2016 Butternut Squash Cereal Rye Cover Crop Tillage and Fertility Trial

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A cover crop management trial in butternut squash was planted at the Forgotten Harvest Ore Creek Farm (9153 Major Rd, Fenton, MI 48430) in a Miami loam soil with a 0-2% grade. The objectives were to determine how yields following a cereal rye cover crop were affected by three tillage systems and three at-plant fertilizer treatments in a split-plot Randomized Complete Block Design with four replications. The main plot factor was tillage: including bareground disked rye, no-tilled rye mulch, and strip-tilled rye mulch. Main plots were 600 ft long x 30.5 ft wide. Each main plot was then split into three randomized 200 ft long fertilizer treatment subplots. The fertilizer treatments included a high rate controlled-release fertilizer CRF (67.76 lb per acre actual N as 14-5-25-10S-2Ca), low rate controlled-release fertilizer CRF (47.16 lb per acre actual N as 14-5-25-10S-2Ca), and a grower standard fertilizer GSF (59.69 lb per acre actual N as 24-3-18-6S urea-diammonium phosphate-potassium sulfate). There were a total of 36 plots. High and low rate controlled-release fertilizers were a proprietary polymer-coated blend, provided by ICL Fertilizers (622 Emerson Rd. Suite 500, St. Louis, MO 63141). No plots in the study were irrigated.

On 17 October 2015 cereal rye was drilled into the four-acre experimental area at a rate of 120 lbs/ac. On 26 May 2016 the entire area was sprayed with glyphosate (1qt/ac), and on 2 June all of the rye was rolled perpendicular to the direction it was planted with a roller-crimper (I & J Manufacturing, 5302 Amish Rd, Gap, PA 17527). Rye was at least three feet tall, and heading out. Bareground plots were created on 4 June by incorporating the rye residue with a chisel plow and disc, and strip-till plots were created on 8 June with a single-row Zone-Builder® Subsoiler (Unverferth Manufacturing Co, Inc. 601 Broad St, P.O. Box 357, Kalida, OH 45853). Butternut squash (Betternut cultivar) was seeded with a custom single-row Monosem vacuum planter in five pre-marked rows, six feet between rows and two feet in-row. Seeds were coated in the Farmore F1400 chemical treatment consisting of thiamethoxam, mefenoxam, fludioxonil, and azoxystrobin. The seeding unit was set up to simultaneously deposit granular fertilizer in two bands five inches to either side of the seed row, and five inches below it. On 10, 11, and 13 June, each plot was planted while simultaneously delivering the calibrated rates of fertilizer. No planting depth adjustments were made between tillage treatments. On 14 June, we applied a tank mix of 0.5 oz Sandea, 3 pts Curbit, 1.33 pts Command per acre for weed control. No other pest or disease controls were applied for the remainder of the season. Pollination was provided by five bumble bee quads from Koppert Biological Supply (1502 Old US-23, Howell, MI 48843), and four nearby honey bee hives.

Soil inorganic nitrogen concentration was measured 30 days after planting (14 July dap), 60 dap (12 August) and 90 dap (12 September) by taking ten, eight-inch deep soil cores in the crop rows of each plot. On 6 and 7 Oct (108 and 109 dap), entire plants were harvested in 40 ft. transects in the center section of the center rows in each plot. The numbers of squash plants were counted, and fruit were tallied and weighed separately as "clean" and "dirty". "Culls" were counted but not weighed. Weed pressure was assessed in each treatment plot on a 1-5 scale (1 = no weeds visible, and 5 = no crop plants visible).

Results

Planting and Establishment

The number of plants per acre was a factor that was tightly linked with yield. Rye residue, and fertilizer granule sizes interfered with planting and fertilizer application in all plots, respectively. In addition, the harder soil in no-till treatments resulted in a shallower seed depth, and more plant skips in the row. As a result, fewer plants germinated in no-till and bareground plots with heavy residue, and yield appeared to be suppressed (Table 1).

Yield response to tillage practices

The average plant populations and yields were highest in strip-tilled plots, followed by bareground plots, and no-till plots (Table 1). Compensatory fruit set occurred in no-till plots, where plant populations were lower, but fruit weights were similar across all treatments and yield did not increase proportionally to fruit set. The lower yields in the bareground and no-till treatments were probably due to higher weed pressure and slower germination/poor seeding depth, respectively. We also measured fruit set and yield from plasticulture squash outside the study area which were planted on different dates and were managed with a different fertility program than the study area. We observed more fruit per plant (3.12 fruit/plant), and higher overall yield (11.19 tons/acre), despite similar plant populations (4329.22 plants/acre) as our no-till plots.

Quality response to tillage practices

Despite lower yields, a higher percentage of fruit harvested from no-till plots were free of dirt (Table 1). Bareground plots had the least clean fruit. Plastic rows outside the study area had fewer clean fruit (7.76%) than in strip-tilled plots and no-till plots.

Yield response to fertilizer treatments

Yield was more sensitive to tillage than fertility in this trial. The yields were similar between the GSF and the high rate CRF (Table 1). Although not statistically significant at 0.05, these treatments appeared to yield higher than low-rate CRF. Due to factors that were likely unrelated to fertility treatments, there were fewer plants per acre, but more fruit per plant in GSF subplots, and the inverse was observed in the low rate CRF subplots.

Fruit weight response to fertilizer and tillage treatments

There was a significant interaction between fertility and tillage treatments on fruit weights (Figure 1). Low rate CRF treatments within strip-till plots had significantly lower fruit weights than in other tillage plots (as determined by a specific contrast). This may suggest that the level nitrogen (or other nutrient) became limiting in this tillage treatment as yield increased. However, this effect was not observed on overall tonnage.

Nitrogen availability

Soil N (nitrate and ammonium) concentrations in GSF subplots peaked 30 dap, but were higher than other treatments 90 dap. The high rate CRF subplots appeared to delay peak release of N until 60 dap, but had lower N 90 dap than the GSF subplots. The inorganic nitrogen decline across time in GSF and low rate CRF subplots is likely from crop uptake. However, GSF subplots had higher inorganic nitrogen peaks, and the greater nitrogen remaining in the soil at the last sample period could have been an effect of the lower plant population in GSF subplots.

Tillage may have had an effect on nitrogen mineralization. We would expect nitrogen availability to be higher in no-till plots, where plant population was lower and N uptake from the crop was likely also lower. However, nitrogen availability was similar to other tillage treatments. This suggests that nitrogen was not mineralized into a usable form as efficiently as in other plots. This “tie-up” is known to occur in no-till rye fields as a result of less field disturbance and cooler soils.

Weed pressure

Weed pressure was a complex of pigweed, nightshade, mustard, nutsedge, velvet leaf, marestail, potato, and jimson weed. The bareground plots had the highest weed pressure (averaging 3.33 on a 5-point scale), and strip-till and no-till plots had equal weed pressure (both averaging 1.92). Bareground plots had a higher weed pressure than the other treatments, presumably because of the lack of surface mulch. However, in some subplots, more tillage passes were performed to incorporate residue than in others, and weed pressure was highest in these subplots. This suggests that additional tillage passes may have encouraged weed germination in this trial.

Table 1. This table presents the summary of the main effects of the tillage and fertilizer treatments from Forgotten Harvest Ore Creek Farm, Fenton, MI. Means with the same letter within a column are not significantly different. [1] There was a significant interaction between fertility and tillage treatments on fruit weights, and this was analyzed separately in Figure 1. [2] Weed pressure was scored between 1 (no weeds visible) and 5 (no crop visible). [3] Means differing by more than this amount are significantly different at α=0.05, based on Fisher's LSD. [4] Means differing by more than this amount are significantly different at α=0.05, based on Tukey's HSD.

Treatments	Tons/ acre	Plants/ acre	Fruit/ acre	Fruit/ plant	Weight/ fruit (lb)[1]	% Clean fruit	Weeds[2]	Total inorganic N (ppm) 14 July	12 Aug	12 Sept
Tillage										
Strip-till	12.51 a	7498.03 a	10009.28 a	1.75 b	2.52	11.48 b	1.92 b	12.94 a	11.69 a	6.95 a
Bareground	9.70 b	5400.37 b	8116.92 b	1.99 a	2.36	2.25 c	3.33 a	11.64 a	12.74 a	7.52 a
No-till	8.72 b	4477.99 b	7248.10 b	2.29 a	2.39	19.64 a	1.92 b	14.54 a	13.40 a	7.76 a
LSD 5%[3]	*2.04*	*1671.07*	-	-	-	*7.24*	*0.85*	-	-	-
HSD 5%[4]	-	-	*1652.95*	*0.56*	-	-	-	*7.42*	*6.57*	*1.84*
Fertilizer										
Hi-rate CRF	10.88 a	5623.52 a	8509.67 a	2.05 a	2.55	13.29 a	2.42 a	10.86 a	13.76 a	6.32 a
GSF	10.39 a	5102.83 a	8247.84 a	2.24 a	2.45	8.09 a	2.67 a	15.51 a	14.39 a	9.14 b
Lo-rate CRF	9.65 a	6650.04 a	8616.79 a	1.74 a	2.28	11.99 a	2.08 a	12.75 a	9.68 a	6.76 a
LSD 5%[3]	-	-	-	-	-	-	-	-	-	*1.12*
HSD 5%[4]	*2.93*	*2314.7*	*2039.79*	*0.56*	-	*11.24*	*1.21*	*7.25*	*6.24*	-

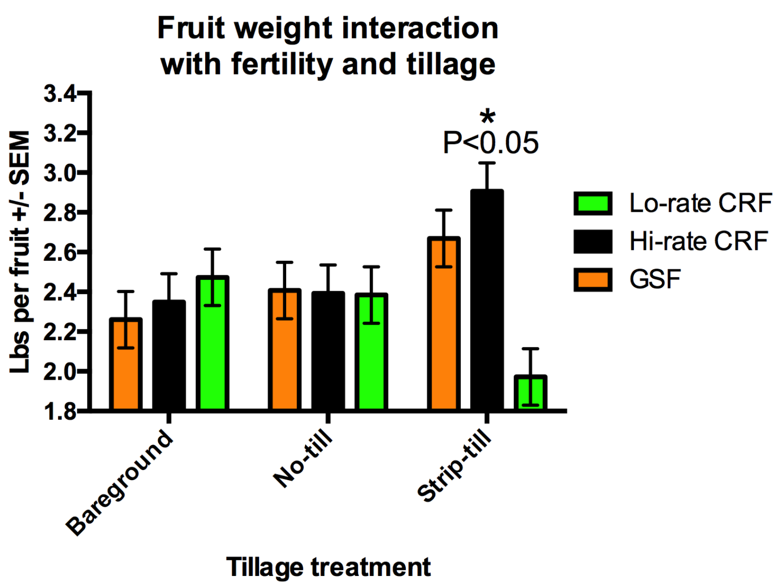

Figure 1. There was a significant interaction between fertility and tillage treatments on fruit weights. Lo-rate CRF treatments within strip-till plots had significantly lower fruit weights than in other tillage plots (as determined by a specific contrast). This suggests that N from low rate CRF became limiting as fruit weight increased in strip-till plots.

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