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Controlling weeds with natural phytotoxic substances (NPS) in direct seeded soybean

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Abstract

At IAPAR institute (Ponta Grossa, Paraná state, Brazil) soybean was direct seeded into residues of precrop black oats (Avena strigosa). Two formulations of natural phytotoxic substances (NPS) were tested for their weed control efficacy. Essential oils (pine oil or d-limonene at 50 L/ha = 8%) were formulated with 50 kg/ha NaCl (8%) and surfactant (1%) and applied at a rate of 600 L/ha. Each formulation was applied once, twice, or three times in weekly intervals starting one week after soybean emergence. A weedy and a clean plot (manually hoed) were used as control treatments. Weed control efficacy was rated visually (0-100 % scale, 70 % is considered "acceptable" in conventional herbicide testing). The single application treatments of limonene and pine oil scored 41 % and 52 %, two applications 53 % and 56 % and three applications 61 % and 67 % respectively. The grain yield for the 'clean' control treatment was highest with 4.07 t/ha and lowest for the untreated control treatment with 2.61 t/ha. The limonene treatments yielded 3.07, 3.22, 3.57, and the pine oil treatments 2.68, 3.00 and 2.96 t/ha with one, two and three applications, respectively. The lower grain yields of pine oil despite better weed control efficacy can be explained by phytotoxic effects of the applied formulation product which accidentally came in contact with soybean crop during application.

Introduction

In the humid tropics torrential rains on tilled soil can cause devastating erosion, Thus, loose-soil husbandry fails to be sustainable. Direct seeding systems prevent erosion, save labour and diesel costs (Holland, 2004). Hence, dense soil husbandry is of great interest to Organic Farming in the tropics. Nevertheless, omitting mechanical weed control direct seeding in Organic Agriculture is limited by the lack of efficient weed control measures such as herbicides, which are common in mainstream agriculture enabling weed control without risking soil erosion. High amounts of straw residues of allelopathic precrops (e.g. *Avena strigosa*) may limit weed infestation during the early development stages of crops considerably (Derpsch et al., 1988) and are one strategy to make occasional direct seeding viable for Organic Agriculture. Nevertheless, the initial weed suppression is often not sufficient and after crop emergence additional control measures are necessary. Labour cost for manual hoeing is high and mechanical hoeing cannot be performed successfully in direct seeding systems due to straw residues and the compact top soil. Hence, additional application of natural phytotoxic substances (NPS) may enable organic farmers to make use of direct seeding in the tropics.

Registered products for weed control that are approved in some countries for use in Organic Agriculture do exist. These products are based on citronella oil (e.g. Barrier H®), d-limonene (Avenger Organic Weed Killer®), Pine-Oil (Organic Interceptor®) (James et al., 2002), acetic acid or pelargonic acid (e.g. Finalsan®). Damage to cuticle and cell membranes is the mechanism of action of all products which leads to desiccation of aerial parts that come in contact with the product. As none of these products has a systemic effect weed meristems often remain intact and plants resprout. Compared with common synthesized mainstream herbicides the efficacy of available NPS is generally lower. Due to high costs use of NPS in agriculture is currently limited.

From 2011 to 2013 a research project on various aspects of the use NPS in direct seeding of grain legumes was conducted primarily at research stations of the Agronomic Research Institute of Paraná State, Brazil (IAPAR). In screening tests we found that mixing NaCl into formulations of known NPS (pine oil, d-limonene) enhances the effect considerably (data not shown). Therefore, the concentration of pine oil and d-limonene (cost critical ingredients) can be lowered and thus, the costs decreased. Also to some extent NaCl proved to have a systemic effect on weeds by destroying meristems that are not directly hit by the spraying solution, killing the plants more effectively or inhibiting resprouting for a longer period. This paper deals with the weed control efficacy and the effect of sequential NPS applications (1, 2 and 3 applications) of two different formulations containing d-limonene or pine oil mixed with NaCl on soybean grain yield.

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Material and methods

Soybean was planted with a direct seeding machine (model Kuhn PDM PG 700) at a seeding density of 30 grains per m² and 45 cm row width on November 6, 2012. Crop establishment occurred one week after. In former years the experimental site at IAPAR research station in Ponta Grossa (25°05'42"S, 50°09'43"W, 975 m a.s.l.) was used for trials on seed bank diminution. Therefore, a randomized split-plot experiment with two whole plot treatments ("Low" and "High" weed density - 30 and 120 weed plants per m² respectively), four replicates, and eight subplot treatments was established. The eight subplot treatments consisted of two NPS formulations, which were applied once, twice or three times in weekly intervals:

Limonene: d-Limonene 8 % (50 L/ha) + NaCl 8 % (50 kg/ha) + 2 % Emulsifier

Pine Oil: pine oil 8 % (50 L/ha) + NaCl 8 % (50 kg/ha) + 2 % emulsifier

The banded application was realized with a CO_2-pressured agricultural sprayer with a 110-025 nozzle at 1.9 bar at a rate of 600 L/ha. The nozzle was approx. 10 cm above ground and the spray fan covered approx. 35-40 cm of the 45 cm row interval (effective application rate approx. 500 L/ha). Eight days after emergence (DAE) the weed density was evaluated and the first application carried out. The second application followed 14 DAE and the third and last application 22 DAE. Weed control efficacy rating was done 14, 22, 27, and 36 DAE. 36 DAE the phytotoxicity effect on soybean resulting from the lack of a protective screen was evaluated too. 78 DAE (beginning to full pod stage) weed shoot and soybean shoot biomass (1.4 m² and 1.1 m² sample size per plot) were determined. Soybean grains were harvested 131 DAE (4.2 m² sample size per plot) and weight and grain humidity determined.

Results and Discussion

The most abundant weed species on the trial site were *Brachiaria plantaginea, Euphorbia heterophylla, Bidens pilosa and Alternanthera tenella*.

5 days after the third application (27 DAE) the weed control efficacy of Limonene and Pine Oil was 41 % and 52 % for one application. Two applications resulted in 53 % and 56 % and three applications in 61 % and 67 % weed control efficacy respectively (Figure 1). A 70 % rating is considered to be an acceptable result in conventional herbicide testing.

Grain yield average over both weed densities was highest in the "clean" treatment with 4.07 t/ha and lowest for the weedy treatment with 2.61 t/ha. The limonene treatments yielded 3.07, 3.22, 3.57, and the pine oil treatments 2.68, 3.00 and 2.96 t/ha with one, two and three applications, respectively.

Despite slightly better performance in the weed control rating the lower yields of pine oil can be explained by phytotoxic effects of the applied solution which came in contact with soybean during application without protective screen (data not shown). In following experiments an adapted protective screen was available that effectively avoided crop damage. Figure 2 shows the grain yield subdivided by weed density. Comparable yields to the "clean" treatment (hand weeded) were achieved with NPS, when weed density was not too high and application repeated two to three times.

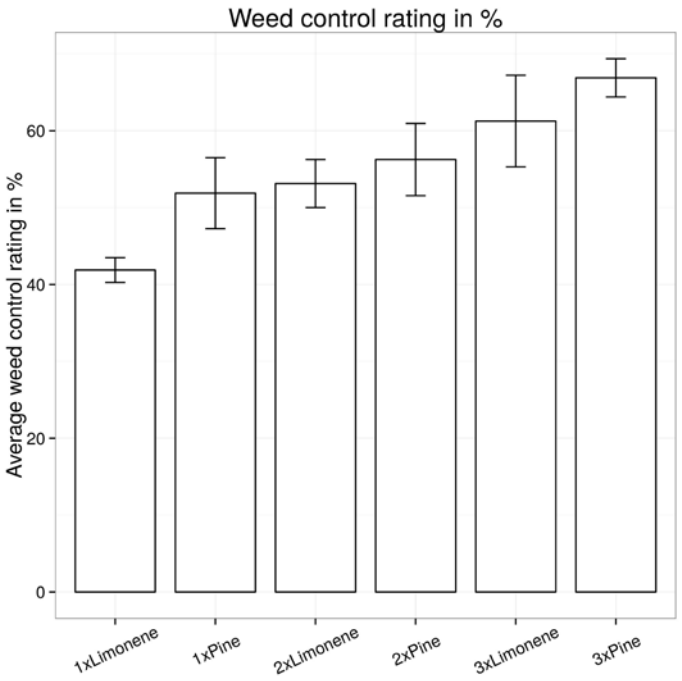

Figure 1. Weed control ratings after 3rd application

In later experiments we observed that an interval between applications of one week is too long for mid-summer conditions. Resprouting of most surviving weeds occured approximately 3-4 days after application. After one week some weeds will have regrown to their size before application. A shorter application interval of about 4-5 days would damage the sensitive sprouting tissues and increase the mortality of weed plants compared with a 7-8 days interval.

NaCl is cheap compared with ingredients like pine oil or d-limonene. Using NaCl can lower application costs considerably. Nevertheless, the application of NaCl to agricultural soils has to be examined critically. It is believed that there is no risk of accumulation of NaCl in the soil under humid tropical conditions, as salt is readily

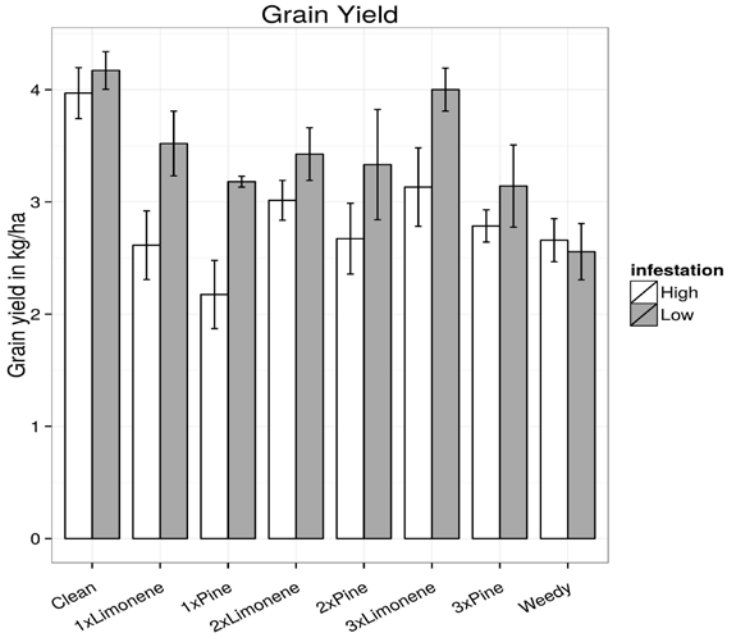

Figure 2. Soybean grain yield for low and high weed densities

leached out. No doubt that application of NaCl is not feasible under drier climates where the risk of salt accumulation would be too high.

Many aspects of NPS-application have to be elucidated further, but first results seem promising. Aspects such as formulation, application technique (nozzle type, pressure, protective screen, optimal application rate, application timing) and optimal environmental conditions (time of day, temperature, solar radiation) as well as sensor driven single plant application have to be investigated intensely.

References

Derpsch, R.; Roth, C.; Sidiras, N.; and Köpke, U., 1988: Erosionsbekämfung in Paraná, Brasilien: Mulchsysteme, Direktsaat und konservierende Bodenbearbeitung. Nr. 205. Dt. Ges. für Techn. Zusammenarbeit (GTZ) (Hrsg.): Schriftenreihe der GTZ,.

Holland, J., 2004: The environmental consequences of adopting conservation tillage in Europe: reviewing the evidence. Agriculture, Ecosystems & Environment, 103(1):1–25.

James, T.; Rahman, A.; Trolove, M.; and Frith, H., 2002: Efficacy of a certified organic herbicide based on pine essence. New Zealand Plant Protection, 55:207–212.