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Peanut (*Arachis hypogaea,* L.) Nutrition

pH: Maintaining the right soil pH for each crop ensures optimal nutrient uptake by plants. For peanut, the recommended pH range is 5.8 – 6.2. If soil pH is higher than 6.2, manganese (Mn) or boron (B) deficiency may occur; if pH is less than 5.8, zinc (Zn) toxicity problems could be favored. Therefore, taking soil samples correctly is very important for correcting soil pH. A single composite sample should be taken for each 5 irrigated and 10 rainfed acres. This sample should be composed of 20 or more subsamples collected from an imaginary grid uniformly covering the land area. The subsamples should be well mixed together and only a small composite sample should be retained and sent to the soil lab. The best sampling time is fall, after harvest; early spring soil sampling is also acceptable. Either way soil sampling after excessive rainfalls or long periods with waterlogging should be avoided. The sampling depth is 6-8 inches. Analyzing the soil samples at the Virginia Tech's Soil Testing Laboratory, 145 Smith Hall (0465), Blacksburg, VA 24061, is free of charge. Soil pH can be corrected to the desired level with liming. Dolomitic limestone provides both calcium and magnesium.

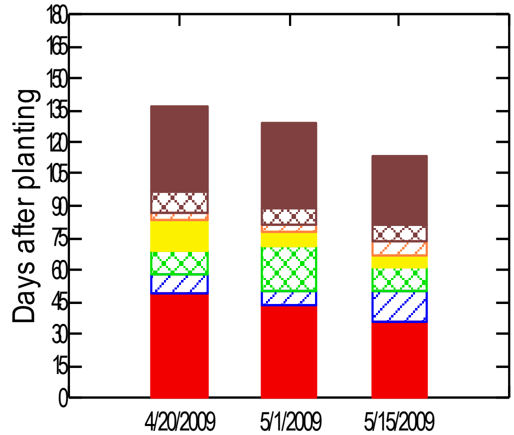
Nitrogen (N): Peanut gets most of its nitrogen needs from nitrogen-fixing bacteria (*Bradyrhizobium*) colonizing the plant's roots. These needed bacteria are freely in soils where peanuts are grown frequently; but in "new" peanut land and strip-tillage fields out of peanut production for 3 years, farmers need to inoculate. In-furrow granular inoculants are less effective than liquids and usually stop-up in the delivery tube. Seed treatment inoculants are not recommended due to having much lower bacterial counts (SC recommendation). Poorly inoculated fields usually will not show any yellowing until about beginning flowering. Checking for nodulation before flowering is, therefore, important and includes counting the nodules on the tap root (there should be over 10 big nodules on the tap root at a month after planting) and slicing a few nodules for determining the color inside (red and pink indicates that nitrogen is being fixed; green indicates that nodules are mature but not fixing nitrogen; white indicates immature nodules; and brown or black indicates old and senesced nodules). If inoculation fails, either by application of inoculants or natural inoculation, broadcast ammonium nitrate (375 lb/ac of 34% = 127 N units) or ammonium sulfate (600 lb/ac of 21% - 126 N units) can be used. Failure of natural inoculation can be expected in very dry and very humid soils, or when phosphorus and molybdenum are deficient. If the canopy has not closed, liquid N can be dripped in the row middle. Foliar nitrogen applications are not cost effective and often cause unacceptable leaf burn. Nitrogen deficiency symptoms include stunted plants with yellow and small leaves. Nitrogen sufficiency levels in peanut leaves are from 3.5 to 4.5 % at beginning flower and early pegging.

Nitrogen deficiency and inoculation failure in peanut: normal plant (left) and N-deficient (right)

Phosphorus (P) and Potash (K): P and K should be applied to the previous crop by soil test to the highest level. Peanuts respond well to residual fertilizer, and typically no additional P and K are needed when the previous crop has been properly managed. This is because of an exceptional ability of legumes to extract these nutrients, phosphorus and zinc in particular, with help from the vesicular arbuscular mycorrhizal (VAM) fungi naturally present in most soils. Excess potash in the pegging zone can potentially interfere with Ca uptake and can cause pod rot; so avoid potash application unless soil test levels are below guidelines by the Virginia Tech's Soil Testing Laboratory, 145 Smith Hall (0465), Blacksburg, VA 24061. On the other hand, potash leaches easily from the soil top layer, therefore transient deficiency in young seedlings with a small root system may occur. Phosphorus sufficiency leaf levels are 0.25 to 0.50% and those for potash 1.7 to 3.3% at beginning flowering.

Potash deficiency in peanut in the green house: tip and margins (sometimes interveinal) yellowing, followed by browning, leaf drop and death of the tissue.

Calcium (Ca): Calcium is critical for pod development. For certified seed production, calcium is important to improve germination and seedling vigor. Adequate Ca uptake reduces pod rot (*Pythium*) and unfilled pods called "pops". Calcium also reduces the risk of aflatoxin. **Foliar Ca applications are not effective** because Ca is immobile in the plant (it cannot move from the leaves to the pods); also, foliar formulations have insufficient Ca content. Calcium can only enter the kernel by direct diffusion from the soil solution, which requires good soil moisture. Therefore in dry soils seed quality can be affected by reduced Ca uptake, even though plenty of Ca may be present. Virginia type peanuts require from 1,200 to 2,000 lb/acre of gypsum, depending on Ca source, variety (large seeded cultivars like Gregory, Titan, and Spain require more calcium) and crop purpose (more gypsum is needed for seed production). Small runners do not respond to gypsum application when soil test calcium is over 600 lb/acre. Larger runner varieties have an intermediate need for calcium. The critical period for calcium absorption begins at the beginning pod stage (around 70 days after planting) but it needs to be in the soil solution before this stage. Therefore, gypsum application is recommended from flowering to beginning peg stage. Depending on the season and planting time, in Virginia, peanuts begin to flower around 50 days after planting (DAP) and first peg around 60 DAP. Ca sufficiency leaf level is from 0.5 to 2.0%.



"Pops" due to calcium deficiency on 'Gregory' peanut (left). Peanut growth stages related to the number of days after planting in Virginia for three planting dates (right). From the bottom up each bar segment represents: beginning flowering, beginning peg, beginning pod, full pod, beginning seed, full seed, beginning maturity (Boote, 1982).

Sulfur (S): Sulfur is important for peanut nutrition because, along with nitrogen, it forms proteins. Because S is very mobile in the soil, its reserves decline where soils are cropped for many years without applications of fertilizers containing sulfur. A rate of 10-20 lb S/acre should suffice for peanut and, typically, this rate is supplied by application of gypsum. However, if gypsum is applied too late during the growing season, sulfur deficiency within the plants can occur and symptoms can be observed throughout the field. Leaf symptoms include pale yellowing of young leaves, while older leaves remain dark green. Since sulfur is essential for protein formation, its absence early in vegetation may reduce vine growth and, with it, the pod yield. A good sulfur source in addition to gypsum is elemental sulfur and ammonium sulfate; if a nitrogen supplement is also required. Leaf S sufficiency is 0.2 to 0.5%.

Young leaf yellowing due to sulfur deficiency.

Sulfur deficiency on 'Gregory' peanut: rows with no gypsum (less green-left) and with gypsum application as a sulfur source (greener-right).

Manganese (Mn): Manganese is an essential micronutrient for peanuts grown in the V-C region. Manganese deficiencies usually occur in soils that have been limed for years and have a pH above 6.3. A general recommendation in Virginia, North Carolina, and South Carolina is to apply twice 0.5 lb/acre elemental Mn as foliar spray starting in early July. This dosage (0.5 lb Mn/acre) can be achieved with application of 2 lb of manganese sulfate 25% or 2 qt of liquid 10% Mn. Ask your selling representative for mixing requirements of Mn with other pesticides as it may cause unacceptable leaf burn; in particular if applications are made during the hottest time of the day. Recently in Virginia, a need for additional Mn application (over 1 lb/acre per season) has been observed in peanut, probably as the result of genetics and weather favoring excesive vine growth. Symptoms of Mn deficiency include yellowing between leaf veins of young leaves. At bloom stage, leaf manganeze is sufficient if it is from 60 to 350 ppm; and at early pegging stage if it is from 20 to 300 ppm.

Manganese deficiency developing on young peanut leaves.

Yellowing between leaf veins due to manganese deficiency.

Boron (B): Boron deficiency in peanut produces kernel and embryo damage called "hollow heart". This damage reduces not only the quality but also kernel weight, therefore yield, and more likely the germination. Foliar symptoms may also occur under severe B deficiency and they resemble calcium deficiency: stubby plants, rosetted branching, split stems and roots, leaves with a yellow-green mosaic appearance, and shell deformity. In the V-C region, all three states recommend that boron be applied on peanuts when a soil test level is less than 0.4 lb/acre (0.2 ppm). Application amounts range from 0.3 to 0.5 lb/acre of elemental boron; but the most used rate by farmers in Virginia is 0.5 lb/acre, which can be achieved with 3 lb/acre boric acid, 2.5 lb Solubor, or 2 qt of liquid 10% B. However, application timing is not clearly determined for any of the V-C states. In NC, recommendation is to apply boron as a foliar spray in early July but some growers apply boron with their preplant incorporated herbicide; in SC, with the first herbicide (preplant incorporated, pre or post emergence) or with the first fungicide; in VA, as a leaf spray with the leaf spot fungicide. In Florida, a split application is recommended due to boron's highly solubility and mobility in the soil.

Just like calcium, boron is freely mobile in soil and many plant species; but it has restricted mobility in peanuts (Brown and Shelp, 1997). This is because boron cannot form certain B-polyol complexes to allow translocation from the leaves (if applied as a foliar spray) to the pods (where it is needed). It can, however, move upwads: from the roots to the leaves with the water flow. Therefore just like for gypsum, soil applications should be better, at least in theory, than foliar sprays when applying boron. In addition, there is a fine borderline between B deficiency and toxicity, and excesive foliar boron is toxic to peanuts. To adress this issue, my program is now looking into determining the best boron application time and method. We considered two products, Solubor and liquid 9% B, two rates, 0.3 and 0.5 lb/A, two cultivars with contrasting kernel sizes, Bailey and Spain, and five application systems. Soil test B level at planting was uniform, 0.1 ppm across the field, indicating justified B application. Since we started the experiment in 2014 as part of a graduate research assistant project, only limited information is available and a summary is presented in Table 1.

Table 1. Effect of application time and method (soil, plant, or both), and boron product and rate on boron content in peanut leaves.

Application time & method	**Liquid 9% B**	**Solubor**
	ppm	
Full rate at beginning peg (uniformly distributed to soil and leaves)	68.4 a[1]	80.0 a
Half rate at planting (only soil) & half at beginning peg (soil & leaves)	59.2 b	53.9 b
Half rate at beginning peg (soil & leaves)	55.1 b	49.0 b
Half rate at planting (only soil)	41.5 c	38.6 c
No boron applied	37.9 c	36.3 c
Mean	**52.1**	**51.6**
$LSD_{0.05}$[2]	**6.2**	**5.0**

[1] Means sharing the same letter(s) are not statistically different.
[2] Fisher's least significant difference (LSD) at P = 0.05.

Normal leaf boron content ranges from 25 to 60 ppm from before blooming to early pegging. Our preliminary data suggest that applying boron in a single leaf spraying may result in high B levels in the leaf tissue (over 80 ppm), which may become toxic to the peanut plants. Leaf boron content was not statistically significant for the 0.3 and 0.5 lb/acre rates when liquid boron was used. With Solubor, leaf boron content was 46 ppm for the 0.3 lb/acre rate and 57 ppm for the 0.5 lb/acre rate (statistically significant at P = 0.005). In average, Spain appeared to uptake significantly more boron than Bailey when Solubor was used; but no differences were detected when liquid B was sprayed. The most interesting observation so far was that boron leaf content exceeded the sufficiency level of 25 ppm with no boron addition, even under very limited soil boron levels.

References:
Boote, K.J. 1982. Growth stages of peanut (*Arachis hypogaea* L.). Peanut Sci. 9:35-40.
Brown, P.H., and B.J. Shelp. 1997. Boron mobility in plants. Plant and Soil 193:85-101.