# Fertility Assay of Sands

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Use of sand as growing media either as a component in soil mixes or alone stems from desirable physical properties imparted by sands, not their fertility. Generally, sands are thought of as being poor nutritionally. Under those circumstances where sand is used in potting soil, the fertility of sand is not important since nutrition in container culture is easily effected with combinations of chemical amendment, liquid fertilization, controlled-release and dry fertilizers. Under conditions where sand is used as a sporting turf soil (putting green, football field) and will not receive the intense fertilizer management of a container soil, inherent fertility is important. If sand can provide some of the plant nutrients, management is easier. Fertility of sands, as a separate class of soil, has not been evaluated, yet it would be useful to have this information.

The purpose of this work was to assess fertility of sands suitable for horticultural purposes with particular references to sands used for turf. The present study evaluates nitrogen (N), phosphorus (P), potassium (K), and sulfur (S) status of 35 sands using the pot testing method (Jenny, Vlamis and Martin, 1950). Soil testing for estimating available P and K in sands is also presented.

Before discussion the results on fertility, it is worthwhile to review briefly the reason for using sand as a traffic soil. It is not necessary that all turf soils receiving traffic be constructed of sand. Under conditions of low to moderate traffic and with good management, soil other than sand can and will support good turf growth. Heavy traffic can cause extra demands on management to keep the soil permeable to water and air, and it is under such conditions that sands are most useful.

Soils containing silt and clay are more or less in a state of aggregation. Under a compactive force, moist soil aggregates deform and flatten, filling in the large air- and water-conditioning pores between the aggregates. The remaining pores are very small and conduct water slowly. Sands form rigid networks of grains that can withstand compaction. After compaction, there is little change in numbers of conducting pores between grains, and so permeability to air and water is preserved. This ability to withstand compaction is the principal reason for preferring sand rather than finer textured soils.

**Particle size distribution**

Since natural sands are generally unsorted sediments, particular attention should be given to the particle size distribution. Not all sands are ideal for growing plants or for managing. See Table 1.

Silt is 0.05 mm and clay is less than 0.002 mm. Fine gravel is greater than 2.00 mm. Sands having a broad particle size distribution, i.e., a fairly continuous particle size representation, are poor horticultural sands, because the finer grains fit into pores between larger grains, and if silt and clay are also present (8 to 10% by weight), the problem is further aggravated. The resulting mixture is a very dense (bulk densities of 1.9g/cc), tough matrix with only fine pores. We seek uniform sands in horticulture, medium sands for sport turfs and medium-coarse sands for potting soils. Uniform medium and medium-fine sands are permeable after compaction (6 to 12 in./hr.) and contain adequate available water (1¼ to 1½ in.) in the surface 4 inches of a 12-inch depth following drainage. Medium-coarse and

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coarse should probably be amended to increase plant-available water. For a review of sands recommended for putting greens see Davis (1973 a,b).

In selecting sand to meet the physical requirements for traffic soil, to what extent is fertility sacrificed? Sands have little or no cation exchange capacity; sands taken from below the surface foot have no organic matter and probably a small microbial population. Visual inspection of some sands suggests that they consist primarily of quartz. Such sands would require careful and complete fertilization. Other sands appear to be rich in primary minerals, such as mica, feldspars and ferr-magnesium minerals. Thus, some sands appear to have no plant nutrient-bearing minerals, while others seem to have a full complement of such minerals.

**Fertility of sands**

The pot test method was used to assess fertilizer requirements of 35 sands obtained from various commercial sources in central California. It consists of treatments with elements in various combinations with elements subtraced one by one - e.g. PKS minus N ($N_0$). Treatments consisted of: NPKS: full; PKS: $N_0$; NKS: $P_0$; NPS: $K_0$; NPK: $S_0$; —: Check.

Plants were grown in 4-inch plastic pots containing 650 grams of sand. The fertilizers were applied as chemically pure salts at the following rates:

Nitrogen was applied as a split applicaton with one-half applied 45 days after planting.

One-hundred mg of sand of bentgrass (*Agrostis tenuis* cv. 'Penncross') were planted per pot. The grass was grown for 60 days, and three harvests were made by taking clippings, 30, 45, and 60 days after planting. Total dry weight yield per pot was obtained by summing the three harvests. There were four replicates per treatment. Relative yield (yield of subtractive treatment per yield of full treatment, x 100) is used to compare fertilizer responses between sands.

All experiments were performed in a cool greenhouse (night temperature 55ºF and day temperature 80ºF) from April through October.

**Results**

The following table summarizes the extent and frequency of fertilizer responses obtained for 35 sands.

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| Relative yield (percent) | Percent of sands deficient in $N_0$ | $P_0$ | $S_0$ | $K_0$ |
|---|---|---|---|---|
| 0 - 20 | 100 | 3.1 | 6.2 | 0. |
| 20 - 40 | — | 6.2 | 18.8 | 3.1 |
| 40 - 60 | — | 25.0 | 31.3 | 6.2 |
| 60 - 80 | — | 15.6 | 25.0 | 37.6 |
| 80 - 100 | — | 50.0 | 18.7 | 53.1 |

*Nitrogen*

The $N_0$ treatment for all sands had relative yields (RY) of 0 to 20 percent. Yields of this treatment were no better than the check, which suggests that the sands were absolutely deficient in available nitrogen. This is not too surprising if the source of sand is considered. All came from subsurface deposits. Nitrogen-deficient grass was stunted and light yellow.

*Phosphorus*

Fifty percent of the sands tested were well supplied with available phosphorus (RY, 80 to 100 percent) and 9 percent were severely deficient. It is interesting to note that, in the $P_0$ treatments for some sands, growth rate increased after the first clipping. This suggests that, with time, more phosphorus became available. Moderately phosphorus-deficient grass is stunted and dark green with narrow blades.

*Sulfur*

Sulfur-deficient sands appeared to be more or less represented in all RY categories. It is speculated that S compounds originally present in these sands were leached with low sulfate waters, and since no organic matter is present, there is no mineralization from organic sources. Sulfur-deficient grass is very similar to N deficiency.

*Potassium*

Fifty-three percent of the sands were adequately supplied with available K. Three percent were severely deficient, and 38 percent were moderately deficient. Potassium-bearing minderals, such as mic and the feldspars (microline and orthoclase), would be the main sources of K; clay-derived K would be minor, since clay was generally less than 3 percent of the sand sample.

Micro-nutrient treatments were included in many of the sands, but no significant yield increment was obtained in these treatments. None of the sands tested indicated a need for lime, and no calcium (Ca) or magnesium (Mg) deficiency symptoms were noted, but this does not rule out the possibility that some sands will be deficient in these nutrients. Since only 35 sands were evaluated, no generalizations can be made regarding micro-nutrient and lime requirements.

*Chemical analyses*

The pot testing method provides a reliable means for assessing the fertility status of soils, but it requires proprer facilities and time. Soil tests are not as reliable, but if they are well correlated with fertilizer requirements, they are very useful. They are also less expensive. Soil analyses for phosphorus and potassium were performed on all sands and were correlated with appropriate subtractive treatments. The test for sulfur has not yet been done for these sands. Nitrogen need not be considered for obvious reasons. (cont'd. page 18)

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*Phosphorus*

Available phosphorus was estimated on untreated sand samples by two methods: 0.5M $NaHCO_3$ extractable P and water soluble P (Rible and Quick, 1960). For the $NaHCO_3$ method, extractable P is reported as ppm P on a soil basis, while water soluble P is expressed as ppm P in the extract. Both values are plotted against the RY of the $P_0$ treatment.

The correlation between $P_0$ RY and $NaHCO_3$ extractable P suggests that this procedure could be useful in predicting phosphorus fertilizer requirements. While the correlation is not excellent, a value of 3 ppm P appears to be near the critical level. This value is lower than is recommended for soil (6 ppm). The relation between $P_0$ RY and water soluble P provides a better correlation. The critical level is about 0.15 ppm P. This value is at the same as that cited by Bingham (1962) for soil, with cereals as the indicator plant. Both methods are useful in estimating phosphorus fertilizer requirements in sands.

*Potassium*

Available K was estimated by extracting with neutral normal $NH_4OAc$ (ammonium acetate). Sands have a very low cation exchange capacity, and extractable K is expected to be low even in sands well supplied with K. Beyond 20 ppm. there is no response to K fertilization. This critical value is considerably lower than for soils containing clay, but it is in keeping with the critical level found for sands in Australia.[2]

In addition to P and K analysis, salt and pH should be determined. Salt should not present a problem since it is easily leached if the sand is a permeable one. Sands having a very low pH (4 to 5) indicate a need for lime or dolomite, while sand having a $pH^{5}8$ may have lime present.

*Conclusions*

The results of the pot test for a limited number of sands indicate that they behave as might be anticipated for sub-soil. The extent and frequency of P deficiency is similar to surface soils which have been tested (Vlamis, 1966). Nitrogen is completely lacking. Occurrence of S and K deficiencies is probably more frequent in pot tests than in valley soils in California.

It is apparent that all sands will require N to start grass, and many will also require S. Soil tests can help decide whether P and K should be added also, but sand well supplied with P and/or K initially may eventually become deficient in these nutrients as clippings are removed. Soil and tissue tests may be useful to indicate when these nutrients should be applied.

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[2]T. Arkley, Agricultural Consultant, Perth, W. A. personal communication.