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Supplemental Material

Trends in Agricultural Triazole Fungicide Use in the United States, 1992–2016 and Possible Implications for Antifungal-Resistant Fungi in Human Disease

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Table S1: Low, high, and average estimates of agricultural triazole use by year in metric tons, United States, 1992–2016

Year	High	Low	Mean
1992	534	323	428
1993	538	312	425
1994	520	309	415
1995	807	409	608
1996	678	430	554
1997	577	404	490
1998	666	491	578
1999	568	472	520
2000	607	487	547
2001	559	463	511
2002	565	457	511
2003	679	467	573
2004	606	469	537
2005	902	682	792
2006	638	440	539
2007	1023	708	866
2008	1,754	1,141	1,447
2009	1,498	982	1,240
2010	1,705	1,227	1,466
2011	2,272	1,589	1,930
2012	2,533	1,783	2,158
2013	2,447	1,804	2,125
2014	2,794	1,922	2,358
2015	3,400	2,357	2,878
2016	3,199	2,560	2,880

Crops were grouped into 8 categories: 1. Corn; 2. Cotton; 3. Orchards and grapes (stone fruit trees, citrus, nut trees, apples, pears, and grapevines); 4. Other crops; 5. Rice; 6. Soybeans; 7. Vegetables and fruit (all vegetables and non-orchard fruit, including beans, peas, greens, berries, and melons); and 8. Wheat. The following crop combinations were grouped into other crop type category: Pasture and Hay (cropland for pasture, fallow and idle cropland, pastureland, and other hay); Alfalfa; and Other (sorghum, non-wheat grains, tobacco, peanuts, sugarcane, sugar beets, and other miscellaneous crops).

Data from USGS. 2017. USGS NAWQA: The Pesticide National Synthesis Project.

Estimates were derived by averaging “low” and “high” USGS agricultural pesticide estimates for each year.

For corresponding figure, see Figure 1.

Table S2: Average agricultural triazole fungicide use by year and compound type in metric tons, United States, 1992–2016

Year	Propiconazole	Tebuconazole	Prothioconazole	Metconazole	Difenoconazole	Myclobutanil	Triadimefon	Other
1992	191	0	0	0	0	126	112	0
1993	172	0	0	0	0	164	88	0
1994	196	68	0	0	0	99	51	0
1995	248	151	0	0	0	94	99	16
1996	265	149	0	0	0	91	35	13
1997	215	135	0	0	0	95	28	18
1998	182	215	0	0	0	127	42	12
1999	158	211	0	0	0	79	8	64
2000	202	180	0	0	0	84	6	75
2001	159	185	0	0	0	90	7	70
2002	198	160	0	0	0	76	5	72
2003	231	197	0	0	0	84	3	59
2004	184	240	0	0	0	63	2	49
2005	368	307	0	0	0	63	2	51
2006	225	217	0	0	0	56	3	38
2007	416	265	49	2	0	50	2	83
2008	807	312	146	2	8	49	0	122
2009	619	324	91	11	33	55	0	106
2010	631	446	113	58	44	52	0	121
2011	845	485	203	113	92	61	0	132
2012	882	629	230	129	104	50	0	134
2013	842	535	248	211	133	50	0	106
2014	833	668	279	200	159	53	0	164
2015	933	1028	357	184	150	44	0	182
2016	1050	866	361	207	164	45	0	186

Fifteen triazoles included in the USGS dataset were grouped into 8 triazole categories: 1. Difenoconazole; 2. Metconazole; 3. Myclobutanil; 4. Other; 5. Propiconazole; 6. Prothiconazole; 7. Tebuconazole; and 8. Triadimefon. The following triazoles were grouped into other triazole compound type category: cyproconazole, fenbuconazole, flusilazole, flutriafol, ipconazole, tetraconazole, triadimenol, and triticonazole.

Data from USGS. 2017. USGS NAWQA: The Pesticide National Synthesis Project.

Estimates were derived by averaging “low” and “high” USGS agricultural pesticide estimates for each year.

For corresponding figure, see Figure 2A.

Table S3: Average agricultural triazole use by year and crop type in metric tons, United States, 1992–2016

Year	Wheat	Corn	Soybeans	Other crops	Orchards	Rice	Vegetables	Cotton	Total
1992	100	0	40	32	217	18	21	0	428
1993	171	1	2	19	177	23	30	2	425
1994	92	7	4	138	120	25	28	1	415
1995	198	20	0	200	142	28	16	4	608
1996	185	12	1	179	119	21	35	2	554
1997	108	26	4	138	150	31	32	2	490
1998	173	0	0	131	221	18	34	0	578
1999	115	0	0	200	157	22	26	0	520
2000	176	0	0	171	156	18	26	0	547
2001	139	0	0	167	165	20	19	0	511
2002	162	0	0	152	148	24	25	0	511
2003	221	0	0	142	156	30	25	0	573
2004	194	0	0	154	126	42	22	0	537
2005	304	0	78	194	132	59	23	0	792
2006	160	0	61	151	104	40	23	0	539
2007	352	82	105	147	99	50	31	0	866
2008	564	243	206	227	104	60	43	1	1,447
2009	461	156	213	164	116	69	59	1	1,240
2010	519	187	164	287	147	83	74	5	1,466
2011	816	236	272	243	192	75	86	10	1,930
2012	897	245	286	359	172	64	108	28	2,158
2013	851	381	248	257	182	90	101	15	2,125
2014	808	447	291	365	199	108	102	37	2,358
2015	1,164	556	364	394	211	79	99	12	2,878
2016	1,253	437	361	327	229	140	99	35	2,880

Crops were grouped into 8 categories: 1. Corn; 2. Cotton; 3. Orchards and grapes (stone fruit trees, citrus, nut trees, apples, pears, and grapevines); 4. Other crops; 5. Rice; 6. Soybeans; 7. Vegetables and fruit (all vegetables and non-orchard fruit, including beans, peas, greens, berries, and melons); and 8. Wheat. The following crop combinations were grouped into other crop type category: Pasture and Hay (cropland for pasture, fallow and idle cropland, pastureland, and other hay); Alfalfa; and Other (sorghum, non-wheat grains, tobacco, peanuts, sugarcane, sugar beets, and other miscellaneous crops).

Data from USGS. 2017. USGS NAWQA: The Pesticide National Synthesis Project.

Estimates were derived by averaging “low” and “high” USGS agricultural pesticide estimates for each year.

For corresponding figure, see Figure 2B.

Table S4: Triazole use by state over five time periods in metric tons, United States, 1992–2016

State	Differences during 2012–2016 and 1992–1996		Percent change between 1992–1996 and 2012–2016		Sum of use during 1992–1996		Sum of use during 2012–2016	
	Order	Metric tons	Order	Percent change	Order	Metric tons	Order	Metric tons
North Dakota	1	1,731	2	2,517%	10	69	1	1,800
Georgia	2	719	26	249%	2	289	2	1,008
Kansas	3	621	12	828%	8	75	4	696
Minnesota	4	581	7	987%	12	59	5	640
Illinois	5	505	3	2,309%	28	22	6	527
South Dakota	6	432	46	N/A	44	-	9	432
Arkansas	7	424	22	431%	6	98	8	522
Texas	8	390	25	291%	4	134	7	523
Iowa	9	387	1	5,345%	34	7	11	394
Nebraska	10	377	6	1,179%	19	32	10	409
Montana	11	312	9	886%	17	35	12	347
Michigan	12	258	20	484%	13	53	14	312
Indiana	13	256	4	1,585%	32	16	18	272
Louisiana	14	253	13	708%	16	36	16	289
Missouri	15	242	5	1,225%	29	20	20	262
Florida	16	233	21	447%	14	52	17	285
California	17	230	39	48%	1	480	3	711
North Carolina	18	229	23	315%	9	73	15	301
Washington	19	220	32	174%	5	127	12	347
Mississippi	20	212	11	856%	24	25	21	237
Alabama	21	185	28	213%	7	87	18	272
South Carolina	22	161	16	596%	22	27	23	188
Kentucky	23	158	14	675%	25	23	24	182
Ohio	24	152	15	650%	25	23	26	176
Tennessee	25	150	19	511%	20	29	25	179

State	Differences during 2012–2016 and 1992–1996		Percent change between 1992–1996 and 2012–2016		Sum of use during 1992–1996		Sum of use during 2012–2016	
	Order	Metric tons	Order	Percent change	Order	Metric tons	Order	Metric tons
Idaho	26	146	17	568%	23	26	27	172
Oklahoma	27	144	27	235%	11	61	22	206
Colorado	28	126	18	539%	25	23	28	149
Wisconsin	29	94	8	961%	33	10	30	104
Virginia	30	58	34	128%	15	45	31	103
Maryland	31	35	30	178%	29	20	32	55
Pennsylvania	32	23	36	83%	21	28	34	51
New York	33	18	38	54%	18	34	33	52
Wyoming	34	11	46	N/A	44	-	38	11
New Mexico	35	9	29	184%	37	5	36	14
New Jersey	36	7	33	140%	37	5	37	12
Maine	37	6	24	311%	40	2	39	8
Delaware	38	2	42	12%	31	19	35	21
Nevada	39	2	9	868%	44	0	43	2
Utah	40	1	41	23%	36	6	39	8
West Virginia	40	1	40	40%	39	4	41	5
Vermont	40	1	30	178%	42	1	43	2
Connecticut	40	1	35	114%	42	1	46	1
New Hampshire	40	1	46	N/A	44	-	46	1
Massachusetts	45	0	43	-2%	40	2	43	2
Rhode Island	45	0	37	81%	44	0	48	0
Arizona	47	-3	45	-48%	34	7	42	4
Oregon	48	-81	44	-43%	3	191	29	109

Data from USGS. 2017. USGS NAWQA: The Pesticide National Synthesis Project.

Estimates were derived by averaging “low” and “high” USGS agricultural pesticide estimates for each year.

For corresponding figure, see Figure 3.

Table S5: Average agricultural triazole fungicide use by state over five time periods in metric tons, United States, 1992–2016

State	1992–1996	1997–2001	2002–2006	2007–2011	2012–2016
Alabama	87	119	103	181	272
Arizona	7	6	5	3	4
Arkansas	98	82	126	255	522
California	480	468	302	411	711
Colorado	23	11	8	50	149
Connecticut	1	2	1	2	1
Delaware	19	8	7	20	21
Florida	52	93	81	197	285
Georgia	289	397	485	604	1008
Idaho	26	8	17	74	172
Illinois	22	29	42	331	527
Indiana	16	16	25	129	272
Iowa	7	9	14	185	394
Kansas	75	9	27	293	696
Kentucky	23	52	27	81	182
Louisiana	36	51	43	157	289
Maine	2	0	0	3	8
Maryland	20	15	11	32	55
Massachusetts	2	2	1	3	2
Michigan	53	92	100	156	312
Minnesota	59	195	246	451	640
Mississippi	25	39	64	157	237
Missouri	20	19	33	155	262
Montana	35	38	66	140	347
Nebraska	32	11	28	278	409
Nevada	0	0	0	1	2
New Hampshire	0	1	1	1	1

New Jersey	5	7	7	7	12
New Mexico	5	6	7	10	14
New York	34	27	20	39	52
North Carolina	73	106	85	183	301
North Dakota	69	211	421	997	1800
Ohio	23	19	25	158	176
Oklahoma	61	25	18	96	206
Oregon	191	45	52	85	109
Pennsylvania	28	21	20	22	51
Rhode Island	0	0	0	0	0
South Carolina	27	30	58	137	188
South Dakota	0	36	84	268	432
Tennessee	29	33	27	89	179
Texas	134	130	127	180	523
Utah	6	4	2	4	8
Vermont	1	1	1	1	2
Virginia	45	60	31	61	103
Washington	127	95	86	196	347
West Virginia	4	4	6	3	5
Wisconsin	10	13	12	56	104
Wyoming	0	0	0	8	11

Data from USGS. 2017. USGS NAWQA: The Pesticide National Synthesis Project.

Estimates were derived by averaging "low" and "high" USGS agricultural pesticide estimates for each year.

For corresponding figure, see Figure 3.

Table S6: Triazole fungicide use in California, 2017

Category	Metric ton
Turf	7.23
Ornamental	1.87
Treated lumber	1.38
Other	0.02
Total non-food production use (turf, ornamental, treated lumber, and other)	10.50
Total food production use	190.50

Turf included golf course turf, landscape maintenance, bermudagrass, rights of way, and turf/sod. Ornament included garland chrysanthemum, greenhouse flower, greenhouse plants in containers, greenhouse transplants, outdoor flower, outdoor plants in containers, and outdoor transplants. Other included airport, animal burrows, animal premise, beehive, Christmas tree, non-agricultural outdoor buildings, commercial storages or warehouses, commodity fumigation, dairy equipment, ditch bank, farm building, agricultural building, food processing plant, timberland forest, other fumigation, seed grass, greenhouse fumigation, household, industrial processing water, industrial site, industrial disposal water waste disposal systems, public health, regulatory pest control, research commodity, structural pest control.

Data from California Department of Pesticide Regulation. 2017 Annual Statewide Pesticide Use Report Indexed by Chemical.

Figure S1: Agricultural triazole fungicide usage by state and crop type in metric tons, United States, 1992–2016. A) Wheat, B) Corn, C) Soybeans, D) Other crops (cropland for pasture, fallow and idle cropland, pastureland, other hay, alfalfa, sorghum, non-wheat grains, tobacco, peanuts, sugarcane, sugar beets, and other miscellaneous crops)



