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Peanut pod, seed, and oil yield for biofuel following conventional and organic production systems

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ABSTRACT

Peanut (*Arachis hypogaea* L.) is a crop that can enter the human diet in various forms or be used as an alternative feedstock for livestock or industrial applications. Increased use of organic production systems and peanut's potential use as a biodiesel feedstock makes it increasingly necessary to develop organic methods in their production. Corn gluten meal (CGM) and vinegar are materials used in organic weed control. These were used alone, or in conjunction with cultivation, to evaluate their efficacy for weed control in peanut that had followed winter cover crops of red clover (*Trifolium pratense* L.) or wheat (*Triticum vulgaris* L.). Comparisons were made to conventional weed control (Dual®, S-metolachlor) and cultivation. Pod and oil yields and seed oil percentages were determined over 2 years in high oil cultivars Olin and Tam Runner. In 2009, cover crop, cultivar, and weed control treatments resulted in significant interactions impacting pod, seed oil yields, and seed oil percentages. Conventional weed control produced greater pod yields with clover (8220 kg ha^{-1}) and wheat (7800 kg ha^{-1}) cover crops, compared to all alternative weed control treatments. When averaged across cover crops, the conventional treatment produced greater seed oil yields (295.9 L ha^{-1}) and few differences in seed oil percentages. In 2010, the conventional weed control treatment produced superior seed oil yield and oil percentage for both cover crops and cultivars, and greater pod yields when the wheat cover crop was used for both cultivars; and Tam Runner with clover as a cover crop. Application of CGM and vinegar did not produce pod or oil yields at levels produced with conventional weed control, and/or reduced seed oil percentage. Further research should investigate additional alternative weed control systems that would increase weed control efficacy for organic peanut production systems.

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1. Introduction

Peanut (*Arachis hypogaea* L.) is a crop that can enter the human diet in various forms or be used as an alternative resource for livestock or industrial applications (Faircloth et al., 2008). The high protein above ground biomass can be used as an animal feed and the oil has multiple industrial applications, including bio-fuel, specifically biodiesel. As demand for organic products increases it is likely that the demand for organically produced peanut products will also increase. As a nitrogen fixing crop, peanut would be an outstanding rotational crop for many organic production systems, while providing a diversity of uses beyond human consumption.

One of the most time consuming and expensive components of organic production is weed control (Smith et al., 1998) due in part to extensive weed seed banks in the soil (Menges, 1987; Roberts, 1964; Roberts and Dawkins, 1967). Peanut produced in organically based systems provide unique challenges in weed control due to its agronomic requirements and habit (Johnson et al., 2008; Johnson and Mullinix, 2008). Benefits from intensive weed control in peanut can be lost in as little as 3 years after aggressive weed control practices are discontinued (Schweizer and Zimdahl, 1984). The use of year-to-year, and in-season rotations and herbicides can influence weed pressure in peanuts (Henning et al., 1982; Johnson et al., 1992).

Weeds in cropping systems, which include peanut, have been controlled with use of cultivation and herbicides (Glaze et al., 1984). Because of its growth habit and indeterminate pod-set cultivation may damage pods (Bunting et al., 1985). Early season cultivation in peanut can be an effective way to control weeds (Jordan et al., 1991).

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Under the National Organic Program (NOP; USDA/AMS, 2004) cover crops are required to be used, but synthetic fertilizers and pesticides are not allowed. Over wintering cover crops can hold the soil, affect microflora dynamics, and affect nutrient cycling and availability. The type of winter cover crop may also influence weed dynamics especially if the winter cover is effective in competing with weed species in the spring prior to planting peanut.

Alternatives to synthetic herbicides exist and include corn gluten meal (CGM) and vinegar. These products have been used in other crops (McDade and Christians, 2000). These products are non-selective herbicide and are capable of injuring weeds and crops (Bingaman and Christians, 1995; Liu et al., 1994) and their weed control efficacy needs to be determined if they are to be used in peanut production. Johnson et al. (2008) examined the phytotoxic effects of clove oil and citric plus acetic acids for weed control in peanut, which are cleared for use in organic production; peanut yields were not affected by their use. Johnson and Mullinix (2008) reported that for organically produced peanut, yields from treatments using mixes of row patterns, cultivation and remedial weed control generally produced poor yields due to lack of season long weed control.

This project was undertaken to determine the impact of winter cover crops and weed control systems for conventional and organic peanut seed production for use as biofuel.

2. Materials and methods

The experiments were conducted at the Wes Watkins Agricultural Research Laboratory, Lane, Oklahoma, USA, on a Bernow fine-loamy, siliceous, thermic Glossic Paleudalf soil. Two fields with the same soil type were physically separated by 50 m. In early fall the soil in both fields were prepared by disking and smoothed with a multipurpose finishing implement (Do-All, Forrest City, Arkansas). Following bed preparation, wheat seed (*Triticum vulgaris* L.) was drilled in one field and red clover (*Trifolium pratense* L.) 'Dixie' broadcast in the other in 2008. No irrigation was required to establish and maintain the cover crops. In late spring 2009 wheat and clover covers were cut and the above ground biomass removed from the fields.

2.1. First year, 2009

Approximately 5 Mt ha^{-1} of well composted chicken litter was broadcast applied to the soil supporting organic treatments. In the conventional treatment synthetic fertilizer (17:17:17, N:P:K) was applied pre-plant at 54 kg ha^{-1}. The nitrogen was from urea, phosphorus from P_2O_5, and potassium from muriate of potash. Synthetic fertilizer rates used were based on results of soil tests and in line with recommendations for peanut in Oklahoma (Sholar et al., 1996). Manure was applied at a rate that did not exceed that dictated by State of Oklahoma for a single year application. The crop stubble was incorporated and seed beds prepared by disking and with the multipurpose finishing implement. Untreated seed of the cultivars Olin and Tam Runner were sown at rates of 9.6 kg ha^{-1} into single rows 0.91 m apart on 28 June. Plots consisted of four rows approximately 70 m in length.

Treatments consisted of: conventional weed control with application of the synthetic herbicide S-metolachlor applied pre-emergence to peanut at 0.49 kg ha^{-1}; CGM (4.9 Mt ha^{-1}) applied to the soil surface (9 June); vinegar (20% acetic acid banded application at 274 L ha^{-1}) applied at 23 June (early post-emergence); vinegar applied at early and 10 July (late-post-emergence of peanut); CGM + vinegar applied at early post-emergence; CGM + vinegar applied at late post-emergence; cultivation only, and weed free and weedy checks. To the conventional treatment the fungicide chlorothalonil was applied once at 0.76 L ha^{-1}. The CGM was applied in bands, and the rate used based on previous experience at this location. There were no fungicidal materials applied to the organic treatments. Overhead irrigation was supplied based on a minimum soil moisture meter (model TEMP-200, Aquaterra, Fremont, CA) reading of 45–50 kPa. Plants were dug on 6 November and harvested with a peanut combine on 12 November. Shelled seed (10–13% moisture) of known weight were placed in a locally constructed cold press and 1.4 Mt cm^{-2} of pressure applied. Total milliliters of expressed oil were extrapolated to a hectare basis.

2.2. Second year, 2010

Soil preparation was the same as in 2009. The same amount of manure was applied pre-plant. In the conventional treatment synthetic fertilizer (9:23:30, N:P:K) was applied pre-plant to the soil at 108 kg ha^{-1}. Sources of N:P:K were as previously described. The crop stubble was incorporated and seed beds prepared as in 2009. Untreated seed of the cultivars Olin and Tam Runner were sown on 26 May at the same rates and plots were the same size as in 2009.

Based on first year results weed control treatments were adjusted in 2010 and consisted of the same conventional weed control as in 2009; cultivation only; CGM applied at 27 May followed by cultivation, cultivation followed by CGM applied at 18 June; cultivation followed by vinegar applied at 13 July; and cultivation followed by hand hoeing. There were no fungicides applied to any treatment in 2010. Conventional herbicide and cultivation treatments were identical in both years. Plants were dug on 8 October and harvested with a peanut combine on 13 October. Intact pods (13–15% moisture) of known weight were processed through a hot press (model CLB-300, Cropland Biodiesel, Linden, WA). Total milliliters of expressed oil were extrapolated to a hectare basis.

2.3. Analyses

In both years a split–split-plot was used with winter cover as the main plot, the first split was weed control treatment, and cultivar was the second split with treatments arranged in a randomized manner within weed control treatments. All treatments were replicated three times. Data were subjected to analysis of variance. If interactions were present they were used to explain results. If interactions were not significant means were separated with the Ryan–Gabriel–Einot–Welsch test.

3. Results

3.1. Weed species and coverage

The conventional and weed free treatments resulted in virtually weed free conditions. Most other treatments, with the exception of cultivation only, resulted in the establishment of a grass mat with a 100% cover that occurred just before or during flowering. Cultivation resulted in a weed cover density that was closer to the conventional and weed free treatments. The grasses were primarily Bermudagrass [*Cynodon dactylon* (L.) Pers. (Bogdan)] and occasionally smooth crabgrass [*Digitaria ischaemum* (Shreb. Ex Muhl.); <5%]. Broadleaf weeds, where they occurred, were cocklebur (*Xanthium strumarium* L.) or lambsquarter (*Chenopodium album* L.).

3.2. Environmental conditions

In 2009, total precipitation during the growing period (157 days) was 69.9 cm and average day time and night time temperatures were 27.3 and 16.5 °C, respectively. In 2010, total precipitation