each irrigation. Constant fertilization is common practice with most growers today, and using constant feed with rockwool should present no additional problems.

Plant Growth

Plants have been grown in rockwool either alone or in combination with other components to create a substrate that will permit good plant growth. Hanan (1983) used rockwool as a substitute for peat moss in combination with pearlite and soil. He found that the growth of geraniums, chrysanthemums and kalanchoe was equal in the rockwool blend and the peat blend. Hanan noted that mixing rockwool in a rotary mixer, wetting at the same time created "pills" of rockwool that needed to be broken up by shredding. He also noted that there was substantial shrinkage when using rockwool as a component of the substrate.

Hanan (1986) compared rose production in rockwool and gravel and determined that more roses were produced on plants grown in loose rockwool than on those in gravel culture. He concluded that the greater flower yield in the rockwool was because of its greater water holding capacity, and that more frequent irrigations should have been used in gravel culture. He concluded that excellent rose yields were possible in rockwool, but since there is little buffering capacity there is little room for error in fertilization. Many rose growers are now experimenting with rose production in rockwool slabs, and a few growers are growing a substantial number of rose plants in rockwool.

Water resistant rockwool can be used as a potting media for orchids. Orchids are epiphyte that must have very well drained substrates. Some growers have been quite successful using unamended rockwool as a substrate for growing orchids.

Since many floricultural crops are grown in pots, it is important to determine how rockwool performs as a substrate for plan production in containers. Lee et al. (1987) compared the growth of poinsettia plants in a soil mix, a peatlite mix, and rockwool. At flowering there were few if any substantial differences among poinsettias produced in the three media. Lee et al. (1987) noted that initial poinsettia growth was slower in rockwool, but by the time of flowering the initially slower growing plants were very similar to other plants in size and development. They attributed the initial delay in the growth of the poinsettias to the absence of initial fertilizer in the rockwool. The researchers felt that the poinsettias would have benefitted from an early fertilization. Contrisciano (1993) observed that impatiens and begonias grown in unamended mineralwool were smaller than those grown in a peat moss/mineralwool blend at harvest. He also determined that these species grew as well in mixes with 25% mineralwool as with 50 or 75% mineralwool-peat blend, suggesting that there may not be a critical percentage of mineralwool for a substrate.

There is a concern that mineral wool blends require a different fertilization program that used with success with substrates containing no mineralwool. Contrisciano (1993) determined that the leaf nutrient content of begonias and impatiens grown in mineralwool and mineralwool/peat substrates were in the normal rages for all nutrients tested. The conclusion is that a special fertilization program is not needed as long as the plants are being fertilized on a constant liquid fertilization program.

In summary mineralwool has a very high pore space and high aeration porosity, reducing concerns with over watering. Mineralwool also holds a great deal of readily available water which may extend the time between irrigations. Mineralwool is sterile, low in nutrients, and does not break down. These are all important attributes of a good substrate. As long as mineralwool substrates are regularly fertilized to make up for their low exchange capacities many crops can be successfully grown in mineral or rockwool.

TABLES 2 and 3 on next two pages.

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Table 2

Physical properties of mineralwool alone or in combination with peat moss.

Substrate	Bulk Density ($g \cdot cm^{-3}$)	Total Porosity (%)	Container capacity (%)	Aeration porosity (%)
100% MW	0.113	97.0	54.2	42.8
75%MW/25%PM	0.148	94.3	72.7	21.6
50%MW/50%PM	0.132	91.6	71.2	20.4
25%MW/75%PM	0.112	94.8	75.2	19.6
100%PM	0.124	95.1	72.5	22.6

MW = mineralwool
PM = peat moss

From Thesis of Contrisciano, 1983.

Table 3
Aeration and container capacity affected by small percentage additions of water resistant rockwool to a moist or dry peat-vermiculite substrate.

Substrates – blended with dry components All 50% peat	TPS (%)	CC (%)	AP (%)
V50 - W0	88.5	82.7	5.80
V45 - W5	87.4	80.9	6.5
V40 - W10	85.4	79.1	6.3
V30 - W20	83.9	74.2	9.7
V0 - W 50	73.9	64.8	9.0

Substrates – blended with premositened components All 50% peat	TPS (%)	CC (%)	AP (%)
V50 - W0	89.5	80.7	8.8
V45 - W5	88.0	76.0	12.0
V40 - W10	86.4	73.6	12.8
V30 - W20	84.2	72.4	11.8
V0 - W 50	79.3	65.1	14.2

TPS – total pore space CC – container capacity AP – aeration porosity
V – vermiculite as a percentage W – water resistant rockwool as a percentage.