Table 2.2. Aboveground biomass ($Mg \cdot ha^{-1}$) and carbon-to-nitrogen (C:N) ratio of cereal rye-hairy vetch cover crop at termination[z], Ames, IA, 2014 and 2015.

	2014		2015	
Treatment[y]	Biomass	C:N ratio	Biomass	C:N ratio
CT	6.2 b[w]	23:1 b	6.2 b	25:1 b
ST	13.0 a	42:1 a	9.3 a	31:1 a
NT	11.6 a	43:1 a	7.0 b	34:1 a
Significance	***	***	**	*

[z]Dates of termination: conventional tillage = 7 May 2014 and 13 May 2015; no tillage and strip tillage = 3 June 2014 and 1 June 2015.
[y]CT = Conventional tillage; ST = Strip tillage; NT = No tillage.
[x]Biomass data were log-transformed for homogeneity of variance and normality before analysis and back transformed for presentation.
[w]Means and medians within the same column followed by the same letter are not significantly different according to Fisher's protected LSD ($P \leq 0.05$).
*, **, ***Significant at $P \leq 0.05$, 0.01, or 0.001, respectively, based on F test.

Table 2.3. Marketable and total broccoli yield and average marketable broccoli head diameter as affected by tillage and fertility treatments, Ames, IA, 2014 and 2015.

	2014			2015		
Treatment[z]	Marketable yield ($Mg \cdot ha^{-1}$)	Total yield ($Mg \cdot ha^{-1}$)	Head diam (cm)	Marketable yield ($Mg \cdot ha^{-1}$)	Total yield ($Mg \cdot ha^{-1}$)	Head diam (cm)
Tillage (T)						
CT	5.9 a[y]	7.1 a	8.6	20.6	21.3	11.3
ST	3.2 b	4.1 b	7.7	19.0	21.5	10.7
NT	4.1 b	3.9 b	8.5	20.4	19.8	11.1
Significance	***	**	NS	NS	NS	NS
Fertility (F)						
Preplant	6.4 a	7.2 a	9.1 a	22.6 a	23.5 a	11.7 a
Split	5.8 a	6.8 a	8.6 a	22.5 a	23.2 a	11.5 a
No fert	0.9 b	2.3 b	7.1 b	14.9 b	15.9 b	9.8 b
Significance	***	***	*	***	***	***
T × F	NS	NS	NS	NS	NS	NS

[z]CT= Conventional tillage; ST=Strip tillage; NT=No tillage; Preplant = only preplant fertilizer; Split = 2/3 of N from preplant fertilizer and 1/3 from fertigation; No fert = unfertilized control.

[y]Means in a column within the same column and treatment followed by the same letter are not significantly different according to Fisher's protected LSD ($P \leq 0.05$).

NS, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively, based on F test.

Table 2.4. Leaf nitrogen, SPAD readings, plant height, stem diameter, and dry weight of broccoli plants as affected by tillage and fertility treatments, Ames, IA, 2014 and 2015[z].

Treatment[y]	2014					2015				
	Leaf N[x] (%)	SPAD	Plant height (cm)	Stem diam[w] (mm)	Plant dry weight[v] (g)	Leaf N (%)	SPAD	Plant height (cm)	Stem diam (mm)	Plant dry weight (g)
Tillage										
CT	4.3[u]	70.9	48.1 a	16.9 a	195.3	3.9	75.0	63.7	20.5	226.5
ST	4.2	70.8	41.2 b	15.2 b	175.1	3.8	74.3	59.5	18.2	258.4
NT	4.1	67.5	37.1 b	14.2 b	156.2	3.7	74.0	57.7	19.9	255.1
Significance	NS	NS	*	**	NS	NS	NS	NS	NS	NS
Fertility										
Preplant	4.4	73.4 a	47.2 a	17.6 a	219.3 a	4.1 a	75.4 a	63.4 a	21.3 a	288.3 a
Split	4.2	70.8 a	46.8 a	16.8 a	180.4 b	3.9 a	75.1 a	62.6 a	20.2 a	247.7 a
No fert	4.0	65.0 b	32.3 b	11.9 b	126.9 c	3.4 b	72.7 b	54.9 b	17.1 b	203.9 b
Significance	NS	***	***	***	***	**	**	***	*	**
T × F	NS	NS	***	NS	*	NS	NS	NS	NS	NS

[z]Measurements were taken on 8 Aug. 2014 and 26 July 2015, after the final fertigation event.

[y]CT= Conventional tillage; ST=Strip tillage; NT=No tillage; Preplant = only preplant fertilizer; Split = 2/3 of N from preplant fertilizer and 1/3 from fertigation; No fert = unfertilized control.

[x]Percent nitrogen of dried and ground leaf-petioles. Samples were comprised of 20 broccoli leaves.

[w]Diameter of stem measured 2 cm above soil level.

[v]Dry weight of two whole plants.

[u]Means in a column within the same column and treatment followed by the same letter are not statistically different according to Fisher's protected LSD ($P \leq 0.05$).

NS, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively, based on F test.

Table 2.5. Effects of no tillage, strip tillage, and conventional tillage on average minimum, mean, and maximum soil temperature (°C) at 6-inch depth during early[z], mid[y], and late[x] seasons of broccoli production, Ames, IA, 2014 and 2015.

	Minimum			Mean			Maximum		
Treatment[w]	Early	Mid	Late	Early	Mid	Late	Early	Mid	Late
				2014					
CT	20.2 a[v]	20.4 a	19.6	22.3 a	22.6 a	21.7 a	24.8 a	24.9 a	24.3 a
ST	19.4 b	19.8 b	19.6	20.9 b	21.2 b	20.9 b	22.7 b	22.7 b	22.4 b
NT	19.1 b	19.3 c	19.2	20.7 b	20.8 b	20.6 b	22.5 b	22.6 b	22.3 b
Significance	***	***	NS	***	**	*	***	*	***
				2015					
CT	20.6 a	22.3	19.9	23.0 a	23.8 a	22.0 a	25.9 a	25.6 a	24.7 a
ST	19.5 b	21.8	19.7	21.2 b	22.9 b	21.2 b	23.2 b	24.1 b	22.9 b
NT	19.3 b	21.8	19.6	20.6 c	22.8 b	20.9 b	22.1 c	23.9 b	22.3 b
Significance	**	NS	NS	***	**	***	***	**	**

[z]Early season: 14 June–14 July 2014; 17 June–12 July 2015.

[y]Midseason: 15 July–13 Aug. 2014; 13 July–6 Aug. 2015.

[x]Late season: 14 Aug.–15 Sept. 2014; 7 Aug.–2 Sept. 2015.

[w]CT= Conventional tillage; ST=Strip tillage; NT=No tillage.

[v]Means within column and year followed by the same letter are not significantly different according to Fisher's protected LSD ($P \leq 0.05$).

NS, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively, based on F test.

Table 2.6. In-row and between-row weed biomass ($g \cdot m^2$) and density (weeds$\cdot m^2$) as affected by three tillage treatments, Ames, IA, 2014[z] and 2015.

		2014		2015	
Tillage[y]	Region[x]	Biomass	Density	Biomass	Density
CT	BR	1.1 ab[w]	129.9 a	24.4 a	113.6 a
	IR	1.8 a	171.5 a	4.3 b	57.4 ab
ST	BR	0.3 c	1.3 b	0.6 c	4.5 c
	IR	1.0 ab	124.2 a	1.2 bc	29.8 bc
NT	BR	0.0 c	0.0 b	2.0 bc	29.8 bc
	IR	0.5 bc	53.9 ab	2.4 bc	36.9 bc

[z]Weeds were sampled on 2 July 2014 and 8 July 2015.
[y]CT= Conventional tillage; ST=Strip tillage; NT=No tillage;
[x]IR=In-row; BR=Between- row.
[w]Means within a column and treatment followed by the same letter are not significantly different according to the unprotected LSD ($P \leq 0.05$).
NS, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively, based on F test.

Table 3.2. Effects of no tillage, strip tillage, and conventional tillage on minimum, mean, and maximum soil temperature (°C) at 15 cm depth during early, mid, and late seasons of pepper production, Ames, IA, 2014 and 2015.

	Minimum			Mean			Maximum		
Treatment[y]	Early[x]	Mid	Late	Early	Mid	Late	Early	Mid	Late
				2014					
CT	20.3 a[z]	22.0 a	16.9	22.7 a	25.2 a	18.8	25.2 a	27.0 a	20.8 a
NT	18.9 b	20.5 b	16.7	20.7 c	23.1 c	18.1	22.6 c	23.6 c	19.7 b
ST	18.9 b	20.7 b	16.4	21.4 b	23.7 b	18.6	24.2 b	25.6 b	21.5 a
Significance	***	***	NS	***	***	NS	***	***	*
				2015					
CT	22.1 a	22.9 a	19.3	24.7 a	24.4 a	21.4 a	27.7 a	27.8 a	23.9 a
NT	20.6 b	21.7 b	19.3	22.3 c	22.0 c	20.5 b	24.1 b	24.7 b	22.0 b
ST	20.8 b	22.0 b	19.3	22.8 b	22.9 b	20.9 ab	25.1 b	25.6 b	22.7 b
Significance	***	***	NS	***	***	*	***	***	*

[x]Early: 14 June – 21 July 2014; 14 June – 17 July 2015. Mid: 22 July – 28 Aug. 2014; 18 July – 19 Aug. 2015. Late: 29 Aug. – 2 Oct. 2014; 20 Aug. – 22 Sept. 2015.

[y]CT= Conventional tillage; ST=Strip tillage; NT=No tillage.

[z]Means within a column and year followed by the same letter are not significantly different according to Fisher's protected lsd ($P \leq 0.05$).

NS, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively, based on F test

Table 3.3. Effects of tillage treatments on volumetric soil moisture content ($m^3 m^{-3}$ soil) measured at 15 cm depth during early, mid, and late seasons[x] of pepper production, Ames, IA, 2014 and 2015.

	2014			2015		
Treatment[y]	Early	Mid	Late	Early	Mid	Late
CT	40.1[z]	38.7	39.2	29.8 b	29.4 b	30.8
ST	40.3	38.8	39.7	34.4 a	33.3 a	33.5
NT	39.4	37.9	39.0	34.4 a	32.9 a	33.0
Significance	NS	NS	NS	***	**	NS

[x]Early: 26 June – 31 July 2014; 20 June – 22 July 2015. Mid: 1 Aug. – 31 Aug. 2014; 23 July – 23 Aug. 2015. Late: 1 Sept. – 2 Oct. 2014; 24 Aug. – 24 Sept. 2015.

[y]CT= Conventional tillage; ST=Strip tillage; NT=No tillage.

[z]Means within a column followed by the same letter are not significantly different according to Fisher's protected LSD ($P \leq 0.05$).

NS, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively, based on F test

Table 3.4. Marketable and total pepper yield as affected by tillage and fertility treatments, Ames, IA, 2014 and 2015.

Treatment[y]	2014				2015			
	Marketable		Total		Marketable		Total	
	Yield (Mg ha^{-1})	No. of fruits (1000s ha^{-1})	Yield (Mg ha^{-1})	No. of fruits (1000s ha^{-1})	Yield (Mg ha^{-1})	No. of fruits (1000s ha^{-1})	Yield (Mg ha^{-1})	No. of fruits (1000s ha^{-1})
Tillage (T)								
CT	17.9	107	21.5	140	37.7 a	202 a	43.8 a	257 a
NT	16.0	96	19.9	134	21.8 b	143 b	27.7 b	208 b
ST	16.6	102	26.4	152	23.4 b	139 b	29.3 b	193 b
Significance	NS	NS	NS	NS	**	**	**	*
Fertility (F)								
Preplant	18.9 a[z]	114 a	25.6	156 a	26.1	153 b	31.4 b	203 b
Split	14.7 b	90 b	19.6	127 b	29.2	169 a	35.8 a	236 a
Significance	**	**	NS	**	NS	*	*	**
T × F	NS	NS	NS	NS	NS	NS	NS	*

[y]CT= Conventional tillage; ST=Strip tillage; NT=No tillage; Preplant = only preplant fertilizer; Split = 2/3 of N from preplant fertilizer and 1/3 from fertigation.

[z]Means within a column and treatment followed by the same letter are not significantly different according to Fisher's protected LSD ($P \leq 0.05$).

NS, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively, based on F test

Table 3.5. Plant growth (leaf nitrogen concentration, SPAD readings, plant height, stem diameter, and dry weight) as affected by tillage and fertility treatments, Ames, IA, 2014 and 2015[u].

Treatment[v]	2014					2015				
	Leaf N[w] %	SPAD	Plant height (cm)	Stem dia[x] (mm)	Plant dry weight[y] (g)	Leaf N %	SPAD	Plant height (cm)	Stem dia (mm)	Plant dry weight (g)
Tillage (T)										
CT	5.1 a[z]	60.0	35.3	9.0	109.3	4.6 a	67.3 a	52.1	12.6	211.2
NT	4.5 b	58.0	38.4	9.3	91.5	4.2 b	60.1 b	54.7	12.4	211.1
ST	4.5 b	57.5	39.8	10.2	105.5	3.9 b	60.9 b	56.0	12.3	205.9
Significance	*	NS	NS	NS	NS	*	***	NS	NS	NS
Fertility (F)										
Preplant	4.8	59.9 a	39.3 a	9.6	109.6	4.2	63.3	54.1	12.4	213.3
Split	4.6	57.1 b	36.4 b	9.4	94.6	4.2	62.2	54.4	12.5	205.5
Significance	NS	**	**	NS	NS	NS	NS	NS	NS	NS
T × F	NS	NS	NS	NS	NS	NS	NS	NS	*	NS

[u]Leaf N, SPAD, height, and diameter measurements were taken on 8 Aug. 2014 and 26 July 2015, after the final fertigation event. Plant dry weight samples were collected on 3 Oct. 2014 and 22 Sept. 2015.

[v]CT= Conventional tillage; ST=strip tillage; no tillage (NT). Preplant = only preplant fertilizer; Split = 2/3 of N from preplant fertilizer and 1/3 from fertigation.

[w]Percent nitrogen of dried and ground leaf-petioles. Samples were comprised of 40 pepper leaves.

[x]Stem diameter measured 2 cm above soil level.

[y]Dry weight of two whole plants with fruits removed.

[z]Means within the same column and treatment followed by the same letter are not statistically different according to Fisher's protected LSD ($P \leq 0.05$).

NS, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively, based on F test.

Table 3.6. Aboveground biomass and carbon-to-nitrogen (C:N) ratio of cereal rye/hairy vetch cover crop at time of termination with roller crimper, Ames, IA, 2014 and 2015.

	2014		2015	
Treatment[y]	Dry weight (Mg ha^{-1})	C:N Ratio	Dry weight (Mg ha^{-1})	C:N Ratio
CT	6.7 b[z]	19 c[z]	4.0 c	24 c
NT	13.9 a	40 a	6.5 b	37 a
ST	13.7 a	35 b	9.5 a	32 b
Significance	***	***	***	***

[y]CT= Conventional tillage; ST=Strip tillage; NT=No tillage.
[z]Medians within dry weight columns and means within C:N ratio columns followed by the same letter are not significantly different according to Fisher's protected LSD ($P \leq 0.05$). Dry weight data were log-transformed for homogeneity of variance and converted to original units for presentation.
NS, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively, based on F test.

Table 3.7. Main effects of tillage, fertility, sampling region, and sampling depth on microbial biomass carbon (MBC) and microbial biomass nitrogen (MBN) on early mid, and late sampling dates[x], Ames, IA, 2014.

	MBC (µg g^{-1} oven-dry soil)			MBN (µg g^{-1} oven-dry soil)		
	Early	Mid	Late	Early	Mid	Late
Tillage						
Conventional (CT)	452[z]	334	568	87	51	78
No tillage (NT)	498	320	528	108	48	73
Strip tillage (ST)	440	335	580	90	48	83
Fertility[y]						
Preplant	464	341	538	101	51	75
Split	462	319	580	89	48	81
Region						
Between-row	466	305	544	90	44	76
In-row	459	357	573	100	56	80
Depth						
0–7.5 cm	495	367	596	101	56	85
7.5–15 cm	432	297	522	89	43	72
Contrasts						
CT vs. NT	0.1977	0.5599	0.3423	**0.0512**	0.6153	0.5498
CT vs. ST	0.7268	0.9794	0.7784	0.7508	0.6171	0.5976
NT vs. ST	0.1061	0.5428	0.2229	**0.1020**	0.9980	0.2641
Fertility	0.9405	0.2143	0.1552	0.1643	0.5149	0.4470
Region	0.7471	**0.0010**	0.2865	0.2399	**0.0082**	0.5962
Depth	**0.0046***	**<.0001**	**0.0065**	0.1416	**0.0037**	**0.0710**

[x]Early = 8 July 2014; Mid = 14 Aug. 2014; Late = 30 Sept. 2014.

[y]Preplant = only preplant fertilizer; Split = 2/3 of N from preplant fertilizer and 1/3 from fertigation.

[z]Data were log-transformed for homogeneity of variance and converted to original units for presentation.

*P-values highlighted in bold font are significant ($P \leq 0.10$) based on 1-df contrasts.

Table 3.8. Main effects of tillage, fertility, sampling region, and sampling depth on microbial biomass carbon (MBC) and microbial biomass nitrogen (MBN) on early, mid, and late sampling dates, Ames, IA, 2015.

	MBC (µg g^{-1} oven-dry soil)			MBN (µg g^{-1} oven-dry soil)		
Treatment:	Early[x]	Mid	Late	Early	Mid	Late
Tillage						
Conventional (CT)	832[z]	729	698	118	87	100
No tillage (NT)	891	788	789	116	102	124
Strip tillage (ST)	914	819	744	123	104	116
Fertility[y]						
Preplant	870	776	754	119	98	115
Split	887	779	732	120	97	111
Region						
Between-row	896	787	744	128	98	112
In-row	861	768	742	111	97	114
Depth						
0–7.5 cm	902	843	831	118	104	124
7.5–15 cm	856	718	664	120	91	103
Contrasts						
CT vs. NT	0.3817	0.2906	0.1821	0.8783	**0.0872**	**0.1026**
CT vs. ST	0.2328	0.1245	0.4824	0.7852	**0.0618**	0.2750
NT vs. ST	0.7393	0.5992	0.5174	0.6704	0.8736	0.5867
Fertility	0.7094	0.9318	0.6503	0.9374	0.9219	0.7474
Region	0.4027	0.5524	0.9692	0.1776	0.9478	0.9069
Depth	0.2744	**0.0001***	**0.0002**	0.8339	**0.0965**	**0.0846**

[x]Early 1 = 2 July 2015; Mid = 14 Aug. 2015; Late = 23 Sept. 2015.

[y]Preplant = only preplant fertilizer; Split = 2/3 of N from preplant fertilizer and 1/3 from fertigation.

[z]Data were log-transformed for homogeneity of variance and converted to original units for presentation.

*P-values highlighted in bold font are significant ($P \leq 0.10$) based on 1-df contrasts.

Table 3.9. Interaction effects of sampling depth, region, and tillage treatment on average well color development (AWCD) and substrate richness based on community-level physiological profiling, Ames, IA, 2014 and 2015.

Treatment			AWCD		Richness	
Depth	Region	Tillage	2014	2015	2014	2015
0 – 7.5 cm	Between-row	Conventional	0.385[z]	0.629	21.3	24.9
		No tillage	0.415	1.088	18.2	26.7
		Strip tillage	0.274	1.247	19.0	28.3
	In-row	Conventional	0.351	1.010	21.0	25.8
		No tillage	0.507	1.033	17.2	25.8
		Strip tillage	0.429	1.189	21.7	27.5
7.5 – 15 cm	Between-row	Conventional	0.308	0.665	20.7	22.7
		No tillage	0.346	0.747	19.7	23.3
		Strip tillage	0.223	1.065	16.5	26.5
	In-row	Conventional	0.357	0.661	20.7	22.0
		No tillage	0.260	0.989	19.0	19.2
		Strip tillage	0.465	1.166	22.3	27.2
	Significance					
		Depth (D)	0.1198	**0.0026***	0.9545	0.0867
		Region (R)	0.1087	0.4056	0.5451	0.7095
		Tillage (T)	0.7546	0.0588	0.6646	0.7107
		D × R	0.9756	0.8062	0.6646	0.7107
		D × T	0.3220	0.7055	0.5383	0.3264
		R × T	0.1097	0.8397	0.7337	0.5553
		D × R × T	0.3582	**0.0185**	0.4594	0.8493

[z]Data were log-transformed for analysis and converted to original units for presentation.
*P-values highlighted in bold font are significant ($P \leq 0.05$) based on 1-df contrasts.

Table 3.10. Post-harvest soil chemical characteristics as affected by tillage and fertility treatments, Ames, IA, 2014 and 2015.

Treatment[y]	2014					2015				
	Inorg. N	P	K	pH[z]	OM[z]	Inorg. N	P	K	pH	OM
	(mg kg^{-1})				(%)	(mg kg^{-1})				(%)
Tillage										
CT	0.22	25	146	6.7	3.3	1.11	33	116	6.6	4.0
NT	0.32	34	132	6.8	3.2	1.55	45	112	6.8	4.0
ST	0.29	34	144	6.7	3.2	1.25	36	98	6.7	4.0
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Fertilty										
Preplant	0.25	38	138	---	---	1.48	52	113	---	---
Split	0.29	39	144	---	---	1.11	42	112	---	---
Significance	NS	NS	NS			NS	NS	NS		

[y]CT= Conventional tillage; ST=Strip tillage; NT=No tillage; Preplant = only preplant fertilizer; Split = 2/3 of N from preplant fertilizer and 1/3 from fertigation.

[z]pH and organic matter (OM) were sampled only to the whole plot level before fertilizer treatments were applied.

NS, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively, based on F test.

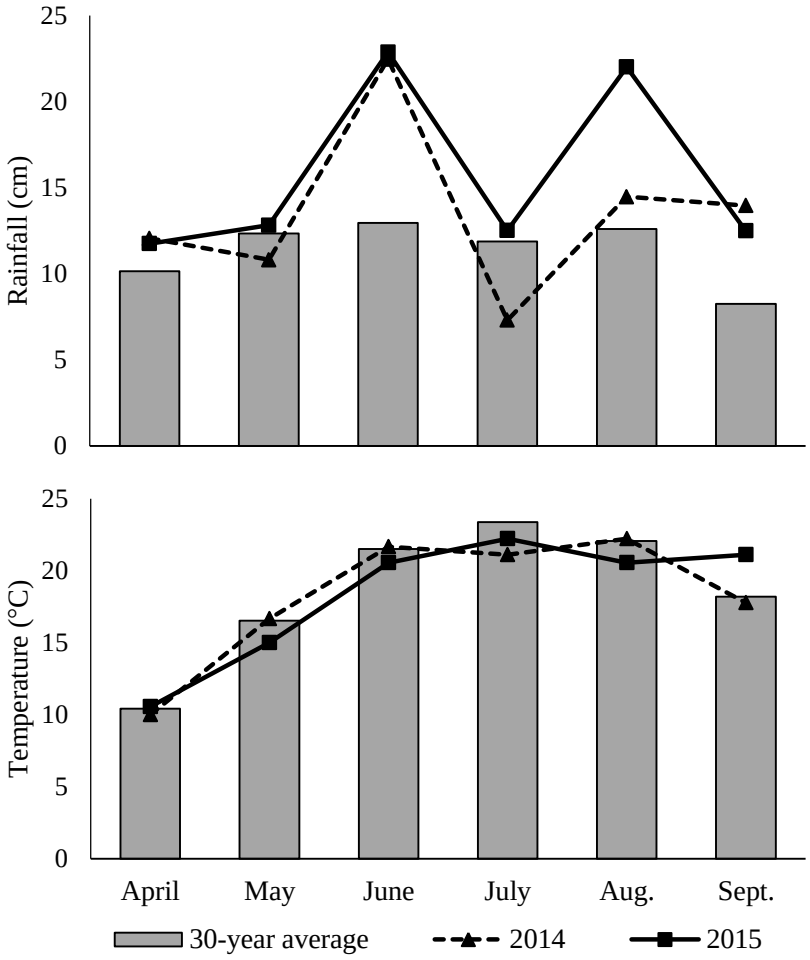

Fig. 3.1. Average monthly rainfall (above) and air temperature (below) in 2014 and 2015 compared with 30-year averages in Ames, IA. Data were obtained from the Iowa Environmental Mesonet Network, Iowa State University.

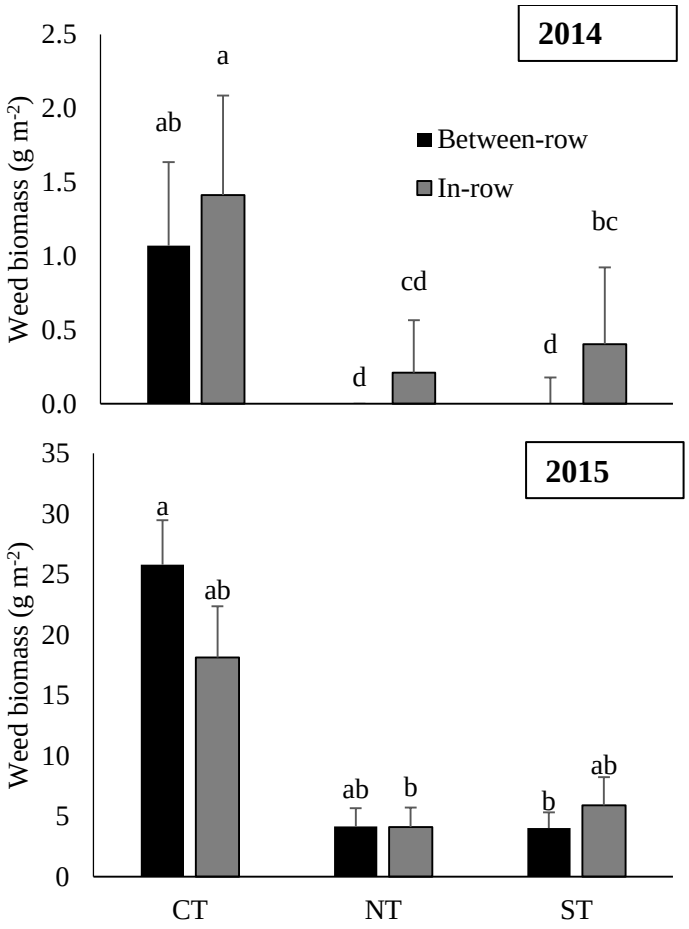

Fig. 3.2. Weed biomass in between-row and in-row regions of conventional tillage (CT), no tillage (NT), and strip tillage (ST) plots in 2014 (top) and 2015 (bottom). Samples were taken on 2 July 2014 and 8 July 2015. Bars with labels not containing the same letter are significantly different according to Fisher's protected LSD ($P \leq 0.05$). Error bars represent standard errors of means.

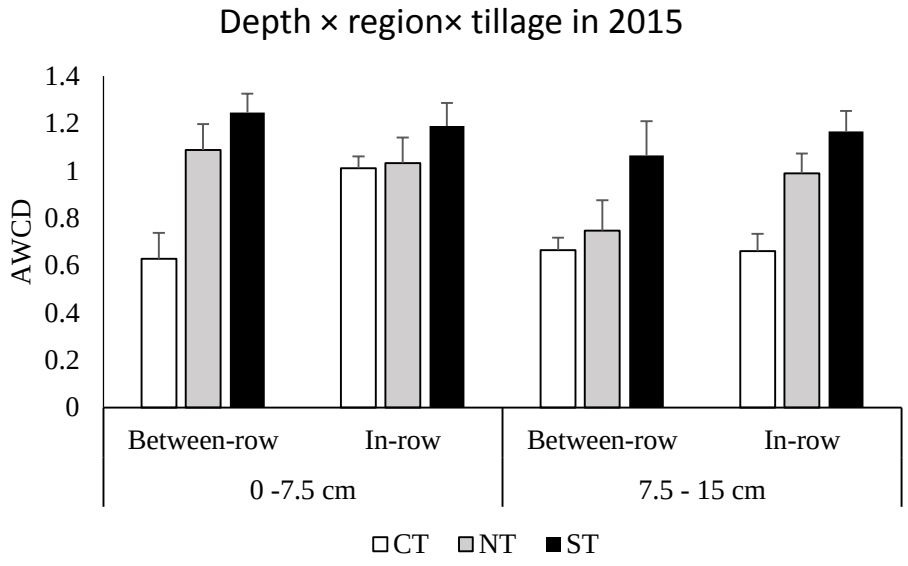

Fig. 3.3. Interaction effects of sampling depth, region, and tillage treatment on average well color development (AWCD) in Biolog-Ecoplates© in 2015. Error bars represent standard errors of means.

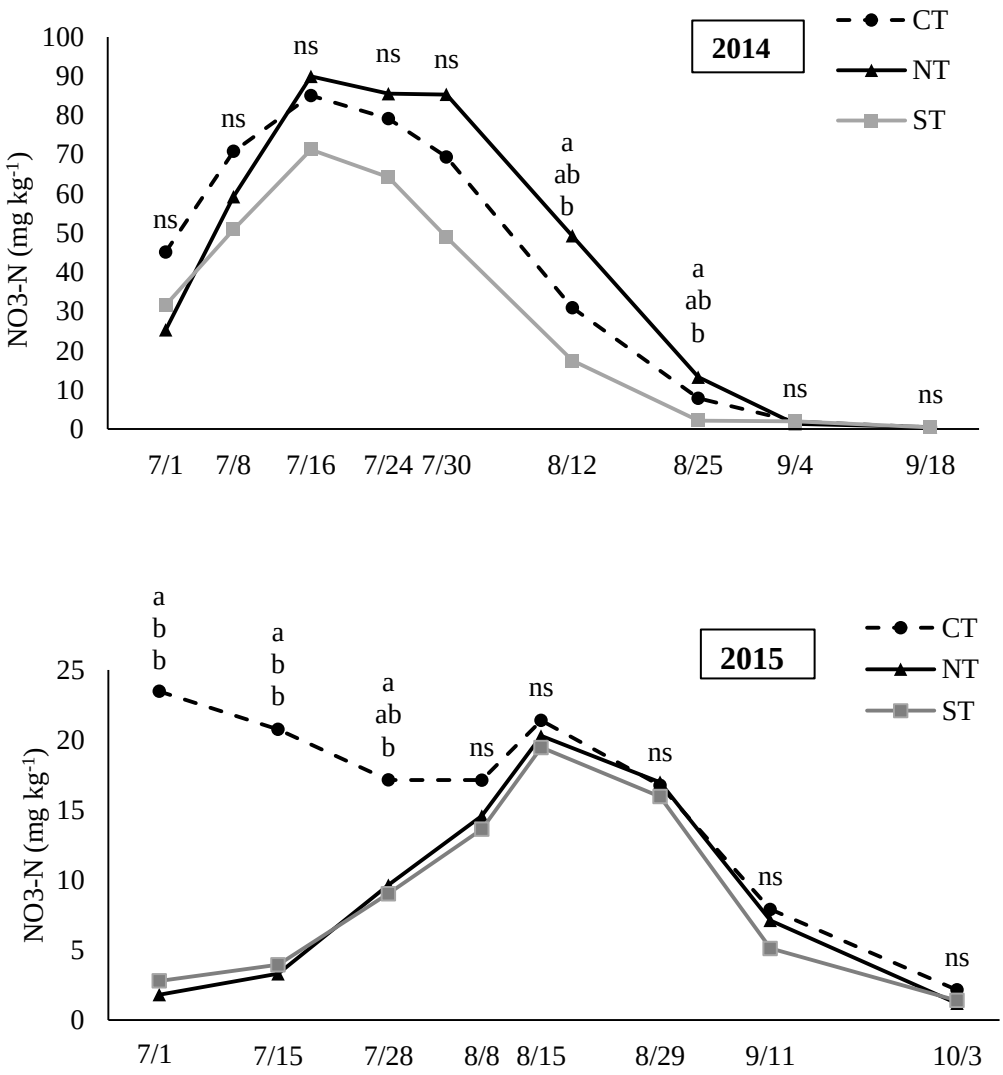

Fig. 3.4. Nitrate-N concentration in leachate under conventional tillage (CT), no tillage (NT), and strip tillage (ST). Samples were collected on different dates in 2014 (above) and 2015 (below) from lysimeters installed to 24-inch depth. Points within a date containing the same letter are not significantly different according to Fisher's protected LSD ($P \leq 0.05$). NS = nonsignificant.