**Title**. Field-level yield benefits and risk effects of intensive soybean management across the US

Table S1. Product makeup and application information for the high-input system used during 2009 to 2014.

| Product† | Product component | Active ingredient | Application: Growth stage | Application: Product rate | Application: Sprayer volume |
|---|---|---|---|---|---|
| **Seed applied** | | | | mL kg seed$^{-1}$ | |
| Vault (2009-2011) | Inoculant | Bradyrhizobium japonicum | seed | 2.69 | |
| Acceleron§ | fungicide | pyraclostrobin + metalaxyl | seed | 1.04 | – |
| Trilex 2000§ (2009-2012) | fungicide | trifloxystrobin + metalaxyl | seed | 0.65 | – |
| EverGol Energy + Precise§ (2013–2014) | fungicide | prothioconazole + penflufen + metalaxyl | seed | 0.65 | – |
| Acceleron | insecticide | imidacloprid | seed | 2.60 | – |
| Poncho/VOTiVO (2012-2014) | insecticide + nematistat | clothianidin + Bacillus firmus | seed | 0.64 | – |
| Optimize (2012-2014) | LCO | lipo-chitooligosaccharide | seed | 1.83 | – |
| **Soil applied** | | | | kg ha$^{-1}$ | – |
| Superphosphate (2009-2011) | phosphorus | 0-46-0 | Pre-plant | 85 | – |
| Potassium Sulfate (2009-2011) | Potassium + Sulphur | 0-0-53-17S | Pre-plant | 57 and 18 | – |
| Zinc Sulfate (2009-2011) | Zinc | 30% Zn | Pre-plant | 0.6 | – |
| Boron fertilizer (2009-2011) | Boron | 17.5% B | Pre-plant | 0.6 | – |
| Manganese Sulfate (2009-2011) | Manganese | 26% MN | Pre-plant | 2.4 | – |
| Urea¶ (2012-2014) | nitrogen | 46–0–0%N–$P_2O_5$–$K_2O$ | V4 | 84 | – |
| ESN (20012-2014) | nitrogen | 44–0–0%N–$P_2O_5$–$K_2O$ | V4 | 84 | – |
| **Foliar applied** | | | | mL ha$^{-1}$ | L ha$^{-1}$ |
| Ratchet (2013-2014) | LCO | lipo-chitooligosaccharide | V4-V6 | 292 | 140 |
| Task Force | fertilizer | 11–8-5–0.1–0.05–0.04–0.04–0.02–0.00025–0.00025% N–$P_2O_5$–$K_2O$–Fe–Mn–Zn–B–Co–Mo | R1 | 4676 | 140 |
| Bio-Forge (2012-2014) | antioxidant | N,N'-diformyl urea | R3 | 1169 | 187 |
| Headline (2009-2012) | fungicide | pyraclostrobin | R3 | 438 | 187 |
| Priaxor (2013–2014) | fungicide | fluxapyroxad + pyraclostrobin | R3 | 585 | 187 |
| Warrior II (2012) | insecticide | lambda-cyhalothrin | R3 | 140 | 187 |
| Endigo (2013–2014) | insecticide | lambda-cyhalothrin + thiamethoxam | R3 | 292 | 187 |

† Acceleron (Monsanto Co., St. Louis, MO); Trilex 2000, EverGol Energy + Precise, Poncho/VOTiVO (Bayer Crop Science, Research Triangle Park, NC); Optimize (Novozymes, Brookfield, WI); ESN [environmentally smart nitrogen (polymer-coated urea)] (Agrium, Calgary, Alberta, Canada); Ratchet (Novozymes, Brookfield, WI); Task Force 2 (Loveland Products, Inc., Greeley, CO); Bio-Forge (Stoller USA, Inc., Houston, TX); Headline and Vault (BASF Corp., Florham Park, NJ) used in 2012; Priaxor (BASF Corp., Florham Park, NJ) used in 2013–2014; Warrior II used in 2012; Endigo used in 2013–2014 (Syngenta Crop Protection, LLC, Greensboro, NC).

‡ For all input systems, fertilizers and herbicides were applied according to university best management recommendations.

§ Acceleron fungicide was applied to all Monsanto Co. related cultivars [Asgrow, Channel, Kruger, Gold Country, Stewart]; Trilex 2000 used in 2009-2012 and EverGol Energy + Precise used in 2013–2014 was applied to all Pioneer Hi-Bred International, Inc. related cultivars.

¶ Treated with Agrotain [N-(n-butyl) thiophosphoric triamide] at 3.1 mL kg urea$^{-1}$.

Table S2. Mean yield and posterior summaries with 95% high posterior density (HPD) intervals for the yield difference between the "high" and "low" input management systems within each state.

| State | Mean yield (kg/ha) | Mean yield difference (kg/ha) | Percent of mean yield | Standard Deviation | 95% HPD Interval | | †Probability (%) for yield difference >0 |
|---|---|---|---|---|---|---|---|
| AR | 4325 | 353 | 8.2 | 83 | 186 | 507 | 100 |
| IA | 4460 | 283 | 6.3 | 80 | 122 | 438 | 100 |
| IL | 4177 | 372 | 8.9 | 141 | 101 | 650 | 100 |
| IN | 4302 | 429 | 10.0 | 142 | 156 | 712 | 100 |
| KS | 3892 | -191 | -4.9 | 202 | -574 | 204 | 17 |
| KY | 3792 | 431 | 11.4 | 80 | 276 | 584 | 100 |
| LA | 2930 | 216 | 7.4 | 119 | -12 | 456 | 97 |
| MI | 3564 | 398 | 11.2 | 88 | 229 | 580 | 100 |
| MN | 4275 | 541 | 12.7 | 92 | 350 | 712 | 100 |
| WI | 4749 | 576 | 12.1 | 142 | 286 | 840 | 100 |

†Probability for yield difference > 0 in the posterior sample distribution (n=5,100).

Table S3. Posterior summaries and 95% high posterior density (HPD) intervals for the yield variance difference ($x10^3$) between the "high" and "low" input management systems within each state.

| State | Mean yield variance difference | Standard Deviation | 95% HPD Interval | | †Probability (%) for yield variance difference >0 |
|---|---|---|---|---|---|
| AR | -46 | 35 | -113 | 22 | 10 |
| IA | 54 | 34 | -14 | 118 | 94 |
| IL | 42 | 59 | -72 | 159 | 76 |
| IN | 58 | 60 | -56 | 178 | 84 |
| KS | -3 | 85 | -164 | 163 | 49 |
| KY | 94 | 34 | 29 | 158 | 100 |
| LA | -15 | 50 | -108 | 88 | 38 |
| MI | 19 | 37 | -52 | 95 | 70 |
| MN | -39 | 39 | -117 | 35 | 16 |
| WI | 21 | 59 | -101 | 131 | 64 |

†Probability for yield variance difference > 0 in the posterior sample distribution (n=5,100).

Table S4. Posterior summaries and 95% high posterior density (HPD) intervals for the yield skewness ($x10^6$) in the “high” and “low” input management systems within each state.

| State | Input system | Mean yield skewness | Standard Deviation | 95% HPD Interval | | †Probability (%) for yield skewness < 0 |
|---|---|---|---|---|---|---|
| AR | high | -4 | 28 | -59 | 49 | 56 |
| | low | 5 | 28 | -49 | 58 | 42 |
| IA | high | 7 | 27 | -46 | 59 | 40 |
| | low | -20 | 27 | -73 | 31 | 77 |
| IL | high | 22 | 47 | -70 | 114 | 32 |
| | low | 6 | 47 | -83 | 104 | 44 |
| IN | high | 7 | 47 | -84 | 99 | 44 |
| | low | -1 | 48 | -93 | 94 | 50 |
| KS | high | 50 | 68 | -82 | 182 | 23 |
| | low | -39 | 67 | -167 | 95 | 72 |
| KY | high | 1 | 27 | -53 | 52 | 48 |
| | low | 4 | 26 | -49 | 53 | 44 |
| LA | high | -22 | 40 | -99 | 57 | 71 |
| | low | -4 | 39 | -81 | 73 | 55 |
| MI | high | -12 | 30 | -69 | 49 | 66 |
| | low | -7 | 30 | -65 | 51 | 59 |
| MN | high | -1 | 31 | -61 | 60 | 51 |
| | low | -28 | 32 | -91 | 33 | 81 |
| WI | high | -15 | 47 | -105 | 79 | 62 |
| | low | 13 | 48 | -75 | 111 | 40 |

†Probability for yield skewness < 0 in the posterior sample distribution (n=5,100).

Table S5. Posterior summaries and 95% high posterior density (HPD) intervals for the yield kurtosis ($x10^9$) in the "high" and "low" input management systems within each state.

| State | Input system | Mean yield kurtosis | Standard Deviation | 95% HPD Interval | | †Probability (%) for yield kurtosis > 0 |
|---|---|---|---|---|---|---|
| AR | high | 54 | 25 | 5 | 101 | 99 |
| | low | 87 | 25 | 39 | 135 | 100 |
| IA | high | 116 | 24 | 69 | 163 | 100 |
| | low | 63 | 24 | 15 | 108 | 100 |
| IL | high | 54 | 43 | -29 | 137 | 90 |
| | low | 12 | 42 | -67 | 100 | 62 |
| IN | high | 19 | 42 | -63 | 101 | 68 |
| | low | 1 | 43 | -81 | 87 | 52 |
| KS | high | 77 | 61 | -41 | 197 | 89 |
| | low | 89 | 60 | -25 | 209 | 93 |
| KY | high | 188 | 24 | 139 | 233 | 100 |
| | low | 112 | 24 | 64 | 155 | 100 |
| LA | high | 29 | 36 | -40 | 100 | 79 |
| | low | 33 | 35 | -36 | 102 | 83 |
| MI | high | 34 | 27 | -18 | 88 | 89 |
| | low | 26 | 27 | -27 | 77 | 84 |
| MN | high | 28 | 28 | -26 | 83 | 84 |
| | low | 75 | 28 | 18 | 128 | 99 |
| WI | high | 36 | 42 | -45 | 121 | 80 |
| | low | 35 | 43 | -43 | 124 | 79 |

†Probability for yield kurtosis > 0 in the posterior sample distribution (n=5,100).

Table S6. Posterior summaries and 95% high posterior density (HPD) intervals for the total cost of yield risk (kg/ha) difference between the "high" and "low" input management systems within each state for risk-neutral farmer (r=3).

| State | Mean yield risk difference (kg/ha) | Standard Deviation | 95% HPD Interval | | †Probability (%) for yield risk difference >0 |
|---|---|---|---|---|---|
| AR | -21 | 18 | -55 | 15 | 13 |
| IA | 15 | 17 | -19 | 50 | 81 |
| IL | 21 | 31 | -37 | 83 | 76 |
| IN | 18 | 31 | -42 | 79 | 72 |
| KS | -3 | 44 | -87 | 83 | 47 |
| KY | 30 | 17 | -5 | 62 | 96 |
| LA | -11 | 26 | -58 | 43 | 34 |
| MI | 4 | 19 | -32 | 44 | 60 |
| MN | -21 | 20 | -64 | 15 | 14 |
| WI | 6 | 31 | -56 | 64 | 58 |

†Probability for total cost of risk yield difference > 0 in the posterior sample distribution (n=5,100).

Table S7. Posterior summaries and 95% high posterior density (HPD) intervals for the total cost of yield risk (kg/ha) difference between the “high” and “low” input management systems within each state for high level of risk (r=5).

| State | Mean yield difference (kg/ha) | Standard Deviation | 95% HPD Interval | | †Probability (%) for yield difference >0 |
|---|---|---|---|---|---|
| AR | -36 | 36 | -105 | 34 | 16 |
| IA | 27 | 35 | -42 | 95 | 79 |
| IL | 39 | 61 | -78 | 160 | 74 |
| IN | 30 | 61 | -89 | 152 | 69 |
| KS | -10 | 88 | -178 | 160 | 45 |
| KY | 54 | 35 | -16 | 118 | 94 |
| LA | -18 | 51 | -116 | 86 | 36 |
| MI | 8 | 38 | -66 | 86 | 59 |
| MN | -41 | 40 | -124 | 34 | 15 |
| WI | 12 | 61 | -114 | 126 | 58 |

†Probability for total cost of risk yield difference > 0 in the posterior sample distribution (n=5,100).

Table S8. Yield variance difference (x$10^3$) between the “high” and “low” input management systems within each state using the frequentist analysis approach.

| State | Mean yield variance difference | Standard Error | t Value | Pr > \|t\| |
|---|---|---|---|---|
| AR | -45 | 29 | -1.54 | 0.1234 |
| IA | 53 | 29 | 1.86 | 0.0639 |
| IL | 42 | 58 | 0.72 | 0.4747 |
| IN | 58 | 9 | 6.57 | <.0001 |
| KS | -3 | 58 | -0.05 | 0.9623 |
| KY | 93 | 44 | 2.12 | 0.0346 |
| LA | -14 | 13 | -1.1 | 0.2711 |
| MI | 20 | 4 | 4.74 | <.0001 |
| MN | -38 | 47 | -0.8 | 0.4218 |
| WI | 21 | 21 | 0.99 | 0.3208 |

Table S9. Yield skewness (x$10^6$) in the "high" and "low" input management systems within each state using the frequentist analysis approach.

| State | Input system | Mean yield skewness | Standard Error | t Value | Pr > \|t\| |
|---|---|---|---|---|---|
| AR | high | -4.0 | 20.1 | -0.2 | 0.8436 |
| | low | 4.4 | 10.9 | 0.4 | 0.6890 |
| IA | high | 6.3 | 35.2 | 0.18 | 0.8578 |
| | low | -19.2 | 18.4 | -1.04 | 0.2986 |
| IL | high | 22.9 | 29.2 | 0.78 | 0.4349 |
| | low | 7.0 | 6.5 | 1.08 | 0.2804 |
| IN | high | 7.7 | 3.8 | 2.01 | 0.0455 |
| | low | -0.8 | 1.4 | -0.56 | 0.5738 |
| KS | high | 49.8 | 39.9 | 1.25 | 0.2129 |
| | low | -38.6 | 60.6 | -0.64 | 0.5241 |
| KY | high | 0.5 | 25.0 | 0.02 | 0.9829 |
| | low | 4.1 | 28.2 | 0.15 | 0.8838 |
| LA | high | -22.0 | 21.1 | -1.04 | 0.2985 |
| | low | -5.1 | 6.9 | -0.74 | 0.4581 |
| MI | high | -11.7 | 7.6 | -1.54 | 0.1249 |
| | low | -7.7 | 6.4 | -1.2 | 0.2309 |
| MN | high | -0.9 | 10.4 | -0.08 | 0.9331 |
| | low | -27.9 | 14.7 | -1.9 | 0.0581 |
| WI | high | -14.8 | 23.3 | -0.63 | 0.5274 |
| | low | 12.8 | 18.4 | 0.7 | 0.4868 |

Table S10. Yield kurtosis (x$10^9$) in the "high" and "low" input management systems within each state using the frequentist analysis approach.

| State | Input system | Mean yield kurtosis | Standard Error | t Value | Pr > \|t\| |
|---|---|---|---|---|---|
| AR | high | 53 | 16 | 3.33 | 0.001 |
| | low | 84 | 23 | 3.67 | 0.0003 |
| IA | high | 115 | 38 | 3.05 | 0.0024 |
| | low | 62 | 29 | 2.11 | 0.0357 |
| IL | high | 55 | 38 | 1.44 | 0.1519 |
| | low | 13 | 7 | 1.8 | 0.073 |
| IN | high | 20 | 5 | 3.56 | 0.0004 |
| | low | 2 | 0 | 3.53 | 0.0005 |
| KS | high | 78 | 45 | 1.74 | 0.0829 |
| | low | 89 | 30 | 2.95 | 0.0034 |
| KY | high | 187 | 41 | 4.62 | <.0001 |
| | low | 111 | 41 | 2.73 | 0.0066 |
| LA | high | 30 | 15 | 2.05 | 0.0415 |
| | low | 33 | 9 | 3.52 | 0.0005 |
| MI | high | 33 | 16 | 2.08 | 0.0378 |
| | low | 24 | 13 | 1.93 | 0.0548 |
| MN | high | 28 | 7 | 4.08 | <.0001 |
| | low | 74 | 38 | 1.93 | 0.054 |
| WI | high | 36 | 14 | 2.56 | 0.011 |
| | low | 35 | 16 | 2.15 | 0.0322 |

Figure S1. Within each input cropping system, state-specific estimated cost of yield risk (risk-neutral farmer, r=3) as percent of average yield, and variance, skewness and kurtosis as percent of yield risk.

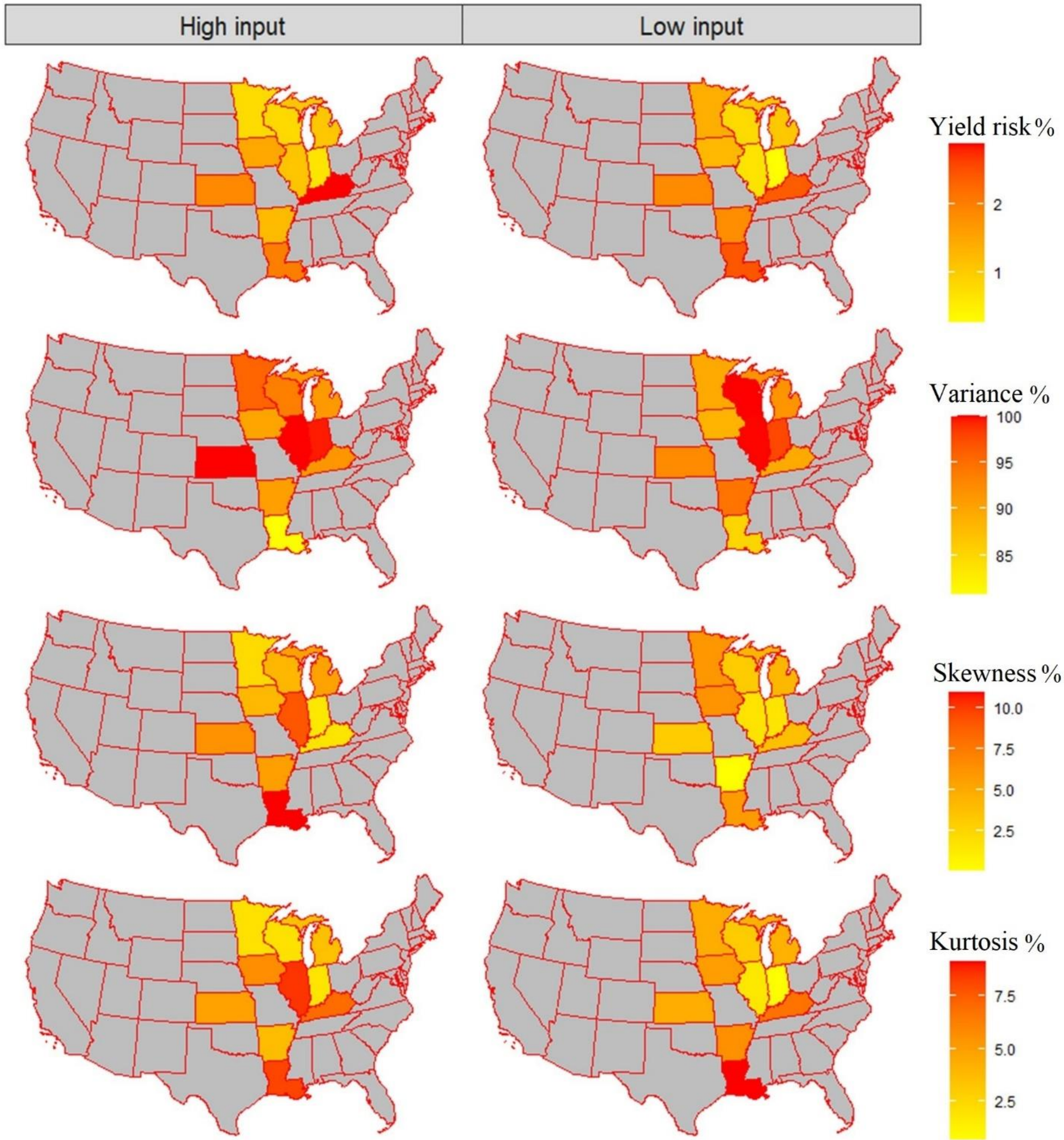

Figure S2. Distribution of total cost of yield risk (kg/ha) difference between high and low input cropping systems in each state and probability (P) for yield difference > 0 in the posterior sample distribution (n=5,100) for high level of risk aversion (r=5). Within each state, the red dash line shows the zero difference and the black line shows the mean difference (Yd).

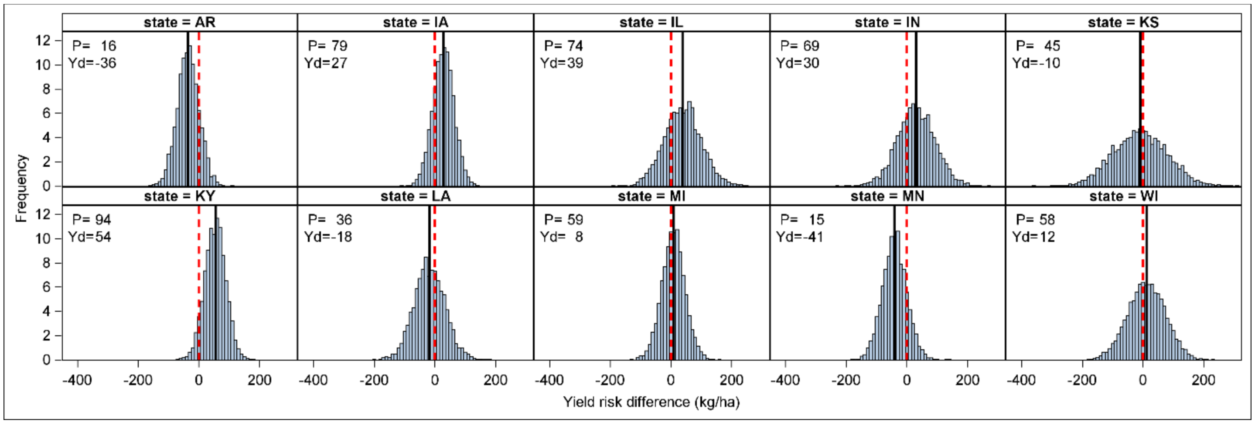


Figure S3. Mean yield difference (kg/ha) between high and low input cropping systems in each state. The errors show the 95% confidence intervals using the frequentist analysis approach.

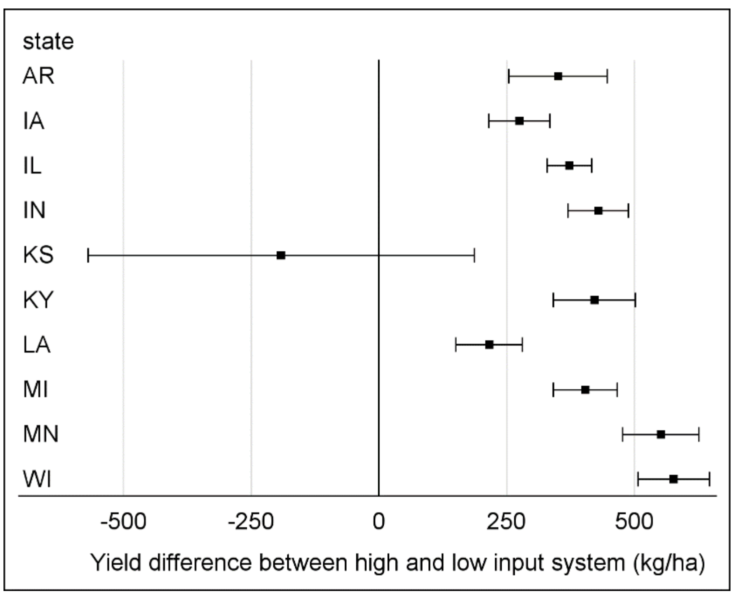

Figure S4. Mean cost of yield risk (kg/ha) difference between high and low input cropping systems in each state for moderate level of risk-neutral farmer (r=3) using the frequentist analysis approach. The errors show the 95% confidence intervals.

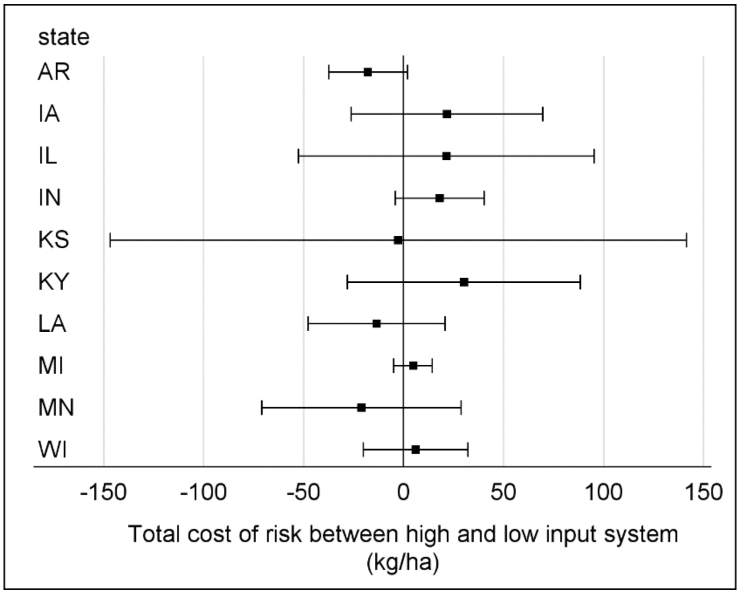


Figure S5. Mean cost of yield risk (kg/ha) difference between high and low input cropping systems in each state for high level of risk (r=5) using the frequentist analysis approach. The errors show the 95% confidence intervals.