Efficacy of NanoPro™ for management of Anthracnose and Botrytis fruit rots and Angular leaf spot

Adrian Zuniga, Andre Bueno Gama, Jim Mertely, and Natalia A. Peres

Summary

NanoPro™ is one of the nanotechnologies available in agriculture that aims to deliver molecules of active ingredients of pesticides with greater efficacy to plant cells. In this study, we investigated the efficacy of NanoPro™ mixed with pesticides commonly used to control anthracnose fruit rot (AFR), Botrytis fruit rot (BFR), and angular leaf spot (ALS). We found that the AFR and BFR incidences obtained using fungicides with NanoPro™ were similar to those using fungicides alone. In other words, control of these diseases was not enhanced by adding NanoPro™. Various challenges were faced in the ALS experiment that might have affected the results. Thus, further investigation is needed to better understand the potential of NanoPro™ for ALS management.

Methods

Evaluation of NanoPro™ mixed with commonly used fungicide programs for Botrytis fruit rot (BFR) control.

On 8 October 2020, bare-root 'Florida Brilliance' plants from California were transplanted into plastic-mulched, raised beds on a commercial farm in Plant City, FL. Treatments consisted of NanoPro™ mixed with two standard fungicide programs, fungicide programs without NanoPro™, and a non-treated control. Treatments were applied using a CO_2 backpack sprayer calibrated to deliver 100 gal/A at 60 psi through a boom fitted with two hollow-cone T-Jet 8002 nozzles. Treatments were applied weekly from 26 November 2019 to 25 February 2020 (14 applications). Single-site fungicides were applied when environmental conditions favored infection according to the Strawberry Advisory System (StAS). During the other weeks, Captan was applied instead. Fruit were harvested and graded twice a week from 17 December 2020 to 4 March 2020 (21 harvests).

Evaluation of NanoPro™ mixed with two fungicides use to control anthracnose fruit rot (AFR), and evaluation of NanoPro™ mixed with products to control angular leaf spot (ALS) compared to a product delivering nanoparticles of zinc.

On 8 and 9 October 2019, 'Florida Radiance' and 'Florida Beauty' bare-root transplants from Canada were used for two experiments, angular leaf spot (ALS) and anthracnose fruit rot (AFR), respectively. Transplants were set into plastic-mulched, raised beds at the University of Florida Gulf Coast Research and Education Center.

The AFR experiment consisted of NanoPro™ added to two fungicide programs, fungicide programs without NanoPro™, and a non-treated control. Treatments including Captan Gold 80WDG were applied weekly, and Abound® was applied when weather conditions favored disease development as indicated by the Strawberry Advisory System (StAS). Fungicides were applied at weekly intervals from 26 November 2019 to 28 February 2020 (14 applications). Treatments for both experiments were applied with a CO_2 backpack sprayer delivering 100 gal/A at 60 psi through two TeeJet disc-core hollow cone nozzles spaced 12 in. apart on the boom. Fruit were harvested from 9 December 2019 to 2 March 2020 (23 harvests) to evaluate yield and AFR incidence, which was expressed as a percentage of the total number of marketable and unmarketable fruit harvested.

The ALS experiment consisted of five product treatments and a non-treated control. The experimental area received a weekly standard farm sprays to control fungal diseases, insects, and mites. ALS symptoms were minimal in the experimental area; thus plots were inoculated on 4 and 29 January with infected green leaves from a nearby experiment. On each occasion, a single green leaf with multiple ALS lesions was pushed into the crown of four staggered plants/plot, followed by 1-2 h of overhead irrigation. Six applications were made at weekly intervals from 31 January to 7 March 2020. ALS incidence was evaluated from 20 to 22 March 2020 by removing plants from plots and counting the number of ALS-infected leaflets/plant.

Results

NanoPro™ mixed with commonly used fungicide programs for Botrytis fruit rot (BFR) control.
BFR incidence in the non-treated control (NTC) reached 14.2, 31.9, and 29.9% during the early, late, and whole season, respectively. During early season (Table 1), which included harvests before 15 January, all treatments reduced BFR incidence except the program involving Switch® mixed with NanoPro™. The efficacy of the treatments was similar during the late season, which included harvests after 15 January, and the whole season. During these periods, BFR incidence was reduced by the programs involving Switch® or Kenja® alone or mixed with NanoPro™. Over the whole season, all treatments increased yield compared to the non-treated control.

NanoPro™ mixed with two fungicides used to control anthracnose fruit rot (AFR).
The incidence of AFR was moderate to high during the 12-week harvest period. Disease incidences in the non-treated control (NTC) were 42.1, 25.7, and 29.4% during the early, late and whole season, respectively (Table 2). During these periods, all treatments reduced AFR incidence compared to the NTC. The most effective treatment was Captan Gold 80WDG during the whole and late season (harvests made after 15 January). However, no difference was observed between using fungicides alone or mixed with NanoPro™. All treatments increased yield compared to the NTC, except for the treatment that included Abound® + NanoPro™. The Captan Gold 80WDG treatment was associated with the highest yield during the entire season.

Evaluation of NanoPro™ mixed with products to control ALS compared to a product delivering nanoparticles of zinc.
A few ALS lesions were observed 7 to 10 days after each inoculation; however, disease spread was slow due to lack of consistent rainfall. Thus, all leaflets on each plant were evaluated for the presence or absence of typical ALS lesions. Only leaflets with two or more angular translucent lesions were counted as diseased. A different cultivar was discovered mixed in the trial during the late season. The other cultivar developed fewer lesions than 'Florida Radiance'; therefore, only 'Florida Radiance' plants were considered for evaluation. This resulted in irregular numbers of plants evaluated in each plot. Consequently, none of the treatments significantly reduced disease incidence over the non-treated control. This caused the experimental standards Actigard or Badge, which typically reduce disease incidence, to have no effect in this experiment (Table 3). Although treatments were not significantly different according to statistical analysis, we observed low disease incidence with NanoZn and Actigard + NanoPro™. Thus, we recommend repeating the experiment next season to evaluate the potential of NanoPro™ for ALS management. Phytotoxicity was not observed in this experiment.

Disclaimer

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Contact

Dr. Natalia A. Peres
UF/IFAS Gulf Coast Research and Education Center
P: 813.419.6602
E: nperes@ufl.edu

Table 1. Evaluation of NanoPro™ mixed with commonly used fungicide programs to control Botrytis fruit rot of strawberry for three periods of evaluation during the 2019-2020 season.

			BFR incidence (%)[y]		
Treatment (products and rates/A)	Application timing[w]	Yield (lb/A)[x]	Early Season	Late Season	Whole Season
Switch 62.5WG 14 oz Captan Gold 80WDG 1.9 lb	2, 4, 5, 11, 14 all other weeks	38681 a	2.7 b	16.8 b	14.9 b[z]
Switch 62.5WG 14 oz + NanoPro 4 oz Captan Gold 80WDG 1.9 lb + NanoPro 4 oz	2, 4, 5, 11, 14 all other weeks	35982 a	5.7 ab	20.5 b	19.0 b
Kenja 400SC 15 fl oz Captan Gold 80WDG 1.9 lb	2, 4, 5, 11, 14 all other weeks	36156 a	5.6 b	21.4 b	19.6 b
Kenja 400SC 15 fl oz + NanoPro 4 oz Captan Gold 80WDG 1.9 lb + NanoPro 4 oz	2, 4, 5, 11, 14 all other weeks	35240 a	4.8 b	18.6 b	17.3 b
Non-treated control	n/a	30428 b	14.2 a	31.9 a	29.9 a
Probability of a greater F value		0.0306	0.0417	0.0070	0.0049

[w] Week of product application over the 14 weeks from 26 November 2019 to 25 February 2020.
[x] Yield from 21 harvests made from 17 December 2019 to 4 March 2020 (whole season).
[y] Average Botrytis fruit rot (BFR) incidence during three periods: early season (17 December to 15 January), late season (15 January to 4 March), and whole season (17 December to 4 March).
[z] Means in a column with the same letter are not significantly different based on least significant difference (LSD) test (α = 0.05).

Table 2. Evaluation of NanoPro™ mixed with two fungicide programs use to control anthracnose fruit rot of strawberry for three periods of evaluation during the 2019-2020 season.

			AFR incidence (%)[y]		
Treatment (products and rates/A)	Application timing[w]	Yield (lb/A)[x]	Early Season	Late Season	Whole Season
Captan Gold 80WDG 2.5 lb	weekly	14699 a	14.6 b	4.8 cd	7.0 cd
Captan Gold 80WDG 2.5 lb + NanoPro 4 oz	weekly	16359 a	13.9 b	2.8 d	5.1 d[z]
Abound 15 fl oz Captan Gold 4L 1.5 qt	1, 3, 6, 12 all other weeks	12387 b	20.3 b	6.8 bc	10.1 bc
Abound 15 fl oz + NanoPro 4 oz Captan Gold 4L 1.5 qt + NanoPro 4 oz	1, 3, 6, 12 all other weeks	11421 bc	18.1 b	11.3 b	13.2 b
Non-treated control	n/a	9942 c	42.1 a	25.7 a	29.4 a
Probability of a greater F value		0.0001	<0.0001	<0.0001	<0.0001

[w] Weekly applications were made for 14 weeks from 26 November 2019 to 28 February 2020.
[x] Yield based on harvest data from 9 December 2019 to 2 March 2020 (23 harvests total).
[y] Average anthracnose fruit rot (AFR) incidence during the early (9 December to 15 January), late (15 January to 2 March), and whole season (9 December to 2 March).
[z] Means in a column with the same letter are not significantly different based on least significant difference (LSD) test (α = 0.05).

Table 3. Evaluation of NanoPro™ mixed with products to control angular leaf spot of strawberry in comparison to a product delivering nanoparticles of zinc during the 2019-2020 season.

Treatment (products and rates/A)	Disease Incidence[w]
NanoZn 4 fl oz	5.2
Actigard 50WDG 0.375 oz	12.7
Actigard 50WDG 0.375 oz + NanoPro 4 fl oz	8.4
Badge SC 0.75 pt	15.6
Badge SC 0.75 pt + Nanopro 4 fl oz	10.3
Non-treated control	9.2
Probability of a greater F value	0.3702

[w] Disease incidence = average number of ALS infected leaflets per plant.