Designing a Better Sprayer for Pesticide Application in Strawberries

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Strawberry growers using conventional boom sprayers find it difficult to obtain good disease and insect control due to poor pesticide coverage on the undersides of leaves, on the lower leaves, and on the fruit when the strawberry plant is in full canopy. Inadequate crop protectant coverage results in higher levels of disease and insect activity translating to consumer rejection of poor quality fruit and lower overall profitability of the planting.

This project allowed an opportunity to work with strawberries – a high value crop with a low, 3-dimensional canopy. Strawberry diseases are a big concern for growers, so adequate spray coverage is important – better coverage would allow growers to make fewer applications of fungicides during the growing season.

Drift is often targeted as being the biggest source of problems with spray deposition. In fact there are other, inter-related factors that combined with drift, make designing the perfect crop protectant delivery system a challenge. These include the sprayer design, the droplet size and the size of the spray fan. The air volume, direction and velocity will also affect the amount of material that is deposited vs. the amount that is lost to drift. Application rate, nozzle orientation and the speed of the tractor, plus the skill and attitude of the tractor operator are also factors. Additionally the crop canopy will determine deposition rate and the weather has a great deal of influence.

There is very little work published specifically for strawberry spraying. Nils Bjugstad, a colleague at the University of Norway has conducted an eight year trial on improving spraying equipment. Bjugstad and Sonsteby (2004) observed the main issue is to obtain approximately the same spray and pesticide coverage and amount on the leaf surface on the outer and inner leaves as well as the upper and underside of the leaves (mainly spraying against grey mold in Norway).Because the plant canopy increases considerably during the growing season, they concluded that they had to adapt the volume rate according to this change of mass. As shown in their papers, they recommend using three nozzles in the start of the season; two from each side and one from the top, and for larger plants five nozzles per single row; one from the top and two from each of the sides, and in this way adjust the volume rate from 6 litres (12.5 pints),
9 litres(19 pints), 12 litres (25 pints) per 100 m (109 yards) row length as the season progresses.

A prototype 'modified boom' was built at Cornell University and in 2007 the first field work was conducted to determine appropriate volume rates, proper nozzle selection and the best pressure and nozzle positioning. There were 3 treatments, one from a traditional boom, a hoop with 3 nozzles and a hoop with 5 nozzles. Deposition onto the crop was measured by adding Pyranine fluorescent tracer into the sprayer tank. Leaves were picked from the top, middle and bottom part of the canopy. Three leaves from each area were placed into plastic bags and sealed. 10 plants per treatment were selected, there were five replicates.

It was found that adjusting the volume rates from 6 litres/100 meter of row length to 9.5 litres then finally to 12.5 litres per 100 metres row length as the season progressed and as the crop canopy grew resulted in the best spray deposition over the season. See Table 1.

The most appropriate nozzles were found to be 02 and 03 nozzles because 015 nozzles were too small and the resulting small droplet size increased the risk of drift and lowered the capacity (rows per hour). See Table 2. Best coverage results were at 75 psi with the nozzles 4-8 inches above the target. See Figure 1.

The following growing season, 2 more "hoops" were constructed and fitted to the sprayers belonging to berry growers John Hand of Hand Melon Farm in Greenwich, NY and Dale Ila Riggs of The Berry Patch in Stephentown, NY. The modified booms or hoops were connected to the existing plumbing system. The hoop was designed with 5 nozzles and the grower could target the canopy with the appropriate number of nozzles, most likely increasing from 3-5 targeted nozzles as the strawberry canopy developed. See photo below.

Florescent pyranine tracer was used to reveal the coverage of spray distributed throughout plant canopy at two different dates. The traditional boom sprayer delivered the best coverage to the outer leaves at both farms on both dates, but this was not the case for the mid and lower canopy leaves as the season progressed. The farm (Farm D) with the smaller boom sprayer and lower pressure application got better coverage from the modified hoop sprayer in the mid and lower canopy leaves and the improved coverage continued throughout the season. The larger boom that uses higher pressure during spray application did not see an advantage to the hoop until later in the season. Then, the inner and lower leaves were covered more thoroughly by the modified boom than they were with the traditional boom. See Figure 2.

Biological effectiveness was rated by noting the presence or absence of infection or insect damage on leaf and fruit tissue. These observations were made for 3 different canopy stages on 2 farms. The degree of infection on leaf and fruit tissue was also rated. Seven leaves were evaluated for each of 5 replications with 1 being no infection/damage and 5 being entire surface infected/damaged. Twenty-five fruit for each of 4 replications were evaluated using the same rating system. This rating protocol helped to determine if differences existed in effectiveness of spray coverage from each treatment.

The biological data did not support significant statistical differences between treatments, **(Except on Farm A for one date)** however, clear and consistent trends are apparent. See Figures 3 and 4. For 4 of the 6 comparisons, the use of the modified boom (hoop) appears to have an advantage over the traditional boom in the control of foliar disease. For all 6 comparisons, the use of the modified boom (hoop) appears to result in a lower incidence of disease infection and/or insect damage on the fruit than does the use of the traditional boom.

Summary: Applying crop protectants to strawberries can be improved with attention to variables like drift reduction, appropriate nozzle selection, increasing spray volume as the canopy grows and applicator skill and attention. The use of a modified boom may help growers perfect spray application, but more work on this prototype is necessary to better understand the importance of factors like row alignment in the field. The two farmer participants observed that straight rows and level fields would positively affect the spray application from a modified boom even more than those field attributes affect the performance of a traditional boom. Conversely, sloping fields and crooked rows will make it very challenging to use the more exacting modified boom successfully.

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Table 1. Application volumes

Treatment	Litres/100 meter	Gallons/A
1	6	40
2	9.5	79
3	12	105.2

Table 2. Application Methods

Treatment #	Nozzle Type	Nozzle Number	Flow rate/nozzle	Pressure	Speed
1	Flat fan – yellow 80 02	Horizontal boom	0.98 l/m (0.26 gpm)	5bar (75psi)	3.2 km/h 2 mph
2	Flat fan – blue 80 03	3 nozzle hoop	1.52 l/m (0.4 gpm)	5 bar (75 psi)	3.2 km/h 2 mph
3	Flat fan – blue 80 03	5 nozzle hoop	1.52 l/m (0.4 gpm)	5bar (75 psi)	4.0 km/h 2.5 mph

Figure 1 - Amount of spray coverage measured on Plant Canopy - 2007

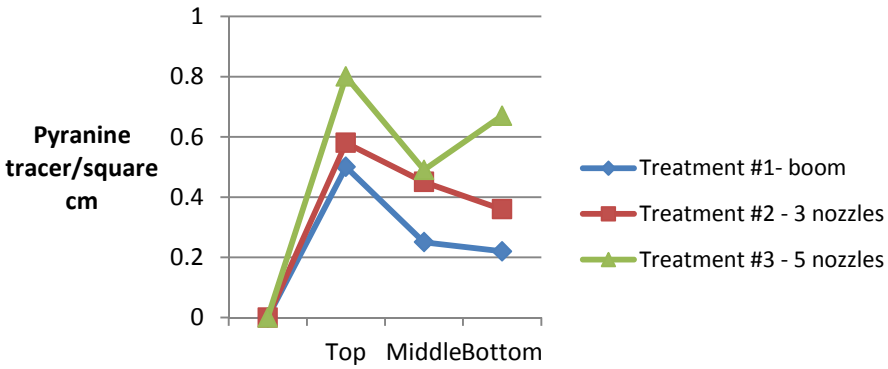


Fig. 2. Spray coverage within strawberry canopy - 2008

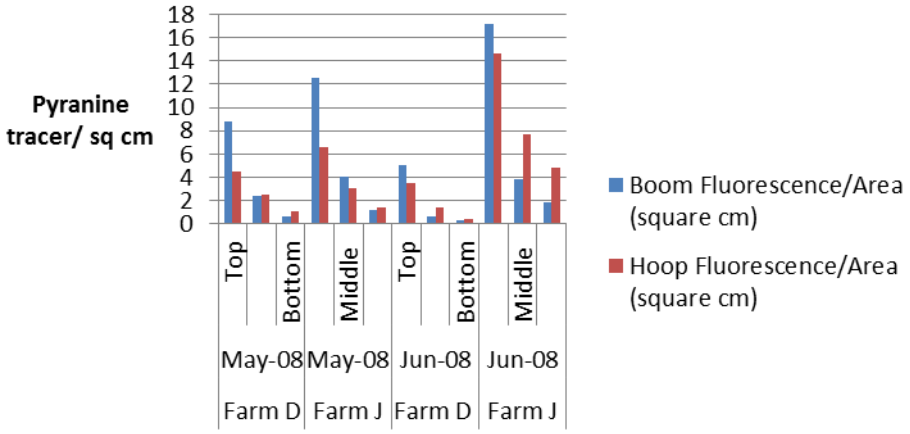
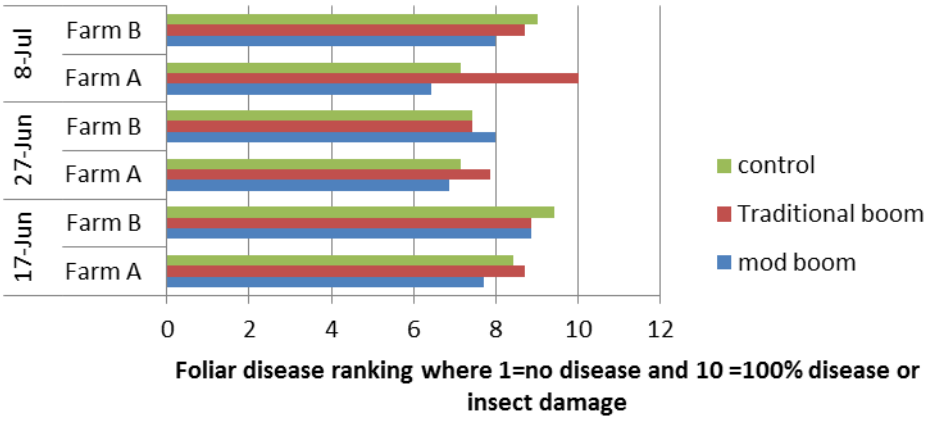
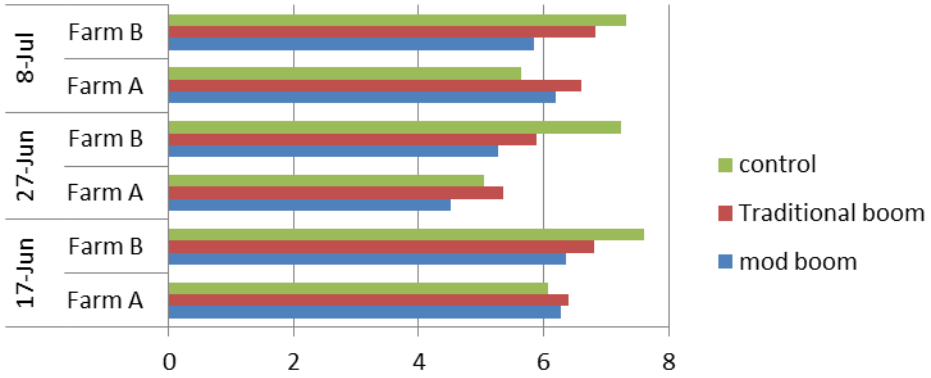


Fig. 3 - Severity of foliar damage following sprays with modified boom vs. traditional boom



Foliar disease ranking where 1=no disease and 10 =100% disease or insect damage

Fig. 4. Severity of fruit diseases following sprays with modified boom vs. traditional boom



Fruit disease ranking; 1=no disease, 10 = 100% disease

Modified boom attached to spray rig, above.

Close up of boom design with all 5 nozzles, below.

Reference
Bjugstad N. and Sonsteby A. (2004) Improved spraying equipment for strawberries. In: *Aspects of Applied Biology 71*, International advances in pesticide application. Pp.335-342