Insect Losses and Management on Desert Lettuce: An 18-Year Summary

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Introduction: The development of accurate data on lettuce yield losses is important to the assessment of IPM programs in Arizona. Reliable estimates of yield losses caused by key insect pests occurring in lettuce is our most objective tools for assessing change in management practices. This information allows us to build relevant databases for measuring the pest status of important insect species found on desert lettuce, as well as the economic impacts they are responsible for. This information also serves as a resource to assist applied scientists in prioritizing research projects in developing IPM programs for desert lettuce. For PCAs, this data can demonstrate their efforts into economic terms for their growers, and justifies their value to the lettuce industry by showing the importance of insect pests in desert lettuce production. This summary over the past eighteen growing season (2004-2022) provides real world data on the pest status of key insect species, economics of insect management, and estimates of yield losses in lettuce.

Methods: The data were developed through the administration of a three-part survey that was conducted in an interactive process with stakeholder input. Growers, PCAs, Extension personnel and industry professionals attended Lettuce Insect Losses and Impact Assessment Workshops in Yuma and completed surveys in a guided process. The workshops were conducted in an interactive manner where participants were given a presentation that established the incentives for participation, explained the crop insect loss system, and further walked the participants through the estimation process. The three-part survey instrument collected the following information:

First, Information was collected on the lettuce acreage represented by the respondents. Costs associated with aerial and ground applications and insect management fees for scouting were estimated. To provide data consistent with lettuce production in the desert southwest, separate information was collected for fall lettuce acres (crops grown from September through November) and spring lettuce acres (December-March) because of differences in weather and insect pressures. Second, Information was collected on IPM and crop insect losses through estimates of the % of acres where key insect pests were present and the % of acres treated with insecticide sprays aimed at the key insects. Included with those estimates are the frequency and costs of insecticide applications directed towards those insects. Overall, these costs represent an economic loss to the grower associated with preventing insects from damaging plants and reducing yields. Finally, actual percent yield losses (product not harvested due to insect damage or reduced quality) for individual insect species was estimated. Data on insecticide use patterns was also collected. These data identify the frequency of use of various chemistries (identified by both product name and IRAC mode-of-action classification) and the percentage of treated acres for each product. This data has previously been summarized in the ***Insecticide Usage on Conventional and Organic Lettuce in the Desert,*** *2021-2022* (UA VegIPM Update, Vol. 13, No. 13, June 29, 2022).

Pest Status and Economic Yield Losses, 18-year Average

Table 1 presents data on survey participation by local PCAs over the past 18 years. Surveys completed by PCAs represented a large proportion of the lettuce acres grown in Yuma, and neighboring Bard/Winterhaven growing areas (65-80% of total). Furthermore, the table reflects the large number of acres, that on average, PCAs scout and make management decisions on. The average number of sprays applied to lettuce and the associate cost of a spray application (aerial and ground averaged) costs are shown in this table. The estimated number of applications PCAs applied for insect management has averaged between 4.2-5.6 sprays over the past 18 years on fall and spring lettuce. Not surprising, the surveys showed that annually 100% of the acres are scouted in lettuce crops. Scouting for lettuce pests in Yuma is also very intensive where lettuce fields during the fall and spring are in general visited >4 times per week. Finally, IPM scouting comes at a cost; average scouting fees have continually increased over the past 18 years and were estimated at $34.50 / acre last season.

<u>Table 2</u> presents a 18-year summary on the estimated pest status of insects and economic yield losses on *fall* lettuce. PCAs estimated that the Lepidopterous larvae complex (beet armyworm/cabbage looper/corn earworm), western flower thrips and seedling pests are the most important economic pests on fall lettuce. On average, beet armyworm control required 3 applications at over $100/ acre and resulted in average losses less than 1%. This is clear documentation to the importance of this damaging pest. Cabbage looper and corn earworm often occur simultaneously with armyworms but are not as prominent armyworms during the fall. Western flower thrips has recently become a major pest of fall lettuce as shown in Table 1. Although thrips were not treated on as much acreage as the Lep complex, they were treated, on average, 1.8 times on about 2/3 of the acres. A second group of pests that are important in fall lettuce is comprised of the seedling, soil pests (beetles/crickets), and flea beetles. These pests are annually treated on greater than 50% of the acreage, and each species caused yield losses over 0.5%. Other pests such as trash bugs, aphids, grasshoppers and leafminers are of less economic importance on fall lettuce, but still required management. Bean thrips have become a new pest on fall lettuce over the past three years.

<u>Table 3</u> presents an 18-year summary on the estimated pest status of insects and economic yield losses on *spring* lettuce. Western flower thrips has clearly been the primary pest on spring crops over the course of these surveys, requiring the highest number of applications and spray costs and causing the greatest yield loss. The Aphids (green peach aphid, foxglove aphid and lettuce aphid) and Lep complexes were also major pests of spring lettuce. Among the aphid species, green peach aphid required the most economic management and responsible for losses in excess of 0.5%. In contrast, seedling pests, flea beetles and whiteflies were not as important on spring crops. In spring 2022, an outbreak of lettuce aphid occurred which required considerably a higher number of sprays on more acreage than normal and resulted in significantly higher yield losses.

<u>Note:</u> Yield losses for any one pest never exceeded 1% in either fall or spring lettuce. It is commendable that PCAs and growers can keep insect losses to such low levels over a 18-year period. However, it is important to note that this was accomplished largely by the considerable amount of time PCAs spend scouting for these pests, and certainly by the significant investment in insecticide sprays and applications costs used each season to prevent these key pests from causing economic damage to lettuce crops.

Seasonal Trends in Pest Status and Economic Yield Losses

<u>Beet armyworm</u> (BAW) - Figure 1.

BAW is the number one pest of fall lettuce in the desert. The fact that the percent acres where BAW was present are almost equal to percent treated acres is an indication how damaging this pest can be, particularly during the first 30 days of the growing season when plants are small. Thresholds for BAW control at this time are 1 larvae/100 plants, and control is more important in the fall when temperatures are ideal for BAW development and oviposition. The percent acres treated for BAW were above average in the last four seasons, where more acres were treated than where the pest was present. Similarly, PCAs estimated they used almost twice as many sprays to control BAW on fall lettuce as opposed to spring lettuce. Estimates of yield losses have historically fluctuated over the years. Losses were particularly high in 2005, and losses in fall lettuce have been below average over the past several years. This decline is likely due to the availability of several effective insecticides with extended residual activity, including soil applied diamides (e.g., Coragen) (see 2022 *Insecticide Use Summary* for data).

Cabbage looper (CL) - Figure 2.

Similarly, CL is an important lettuce pest in both fall and spring lettuce. Like BAW, when CL was present in lettuce a very high percentage of the acres were treated. This is apparent for both fall and spring lettuce. In fall lettuce, trends in the % treated acres for CL have decreased over the past 12 years, whereas percent acres treated has steadily increased in spring lettuce, likely varying with increased winter temperatures observed over the past several years. Numbers of spray treatments for CL on fall lettuce are usually higher than spray treatments applied to spring lettuce and remained relatively stable over the past 18 years. Number of spray application in fall lettuce in 2022 were well below average. Yield losses were highest in 2005 and have declined steadily since then. However, losses have remained at below average levels since 2011. This is also likely due to the availability of a number of effective insecticides with extended residual activity, including soil applied diamides.

Corn earworm (CEW) - Figure 3

CEW is an example of a pest that PCAs will treat preventatively. In several seasons, a greater % acres were treated than on where CEW was present. This occurs due to the potential for CEW larvae to cause unexpected heavy yield losses by contaminating heads at harvest (e.g., 2013, 2015, 2017). Larvae are difficult to detect in the field because of their ovipositional patterns and their ability to quickly enter heads upon hatching. The prophylactic management of CEW on fall and spring lettuce was particularly effective where lower yield losses were reported the past 5 seasons. Furthermore, the number of sprays for control of CEW has generally been higher on fall lettuce. The trend in yield losses to CEW has varied over the past 18 years, and peak yield losses were seen from 2013-2017. It is unknown why these heavy infestations occurred but may reflect presence of alfalfa and summer corn crops in the affected areas, particularly in Dome Valley, Wellton, and Roll.

Seedling, Soil Insects (SSI) - Figure 4

The management of SSI often includes the use of sprinkler chemigation treatments with pyrethroids applied during stand establishment and are not reflected in this data. These treatments are important during the fall when crickets, ground beetles and ants can rapidly damage germinating seedlings in large area of fields. Insecticide use data indicates that on average, PCAs chemigate with pyrethroids for these pests on ~75 and 30% of fall and spring acres, respectively (see *Insecticide Use Summary* for data). However, despite this, PCAs still treated for SSI with foliar applications an average of 1.1 - 1.2 times per season on about 60 % of fall lettuce. These applications typically occur after sprinkler pipe used for germination are removed from the field. Yield losses have been consistently at, or below average, since 2010. However, a significant increase in yield losses were seen in 2022 on fall lettuce, particularly in organic lettuce where no viable control options are available.

Flea beetles (FB) - Figure 5

FB is a good example of a lettuce pest where the presence of the pest on the crop does not necessary mean that PCAs need to control them. This is clearly illustrated by the data. Size of the crop will often determine the need for control. Small seedling lettuce plants (cotyledon-4 leaf stage) are very susceptible to FB feeding, whereas larger plant (> 4-leaf stage) can better tolerate low numbers of FB without economic damage. The number of treated acres and spray applications for FB have remained relatively steady over the years likely because FB is primarily a pest on young lettuce stands in early fall plantings. Incidence of FB on spring crops is much lower due to cooler temperatures and lack of alternative host like cotton and summer annual weeds) that serve as a source of infestations. Yield losses attributed to FB have been at or below average since 2012 and were at historically low levels in the 2019 season, only to peak on fall lettuce in 2022 again due to heavy pressure in organic lettuce where viable control options are limited.

***Bemisia* whiteflies** **(WF) - Figure 6**

WF are another example where presence of the pest on the lettuce crop does not necessarily trigger spray treatments. Whiteflies are still considered a major threat to fall lettuce, but estimates show that on average, less than 50% of the fall lettuce acers are treated with foliar sprays. However, it should be noted that about since 2005, about 80% of lettuce acers are annually treated with soil, at-planting applications of imidacloprid (see 2022 *Insecticide Use Summary*). When used at high rates (0.375 lb. AI/acre), imidacloprid can provide residual control of WF during stand establishment up to 30 days. If pressure is still heavy after this time, foliar sprays are often necessary. Because of the use of imidacloprid at-planting, coupled with an average of 1.4 sprays per season on almost 50% of the acres, yield losses have remained low (<0.4%) for fall lettuce. Yield losses on spring lettuce have historically been less than 1% (often 0%) because populations are much lower in the spring.

Green peach aphids **(GPA) - Figure 7**

GPA is an important economic pest on spring lettuce, where the presence of aphid colonies on lettuce plants will trigger spray treatments. In some cases, PCAs will treat prophylactically with foliar sprays, particularly near harvest where even low aphid numbers on lettuce heads/hearts can cause the product to be rendered unmarketable. Similar to WF control, a little more than 70% of lettuce acers are annually treated with soil, at-planting applications of imidacloprid specifically for aphid management (see *Insecticide Use Summary*). Although imidacloprid will effectively control aphids, PCAs annually treat about 70% of the acers >1.5 times per season to prevent contamination of spring lettuce at harvest. Average treated acres and numbers of sprays were well above average in 2022 largely due to the outbreak of lettuce aphids that occurred concurrently. Yield losses to GPA have remained below average over the past seven season but were above average in 2020. The overall trend in lower yield losses may reflect the availability of several effective insecticides with extended residual activity (e.g., Movento, Sequoia, Beleaf, Sivanto, PQZ and Versys).

Foxglove aphids **(FGA) - Figure 8**

FGA is the second most important next to GPA requiring treatments primarily in the spring. Because of the damage potential of FGA (infest hearts/heads), PCAs tend to treat lettuce acres prophylactically. For example, in 2019, FGA was present on ~20% of the acres, but almost 40% of the acres were treated. PCAs, on average spray 1.5 times to control FGA, as imidacloprid only provided marginal control of this species. Yield losses to FGA have been low over the past 10 years, following the registration of Movento in 2008. Like GPA, average treated acres and numbers of sprays were well above average in 2022 largely due to the outbreak of lettuce aphids that occurred concurrently.

Lettuce aphids **(FGA) - Figure 9**

LA is an important pest of spring lettuce, like FGA, but historically found on few fall and spring lettuce acres. However, LA reached outbreak levels in 2022 like we've never seen before, particularly in spring lettuce where >80% of the acres were sprayed an average of 3 times. Similarly, yield losses were 3-fold higher than average. Although LA is seldom seen on fall lettuce, it occurred earlier last season and PCA treated almost 60% of the fall acres twice to control the pest. PCAs tend to treat lettuce acres prophylactically because of the LA's behavior of infesting hard-to-reach terminal growth. Similarly, imidacloprid is marginally effective against LA, and PCAs tend to rely heavily on Movento, with additional help from Sequoia, Beleaf and Sivanto.

Western flower thrips **(WFT) - Figure 10**

WFT has always been a major pest of spring lettuce but has steadily emerged as a major pest of fall lettuce. This has been evident the past few years where percent treated acres and the number of spray applications have been well above average. Since 2005 it has been present in, and treated for, on a large percentage of the spring lettuce crop (> 90%), averaging almost 2.5 sprays per season. More recently, PCAs have reported a steady increase in treated acers for WFT on fall lettuce. In 2004 and 2005, PCAs reported they treated <40% of the fall acreage, whereas in 2019, greater than almost 90% of the fall acres were treated for WFT. This may in part be due to the increase in alfalfa acreage grown locally that serve as a source of WFT in the fall. This trend could also reflect the increased usage of the diamide insecticides for Lep control that are not effective against WFT, as opposed to Radiant and the OPs/Carbamates (acephate/methomyl). Yield losses to WFT have decreased steadily in spring lettuce. However, the discovery of Impatiens Necrotic Spot Virus in 2021 may account for above average spraying and record low yield losses in 2022.

Trash bugs (TB) - Figure 11

TB are considered minor pests and are comprised of several plant bug species (false chinch bug, Lygus bug, stink bugs, three-corned alfalfa hopper) that are contaminants on lettuce at harvest. TB occur on a large percentage of the acers but are treated on less than 30% of the acres where they are present. PCAs have consistently applied on average 1.3-.5 sprays per season for TB control. As a result, yield losses to TB have annually been minimal.

***Liriomyza* leafminers (LM) - Figure 12**

LM were a major pest of lettuce in the late 1980's and early 1990's, almost uncontrollable until the Section 18 registration of Agri-Mek. LM would now be considered an occasional pest which requires minimal management, and has caused almost no yield losses in lettuce. This is likely due to the use of selective chemistry being used in lettuce in general that preserves the LM's natural enemies, and specifically the high usage of Radiant (spinetoram) and Diamide insecticides being used for control of Lep larvae and thrips in fall and spring lettuce (see 2022 *Insecticide Use Summary*).

Grasshoppers (GH) - Figure 13

GH are a sporadic pest but can be very damaging when they are abundant. We began collecting data in 2007 after a large number of GH occurred the previous fall season. In 2008, large outbreaks were reported on fall lettuce and caused considerable damage. Since then treated acres have varied from year to year, and yield losses has generally been minimal. Treated acres have been well below average the past seven seasons.

Lygus bugs (LB) - Figure 14

Presence of LB on lettuce have only been estimated since 2010. Overall the average epercent acres where the pest is present and treated for have been < 10%. However, LB appears to be most important on spring lettuce where in 2019, PCAs reported treating ~50% of the acres, and reporting >1% damage. This outbreak of lygus can bee attributed largely to the higher rainfall conditions this winter and the resulting plant and weed growth in the surrounding landscape. LB have also been problematic on seed crops and melons in 2019.

Bean thrips (BT) - Figure 15

BT emerged as a pest in the fall of 2017, particularly on fall lettuce where they migrate from cotton and alfalfa consistent with changes in wind pattens when the monsoon flow ends. PCAs treated on average about 15% of fall and spring acers, 1-1.5 times. Yield losses to date were highest in fall 2019. Last season PCAs treated for BT over 2 times.

Acknowledgement: *Special thanks go out to all the PCAs and growers who took time away from their busy schedules to participate in these surveys over the pest 18 years. Without your efforts, this historical data would not exist.*

Table 1. Estimates of acres scouted by PCAs and the costs associated with applying insecticide sprays and scouting in lettuce.

Season	No. PCAs reporting	Acres reported		Avg. no. sprays		Spray application cost ($)	Acres scouted (%)	No. field visits/week	Scouting fees/ac ($)
		Fall	Spring	Fall	Spring				
2004_05	16	19,760	14,210	5.6	5.6	12.45	100	3.4	21.11
2005_06	18	24,300	21,970	5.5	5.0	11.50	100	4.1	24.50
2006_07	13	18,370	14,180	4.7	4.5	13.25	100	4.0	22.20
2007_08	11	16,219	11,000	4.8	4.5	14.50	100	3.7	22.80
2008_09	12	18,340	16,100	4.6	4.4	15.15	100	4.0	22.50
2009_10	14	20,133	18,667	4.6	4.3	15.75	100	4.1	24.00
2010_11	18	24,342	20,380	4.4	4.3	16.80	100	4.2	23.10
2011_12	13	21,245	15,920	4.3	4.3	17.75	100	3.8	22.50
2012_13	15	18,350	16,180	4.5	4.2	19.10	100	4.3	23.40
2013_14	23	31,587	28,502	4.5	4.6	20.60	100	4.3	22.80
2014_15	19	26,904	27,255	5.0	5.1	23.10	100	4.1	23.60
2015_16	22	28,650	29,920	4.7	4.8	22.90	100	5.0	23.15
2016_17	20	33,562	33,469	5.3	5.7	23.75	100	4.1	25.76
2017_18	25	44,180	37,720	4.7	4.7	24.11	100	3.8	25.55
2018-19	28	33,275	35,156	4.5	5.7	25.50	100	3.7	23.11
2019-20	15	22,070	25,520	4.6	5.7	24.12	100	3.9	30.30
2020-21	12	21865	21112	4.2	5.0	23.70	100	4.4	30.20
2021-22	24	34411	32761	4.6	4.6	26.50	100	4.2	34.50

Table 2. 18-year summary of pest status, economic and yield losses to insects in fall lettuce.

	Fall Lettuce				
Pest	**Acres pest present (%)**	**Acres treated (%)**	**No. of sprays**	**Avg. Spray Cost ($/ac)**	**Yield loss (%)**
Beet armyworm	95.8	95.4	3.0	109.80	0.76
Cabbage looper	80.8	80.2	2.5	82.39	0.51
Western flower thrips	84.6	63.4	1.8	46.92	0.41
Seedling, soil pests	82.3	59.8	1.2	10.72	0.72
Corn Earworm	51.1	53.7	2.1	41.75	0.50
Whitefly	75.3	40.0	1.4	20.85	0.32
Flea beetle	59.8	42.4	1.2	8.18	0.52
Trash bugs	60.0	27.5	1.5	6.99	0.08
Grasshoppers	23.1	13.2	1.1	3.37	0.20
Bean Thrips	14.6	17.3	1.7	12.17	0.09
Green peach aphid	12.5	12.3	1.3	6.54	0.11
Leafminers	51.3	11.0	1.1	6.08	0.07
Lygus bug	8.6	3.8	0.9	1.02	0.05
Foxglove aphid	2.7	2.5	1.1	0.93	0.06
Lettuce aphid	1.8	1.8	1.0	1.21	0.08
Salt marsh Caterpillar	2.8	0.9	0.8	0.27	0.05

[1] Does not include the cost of imidacloprid applications applied at-planting (18-year avg. of $22.78).

Table 3. 18-year summary of pest status, economic and yield losses to insects in spring lettuce.

Pest	Spring Lettuce				
	Acres pest present (%)	Acres treated (%)	No. of sprays	Avg. Spray Cost ($/ac)	Yield loss (%)
Western flower thrips	94.2	89.2	2.3	78.84	0.68
Green peach aphid	72.3	73.9	1.8	51.82	0.48
Cabbage looper	71.3	69.4	1.8	46.17	0.34
Beet armyworm	67.0	65.1	1.7	43.20	0.37
Corn Earworm	37.8	40.2	1.6	24.60	0.50
Seedling, soil pests	45.7	22.7	1.1	3.77	0.31
Trash bugs	46.2	22.5	1.3	5.34	0.09
Foxglove aphid	16.2	23.1	1.5	12.75	0.23
Flea beetle	22.7	12.8	1.1	2.97	0.15
Bean thrips	7.4	11.7	1.4	2.93	0.01
Whitefly	26.6	7.4	1.1	3.36	0.05
Lettuce aphid	10.9	15.7	1.5	6.54	0.25
Lygus bug	7.9	5.1	0.7	2.95	0.22
Leafminers	27.9	6.0	0.8	3.30	0.01
Grasshoppers	4.6	1.7	0.6	0.31	0.02
Salt marsh Caterpillar	0.8	0.1	1.0	0.08	0.00

[1] Does not include the cost of imidacloprid applications applied at-planting (18-year avg. of $22.78).

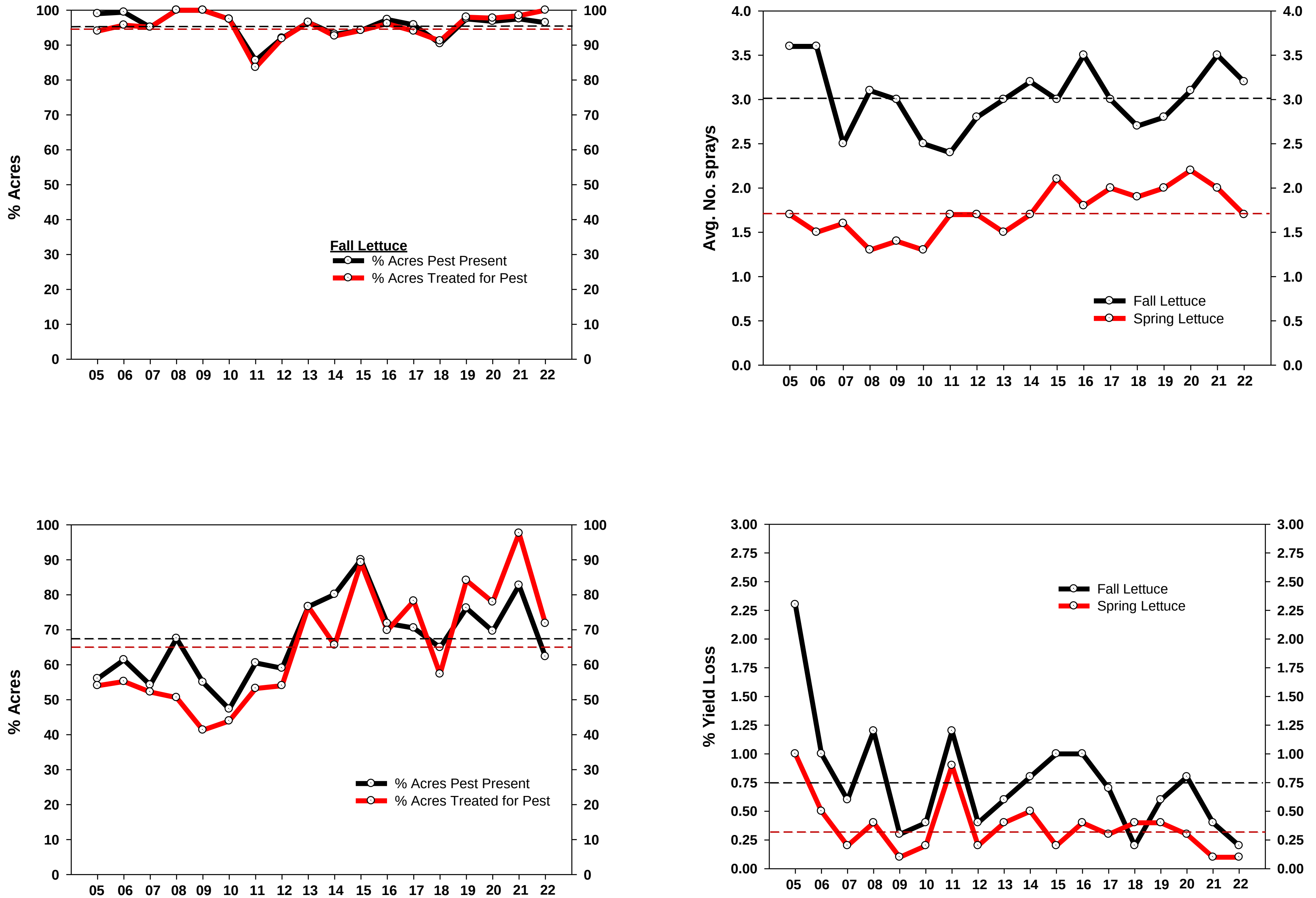

Figure 1. The % acres where **Beet armyworm** were present and % acres treated for in fall (top, left) and spring lettuce (bottom, left); seasonal average no. sprays to control pest (top, right); and % yield loss due (bottom, right) to beet armyworm in fall and spring lettuce, 2005-2022. Dashed lines denote 18-year average.

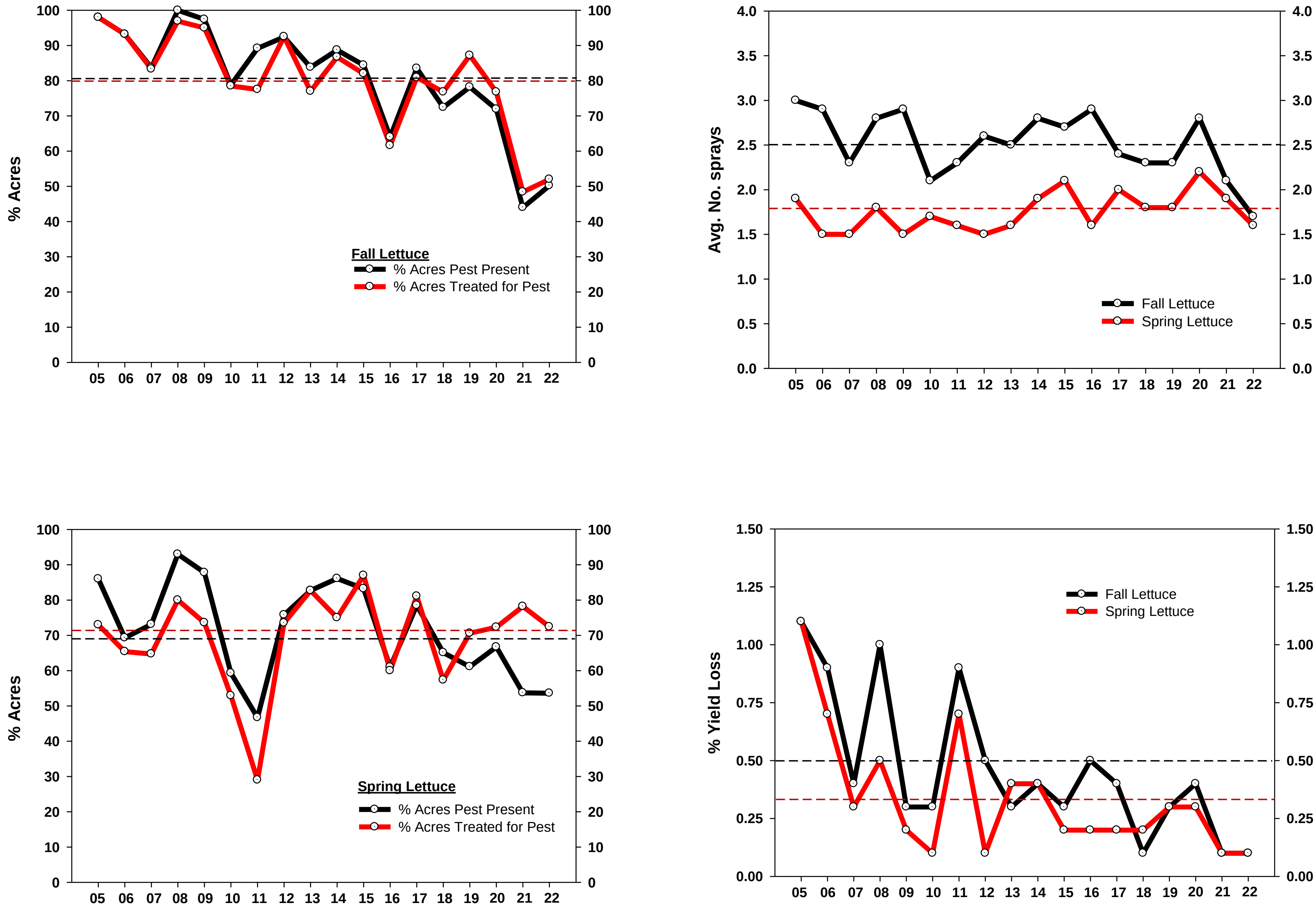

Figure 2. The % acres where **Cabbage looper** were present and % acres treated for in fall (top, left) and spring lettuce (bottom, left); seasonal average no. sprays to control pest (top, right); and % yield loss due (bottom, right) to beet armyworm in fall and spring lettuce, 2005-2022. Dashed lines denote 18-year average.

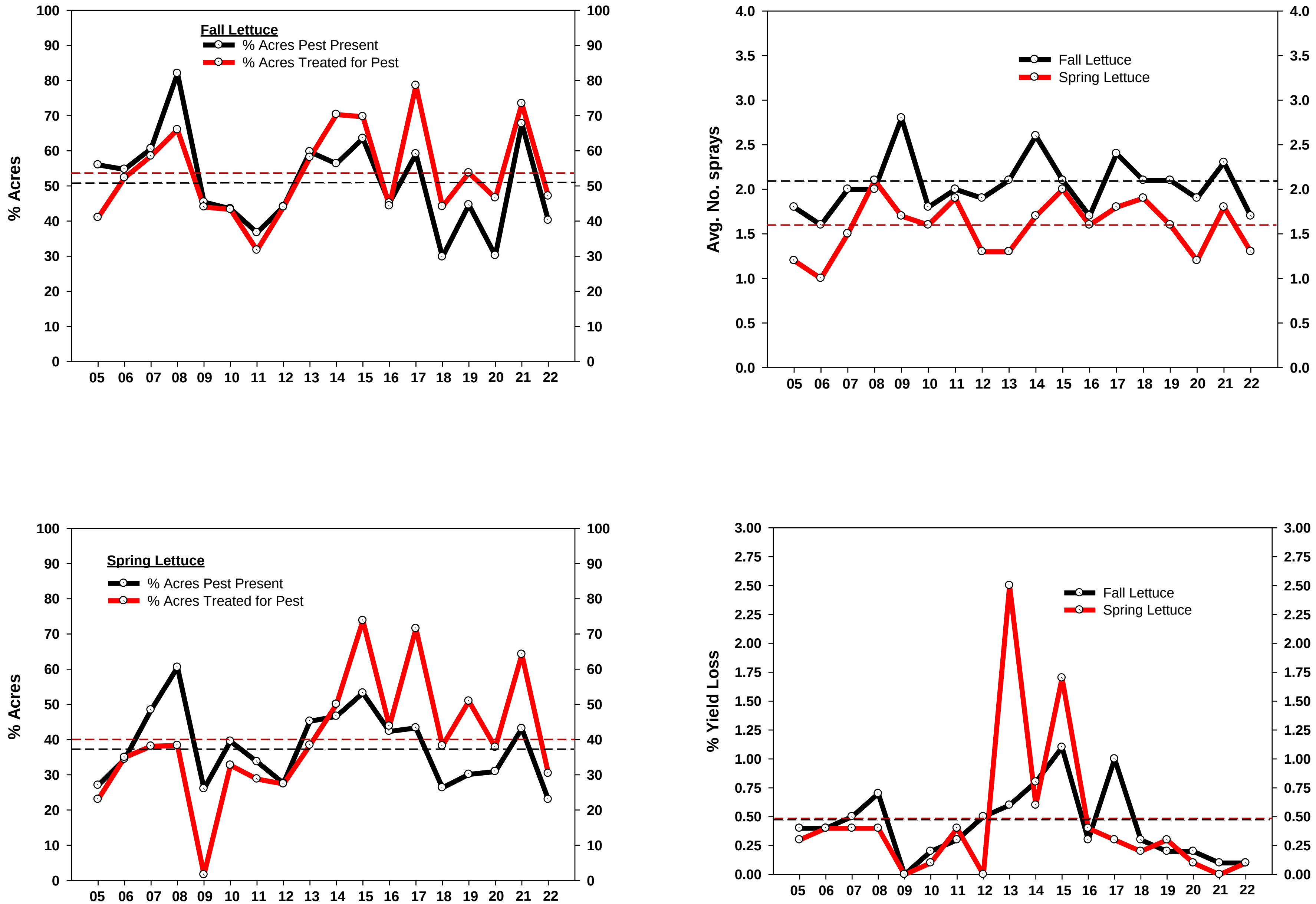

Figure 3. The % acres where **Corn earworm** were present and % acres treated for in fall (top, left) and spring lettuce (bottom, left); seasonal average no. sprays to control pest (top, right); and % yield loss due (bottom, right) to beet armyworm in fall and spring lettuce, 2005-2022. Dashed lines denote 18-year average.

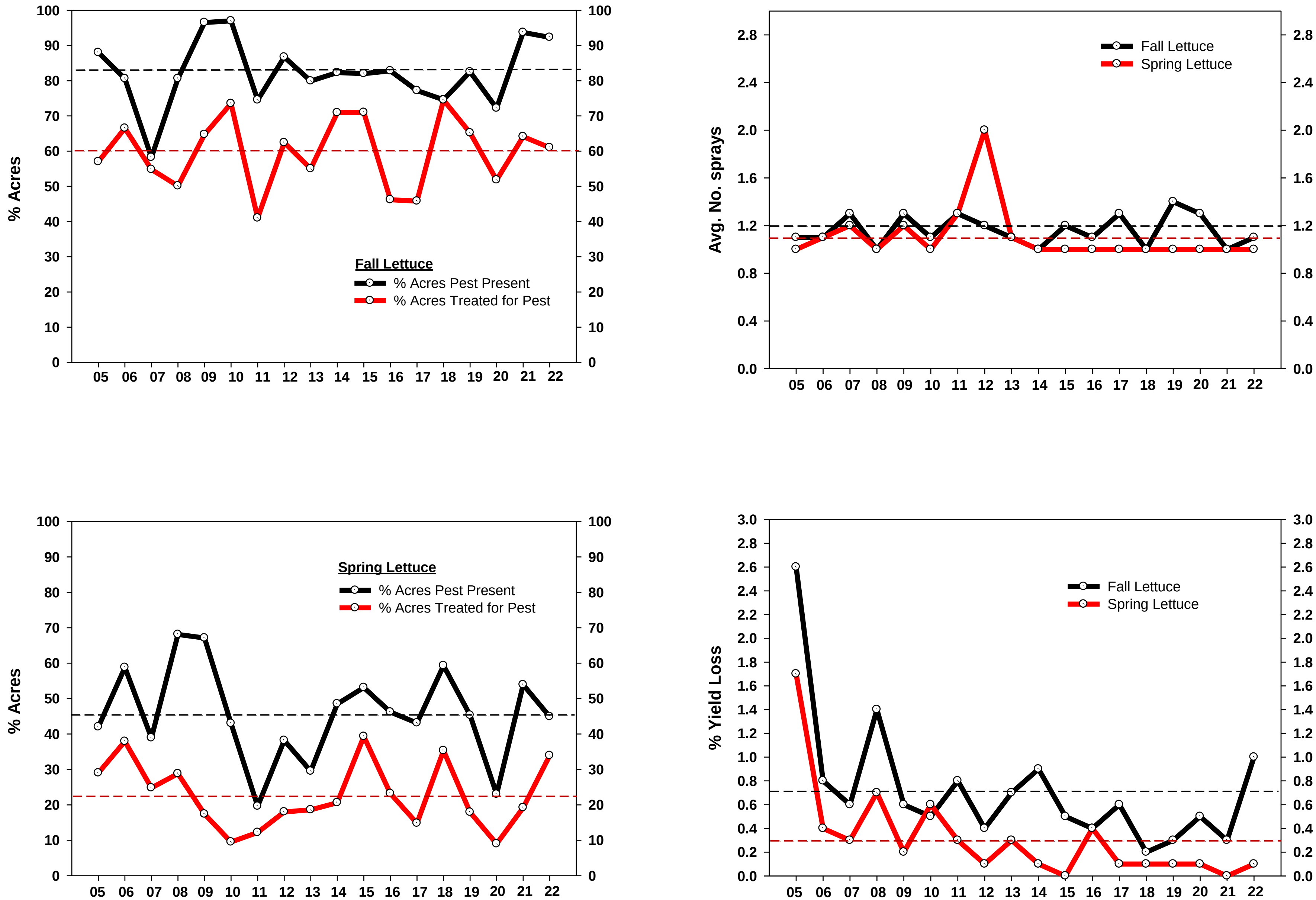

Figure 4. The % acres where **Seedling, soil pests** were present and % acres treated for in fall (top, left) and spring lettuce (bottom, left); seasonal average no. sprays to control pest (top, right); and % yield loss due (bottom, right) to beet armyworm in fall and spring lettuce, 2005-2022. Dashed lines denote 18-year average.

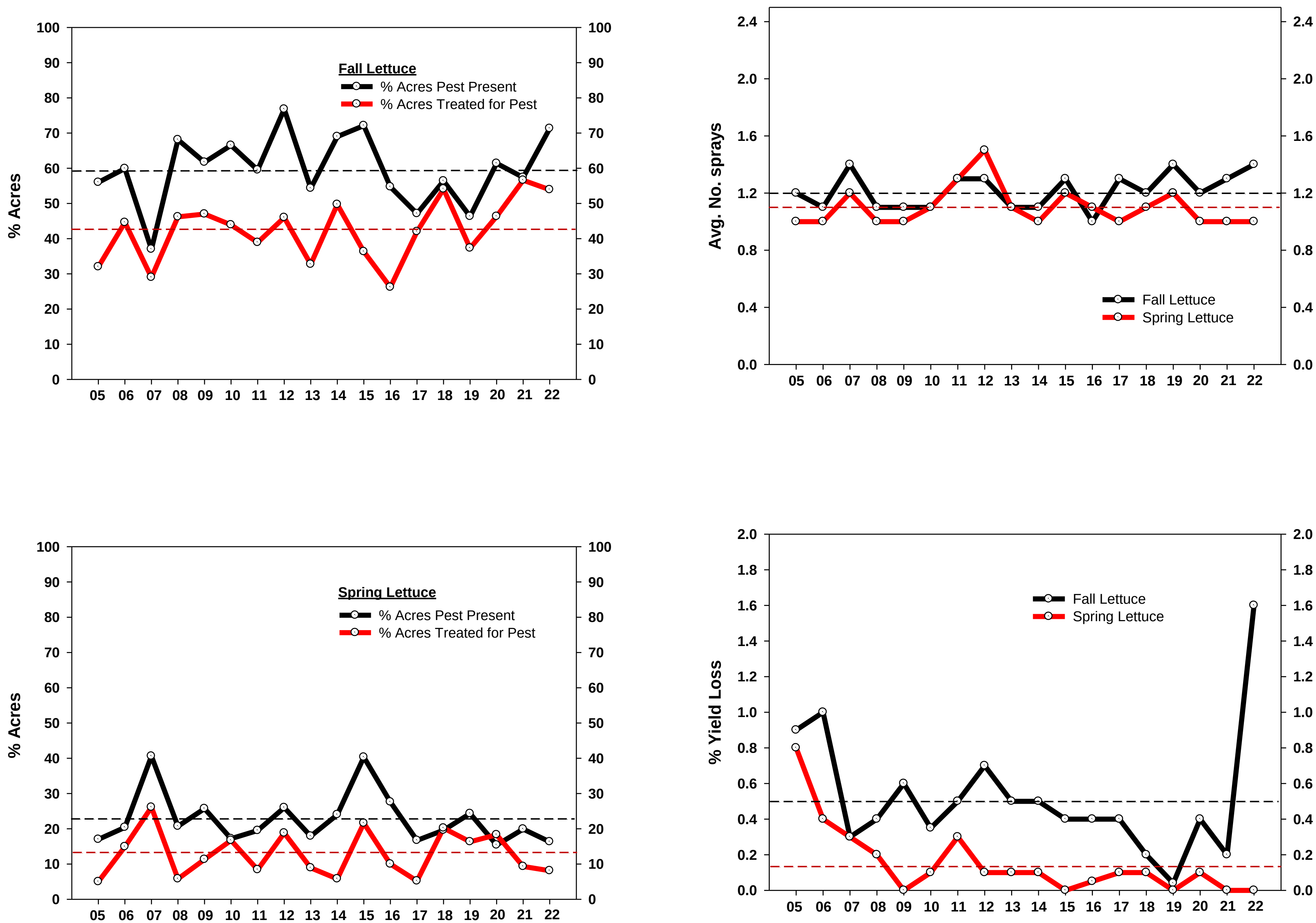

Figure 5. The % acres where **Flea beetles** were present and % acres treated for in fall (top, left) and spring lettuce (bottom, left); seasonal average no. sprays to control pest (top, right); and % yield loss due (bottom, right) to beet armyworm in fall and spring lettuce, 2005-2022. Dashed lines denote 18-year average.

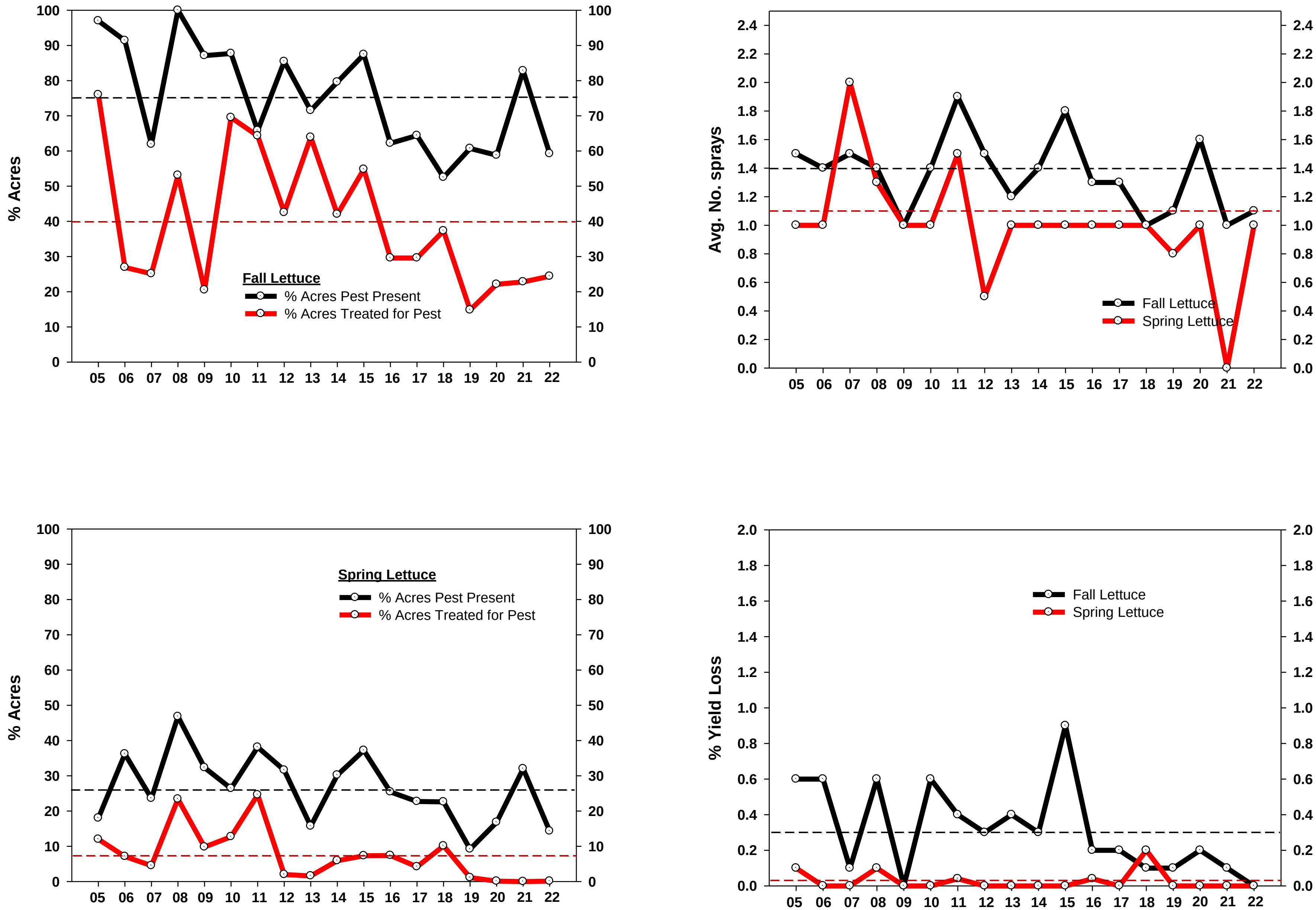

Figure 6. The % acres where ***Bemisia* whiteflies** were present and % acres treated for in fall (top, left) and spring lettuce (bottom, left); seasonal average no. sprays to control pest (top, right); and % yield loss due (bottom, right) to beet armyworm in fall and spring lettuce, 2005-2022. Dashed lines denote 18-year average.

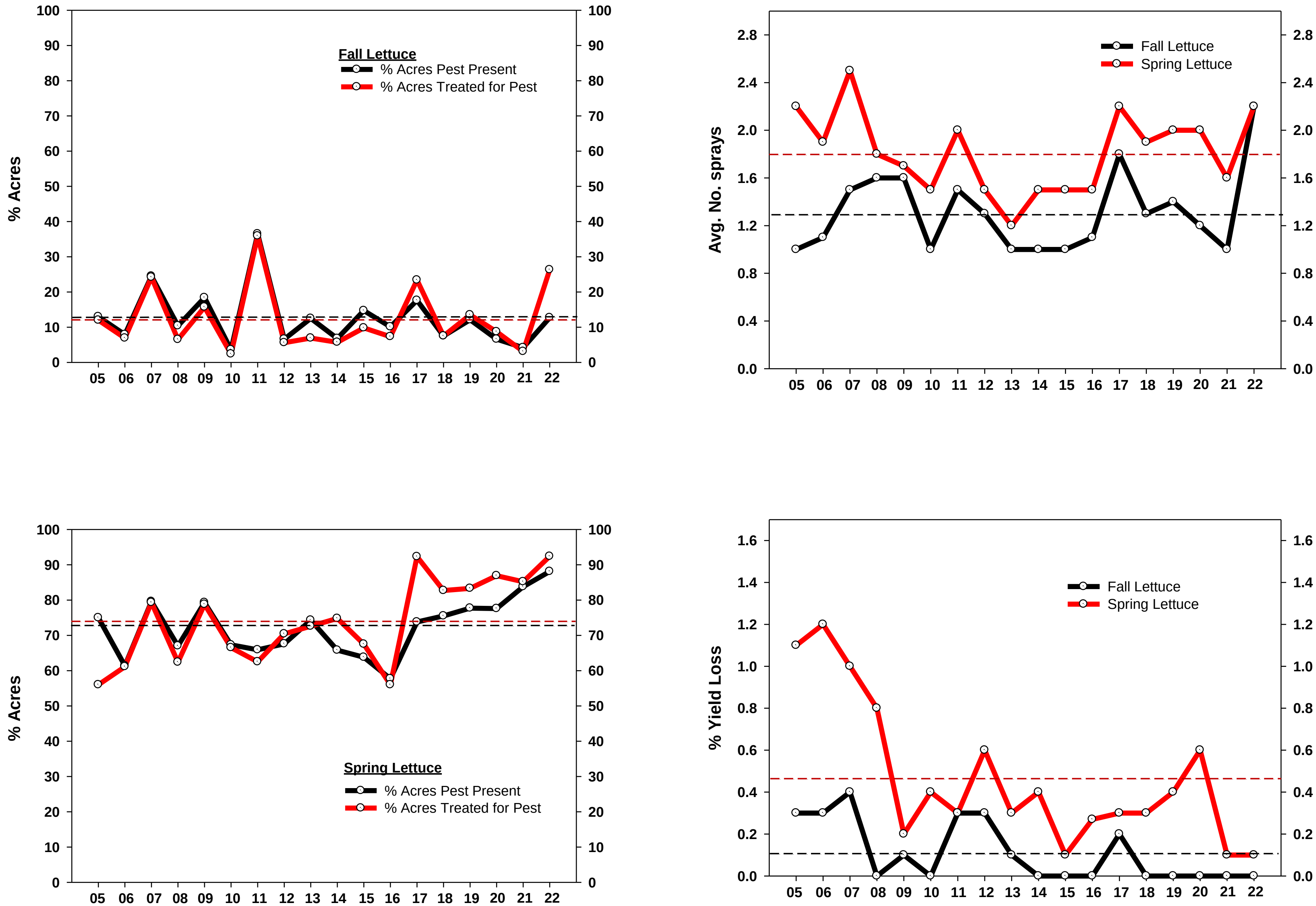

Figure 7. The % acres where **Green peach aphids** were present and % acres treated for in fall (top, left) and spring lettuce (bottom, left); seasonal average no. sprays to control pest (top, right); and % yield loss due (bottom, right) to beet armyworm in fall and spring lettuce, 2005-2022. Dashed lines denote 18-year average.

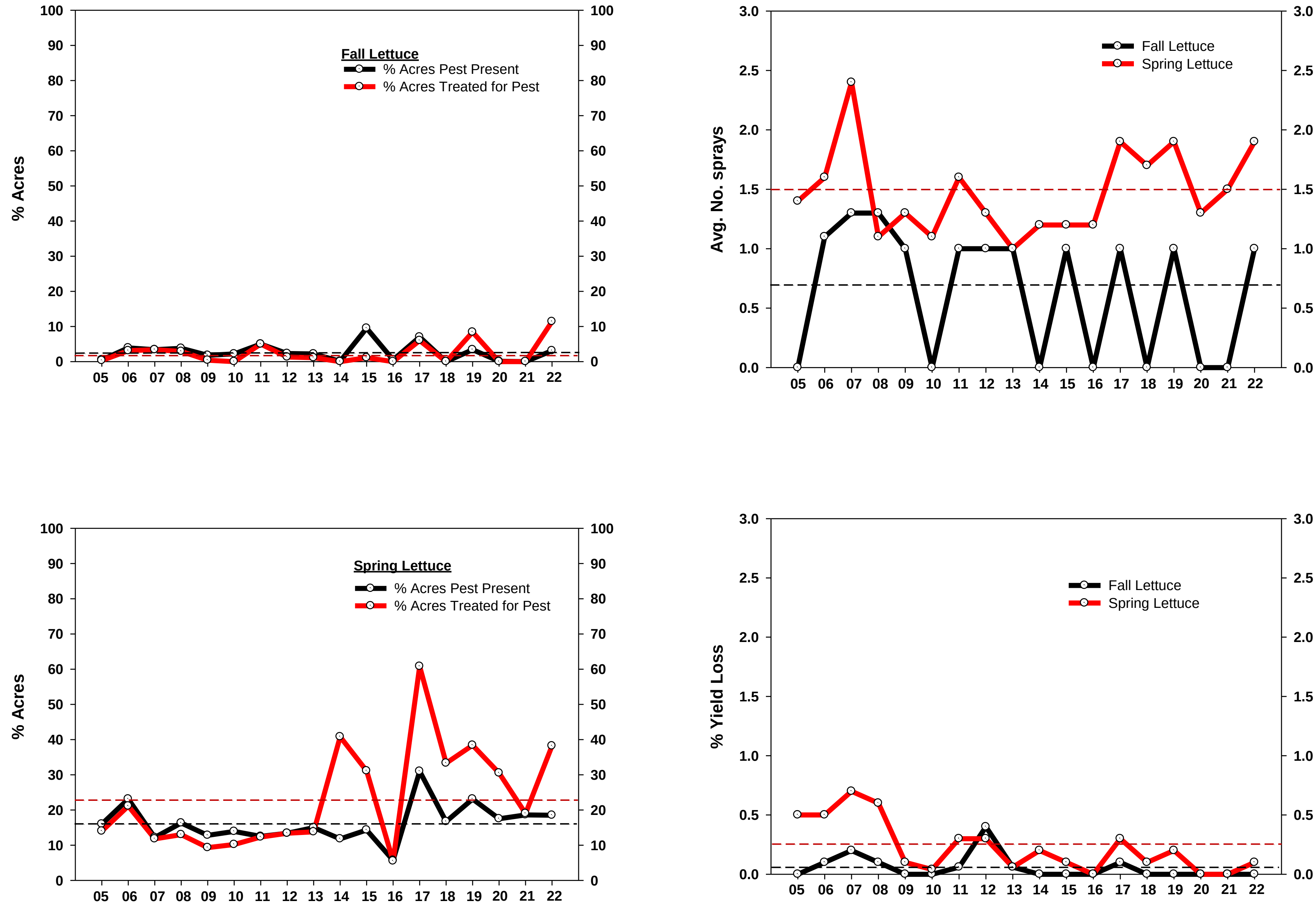

Figure 8. The % acres where **Foxglove aphids** were present and % acres treated for in fall (top, left) and spring lettuce (bottom, left); seasonal average no. sprays to control pest (top, right); and % yield loss due (bottom, right) to beet armyworm in fall and spring lettuce, 2005-2022. Dashed lines denote 18-year average.

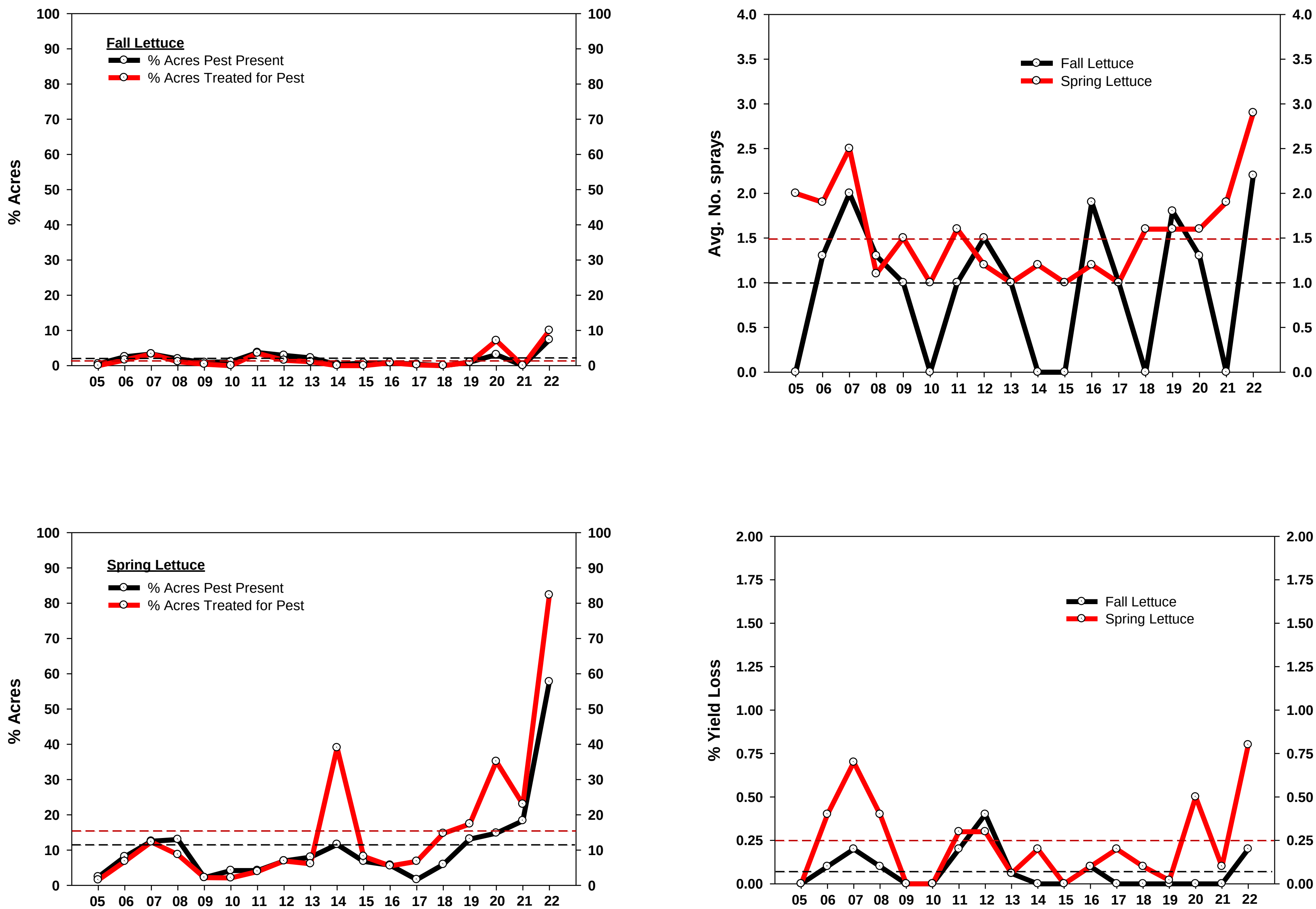

Figure 9. The % acres where **Lettuce Aphids** were present and % acres treated for in fall (top, left) and spring lettuce (bottom, left); seasonal average no. sprays to control pest (top, right); and % yield loss due (bottom, right) to beet armyworm in fall and spring lettuce, 2005-2022. Dashed lines denote 18-year average.

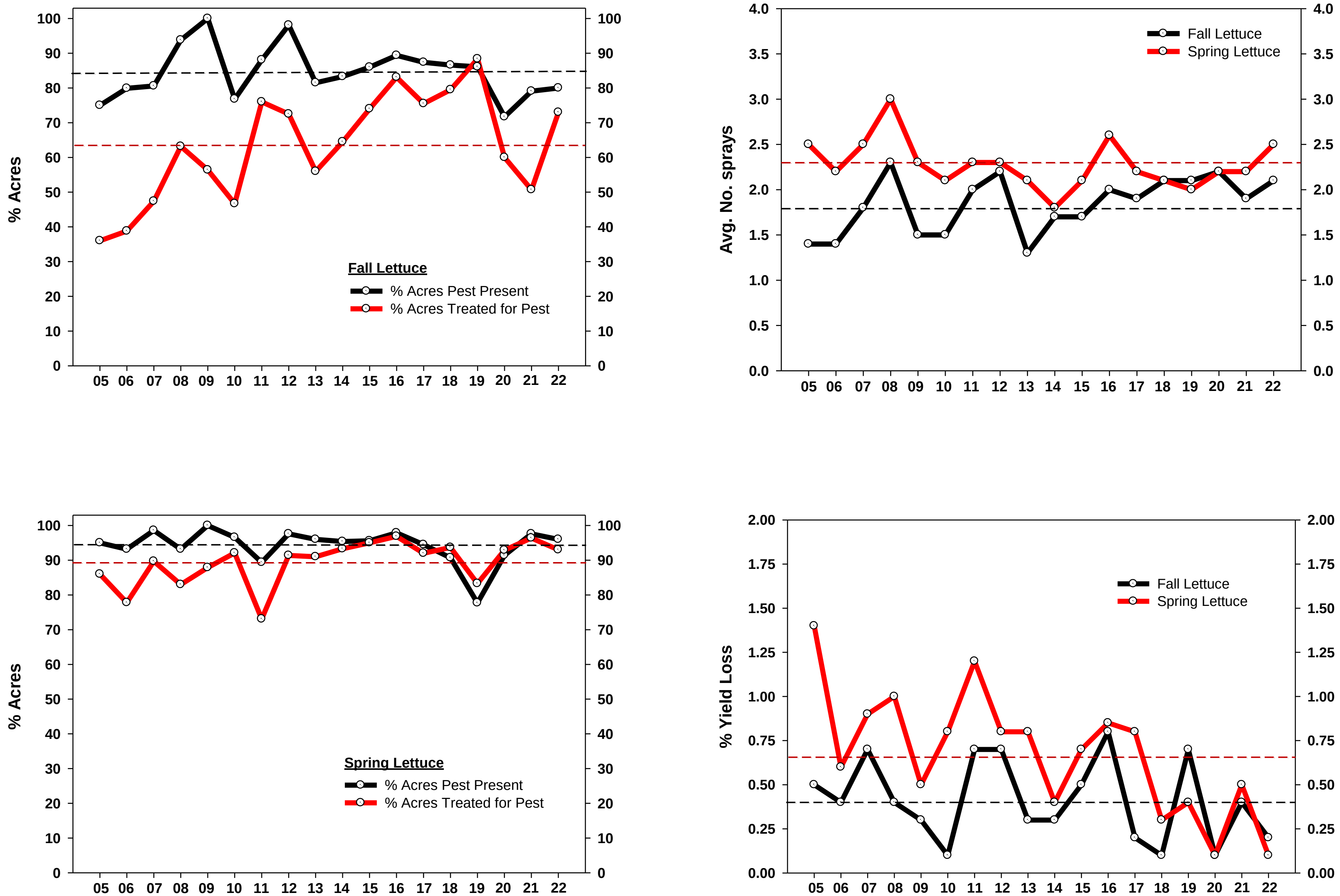

Figure 10. The % acres where **Western flower thrips** were present and % acres treated for in fall (top, left) and spring lettuce (bottom, left); seasonal average no. sprays to control pest (top, right); and % yield loss due (bottom, right) to beet armyworm in fall and spring lettuce, 2005-2022. Dashed lines denote 18-year average.

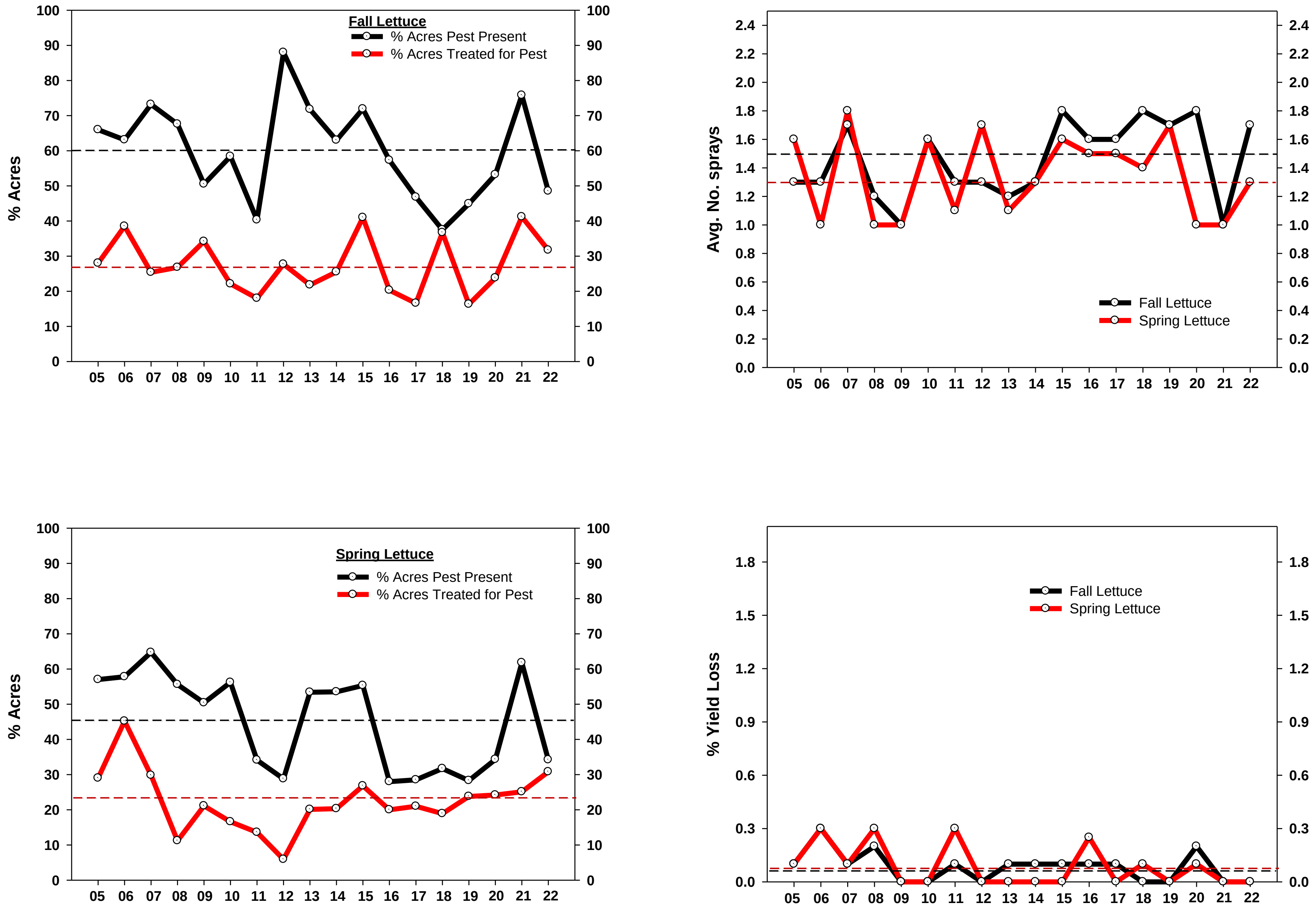

Figure 11. The % acres where **Trash bugs** were present and % acres treated for in fall (top, left) and spring lettuce (bottom, left); seasonal average no. sprays to control pest (top, right); and % yield loss due (bottom, right) to beet armyworm in fall and spring lettuce, 2005-2022. Dashed lines denote 18-year average.

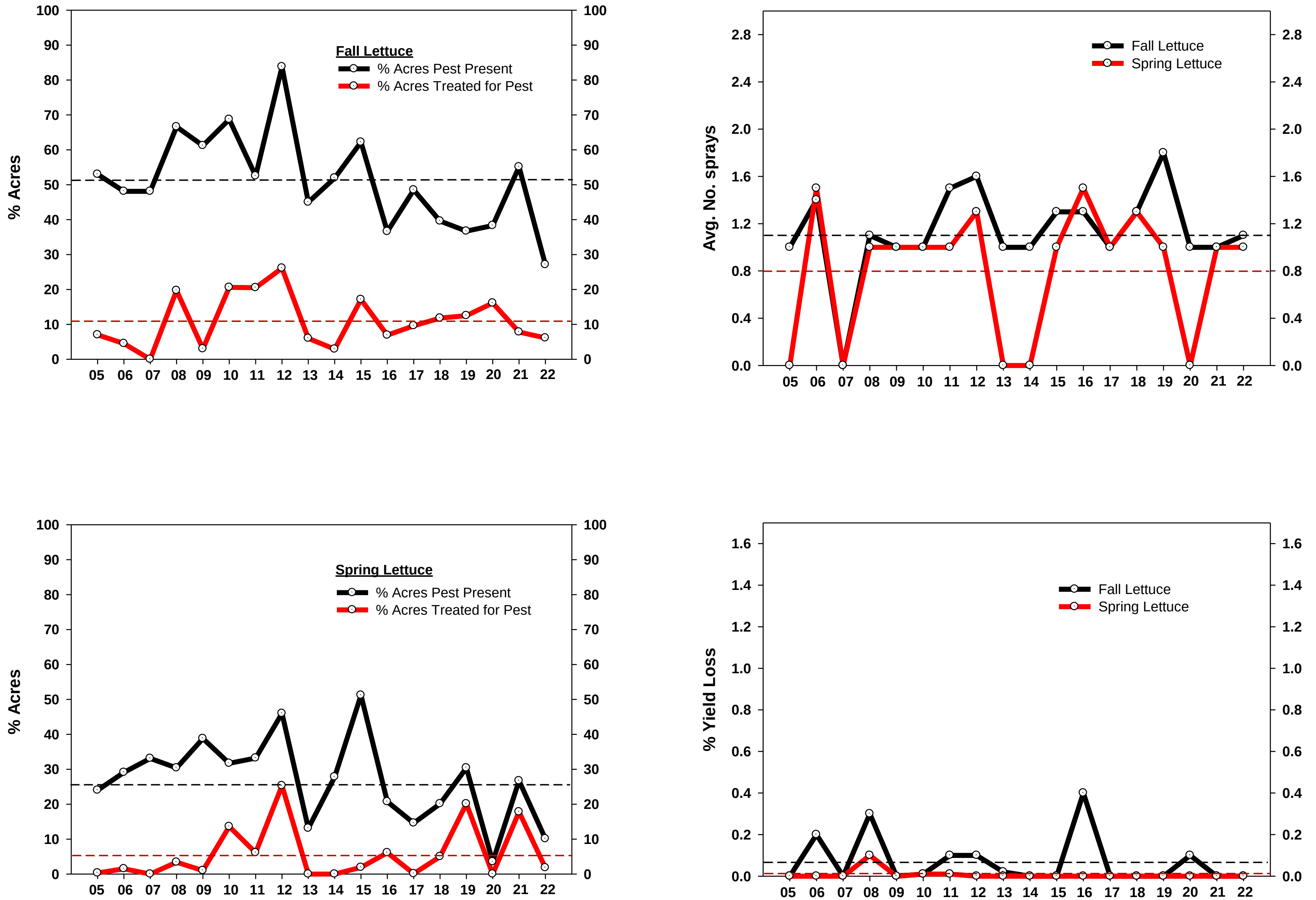

Figure 12. The % acres where ***Liriomyza* leafminers** were present and % acres treated for in fall (top, left) and spring lettuce (bottom, left); seasonal average no. sprays to control pest (top, right); and % yield loss due (bottom, right) to beet armyworm in fall and spring lettuce, 2005-2022. Dashed lines denote 18-year average.

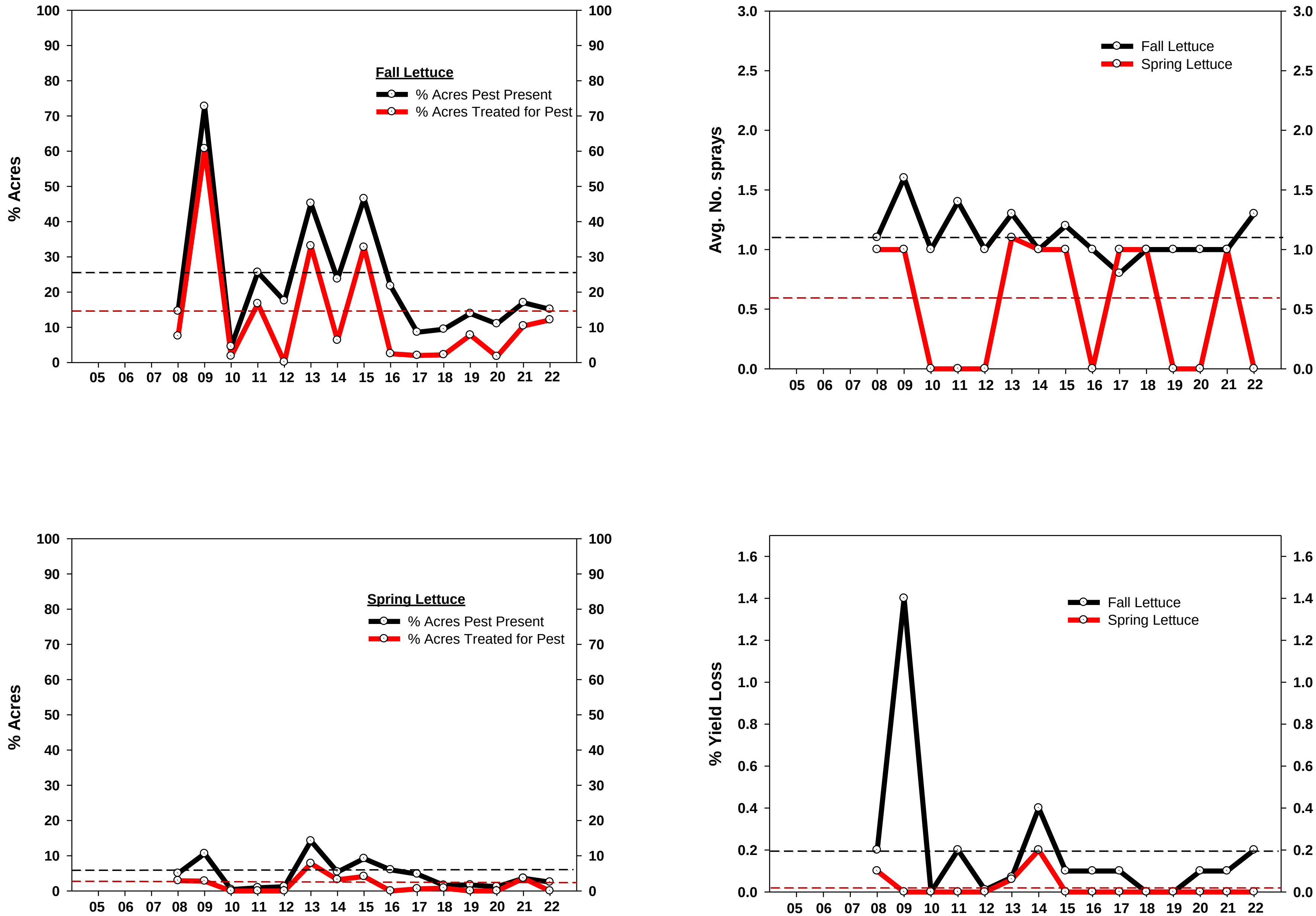

Figure 13. The % acres where **Grasshoppers** were present and % acres treated for in fall (top, left) and spring lettuce (bottom, left); seasonal average no. sprays to control pest (top, right); and % yield loss due (bottom, right) to beet armyworm in fall and spring lettuce, 2005-2022. Dashed lines denote 18-year average.

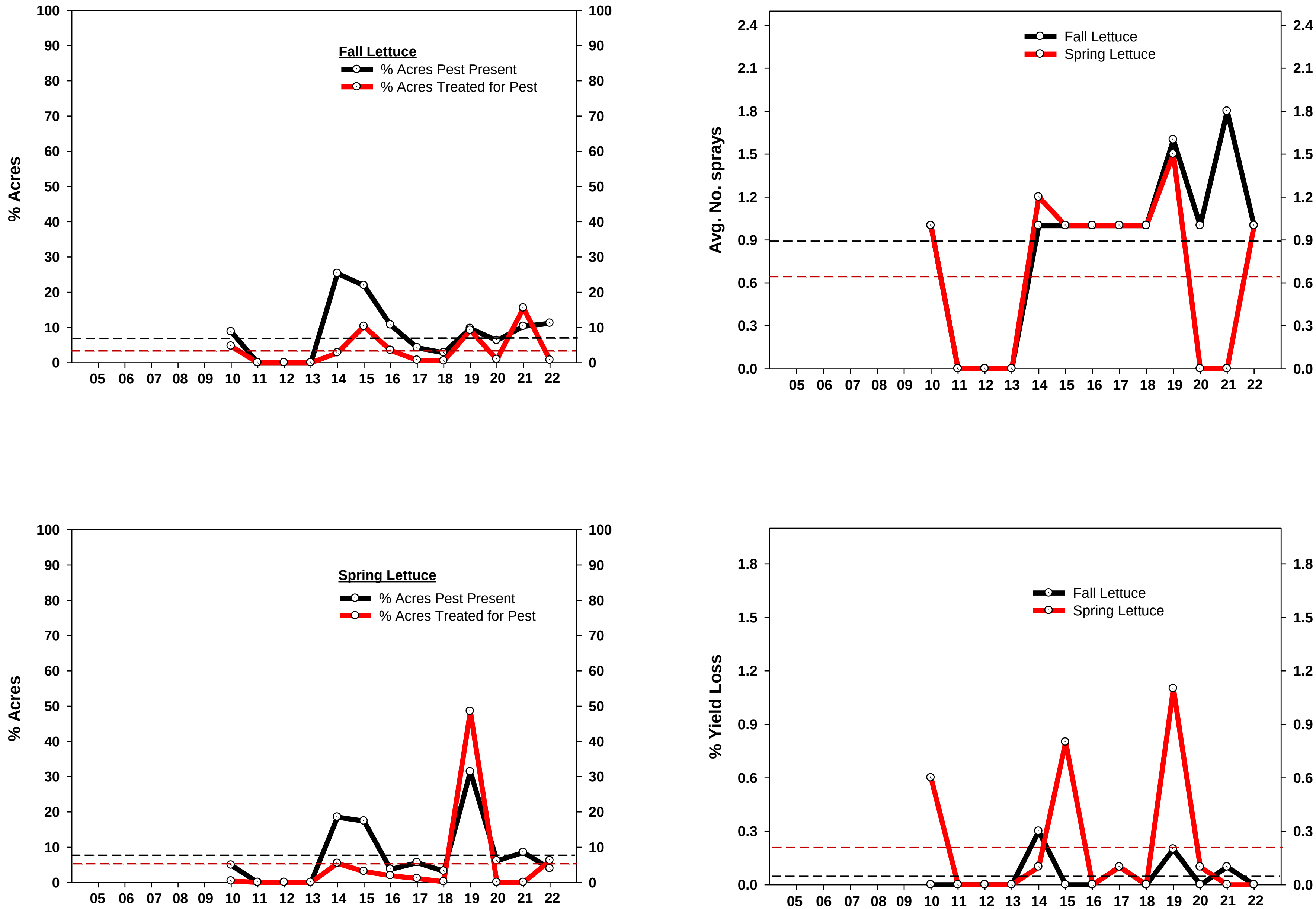

Figure 14. The % acres where **Lygus bugs** were present and % acres treated for in fall (top, left) and spring lettuce (bottom, left); seasonal average no. sprays to control pest (top, right); and % yield loss due (bottom, right) to beet armyworm in fall and spring lettuce, 2005-2022. Dashed lines denote 18-year average.

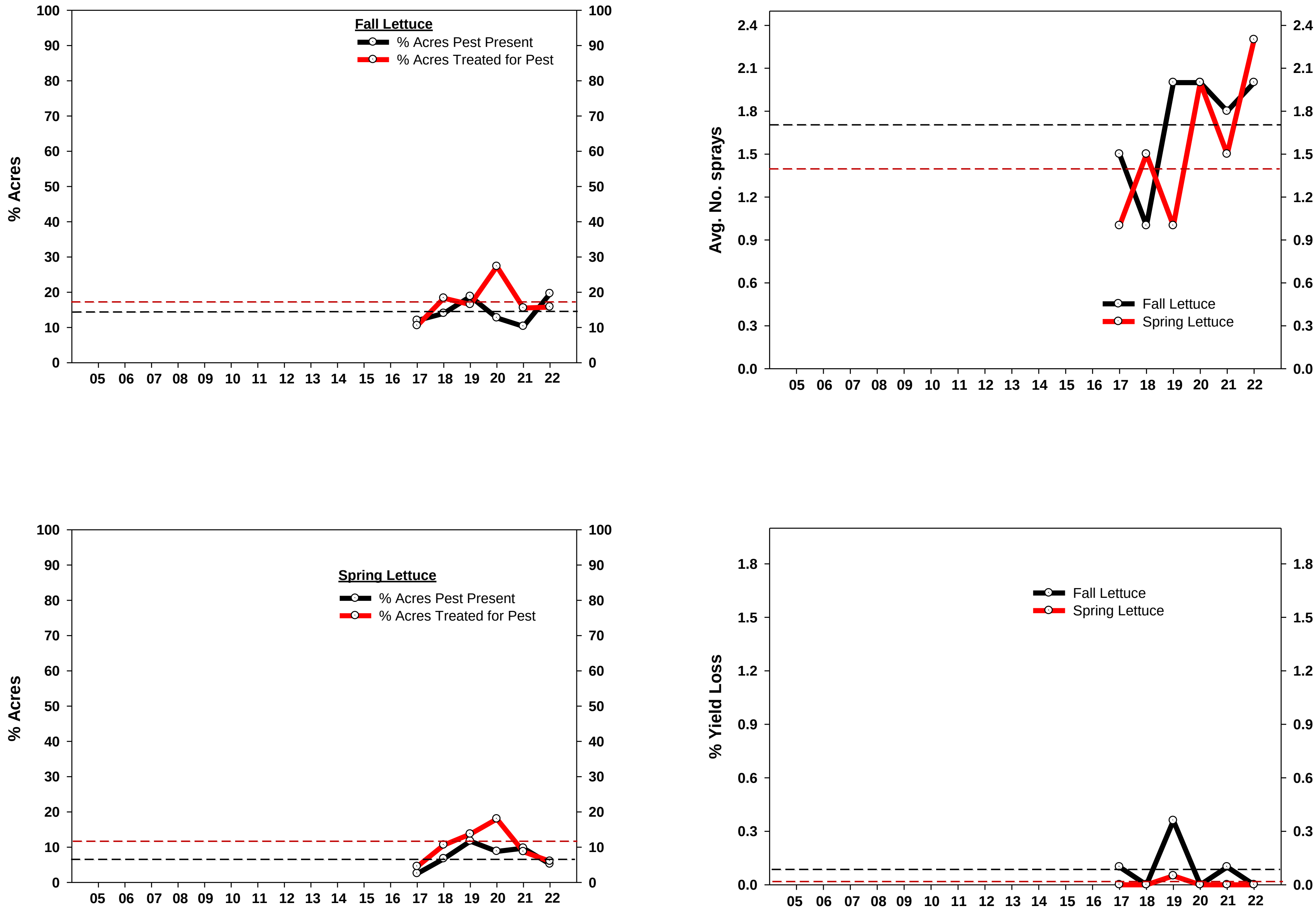

Figure 15. The % acres where **Bean thrips** were present and % acres treated for in fall (top, left) and spring lettuce (bottom, left); seasonal average no. sprays to control pest (top, right); and % yield loss due (bottom, right) to beet armyworm in fall and spring lettuce, 2005-2022. Dashed lines denote 18-year average.