STOP THE ROT!
USING CULTURAL PRACTICES TO REDUCE BACTERIAL BULB DECAY IN ONIONS

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Narrow plant spacing reduced bacterial bulb decay by 53 to 64%

Do you know how easy this is? A simple modification to adjust your planting configuration is all it would take to drastically reduce losses from bacterial bulb decay. Our studies showed that when plant spacing was reduced from 6 or 8 inches to 4 inches with 3 or 4 rows per 3-foot plastic mulch bed (row spacing: 4 rows = 6 inch; 3 rows = 8 inch), this provided 53 to 64% control of bacterial bulb decay at harvest (Table 1). Marketable yield also increased by 1.4 to 2.4 times, representing an increased net economic return of $43 to $258 per 100 feet of bed, due to increased weight of marketable jumbo-sized bulbs (Table 1). We learned that wide plant spacing produces big bushy plants with more leaves, thicker necks, delayed maturity and bigger bulbs. Unfortunately, it was these bigger bulbs that rotted! By narrowing plant spacing, we got fewer colossal-sized bulbs, which we more than made up for by having significantly more healthy jumbo-sized bulbs to market (Table 1).

Figure 1. Compared to the standard plant spacing, narrow plant spacing with fewer rows per bed controlled bacterial bulb rot by 53 to 66%. New Holland, PA: July 20, 2010.

Standard Plant Spacing
36 inch^2: 6" x 4 rows

Narrow Plant Spacing
32 inch^2: 4" x 3 rows

Table 1. Evaluation of onion spacing for reducing incidence of bacterial bulb decay and improving profitability in onion, Interlaken, NY 2009 & 2010 and New Holland, PA, 2010: marketable yield and grade, incidence of bacterial bulb decay at harvest and net return.

At harvest, per 100 feet of bed:

Onion Spacing: Planting Density (inch²/bulb)	No. rows /bed[6]	Plant Spacing (inch)	No. plants /100 ft of bed	Total Marketable Yield (lb)	Onion Grade (lb): Colossal (>4”)	Jumbo (3-4”)	Medium (2.25-3”)	Small (<2.5”)	% bacterial bulb decay by weight	Net Economic Return[5]: Cost of transplants[2]	Variable Price[3]	Uniform Price[4]
Interlaken, NY: 2009 (cv. Nebula) on silver plastic												
24 inch²	4	4	1200	510 a[1]	130 b	330 a	36 a	10 a	13.3 % b	$40.50	$229	$410
32 inch²	3	4	900	460 a	270 a	190 b	10 b	2.0 b	13.8 % b	$30.38	$230	$384
48 inch² standard	4	8	600	330 b	270 a	50 c	6.0 bc	0.0 b	37.3 % a	$20.25	$160	$277
60 inch²	4	10	480	220 bc	200 ab	20 c	0.0 c	1.0 b	41.5 % a	$16.20	$111	$181
80 inch²	3	10	360	160 c	130 b	10 c	1.0 c	0.0 b	53.6 % a	$12.15	$70	$132
			P Value (α=0.05):	***0.0001***	***0.0352***	***0.0000***	***0.0000***	***0.0046***	***0.0064***	--	--	--
Interlaken, NY: 2010 (cv. Candy) on silver plastic												
24 inch²	4	4	1200	873 a	399	434 a	39 a	0	3.1 %	$40.50	$412	$745
32 inch²	3	4	900	716 b	447	253 b	16 b	0	6.0 %	$30.38	$348	$614
36 inch²	4	6	800	697 bc	510	182 b	4.7 c	0	3.6 %	$27.00	$346	$600
48 inch²	3	6	600	559 c	497	59 c	1.3 c	0	7.3 %	$20.25	$283	$483
48 inch² standard	4	8	600	595 bc	525	67 c	4.0 c	0	6.4 %	$20.25	$303	$516
64 inch²	3	8	360	369 d	349	20 c	0.7 c	0	23.3 %	$15.19	$202	$317
			P Value (α=0.05):	***0.0001***	***NS***	***0.0000***	***0.0001***	***--***	***NS***	--	--	--
New Holland, PA: 2010 (cv. Candy) on black plastic												
24 inch²	4	4	1200	339 a	0.0	187	108 a	43 a	29.5 %	$24.00	$315*	$242
32 inch²	3	4	900	277 ab	8.7	197	54 b	17 b	29.4 %	$18.00	$110*	$216
36 inch² standard	4	6	800	151 bc	6.7	122	21 b	1.3 b	63.1 %	$16.00	$57	$118
60 inch²	4	10	480	90 c	8.7	65	15 b	0.7 b	70.8 %	$9.60	$34	$71
80 inch²	3	10	360	77 c	25	43	6.7 b	2.0 b	70.1 %	$7.20	$31	$60
			P Value (α=0.05):	***0.0178***	***NS***	***NS***	***0.0012***	***0.0002***	***NS***	--	--	--

[1]Numbers in a column followed by the same letter are not significantly different, Fisher’s Protected LSD test, $p < 0.05$. [2]**cost of transplants:** NY - $1.35 for 40 plants or $0.03375 per plant (plugs); PA - $0.02 per plant (bare roots from Texas). [3]**Variable Price:** According to PA Simply Sweet prices: Colossal - $0.55/lb; Jumbo - $0.50/lb; Medium - $0.40/lb; Small - $0.20/lb; no more than 30% total marketable weight can be sold as small + medium. [4]**Uniform Price:** According to Interlaken road side stand prices: all grades except small (<2.25” not marketable) - $0.90/lb. [5]**Net return:** gross (data not shown) minus cost of transplants. [6]row spacing: 4 rows = 6”; 3 rows = 8”).

Alternatives to black plastic reduced bacterial bulb decay by 59 to 75%

This is also a very simple and easy modification for small-scale growers producing onions on plastic mulch to make to their cultural practices that could go a very long way towards reducing bacterial bulb decay. Our studies showed that reflective silver mulch, biodegradable black plastic and bare ground had significantly 1.8 to 2.8 times higher marketable yield than black plastic (Table 2). Reflective silver and biodegradable black plastics had significantly 3.7 and 3.6 times, respectively, higher jumbo weight than black plastic, which resulted in an increased net return of $96 to $215 per 100 feet of bed compared to black plastic (Table 2). All of the alternatives to black plastic had significantly lower soil temperatures compared to the black plastic; we suspect that the higher temperatures of the black plastic are more favorable for development of bacterial diseases.

Figure 2. Compared to black plastic, reflective silver mulch controlled bacterial bulb decay at harvest by 53%. New Holland, PA: July 20, 2010.

Black Plastic

Silver Plastic

Table 2. Evaluation of different mulch types for reducing incidence of bacterial bulb decay and improving profitability in onion (cv. Candy), New Holland, PA, 2010: marketable yield and grade, incidence of bacterial bulb rot at harvest and net return.

At harvest (Jul-20-2010) per 100 feet of bed:

Treatment	Total Marketable Yield (lb)	Onion Grade (lb) Colossal (>4”)	Jumbo (3-4”)	Med. (2.25-3”)	Small (<2.25”)	% bacterial bulb decay by weight	Net Economic Return[6] Cost of Mulch/ Herbi-cides[3]	Variable Price[4]	Uniform Price[5]
Black plastic (std)	119.5 c[1]	13	65 a	24 c	16 b	57 %	$2.38	$64	$90
Silver Plastic	331 a	27	242 b	46 bc	16 b	23 %	$4.20	$166	$279
Biodegradable Black Plastic	321 a	14	231 b	54 b	22 b	17 %	$7.00	$160	$262
Bare ground	213 b	0	85 a	82 a	46 a	14 %	$0.11	$121	$150
P Value (α=0.05)	***0.0008***	***NS[2]***	***0.0011***	***0.0026***	***0.0063***	***NS***			

[1]Numbers in a column followed by the same letter are not significantly different, Fisher’s Protected LSD test, p <0.05. [2]**NS:** Not significant, Fisher’s Protected LSD test, p > 0.05. [3]**Cost of herbicides:** Prowl H2O @ 8 fl oz + Goal Tender @ 24 fl oz = $16.67 per acre. [4]**Variable Price:** According to PA Simply Sweet marketing program: Colossal - $0.55/lb; Jumbo - $0.50/lb; Medium - $0.40/lb; Small - $0.20/lb; no more than 30% total marketable weight can be sold as small + medium. [5]**Uniform Price:** According to Interlaken road side stand prices: all grades except small (<2.25” not marketable) - $0.90/lb. [6]**Net Economic return:** gross (data not shown) minus cost of mulch/herbicides.

Bacterial bulb decay is a serious problem in onion production

Small-scale diversified fresh market growers who grow onions intensively in New York and Pennsylvania are constantly challenged by yield losses due to bacterial diseases, which greatly compromise profitability. If bacterial diseases cannot be managed, this onion industry will not be sustained or expanded. Bacterial diseases are also an economically very important disease of large scale onion production, which occurs in New York predominantly on muck soil.

In New York, Sour Skin caused by *Burholderia cepacia*, is the most common cause of bacterial bulb decay, although *Pantoea ananatis* and *Enterobacter cloacae* have also been identified, and several others are likely part of the complex. In Pennsylvania, the most frequently isolated bacterial pathogens include soft rot pathogens, *Pseudomonas marginalis* and *Pectobacterium caratovora*; and center rot pathogens, *Pantoea ananatis* and *P. agglomerans*; *Xanthomonas axonopodis* and *Pseudomonas viridiflava*. Bulbs with bacterial decay are not marketable, although sometimes they are sold unknowingly to detriment, because, a single internal scale can be infected as the outer scales remain firm making the decay undetectable. Losses to bacterial bulb decay have increased steadily over the past decade where onions are grown intensively on plastic mulch. It has become common for the incidence of bacterial bulb decay to be 35 to over 50% in parts of both PA and NY. In 2008 in PA, 34 growers lost a total of $140,000 to bacterial bulb decay. In NY, large scale onion producers report annual losses of 20 to 30% due to bacterial bulb decay.

It is very important to note that this simple technique of reducing plant spacing was equally effective at reducing bacterial bulb rot with different bacterial pathogens. In NY, *B. cepacia* was the main bacterial pathogen with a few *P. ananatis* identified, while in PA, *P. carotovora*, *P. marginalis* and *P. agglomerans* were the main pathogens with some minor *B. cepacia*.

Figure 3. *Left and Middle* – above-ground symptoms of bacterial diseases of onions showing yellowing, bleaching and wilting of inner leaves. *Right* – bacterial bulb decay (pathogen not identified).

How does plant spacing work to reduce bacterial bulb rot?

We don't know for sure, but we suspect that narrow plant spacing produces plants that are less suitable hosts for bacterial diseases to become established and to develop and spread. Our studies showed that wider plant spacing produces larger plants with more leaves, thicker necks with delayed maturity (data not shown). Large bushy plants are more conducive to holding water in the leaf axils, which can favor bacteria entering into the plant. Thick necks take longer to dry and remain succulent and green for a longer time, which provides ideal conditions for bacterial diseases to spread from the leaves into the bulb. Delayed maturity interferes with proper lodging and curing of the neck and bulbs, allowing for increased risk for bacterial infections in the leaves to spread into the bulbs. Alternatively, the smaller plants with thinner, tighter necks that mature earlier in narrow plant spacing configurations are less conducive to bacterial bulb decay.

Does narrow plant spacing reduce bacterial rot for large-scale production of onions?
We suspect that it would make a difference, but have not yet researched this phenomenon in large-scale onion production on the muck. Our results from small-scale production suggest that bacterial bulb decay decreases when planting density is higher than 36 $inch^2$ per bulb, and continues to decrease as planting density increases (Table 1). This could explain why we often see higher incidence of bacterial bulb decay in transplanted onions than we do in direct seeded onions of the same variety. For example, direct seeded onions planted at 7 seeds per foot with 15 inch row spacing have a planting density of 26 $inch^2$ per bulb, which is 2.3 times denser than transplanted onions that are planted at 3 plants per foot with the same row spacing (60 $inch^2$ per bulb).

Our data collected from Interlaken, NY in 2010 suggests that row spacing is a very important factor related to rot: when we increased row spacing from 6 inches (4 rows per bed) to 8 inches (3 rows per bed), incidence of bacterial bulb decay at harvest increased 2 to 4 fold for each plant spacing (4", 6' and 8"). Therefore, in direct seeded onions, would onions planted with 12 inch row spacing (= 21 $inch^2$ per bulb) have less bacterial rot than onions grown with 15 inch row spacing (= 26 $inch^2$ per bulb)? Another unknown is whether row type (single vs. double) effects bacterial bulb decay?

Our results from small-scale production suggest that reducing planting density to 36 $inch^2$ per bulb or less greatly reduces incidence of bacterial bulb decay at harvest. Therefore, with respect to large-scale production of onions from transplants, our data suggests that if growers decreased their row spacing from 15 inches (= 60 $inch^2$ per bulb with 4 inch plant spacing) to 8 to 6 inches, and adjusting plant spacing to achieve a planting density of 36 $inch^2$ per bulb or less (e.g. 6 inch row spacing with 5 or 6 inch plant spacing = 30 to 30 $inch^2$ per bulb) would result in 50% or more control of bacterial bulb rot. It would be very interesting to see whether bulb size could still be met with these different planting configurations on onions grown on muck. We also do not know the effect that the number of plants per hole (1 vs. 2 vs. 3) has on incidence of bacterial diseases?

How does mulch type reduce bacterial bulb decay?
Growers' standard black plastic absorbs sunlight, thus increasing soil temperature, which in turn, promotes early crop development of onions. However, during the heat of June and July, the warmer soil temperatures provided by the black plastic may actually be creating a more favorable environment for bacterial diseases to develop and spread. In contrast, reflective silver mulch keeps soil temperatures cooler, and black biodegradable mulch provides early season added heat, which gives way to cooler soil temperatures as it degrades during the heat of summer. The lower temperatures provided by these alternative mulches could be the difference between optimum and below optimum temperatures for bacteria to grow. Similarly, soil temperatures of bare ground would be cooler than under black plastic, but extra effort would be required to provide effective weed control.

How does the mulch study relate to large-scale production?
Our theory is that the significantly warmer temperature of the black plastic compared to the reflective silver plastic, biodegradable plastic or bare-ground is creating a microclimate that is more conducive to the development and spread of bacterial disease. If black plastic is somewhat analogous to the dark color of the muck soil, than theoretically, onions grown on muck soil would have less bacterial rot if it was possible to reduce the temperature of the muck. In our work with developing a minimum tillage production system for onions, we found twice as much rot in the conventional system (58.1% bacterial canker) compared to the minimum tillage system (27.5% bacterial canker) which had 30% ground cover of winter wheat residue and was cooler.

Ultimately, an integrated approach is needed to manage bacterial disease of onions
We are not telling you that all you have to do is reduce your plant spacing and bacterial diseases will be a thing of the past. Ultimately, managing bacterial diseases of onions will involve an integrated approach for both small and large scale producers. We have several projects planned that are designed to develop different components of an Integrated Pest Management (IPM) program for managing bacterial diseases of onions. Plans beginning in 2011 include:
1) Small-scale grower demonstration and adoption of narrow plant spacing configurations;
2) Continue trialing alternatives to black plastic to elucidate which consistently performs best;
3) Trial combinations of narrow plant spacing and alternatives to black plastic in combination;

4) Elucidate the relationship between bacterial disease of onions and nitrogen fertility. We have anecdotal evidence and preliminary data that shows that as soil nitrogen increases, incidence of bacterial bulb decay increases.
5) Determine the most important sources of bacterial pathogens and how they infect onions. Soil, transplant samples, onion thrips, weeds and seeds will be assayed for presence of bacterial pathogens of onions. We eventually will also study the effect of wind, herbicide and onion thrips injury on incidence of bacterial bulb decay.
6) Various chemical tactics including Actigard and other plant defense inducers, copper bactericides and antibiotics will be trialed for their ability to control bacterial bulb decay of onions. Used alone, chemical tactics have provided virtually no relief from bacterial decay in onions. When used as part of an IPM program that incorporates various cultural tactics including alternative mulches, narrow plant spacing and reduced nitrogen fertility, and starting with clean transplants, etc., proper timing of chemical tactics could prove effective.

Funding for these projects was provided by NESARE Partnership and NE IPM Partnership grants.