Tomato Nitrogen Trial on Clay and Loam Soil Types in 2023-24, Ridgetown Campus

Evaluation prepared for the Ontario Processing Vegetable Growers

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Introduction:

As new tomato cultivars are developed and released for commercial use, a re-evaluation of recommended and economical nitrogen rates is prudent. This is supported increased costs of commercial fertilizers.

In response to this, trials were established in a strip block design with four replications using the processing tomato cultivars C337, H1014 and H3406. Treatments covered two factors:

i) Nitrogen fertilization rate

ii) Environment (encompasses the year and soil type)

There were 6 nitrogen fertilization rates including:

1) 0 kg/ac
2) 50 kg/ac
3) 100 kg/ac
4) 150 kg/ac
5) 200 kg/ac
6) 250 kg/ac

For environment there were 4 different “sites” in the 2 year study:

A) Clay soil type in 2023
B) Loam soil type in 2023
C) Clay soil type in 2024
D) Loam soil type in 2024

The parameter “environment” encompasses both trial years and the two different soil types: loam and clay. The nitrogen factor rate was applied to each year to the two different soil types for each of the three tomato varieties. Each plot was a twin row of tomatoes, 8.0 m long established using a commercial twin row RJ transplanter. The space between twin rows was 45 cm, and in-row plant spacing was also 45 cm, providing 35.5 plants per plot. The twin row plots were centered at 1.5 m giving an overall plant population of 29 617 plants/ha (11 991 plants/acre). The statistical analysis program SAS was used to perform all analyses using the GLIMMIX procedure. The Shapiro-Wilk test was conducted to test normality, and the residual plots were utilized to test the assumptions of variance (ie. Random, homogenous, and independent). The means of the variables tested were separated using the Tukey HSD test with a confidence interval of α=0.05; means followed by the same letter are not different.

Data Collection

i) Plant biomass – dry weight (3 plants)
   a. 2023: taken 8 weeks after transplants
   b. 2024: taken after harvest, since there were not enough plants in some plots to remove
ii) Survival count

At harvest

iii) Yield of 6 plants (in kg) separated into
   a. Red fruit
   b. Green fruit
   c. Breaker fruit
   d. Rotten fruit

Field Management:

Sites were chosen on the Ridgetown Campus Research Farm that had not grown tomatoes for the past 4 years and were classified as either loam or clay. Phosphorous and potash were applied to the trial sites based on soil sample analysis as 0-45-0 and 0-0-60 as not to conflict with the nitrogen treatments. All three cultivars of tomatoes were planted on the same field site (clay or loam) with a twin row tomato plot placed between each treatment plot to act as a buffer for the rates of nitrogen. The planting and harvest dates over the two-year trial can be found in Table 1. Each planting season received a PRE and POST herbicide program, and in the 2024 season Colorado potato beetle pressure was high so the insecticides Admire and Pounce were used. A fungicide program was implemented with a spray every 10-12 days; in 2024 fungicides were selected to focus on late blight that was a concern in the Chatham- Kent area.

Table 1. Planting/Harvest dates and herbicide program for tomato trials over 2 years.

Year	Planting Date	Harvest Dates
2023	Loam- May 26th Clay- May 19th	Loam- Sept 13th to 29th Clay- Sept 6th to 20th
2024	Loam & Clay- May 23rd	Loam- Sept 4th-Sept 11th Clay- Aug 27th- Sept 3rd

A plant survival count was taken 1 week after planting. In 2024 the plant biomass of 3 tomato plants was collected at harvest opposed to 8 weeks after planting. The plant biomass was dried down minus the plant fruit. Plots were harvested when 80% of the fruit across the varieties appeared red. From each plot, 6 plants were harvested and graded into red, green, breaker and rotten fruit. The harvest weights were then calculated into tonnes/ha.

Data from the different 3 cultivars was analyzed individually as there was no need to compare cultivars statistically. This provided a more robust comparison

Results and Conclusions:

When interpreting the data from this type of experimental design, technically you can only consider "main effects" (in this case, Nitrogen Treatment and Environment) if there is no interaction between the two. Interactions are noted at the bottom of the large tables (Tables 2, 3, and 4) by "TRT*ENV"; NS means non-significant or no interaction and a "*" indicates there was one, and you need to look further at the "simple effects" found on the smaller tables following it. Within these "simple effects" tables, Nitrogen Treatments are listed vertically on the left and Environment is listed across the top. The lower case letters from the beginning of the alphabet (a, b, c etc) indicate differences within a column (Nitrogen Treatment) while capitalize letters from the end of the alphabet (X, Y, Z) indicate differences across rows (Environment). We feel this approach to summarizing interactions is simpler than making graphs.

"Contrasts" are also mentioned in the text; these are statistical procedures than can be used to separate the effects which make up Environment, namely soil type and year.

Cultivar C337 *(Table 2, 2.1& 2.2)*

When considering nitrogen treatments, treatment 6 (250 kg/ac) resulted in the lowest survival rate at 71.5 %; this was statistically comparable to treatment 5 (200 kg/ac) at 78.2%. Both treatment 5 and 6 were statistically different from the highest surviving treatments 1 (0kg/ac) and 2 (50 kg/ac), which both had a plant survival rate of 93.7%. When averaged over environment, there was a statistically significant difference in survival between year/soil type. There was a higher plant survival rate for the variety C337 in 2024 than 2023 and plant fatality was generally higher in the soil type clay compared to loam. There was no survival interaction between environment (year/soil type) and nitrogen treatments.

There was a significant interaction between the environment (year/soil type) and nitrogen treatment for the red fruit weight of C337 (Table 2.1). Only the clay site (environment A and C) resulted in differences between nitrogen treatment; the red yield on the loam sites were comparable among all treatments. In environment A, treatment 6 (100 kg/ha) resulted in the highest yield and was significantly different from the other nitrogen treatments. In environment C, treatment 4 (150 kg/ha) resulted in the highest yield which was comparable to treatments 5 and 6 but different from treatments 1 to 3. When looking across N treatments and their interaction with the different environments (Table 2.1) the loam site in 2023 resulted in the highest yields compared to the other soil types for every treatment except treatment 4 where the yields were comparable across both years and soil types. Also, treatment 5 and 6 were comparable to treatment 4 in environment A, showing a yield difference due to year compared to soil type for the higher treatments of nitrogen. When looking at Table 2, the main effect of nitrogen treatment showed that treatment 3 to 6 on average resulted in statistically comparable yield. When looking at the yield of red fruit in Table 2 for environment, all environments were statistically different from one another and were discussed more thoroughly from Table 2.1 because the interaction between the factors were significant.

The fruit variable for green and breaker fruits showed comparable trends, where the yield had no interaction between the main effects of nitrogen treatment and environment. Both fruit categories resulted in yields being comparable between treatment 2 to 6. Only treatment 4 for both and treatment 6 and 4 for green fruit had higher fruit yields compared to the untreated control (treatment 1). Environment for green and breaker fruit showed environments A, B and C having comparable yield. Only environment C (clay, 2024) showed higher green fruit yield compared to environment D (loam, 2024). When run as a contrast, green fruit yield resulted in no significant difference between year but had significant effect for clay versus loam soil type when averaged over both seasons. When breaker fruit was run for contrasts (a contrast is a statistical procedure that allows a comparison between treatments; here it is used to compare year and soil type) there was significant difference between years and soil types, as seen in Table 2., where environments A, B, and C resulted in higher breaker fruit than environment D.

The final parameter of Total Yield which is comprised of all the fruit weights including rots showed comparable trends to the red fruit weight, as seen in Table 2. Total yield demonstrated a significant effect for an interaction between nitrogen treatment and environment which is shown in Table 2.2. The trends of looking down an environment are comparable to the red fruit yield for environment A and C, however total yield also had difference in environment B. The difference being that within environment B (2023, loam) treatments 2 to 6 were comparable for yield. However, only treatment 3 resulted in a significantly higher total yield than the untreated control (treatment 1). As seen in the red fruit interaction table (Table 2.1), the total yield interaction Table 2.2 shows the same trend of treatment 4 being the only treatment to have uniform yield across all environments. When looking across nitrogen treatments effect Table 2.2, environment B resulted in the highest total yield compared to all environments for treatments 2 and 3. Environment B as well as D (both loam) for the untreated nitrogen check (treatment 1) resulted in higher total yield than environment C (clay, 2024) (environment A and C). Treatment 5 showed a year difference with environment A and B (2023) having higher total yields compared to environments C and D which was from the year 2024. Treatment 6 showed another year effect where environment A had significantly higher total yield than environment B (both 2023), however both fields in 2023 had higher yields compared to the fields in 2024 (environment C and D).

Cultivar H1014 *(Table 3, 3.1, 3.2, 3.3 & 3.4)*

When considering plant survival in Table 3, treatments 5 and 6 had the significantly lowest plant survival compared to the nitrogen treatments 1, 2 and 3. Environment D (loam 2024) resulted in the highest plant survival compared to both clay fields (environment A and C) and was comparable to the other loam site in 2023 (environment B). When plant survival was run as a contrast statistically, there was a significant difference in plant survival between 2023 and 2024, as well as between the two different soil types. There was no significant interaction between nitrogen treatment and environment for plant survival.

When looking at red fruit yield only (Table 3), treatments 5 and 6 had higher yields than the untreated control; however treatment 5 is comparable to the yield of other treatments. All environments for red fruit yield are significantly different from each but there is a year and soil type difference when ran as a contrast in SAS. For the parameter red fruit there was a significant interaction between the main effects and are summarized in Table 3.1. When looking at the interactions in Table 3.1 only the clay environments (A and C) have difference among the treatments. In environment A, treatment 6 resulted in the highest red fruit yield compared to all other treatments. Treatment 3, 4, 5 were equivalent statistically for yield, as well as being higher in yield then the untreated nitrogen control (treatment 1). When looking at the nitrogen treatments with environment C (Table 3.1), treatments 4, 5 and 6 were statistically comparable in yield and higher than the control treatment 1. For red fruit yield, treatments 3, 5 and 6 resulted in higher yields in 2023 (environment A and B) then in 2024 (environment C and D). Nitrogen treatment 4 was comparable across all environments, meaning there was no statistical effect between soil type across the two seasons 2023 and 2024.

When evaluating green and breaker fruit yields, the two parameters showed similar trends in Table 3. There are no differences between the nitrogen treatments and the loam field in 2024 (environment D) resulted in the lowest green and breaker fruit yields compared to the other environments. Also, both parameters had significant nitrogen treatment and environment interactions which can be analyzed in Table 3.2 and Table 3.3. When looking at an environment, the variable green fruit had no differences among the treatments. When looking at Table 3.3 only environment C for the variable breaker fruit showed Treatment 3 having higher breaker yields than the control but otherwise the treatments are comparable among each other. When looking at the interaction tables for green fruit and breakers (Table 3.2, 3.3), treatments 3 and 5 both had no differences across the environments and environment D (loam 2024) resulted in the lowest green fruit and breaker fruit yields.

Total fruit yield resulted in similar results to red fruit yield for both the main effects and interaction tables. When looking at the main effect Table 3, the nitrogen treatment effect for total fruit yield resulted in the same trend as red fruit, where treatments 5 and 6 yield higher than the control (treatment 1). For the total fruit yield, treatments 2,3,4, and 5 were comparable, and in the year 2023 (environment A and B) the total fruit yield was higher than 2024 (environment C and D). Total fruit yield had a significant interaction among nitrogen effects and environment which can be seen in Table 3.4. The interaction for total fruit yield on the clay fields (environment A and C) showed differences among the nitrogen treatments. In environment A (2023), treatment 6 resulted in the highest total fruit yield compared to all the other treatments. Treatment 5 had the next highest total yield but is statistically comparable to treatments 3,4, and 5. When analyzing environment C, treatments 3, 4, 5 and 6 were all statistically higher in total fruit yield compared to the control (treatment 1). When looking at the higher yielding treatments in Table 3.4, treatments 3, 5 and 6 showed yearly differences where total fruit yield was higher in 2023 compared to 2024. Treatment 4 for total fruit yield was comparable amongst all the environments with only environment B having a statistically higher yield than environment D.

Cultivar H3406 *(Table 4, 4.1, 4.2 and 4.3)*

Percent plant survival found in Table 4 shows that treatment 6 resulted in the lowest survival rate at 74%, which is statistically comparable to treatment 5. Treatments 1,3, and 4 are all comparable to the highest survival rate of treatment 2 at 94%. When analyzing percent plant survival there is a significant difference between years and soil types when ran in SAS as a contrast. As well, the interaction between nitrogen rate and environment was significant (refer to Table 4). The clay environments resulted in the lowest plant survival rates which can further be seen in the interaction Table 4.1, where environment A and B (both clay fields) have the only difference amongst the treatments. Environments A and C show that treatments 3, 4, and 5 are all comparable to the highest survival percentages from treatment 2. When looking across the treatments in the interaction Table 4.1 there were only differences amongst the environments for the higher nitrogen rate treatments: treatments 4,5, and 6. There was a significant soil type effect for treatments 5 and 6 where the plants survived better on loam fields compared to the clay. When analyzing treatment 4, the clay field in 2024 was also statistically comparable to the loam fields (environment B and D) higher survivability rates.

The red fruit yield and the total fruit yield results in Table 4 showed treatments 6 resulting in the highest yield, which was statistically comparable only to treatment 5. The no nitrogen control resulted in the lowest red and total fruit yields and was statistically different than treatments 3,4,5, and 6 but the same as treatment 2. Total fruit yields and red fruit yields when looking at the main effect environment (Table 4) resulted in significant contrast between soil types and years. The year effect demonstrates how both soil type fields in 2024 resulted in lower yields than 2023. When looking at the soil types in 2023 there is a significant difference between the loam and clay soil type where the loam yields higher red and total fruit. When looking at the interaction table for red fruit (Table 4.2) and total fruit yields (Table 4.3) the trends a very similar. The major similarities being that when looking down environment D (loam, 2024) there were no differences between the treatments. When looking at environment C (clay, 2024) all treatments but the untreated nitrogen control (treatment 1) was comparable to the higher yields of treatment 5 for red fruit and treatment 6 for total fruit yield. This changed slightly in the highest yielding environment, environment B (loam, 2023) for red fruit and total fruit, all treatments except treatments 1 and 2 were comparable to the highest yielding treatment 5 for red fruit and treatment 6 for total fruit yield. For environment A both red fruit (Table 4.2) and total fruit yield (Table 4.3) was highest in treatment 6 and not comparable to all other treatments. When looking across the environments for each nitrogen treatment environment B (loam, 2024) resulted in the highest yields for red fruit (Table 4.2) and total fruit yields (Table 4.3) for treatments 3, 4 and 5. Treatment 6 had a yield effect were environment A and B (2023) yielded higher than in 2024 for both parameters of red fruit and total fruit yield.

When analyzing the green fruit yield values in Table 4 there was no interaction between nitrogen rates and environment. There was a significant difference between years and soil types when ran as a contrast. For green fruit the loam field in 2023 (environment B) resulted in the highest yield which was comparable to the clay field in 2023 (environment A). The loam field in 2024 (environment D) resulted in the lowest yield of green fruit compared to all other fields and the clay fields (environment A and C) were statistically comparable. When looking at the nitrogen treatment effect for green fruit treatment 6 had the highest yield, which was comparable also to treatments 3 and 5. Breaker fruit yields followed similar trends to the green fruit yields with two main differences. The first difference being that treatment 4 is also included in being comparable to the highest breaker yield of treatment 6 along with treatments 3 and 5. The second difference being that the clay fields (environment A and C) for breaker fruit yields are not comparable. There is a distinct year significance where breaker fruit was higher yielding in 2023 than 2024. Which is supported by the contrast statement in SAS that showed a significant difference in breaker fruit yield between years but not between soil types. The interaction between nitrogen rate and environment for breaker fruit yields was also not significant.

Conclusion:

<u>General Trend:</u>

The higher the nitrogen treatment the higher the yield but at the cost of plant survivability.

Yield effect for green and breaker fruit had differences between year and soil type. There was no nitrogen treatment effect for green or breaker for the variety H1014 and for the other two varieties green and breaker fruit treatments were all comparable to the highest yielding treatment with the exception of the control treatment 1 for C337 and treatments 1 and 2 for H3406. Therefore any delay in plants would have been a result of the environment (year and soil types)

Note: 2024 season was extremely wet, with a high threshold of Colorado potato beetle, so plants were stressed on top of receiving the nitrogen treatments. Pest control was obtained for a rigorous spray program of Admire and Pounce.

C337 conclusions:

Treatment 5 and 6 had the lowest plant survival rate of 78 and 71%. Nitrogen treatments 3,4, 5 and 6 were statistically similar in red fruit yield and total fruit yield, with treatment 6 producing the greatest amount. When considering the interactions for red and total fruit yields, only treatment 4 demonstrated no difference in yield across all the environments. All the other treatments favored a soil type or year effect for yield. This means treatment 4 was the most uniform/stable treatment for yield, as well as having plant survival rates, red fruit and total fruit yield statistically comparable to the highest value.

H1014 conclusions:

Treatment 5 and 6 had the lower plant survival rates 79 and 76%. Treatment 6 had the highest red fruit and total yield and was statistically similar to treatment 5. Similarly, treatments 2, 3 and 4 are similar for red fruit yield and total fruit yield and comparable to treatment 5. When considering the interaction table for red fruit, only treatment 4 had no difference in yield across all the environments. All the other treatments favored a soil type or year effect for yield. This means treatment 4 was the most uniform/stable treatment for yield, as well as having plant survival rates comparable to the highest value. Treatment 4 yielded 124.6 tonnes/ha for red fruit but was not statistically the same as the highest yielding treatment 6 at 149 tonnes/ha

H3406 conclusions:

Treatment 5 and 6 had the lowest plant survivability at 83 and 74%. Plant survivability was lowest in the clay field of 2023 (environment A) which was comparable to the clay field of 2024 (environment C). This was the only variety to have a significant environment effect, where survival rate was higher in loam fields generally than clay and in the year 2024 over 2023. Red fruit and total fruit yields had treatment 6 as the highest yielding treatment at 147 tonnes/ha and 179 tonnes/ha respectively. Treatment 6 was comparable to treatment 5 yields, however treatment 5 is also comparable to the yields of treatments 3 and 4. Red fruit and total fruit yielded higher in loam fields than clay when ran as a contrast statements and yields were higher in 2023 over 2024.

C337

Table 2. Effect of nitrogen rates and environment on survival and yield parameters for the tomato variety C337. University of Guelph, Ridgetown Campus.

	Plant Survival[z]	Red[z]	Green[y]	Breaker[z]	Total Yield[z]
Main Effects	(%)	(Tonnes/Ha)	(Tonnes/Ha)	(Tonnes/Ha)	(Tonnes/Ha)
Nitrogen Treatment	*	*	*	*	*
1 (0 kg/ac)	93.70 a	78.93 c	4.84 b	2.42 b	86.98 c
2 (50 kg/ac)	93.71 a	97.18 bc	8.48 ab	3.86 ab	110.79 bc
3 (100 kg/ac)	86.02 ab	108.24 ab	12.86 a	5.56 a	131.33 ab
4 (150 kg/ac)	86.56 ab	116.23 ab	9.99 ab	3.43 ab	133.97 ab
5 (200 kg/ac)	78.22 bc	113.68 ab	11.81 ab	4.08 ab	134.19 ab
6 (250 kg/ac)	71.48 c	129.93 a	12.73 a	4.64 ab	153.03 a
Environment	*	*	*	*	*
A (clay in 2023)	77.39 c	117.14 b	11.41 ab	6.06 a	136.47 b
B (loam in 2023)	82.59 bc	142.93 a	8.58 ab	4.64 a	161.97 a
C (clay in 2024)	85.91 ab	73.88 d	13.44 a	4.34 a	93.05 c
D (loam in 2024)	93.91 a	95.52 c	7.04 b	1.84 b	108.71 c
*N_TRT*ENV*	NS	*	NS	NS	*

ENV: environment, N_TRT: Nitrogen Treatment

[a-d] Means within column followed by the same letter are not different according to Tukey's HSD at α=0.05.

* Significant at P<0.05, respectively; NS, not significant at the P=0.05 level.

[z] significant difference between years and soil types

[y] significant difference between soil types but not years

Table 2.1. Simple effects for C337 red fruit yield (Tonnes/Ha) due to significant treatment by environment interaction.

	2023		2024	
Nitrogen Treatment	ENV A (Clay)	ENV B (Loam)	ENV C (Clay)	ENV D (Loam)
1 (0 kg/ac)	54.30 d X	129.65 Z	38.80 c X	92.98 Y
2 (50 kg/ac)	86.45 cd YX	142.33 Z	59.65 bc X	100.30 Y
3 (100 kg/ac)	115.45 bc Y	163.55 Z	60.28 bc X	93.70 YX
4 (150 kg/ac)	130.97 b	128.88	103.13 a	101.95
5 (200 kg/ac)	132.65 b Z	143.98 Z	88.35 ab Y	89.73 Y
6 (250 kg/ac)	183.00 a Z	149.23 Z	93.05 ab Y	94.45 Y

[a-d] Means within column followed by the same letter are not different according to Tukey's HSD at α=0.05.

[Z-X] Means within row followed by the same letter are not different according to Tukey's HSD at α=0.05.

ENV: Environment

Table 2.2. Simple effects for C337 total fruit yield (Tonnes/Ha) due to significant treatment by environment interaction.

	2023		2024	
Nitrogen Treatment	ENV A (Clay)	ENV B (Loam)	ENV C (Clay)	ENV D (Loam)
1 (0 kg/ac)	64.48 d YX	139.13 b Z	45.18 c X	99.15 ZY
2 (50 kg/ac)	94.55 cd YX	162.35 ab Z	71.65 bc X	114.63 Y
3 (100 kg/ac)	141.33 bc Y	189.55 a Z	88.53 abc X	105.90 X
4 (150 kg/ac)	150.80 b	146.78 ab	123.88 a	114.43
5 (200 kg/ac)	155.2 b Z	166.13 ab Z	110.93 ab Y	104.53 Y
6 (250 kg/ac)	212.45 a Z	167.90 ab Y	118.15 ab X	113.62 X

[a-d] Means within column followed by the same letter are not different according to Tukey's HSD at α=0.05.

[Z-X] Means within row followed by the same letter are not different according to Tukey's HSD at α=0.05.

ENV: Environment

H1014

Table 3. Effect of nitrogen rates and environment on survival and fruit yield parameter for the tomato variety H1014. University of Guelph, Ridgetown Campus.

	Plant Survival[z]	Red[z]	Green[z]	Breaker[z]	Total Yield[z]
Main Effects	(%)	(Tonnes/Ha)	(Tonnes/Ha)	(Tonnes/Ha)	(Tonnes/Ha)
Nitrogen Treatment	*	*	NS	NS	*
1 (0 kg/ac)	92.15 a	86.81 c	3.12	1.78	93.74 c
2 (50 kg/ac)	92.20 a	116.84 b	3.49	2.56	125.63 b
3 (100 kg/ac)	91.59 a	120.30 b	3.38	2.68	137.04 b
4 (150 kg/ac)	87.84 ab	124.60 b	2.60	1.65	133.77 b
5 (200 kg/ac)	78.75 bc	136.16 ab	5.24	3.09	150.94 ab
6 (250 kg/ac)	75.69 c	149.00 a	3.93	2.41	165.29 a
Environment (ENV)	*	*	*	*	*
A (clay in 2023)	81.25 b	142.53 b	7.00 a	4.69 a	147.43 b
B (loam in 2023)	86.32 ab	160.40 a	4.02 a	3.40 ab	177.82 a
C (clay in 2024)	85.27 b	84.54 d	4.06 a	2.20 b	93.90 c
D (loam in 2024)	92.64 a	101.67 c	1.38 b	0.81 c	108.46 c
*N_TRT*ENV*	NS	*	*	*	*

ENV: environment, N_TRT: Nitrogen Treatment

[a-d] Means within column followed by the same letter are not different according to Tukey's HSD at α=0.05.

* Significant at P<0.05, respectively; NS, not significant at the P=0.05 level.

[z] significant difference between years and soil types

Table 3.1. Simple effects for H1014 red fruit yield (Tonnes/Ha) due to significant treatment by environment interaction.

	2023		2024	
Nitrogen Treatment	ENV A (Clay)	ENV B (Loam)	ENV C (Clay)	ENV D (Loam)
1 (0 kg/ac)	67.33 d YX	140.58 Z	35.45 b X	103.88 ZY
2 (50 kg/ac)	112.35 cd Y	182.78 Z	69.90 ab X	102.33 YX
3 (100 kg/ac)	151.0 bc Z	159.58 Z	75.38 ab Y	95.25 Y
4 (150 kg/ac)	133.23 bc	143.68	113.08 a	108.43
5 (200 kg/ac)	171.35 b Z	160.33 Z	108.8 a Y	104.15 Y
6 (250 kg/ac)	219.90 a Z	175.45 Y	104.63 a X	96.03 X

a-d Means within column followed by the same letter are not different according to Tukey’s HSD at α=0.05.

Z-X Means within row followed by the same letter are not different according to Tukey’s HSD at α=0.05.

ENV: Environment

Table 3.2. Simple effects for H1014 green fruit yield (Tonnes/Ha) due to significant treatment by environment interaction.

	2023		2024	
Nitrogen Treatment	ENV A (Clay)	ENV B (Loam)	ENV C (Clay)	ENV D (Loam)
1 (0 kg/ac)	7.88 Z	3.28 ZY	2.86 ZY	1.29 Y
2 (50 kg/ac)	6.18	4.82	2.63	1.90
3 (100 kg/ac)	7.50 Z	5.02 Z	7.14 Z	0.48 Y
4 (150 kg/ac)	3.16 ZY	6.45 Z	2.37 ZY	0.94 Y
5 (200 kg/ac)	6.00	6.05	6.16	3.37
6 (250 kg/ac)	16.78 Z	1.37 Y	5.69 ZY	1.84 Y

a-d Means within column followed by the same letter are not different according to Tukey’s HSD at α=0.05.

Z-X Means within row followed by the same letter are not different according to Tukey’s HSD at α=0.05.

ENV: Environment

Table 3.3. Simple effects for H1014 breaker fruit yield (Tonnes/Ha) due to significant treatment by environment interaction.

	2023		2024	
Nitrogen Treatment	ENV A (Clay)	ENV B (Loam)	ENV C (Clay)	ENV D (Loam)
1 (0 kg/ac)	4.33 Z	2.21 ZY	0.88 b Y	1.19 ZY
2 (50 kg/ac)	3.73	5.37	1.46 ab	1.47
3 (100 kg/ac)	6.23 Z	3.65 Z	5.71 a Z	0.40 Y
4 (150 kg/ac)	2.64 Z	4.12 Z	1.71 ab Z	0.40 Y
5 (200 kg/ac)	4.53	5.62	2.86 ab	1.26
6 (250 kg/ac)	8.86 Z	1.54 Y	3.14 ab ZY	0.78 Y

[a-d] Means within column followed by the same letter are not different according to Tukey's HSD at α=0.05.

[Z-X] Means within row followed by the same letter are not different according to Tukey's HSD at α=0.05.

ENV: Environment

Table 3.4. Simple effects for H1014 total fruit yield (Tonnes/Ha) due to significant treatment by environment interaction.

	2023		2024	
Nitrogen Treatment	ENV A (Clay)	ENV B (Loam)	ENV C (Clay)	ENV D (Loam)
1 (0 kg/ac)	80.43 d YX	146.77 Z	40.18 b X	107.6 ZY
2 (50 kg/ac)	122.67 cd Y	194.22 Z	77.68 ab Y	107.95 Y
3 (100 kg/ac)	167.22 bc Z	187.02 Z	93.05 a Y	100.85 Y
4 (150 kg/ac)	137.67 bc ZY	164.35 Z	118.80 a ZY	114.25 Y
5 (200 kg/ac)	183.87 b Z	186.55 Z	118.52 a Y	114.83 Y
6 (250 kg/ac)	252.68 a Z	188.0 Y	115.20 a X	105.30 X

[a-d] Means within column followed by the same letter are not different according to Tukey's HSD at α=0.05.

[Z-X] Means within row followed by the same letter are not different according to Tukey's HSD at α=0.05.

ENV: Environment

H3406

Table 4. Effect of nitrogen rates and environment on survival and fruit yield parameter for the tomato variety H3406. University of Guelph, Ridgetown Campus.

	Plant Survival[z]	Red[z]	Green[z]	Breaker[y]	Total Yield[z]
Main Effects	(%)	(Tonnes/Ha)	(Tonnes/Ha)	(Tonnes/Ha)	(Tonnes/Ha)
Nitrogen Treatment	*	*	*	*	*
1 (0 kg/ac)	92.18 ab	76.91 d	4.77 c	3.52 c	89.43 d
2 (50 kg/ac)	93.62 a	97.36 cd	6.25 bc	4.15 bc	117.07 cd
3 (100 kg/ac)	89.49 ab	112.33 bc	7.73 abc	6.72 ab	139.04 bc
4 (150 kg/ac)	87.04 ab	116.64 bc	6.51 bc	5.39 abc	136.36 bc
5 (200 kg/ac)	83.25 bc	130.24 ab	9.46 ab	6.07 ab	165.16 ab
6 (250 kg/ac)	73.93 c	147.18 a	13.26 a	6.99 a	178.64 a
Environment	*	*	*	*	*
A (clay in 2023)	79.16 c	115.98 b	11.81 ab	9.40 a	142.16 b
B (loam in 2023)	87.51 b	166.28 a	15.51 a	14.19 a	212.02 a
C (clay in 2024)	83.50 bc	76.92 c	7.50 b	3.91 b	93.14 c
D (loam in 2024)	96.16 a	94.60 c	2.39 c	1.53 c	103.15 c
*N_TRT*ENV*	*	*	NS	NS	*

ENV: environment, N_TRT: Nitrogen Treatment

[a-d] Means within column followed by the same letter are not different according to Tukey's HSD at α=0.05.

* Significant at $P<0.05$, respectively; NS, not significant at the $P=0.05$ level.

[z] significant difference between years and soil types

[y] significant difference between years but not soil types

Table 4.1. Simple effects for H3406 plant survival due to significant treatment by environment interaction.

	2023		2024	
Nitrogen Treatment	ENV A (Clay)	ENV B (Loam)	ENV C (Clay)	ENV D (Loam)
1 (0 kg/ac)	88.40 a	93.77	89.42 a	97.12
2 (50 kg/ac)	88.40 a	94.67	95.22 a	96.17
3 (100 kg/ac)	88.40 a	83.95	88.47 a	97.12
4 (150 kg/ac)	75.85 ab Y	85.72 ZY	89.45 a ZY	97.15 Z
5 (200 kg/ac)	75.00 ab Y	83.02 ZY	77.87 ab Y	97.12 Z
6 (250 kg/ac)	58.92 b Y	83.92 Z	60.58 b Y	92.29 Z

[a-d] Means within column followed by the same letter are not different according to Tukey's HSD at α=0.05.

[Z-X] Means within row followed by the same letter are not different according to Tukey's HSD at α=0.05.

ENV: Environment

Table 4.2. Simple effects for H3406 red fruit yield (Tonnes/Ha) due to significant treatment by environment interaction.

	2023		2024	
Nitrogen Treatment	ENV A (Clay)	ENV B (Loam)	ENV C (Clay)	ENV D (Loam)
1 (0 kg/ac)	53.43 d Y	128.13 c Z	42.30 b Y	83.80 ZY
2 (50 kg/ac)	77.03 cd Y	141.78 bc Z	62.23 ab Y	108.43 ZY
3 (100 kg/ac)	119.32 bc Y	181.65 ab Z	63.15 ab X	85.20 YX
4 (150 kg/ac)	109.00 bc Y	168.45 abc Z	101.5 a Y	87.60 Y
5 (200 kg/ac)	130.45 b Y	181.90 ab Z	97.88 a Y	110.75 Y
6 (250 kg/ac)	206.65 a Z	195.78 a Z	94.45 a Y	91.85 Y

[a-d] Means within column followed by the same letter are not different according to Tukey's HSD at α=0.05.

[Z-X] Means within row followed by the same letter are not different according to Tukey's HSD at α=0.05.

ENV: Environment

Table 4.3. Simple effects for H3406 total fruit yield (Tonnes/Ha) due to significant treatment by environment interaction.

	2023		2024	
Nitrogen Treatment	ENV A (Clay)	ENV B (Loam)	ENV C (Clay)	ENV D (Loam)
1 (0 kg/ac)	65.10 c Y	151.22 c Z	50.00 b Y	91.40 ZY
2 (50 kg/ac)	92.00 bc Y	184.78 bc Z	74.83 ab Y	116.70 Y
3 (100 kg/ac)	152.10 b Y	228.33 ab Z	82.13 ab X	93.60 X
4 (150 kg/ac)	129.32 bc Y	211.00 abc Z	111.05 ab Y	94.08 Y
5 (200 kg/ac)	158.02 b Y	261.68 a Z	118.15 a Y	122.78 Y
6 (250 kg/ac)	256.43 a Z	235.10 ab Z	122.68 a Y	100.37 Y

[a-d] Means within column followed by the same letter are not different according to Tukey's HSD at $\alpha=0.05$.

[Z-X] Means within row followed by the same letter are not different according to Tukey's HSD at $\alpha=0.05$.

ENV: Environment