Potential yield loss in corn, soybean, dry bean and sugar beet due to weed interference in North America

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OBJECTIVES

The objective of this WSSA Weed Loss Committee study was to update the potential yield loss in corn, soybean, dry bean and sugar beet due to weed interference based on quantitative data (from replicated, small plot studies) from the primary growing regions of North America.

METHODS

Research/extension weed specialists in the corn, soybean, dry bean and sugar beet growing areas of the United States and Canada were requested to provide data on yield loss due to weed interference in their states/provinces (Tables 1-4). Data included results from weed control studies from up to 10 individual studies conducted within each calendar year during 2007 to 2013 for corn and soybean, 2007 to 2016 for dry bean and 2002 to 2017 for sugar beet. Researchers were asked to provide the "weedy yield" and "weed-free yield" which was defined as the yield from plots with >95% weed control (based on normal agronomic practices for optimal crop yield with excellent weed management programs). To determine potential crop yield loss for each state/province, percent yield loss (YL%) was determined for each individual study, then averaged within a year, and averaged across years as follows:

Potential YL% = (weed-free yield – weedy yield)/weed-free yield * 100 [1]

Information on total crop harvested, average yield and yearly average commodity prices for each state or province were obtained from USDA-AMS (2017) and AAFC (2017) reports. The potential loss for each state or province was based on the product of the estimated amount of yield loss due to weed interference multiplied by the mean price for 2007 to 2013 for corn and soybean, 2007 to 2016 for dry bean and 2002 to 2017 for sugar beet.

Corn

Table 1. Corn yield loss from weed interference, loss in production and value for each state or province that provided data for the period of 2007 to 2013.

Region State or province	Harvested Area	Average yield	Yield loss	Potential loss in production	Loss in value ($194.48 t^{-1} or $4.94 bu^{-1})
	Hectares x 1000	t ha^{-1}	%	t x 1000	US$ x 1000
Northeast					
Delaware	70	8.2	42.1	241	46,841
Pennsylvania	390	8.1	55.5	1,676	312,669
Appalachian					
Kentucky	526	8.3	83.0	3,866	728,540
Tennessee	298	7.7	29.1	669	134,761
North Carolina	346	6.5	43.6	994	189,276
Lake States					
Michigan	896	9.0	55.8	4,481	871,766
Minnesota	3,104	10.2	52.6	16,716	3,251,777
Wisconsin	1,264	9.1	47.3	5,414	1,053,147
Eastern Canada					
Ontario	820	9.5	51.4	4,018	781,450
Corn Belt					
Illinois	4,949	10.1	50.7	25,303	4,922,303
Indiana	2,407	9.5	58.6	13,469	2,620,136
Iowa	5,408	10.4	39.9	22,520	4,380,904
Missouri	1,238	7.9	73.7	7,238	1,407,990
Ohio	1,373	9.7	60.2	8,001	1,556,446
Northern Plains					
North Dakota	1,005	7.4	51.3	3,811	741,311
South Dakota	1,959	8.2	48.0	7,680	1,494,027
Nebraska	3,683	9.8	52.4	20,825	4,051,151
Kansas	996	4.6	46.3	2,580	501,886
Mountain					
Montana	17	8.2	43.2	62	12,158
Southeast					
Mississippi	308	9.2	18.0	535	121,071
Georgia	140	9.6	41.0	526	98,671
Arkansas	225	10.1	10.0	260	58,141

Averaged across 2007 to 2013, weed interference caused a 50.3% yield loss in corn (Table 1). Based on 2012 census data in the US and Canada corn was grown on 35,374,804 and 1,434,099 hectares with production of 262.5 and 10.7 million tonnes, respectively. Using an average corn price across 2007 to 2013 of US$194.48 t^{-1} ($4.94 bu^{-1}), farm gate value would be reduced by $25.7 billion in the US and $1.05 billion in Canada if no weed management tactics were employed. With the use of a two-pass weed control program, and assuming a herbicide plus application cost of US$100 ha^{-1} for optimum weed control in corn, there would be a $7.25 return for every $1 invested in weed management.

Soybean

Table 2. Soybean yield loss from weed interference, loss in production and value for each state or province that provided data for the period of 2007 to 2013.

Region State or province	Harvested Area	Average yield	Yield loss	Potential loss in production	Loss in value ($389.81 t^{-1} or $10.61 bu^{-1})
	Hectares x 1000	t ha^{-1}	%	t x 1000	US$ x 1000
Northeast					
Delaware	70	2.40	28.7	48	18,698
Pennsylvania	195	2.97	35.2	204	79,581
Appalachian					
Kentucky	572	2.62	82.1	1,232	480,366
North Carolina	621	2.09	47.4	618	240,699
Tennessee	546	2.36	36.0	464	180,992
Lake States					
Michigan	784	2.81	62.6	1,380	537,769
Minnesota	2795	2.78	65.3	5,083	1,981,155
Wisconsin	641	2.82	53.7	972	378,809
Eastern Canada					
Ontario	979	2.92	38.1	1,091	425,193
Corn Belt					
Illinois	3,649	3.15	60.5	6,964	2,714,599
Indiana	2,115	3.30	54.8	3,672	1,431,427
Iowa	3,778	3.28	46.8	5,816	2,266,893
Missouri	2,091	2.52	51.5	2,723	1,061,365
Ohio	1,819	3.09	42.3	2,385	929,800
Northern Plains					
North Dakota	1,623	2.12	61.7	2,111	823,013
South Dakota	1,677	2.53	51.9	2,207	860,080
Nebraska	1,046	2.89	36.3	1,098	428,106
Kansas	1,438	2.26	52.6	1,710	666,435
Delta States					
Arkansas	1,281	2.61	34.1	1,143	445,585
Mississippi	760	2.75	48.6	1,019	397,249

Averaged across 2007 to 2013, weed interference caused a 52.1% yield loss in soybean (Table 2). Based on 2012 census data in the US and Canada, soybean was grown on 30,798,512 and 1,679,203 hectares with production of 80 million and 5 million tonnes, respectively. Using an average soybean price across 2007 to 2013 of $389.81 t^{-1} ($10.61 bu^{-1}), the farm gate value would be reduced by $16.2 billion in the US and $1.0 billion in Canada annually if no weed management tactics were employed. With the use of a two-pass weed control program, and assuming a herbicide plus application cost of US$100 ha^{-1} for optimum weed control in soybean, there would be a $5.67 return for every $1 invested in weed management.

Dry Bean

Table 3. Dry bean yield loss from weed interference, loss in production and value for each state or province that provided data for the period of 2007 to 2016.

State or province	Harvested area	Average yield	Total Value	Yield loss	Potential loss in production	Loss in value ($0.73 kg^{-1} or $33.04 cwt^{-1})
	Hectares	kg ha^{-1}	US$ x 1000	%	kg ha^{-1}	US$ x 1000
United States						
Idaho	46,258	2,129	71,906	50.2	1,069	36,097
Michigan	83,491	2,083	126,988	31.2	650	39,620
Montana	12,469	1,966	17,896	35.6	700	6,371
Nebraska	51,195	2,532	94,669	58.7	1,487	55,571
North Dakota	362,819	1,701	450,536	93.5	1,590	421,251
South Dakota	4,456	2,169	7,058	30.8	668	2,174
Wyoming	14,051	2,550	26,167	70.5	1,798	18,448
Canada						
Ontario	48,455	2,204	77,971	55.9	1,232	43,586
Manitoba	44,608	1,871	60,928	71.9	1,345	43,807

Averaged across 2007 to 2016, weed interference caused a 71.4% yield loss in dry bean (Table 3). Based on 2016 census, dry bean production in the United States and Canada would be reduced by 941,000 and 184,000 tonnes out of their total production of 1,318,000 and 258,000 tonnes valued at approximately $622 and $100 million, respectively, to uncontrolled weeds. With the use of a two-pass weed control program, and assuming a herbicide plus application cost of US$125 ha^{-1} for optimum weed control, there would be a $10.39 return for every $1 invested in weed management.

Sugar Beet

Table 4. Sugar beet yield loss from weed interference, loss in production and value for each state or province that provided data for the period of 2002 to 2017.

State or province	Harvested area	Average yield	Total value	Yield loss	Potential loss in production	Loss in value ($55.79 t^{-1})
	Hectares	t ha^{-1}	US$ x 1000	%	t ha^{-1}	US$ x 1000
Idaho	67,831	78.0	295,208	79.3	61.9	234,100
Michigan	59,956	59.2	197,949	61.4	36.3	121,541
Minnesota	179,307	56.3	562,845	65.6	36.9	369,227
Montana	17,429	65.0	63,212	68.2	44.3	43,111
Nebraska	19,132	59.0	62,928	62.8	37.0	39,519
North Dakota	89,093	56.7	281,892	74.9	42.5	211,137
Ontario	3,866	68.7	14,807	82.6	56.7	12,231
Oregon	3,916	80.3	17,533	78.3	62.8	13,728
Wyoming	12,576	59.6	41,837	77.1	46.0	32,256

Averaged across 2002 to 2017, the average yield loss due to weed interference for the primary sugar beet growing areas of North America was estimated to be 70% (Table 4). Based on 2017 census, growers in the US would lose approximately 22.4 million tonnes of sugar beet yield valued at approximately $1.25 billion and growers in Canada would lose approximately 0.5 million tonnes of sugar beet yield valued at approximately $25 million if weeds are not controlled. Assuming a herbicide plus application cost of US$100 ha^{-1} for optimum weed control in sugar beet, there would be a $23 return for every $1 invested in weed management.

CONCLUSIONS

Corn, soybean dry bean and sugar beet growers in North America would potentially lose 50, 52, 71 and 70% of their crop, with a monetary loss valued at $26.8 billion, $17.2 billion, $722 million and $1.3 billion respectively, if they did not employ any weed management tactics.

The high return on investment with weed management highlights the importance of continued weed science research for sustaining high crop yield and profitability of crop production in North America.