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Research Article

Peanut Response to Interactions of Soil pH and Gypsum

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Abstract

Soil pH and supplemental calcium applied as gypsum can affect peanut yield. The interaction of soil pH and gypsum applied at flowering is not clearly defined in the peer-reviewed literature. Research was conducted in North Carolina in the USA to determine peanut yield when grown in soil with pH values of 4.5, 5.2, 5.6, and 6.0 when no gypsum or gypsum at 340 and 680 kg/ha was applied at the flowering stage of peanut. Peanut yield increased as soil pH increased in absence of gypsum. Applying gypsum at both rates increased peanut yield when soil pH was 4.5 or 6.0 compared with the no-gypsum control. However, at a soil pH of 5.2 gypsum did not increase yield. At a soil pH of 5.6 gypsum did not affect yield when applied at 340 kg/ha; gypsum at 680 kg/ha decreased yield. Results from these experiments demonstrate that peanut response to gypsum can be dependent on soil pH and that soil pH should be considered when deciding when to apply gypsum to supplement native calcium in soil.

Introduction

Virginia market type peanut (*Arachis hypogaea* L.) often require supplemental calcium applied at flowering to optimize pod yield and market grade factors [1-4]. Peanut yield is also optimized when soil pH is between 5.8 and 6.2 [2,4]. Both lime to neutralize soil pH and gypsum to supplement native calcium in soil can be expensive. For example, in NC State Extension enterprise budgets for peanut the cost of lime for a single season when prorated over 3 years is set at approximately \$42/ha [5]. The potential financial return on investment from lime in North Carolina for peanut production during 2018 was estimated at 11:1 based on assumptions associated with planted area, percentage of growers with soil pH between 5.5 and 5.6, and average peanut yield for the state [6]. The cost of gypsum using the same enterprise budgets in North Carolina is \$70/ha [5]. Although variation in peanut response to gypsum can occur [1,3], the general recommendation is that Virginia market type cultivars require supplemental calcium [1].

The interaction of soil pH and gypsum has not been clearly defined in the peer-reviewed literature. Research in North Carolina [3] indicated that a rate of gypsum that was 50% higher than the suggested use rate reduced peanut yield when soil pH was lower than recommended in some experiments. Based on soil testing data provided by the North Carolina Department of Agriculture and Consumer Sciences, approximately 25% of soil samples from farmers for peanut production had soil pH levels below the recommended range for peanut [6]. Additionally, peanut is produced in many areas of the world in soils with low pH [7-9]. However, as inputs including lime and fertilizer become more available and credit to purchase these inputs increases, information on possible interactions of lime and gypsum is needed. In circumstance where land tenure issues exist or access to inputs or credit for purchase (e.g. lime to neutralize soil pH), farmers may focus on inputs that can be used in a single year for peanut (e.g. gypsum) rather lime. Neutralizing soil pH could benefit subsequent crops while gypsum benefits only peanut in that growing cycle. To provide information for these decisions in the peer-reviewed literature, results from research conducted in North Carolina defining interactions of soil pH and gypsum are provided in this article.

Materials and Methods

The experiment was conducted in 2001, 2002, and 2003 near Lewiston-Woodville, NC in the USA (36.135 N, -77.177 W) in a field with pH regimes of approximately 4.5, 5.2, 5.6, and 6.0. Soil was a Norfolk loamy sand soil (fine-loamy, siliceous, thermic Typic Paleudult) with 80% sand, 12% silt, and 8% clay, a cation exchange capacity of 3.8 to 6.0, and 1.2% organic matter content. These pH regimes were established for other experiments in previous years. A gypsum source containing 85% CaSO₄ (USG Ben Franklin Agricultural Gypsum, Chicago, IL USA) was applied in a 48cm band over each row at rates of 0, 340, and 680 kg/ha for each soil pH regime at the R1 stage of peanut development [10] of the cultivar NC 7 [11]. The experimental area was conventionally tilled prior to planting peanut on raised seedbeds spaced 96-cm apart to achieve a final in-row plant population of 15 plants/m. Peanut pods were dug and vines inverted based on pod mesocarp color to optimize yield. Final yield was adjusted to 8% moisture.

The experimental design was randomized complete block with 4 replications. Percent of maximum yield was calculated using the highest yielding plot for each replication and year combination. Data for percent of maximum yield were subjected to analysis of variance for a soil pH regime × gypsum rate factorial arrangement of treatments pooled over years. Means were separated using Fisher's Protected LSD test at p < 0.10.

Results

When pooled over years, significant main effects of both soil pH regime (p < 0.0001, F Ratio = 66.5), gypsum rate (p = 0.0498, F ratio = 3.1), and the interaction of soil pH regime and gypsum rate (p = 0.0939, F ratio = 1.9) were observed (coefficient of variation = 20.8). When pooled over years and gypsum rates, percent of maximum yield at pH 4.5 (51%) and pH 5.2 (57%) was similar and lower than yield for pH 5.6 and pH 6.0 (data not shown in tables). Yield of peanut grown in soil with pH 6.0 (84%) exceed yield for pH 5.6 (75%) (data not shown in tables). When pooled over soil pH regimes, applying gypsum at 340 kg/ha or



680 kg/ha increased yield from 65% to 70% and 72%, respectively.

A major objective of this research was to determine if peanut response to gypsum varied based on soil pH. When pooled over years, percent of maximum yield ranged from 42% to 55% across gypsum rates at pH 4.5 with gypsum at 340 and 680 kg/ha resulting in greater yields compared with the no-gypsum control (Table 1). Percent of maximum yield ranged from 55% to 59% at pH 5.2 and did not differ regardless of gypsum rate. At pH 5.6, applying gypsum at 680 kg/ha resulted in lower yields compared to the no-gypsum control and gypsum at 340 kg/ha. When gypsum was applied at 340 kg/ha and 680 kg/ha peanut yield was greater at pH 6.0 compared with yield without gypsum; yield was similar for gypsum rates of and 340 and 680 kg/ha. These data indicate that at very low pH (pH 4.5) and pH in the suggested range for peanut (pH 6.0) a positive response to gypsum was observed. No differences in response to gypsum were observed at pH 5.2. The lower yield (69%) when gypsum was applied at 680 kg/ha when soil pH was 5.6 compared with the gypsum at 340 kg/ha or the no gypsum control needs to be investigated further. Jordan *et al.* [3] reported that rates above the recommended use rate applied to peanut when soil pH was 5.6 resulted in a decrease in yield compared with the no gypsum control or gypsum applied at the recommended use rate. In the same study, when soil pH was closer to the recommended use value the higher rate of gypsum did not negatively affect peanut yield regardless of gypsum rate.

Table 1: Peanut response to soil pH and gypsum rate.

Peanut yield			
Gypsum rate (kg/ha)			
Approximate soil pH	0	340	680
	Percent of maximum yield		
4.5	42 f (4.2) ^b	55 e (4.3)	55 e (4.1)
5.2	55 e (4.7)	56 e (4.7)	59 e (6.3)
5.6	78 c (4.8)	78 c (4.8)	69 d (6.2)
6	84 b (3.9)	97 a (2.4)	95 a (2.2)

^aMeans followed by the same letter are not significantly different based on Fisher's Protected LSD test at $\alpha = 0.05$. Data are pooled over 3 years.

^bStandard error in parenthesis.

Discussion

Results from this research provide information that can be used to help farmers and those making recommendations to farmers decide if gypsum is warranted based on soil pH. While these results were derived from one location over 3 years, they demonstrate that interactions of soil pH and gypsum rate can occur. In circumstances where resources are limited and soil pH is relatively low, farmers may decide the benefit of applying gypsum is not warranted. It is important to note that there can be confusion on defining gypsum and lime rates based on the method of application. For example, a rate may be described per ha but the product is applied in a concentrated manner closer to the plant. Based on our results, the possibility of interactions among soil pH and gypsum rate can occur, and specific rates need to be developed and evaluated under local conditions where soil characteristics are known.

Peanut response to pH is well established and has been documented across cultivars and botanical classifications [1, 3, 4]. Response to gypsum can be associated with seed size but also can be impacted by soil chemical characteristics, native levels of soil calcium in soil, balance of nutrients in soil, application rate of gypsum, and rainfall [1-4, 7-9].

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