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Editorial

The Importance of Publishing Negative Results

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In a previous Editorial (Weintraub 2015), I stated that the *Journal of Insect Science* would accept well-supported manuscripts with negative data. I feel that the publication of negative results is important, in fact, imperative, as I've outlined below.

1. Scientific thinking is not always open minded and without bias; accepted theories can be hard to overthrow—and I am referring here to scientists, not the general public. Publishing only selective information, i.e. positive results, does not allow one to visualize/understand the whole of the situation. However, by publishing negative data or results that contradict the establish way of thinking, we may more quickly come to a new understanding of the situation, whatever it may be.
2. Negative results are important for the broader field where they are relevant, helping to interpret positive results that may have been obtained in related studies.
3. If negative results are not reported, a nonproductive or flawed concept may continue to receive support from agencies, diverting funding from potentially more fruitful endeavors. How much funding has gone into supporting an idea that looks good on paper but does not come to fruition? And, how many times has this been repeated by funding agencies in different countries around the world? If the initial failure had been reported, the granting agencies could channel that money into other projects.
4. The reporting of negative results can help other scientists adjust their research plans and increase their chances of success. Once an idea has been developed and a team has moved to actually performing the research, they will work in the most logical fashion; A to B, B to C, validating each step. At this point there is no reason to "think outside the box". When the initial attempts fail, how long will a group continue to devote time and resources on the failed effort? If the negative data had been published—the research potentially would have taken a very different direction to solving the problem.

In summation, I feel that it is imperative to publish negative results from well-planned research. I envision a situation where a number of research groups come together to write Forum papers that would elaborate on the ways in which a particular topic was approached, provide a critique on possible reasons for failure, and propose potential future solutions ("thinking outside the box") for tackling the problem. To more clearly illustrate the concept, I suggest that you to read the Case Study below.

I encourage you to contact me with your thoughts and subject areas and I will make the connections between research groups, facilitate scrutinizing negative results, and assist in publishing these comprehensive Forum articles.

Case Study: Seed Treatments With Salicylic or Jasmonic Acid Do Not Adversely Affect Some Major Pest Species

I want to emphasize the difference between publishing any and all trials that produce negative results versus the model I am suggesting. In the following paragraphs I have outlined the kind of comprehensive studies that I think are important to publish. I believe that there are other researchers who have worked on phytohormones treatment of seeds and I invite them to join with me in writing a Forum article that will critique of this kind of research.

Seed treatments have been used since at least the late 1800s (Galloway 1893) to prevent the development of fungal pathogens with first generation pesticides. Just 6 short years after DDT was discovered there were at least five publications using this second generation pesticide as a seed treatment for Lepidoptera (Apple 1945), Hemiptera (Luginbill and Benton 1945), Diptera (Morrison et al. 1945a), and Symphyla (Morrison et al. 1945b). The elucidation of plant defense pathways against herbivores and pathogens, driven by salicylic acid (SA) (Chadha and Brown 1974) and jasmonic acid (JA) (Parthier 1990), led to trials spraying SA (Van Huijsduijnen et al. 1986, Antoniw and White 1986), and JA (Reinbothe et al. 1994) on plants. The use of these exogenous plant hormones could trigger the plant defense system against pests and pathogens. Once this was shown to be effective in stimulating the systemic plant defenses, the next logical step, in terms of application, would provide growers with treated seeds. However a survey of the literature revealed a dearth of publications until today. I believe this is due to the fact that most journals will not publish negative data, not because seed treatments with phytohormones have not been attempted.

Dr. Joshua Klein and myself, Agricultural Research Organization, Israel, have been working for the past six years treating seeds with SA and methyl jasmonate (MJ) to stimulate the systemic plant defense system; this effort has developed from a "back burner" project to grant-funded and finally to the support of two independent Master's students, without success. As our goal was to have the seeds eventually commercially produced, we limited the seed treatment to 2 h so that germination was not triggered. The concentrations were: SA at 1, 2, and 4 mM; MJ at 25, 50, 100, and 200 μM. We knew these to be the correct ranges and seed coat penetration occurred through to the embryo because treatment at 4 mM

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SA severely inhibited seed germination, while 2 mM slightly inhibited germination as compared to control, and 100 and 200 μM MJ could inhibit germination up to 40–50% depending on the seed species.

Over the years we treated a variety of seeds: celery [*Apium graveolens* (Miller) Persoon], parsley [*Petroselinum crispum* (Miller) Fuss], coriander [*Coriandrum sativum* (L.)], three varieties of lettuce [*Lactuca sativa* (L.)], and rocket [*Diplotaxis tenuifolia* (L.) de Candolle]. We also used three species of arthropods in colony and exposed plants to field arthropods. The colony insects were: spider mites (*Tetranychus urticae* C.L. Koch), broad mites [*Polyphagotarsonemus latus* (Banks)], and the sweetpotato whitefly [*Bemisia tabaci* (Gennadius)]. When plants were put in the field for up to a week at a time over a four-year period, the only insect consistently found was *B. tabaci*; there were extremely few aphids and/or thrips.

Initially we exposed the treated plants as groups of five replicates within a cage as a choice test. After a lack of discrimination, we thought that perhaps there were volatiles from the plants as a result of treatment and the arthropods could not distinguish between treatments. We then separately caged treatments, where a fixed number of whiteflies were released; again no significant results. We followed this by conducting field tests where groups of 10 plants were placed in a 6 × 6 × 2.5 m walk-in tunnel covered with 30% shade netting to prevent rabbits and rodents from feasting on the tasty greens. Once again there was no difference in the number of insects attracted to or laying eggs on the various treatments as compared with untreated control plants. We reasoned that there were again too many treatments in the tunnel and so we switched to one treatment per tunnel; initially we left the plants in the field for a full week, but the number of whitefly eggs approached 50/leaf, so we reduced the days of exposure to 3–4 and had a more reasonable number of eggs/leaf, and hoped to discriminate between treatments when the plants were not overwhelmed. We removed the plants from the field, vacuumed them thoroughly to remove whiteflies to prevent further egg laying, kept them in a 50 mesh insect-proof cage and allowed nymphs to develop over a 10–12-day period at ambient conditions. There were no differences in nymphal development among the treatments. Finally, with lettuce and rocket we performed almost 100 control:treatment, 3 h choice tests using almost 20,000 colony whiteflies, with no significant difference among treatments.

We do not think that we have chanced upon a unique idea in treating seeds with SA and MJ; rather, as stated above based on historical record, it is entirely logical to assume that a number of research groups have attempted to treat a variety of seeds with phytohormones unsuccessfully and therefore have been unable to publish the results. We hope that what we have presented here will serve as a basis for research groups coming together to pool collective experiences and direct research on seed treatments in a new course. I invite other research groups who have attempted seed treatments to contact me with the possibility of writing a Forum article bringing together the state of knowledge about seed treatments with phytohormones.

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