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Selective Spraying of Weeds in Peanut

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Abstract

Selective spraying of pesticides on agronomic crops has great but yet unproven economic and environmental potential. This study evaluated the agronomic, economic, and environmental effectiveness of selective spraying of herbicides on peanut (*Arachis hypogaea* L.) – a major crop of the southeastern USA.

Keywords: peanut, selective spraying, economics, yields, weeds, environment

Introduction

In many agricultural production fields, weeds are not evenly distributed. Over the past few years, a limited number of studies have been conducted in Georgia and other states of the USA showing that significant reductions in herbicide use can be achieved by selectively spraying weeds rather than treating them with conventional broadcast spraying.
An evaluation conducted in soybean in Mississippi showed that a sensor-controlled hooded sprayer could allow to save 63% of herbicide quantities (Hanks & Beck, 1998).
A study conducted in soybean and corn in Illinois found that a real-time selective herbicide applicator could grant savings in herbicide quantities ranging from 52 to 71% (Tian, 2002). A study conducted in Germany in winter cereals found that herbicide use could be reduced by 6-81% with site-specific weed management (Gerhards & Oebel, 2006).
A reduction in herbicide use results in a reduction in herbicide cost. However it is not clear if this reduction in herbicide cost can offset the cost of automating selective spraying. While economic analyses have been done using computer decision aids, few studies have involved economic analysis of real field experiments. For example, a simulation conducted in peanuts in North Carolina predicted an increase of USD 21 ha^{-1} in theoretical net return when using selective herbicide application (Jordan et al., 2003).
During the 2006 growing season we began a study to assess the feasibility of selective spraying for peanuts (*Arachis hypogaea* L.) – a major crop of the southeastern USA.
Our objectives were:

1. to compare different weed control strategies in a full-season field experiment;
2. to evaluate agronomic, economic, and environmental effectiveness of selective spraying; and
3. to test both commercially available and locally developed prototype selective spraying technologies.

Materials and methods

For the study, we selected two different selective spraying technologies. The first was the commercially available WeedSeeker® hooded sprayer (NTech Industries, Inc., Ukiah, CA, USA). The WeedSeeker® uses spectral reflectance to detect the presence of a weed. When a weed enters the WeedSeeker® sensor's 30-cm-wide field of view, it signals a spray nozzle to deliver a precise amount of herbicide. The WeedSeeker® was used to control weeds in the alleyways between the peanut beds throughout the season and between the rows of peanuts within the bed early in the growing season.

In Georgia, peanuts are planted on slightly raised beds with 1.8 m centers. On either side of the bed is an alleyway. Within the bed, peanuts are planted in two parallel rows with approximately 0.45 m between them. Each row of peanuts actually consists of two closely spaced parallel rows of plants (Figure 1) commonly referred to as a twin row. The twin rows are typically planted close to the edge of the bed. Once the peanut plants began covering the bare soil of the bed, weeds that emerged above the peanut canopy were controlled with a height-selective sprayer.

The height-selective sprayer was a prototype developed in-house and consequently went through several revisions during the growing season. To trigger spraying, we used an infrared sensor. The sensor consisted of an emitter and a receiver. The emitter sent an infrared beam over a distance of up to 1 m to the receiver. If the beam was interrupted by a weed, hand, or other obstacle, the receiver transmitted a signal indicating an interruption. We captured this signal with a data logger and used the data logger to control solenoids which applied a short burst of herbicide. For field use, the height-selective sensor was installed on the same tool bar as the WeedSeeker® sensors. The height of infrared sensor above the canopy was adjustable to allow for plant growth. Figure 2 shows the WeedSeeker® and the selective spraying system in use.

In order to evaluate the technology while also accounting for the costs and benefits of using selective spraying, we established three treatments: conventional weed control, 100% selective spraying, and a mix of conventional and selective spraying. The 100% selective spraying treatment relied on the WeedSeeker® to control weeds in the alleyways between the peanut beds throughout the season and between the rows of

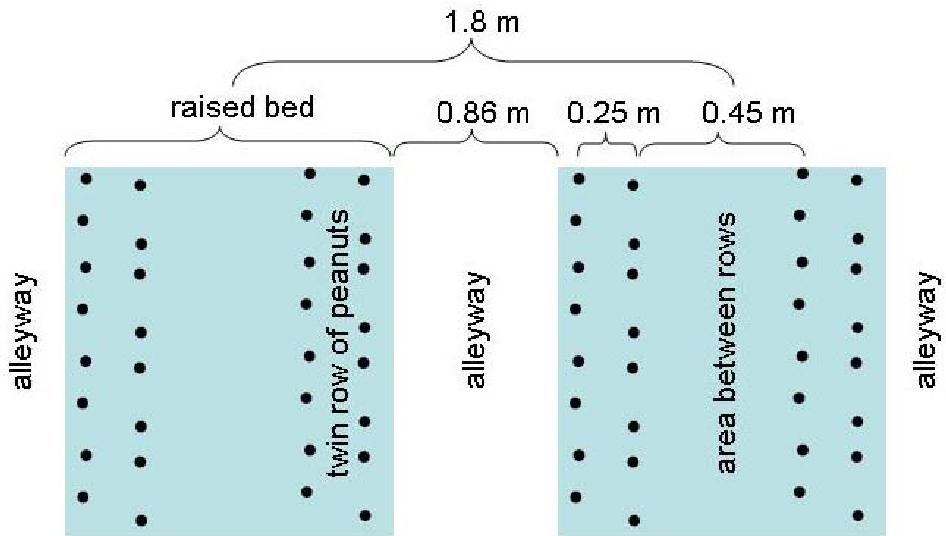

Figure 1. Schematic showing a top view of the typical peanut production layout used in southern Georgia, USA. The small black circles represent peanut plants.

Figure 2. This photograph shows a rear view of the sprayer used for selective spraying in the study. The height-selective sensor and the WeedSeeker® are being used to spot spray weeds emerging over the peanuts and in the alleyways, respectively. The yellow dotted line indicates the path of the infra red beam emitted by the height-selective sensor. Here it is interrupted by a weed.

peanuts within the bed early in the growing season and the height-selective sprayer to control weeds emerging from within the peanut rows. The mix of conventional and selective spraying used a banded application of post-emergence herbicides over the peanut rows during the first month after planting. Weed control between the rows and the alleyways was done with the WeedSeeker®. The conventional treatment relied on broadcast application of herbicides as is typically done by peanut growers.

To evaluate the four treatments, we collected data on the effectiveness of the WeedSeeker® and the height-selective sensor in recognizing and controlling weeds. We also kept a careful record of operating costs and the cost of herbicides for each treatment.

The amount of herbicide active ingredient applied during the whole trial was calculated in order to estimate an environmental impact index, the modified Groundwater Ubiquity Score (GUSm) (Vighi et al., 1998). Data on persisting weed populations were collected a week before harvest. At harvest, we collected yield data from each treatment.

The net revenue for each treatment was calculated as difference between gross revenue (product of yield and price) and production cost (sum of herbicide cost, application cost, and all other costs involved in crop production). Data were analyzed as randomized blocks with three treatments and three replications. Treatment means were compared using a one-way ANOVA test.

Results and discussion

The effectiveness of WeedSeeker® in recognizing and controlling weeds was generally low (data not shown). This was mainly due to two reasons: first, the sensitivity of the equipment was reduced in order to avoid false triggering while the weeds were very small; and second, only glyphosate was used to control weeds. Glyphosate was used for safety reasons because of the continuous presence of project personnel in the field.

The height-selective sprayer was generally good at detecting weeds. However, its effectiveness was rather low (data not shown). By the time the sensor was functional, the weeds were already very tall. At harvest, the weed population was Florida beggarweed [*Desmodium tortuosum* (Sw.) DC.], pitted morningglory (*Ipomoea lacunosa* L.), Texas panicum (*Panicum texanum* Buckl.) and sicklepod (*Cassia obtusifolia* L.). The density of weeds was high in the 100% selective spraying, medium-low in the mix of conventional and selective spraying, low-isolated in the conventional treatment.

The recorded herbicide costs differ significantly (Figure 3). The average herbicide cost was USD 36 ha^{-1}, USD 64 ha^{-1}, and USD 78 ha^{-1} in the 100% selective spraying, in the mix of conventional and selective spraying, and in the conventional treatment, respectively. Thus, the 100% selective spraying granted a 54% reduction of herbicide costs, corresponding to savings of USD 42 ha^{-1}, whereas the mix of conventional and selective spraying granted an 18% reduction of herbicide costs, corresponding to savings of USD 14 ha^{-1}.

The average yield was 3333 kg ha^{-1} in the 100% selective spraying, 3929 kg ha^{-1} in the mix of conventional and selective spraying, and 4073 kg ha^{-1} in the conventional treatment (Figure 4). The mixed and conventional yields do not differ significantly, whereas there was an 18% reduction of yield in the 100% selective spraying treatment.

The conventional treatment registered a net revenue of USD 336 ha^{-1}, whereas the net revenue of the 100% selective spraying treatment was only USD 69 ha^{-1} (Figure 5). The net revenue of the mix treatment (USD 274 ha^{-1}) does not significantly differ from the conventional nor the 100% selective spraying net revenue.

In our study, the savings in herbicide costs were offset by increased application costs. The 100% selective spraying and the mix treatment, in fact, resulted in a greater total number of applications compared to the conventional treatment. Late season herbicide applications were required due to poor early season weed control.

The average GUSm value was 1.08, 1.48, and 1.81 in the 100% selective spraying, in the mix of conventional and selective spraying, and in the conventional treatment, respectively (Figure 6). Higher values correspond to higher potential of groundwater contamination. Thus, the 100% selective spraying treatment reduced the potential weed control environmental impact of 40%, whereas an 18% reduction of the potential groundwater contamination was achieved by the mix of selective spraying and conventional treatment.

Conclusions

Whole season herbicide costs were reduced by 18-54%. The mix of selective spraying and conventional treatment did not cause any yield reduction. The 100% selective spraying treatment led to a yield reduction of 18% caused by high weed infestation.

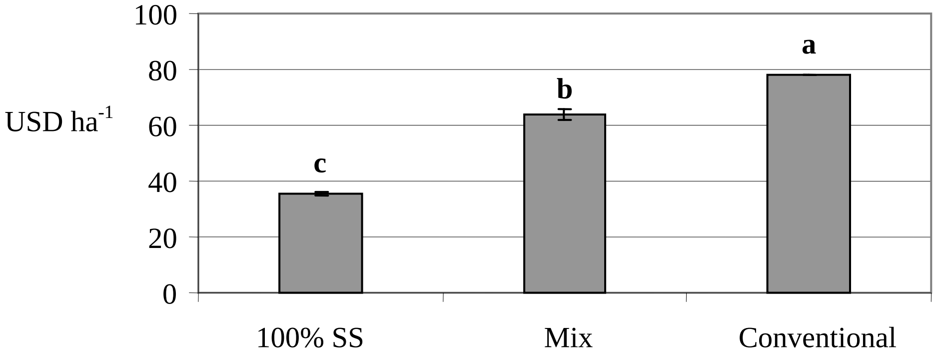

Figure 3. Herbicide costs ($p = 0.05$). SS represents selective spraying.

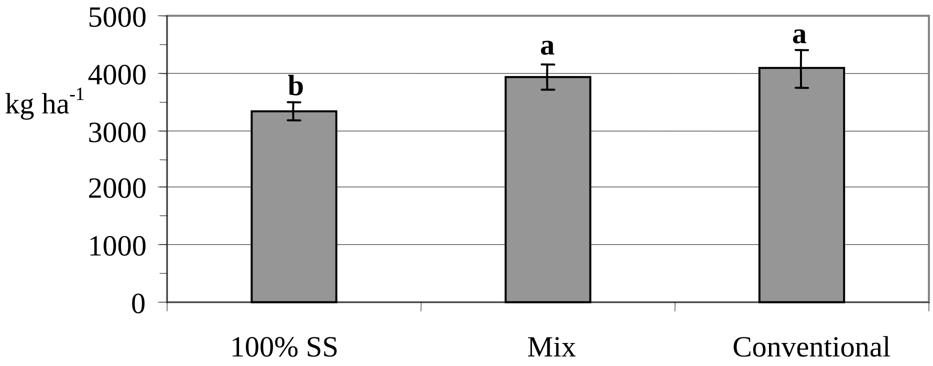

Figure 4. Yields ($p = 0.05$). SS represents selective spraying.

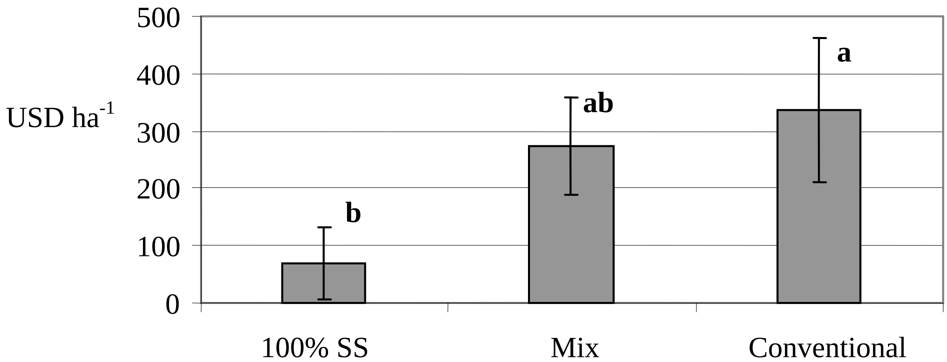

Figure 5. Net Revenue ($p = 0.06$). SS represents selective spraying.

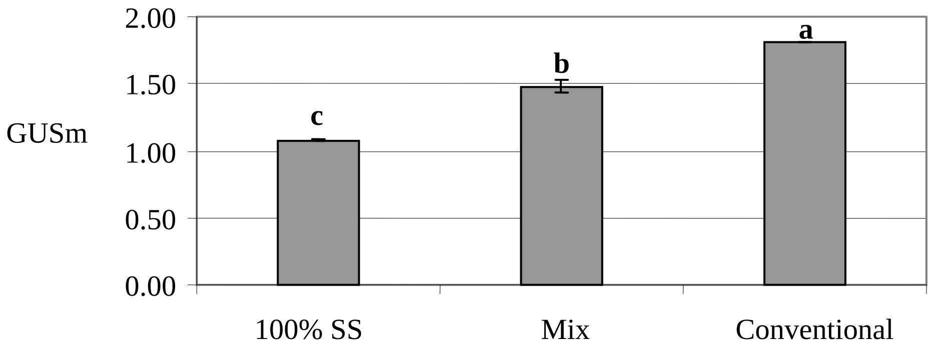

Figure 6. GUSm: potential of groundwater contamination ($p = 0.05$). SS represents selective spraying.

In fact, the efficacy of selective weed control was generally lower therefore additional herbicide applications were needed. Herbicide cost savings (ranging from USD 14 ha^{-1} to USD 42 ha^{-1}) were offset by increased application costs.

In this study, lower weed control in the selective spraying treatments was due in part to technical difficulties and in part to choice of herbicides. A better adjustment of the sprayer prototype, a different herbicide choice, and increased timeliness of application could provide a satisfactory weed control, thus improving the economic effectiveness of selective weed spraying in peanuts. Therefore, further field research is needed.

Selective weed spraying provided environmental benefits, reducing the potential of groundwater contamination by 18-40%. Emphasis is being placed on environmentally sound methods of herbicide application (Swinton, 2005), therefore selective weed spraying in peanuts may qualify for government payments for public benefits provided by the farmer.

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