COMBINING MIDAC FC® AND PONCHO BETA WITH AZTEROID FUNGICIDE AND STARTER FERTILIZER: IMPACTS ON ROOT MAGGOT CONTROL AND YIELD

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Introduction:

The sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder), is one of the most serious economic insect pests of sugarbeet in the Red River Valley (RRV) growing area. In central and northern portions of the Valley, sugarbeet producers typically manage this pest by initially using either a granular, liquid, or seed-applied insecticide during planting operations. In localities where moderately high to severe SBRM fly infestations develop, growers often choose to complement their planting-time protection measure with at least one postemergence insecticide application to protect the crop from major yield and revenue loss.

Since the mid-1970s, most of these applications have involved the use of insecticides involving the same mode of action, which is acetylcholinesterase (ACHE) inhibition. Grower dependence on this single mode of action for SBRM control in the Red River Valley has mostly been due to the fact that a limited number of insecticide products have been commercially available for use in the crop for several decades. As a result of this long-term, repeated use of ACHE inhibitor insecticides, the threat of insecticide resistance development in RRV sugarbeet root maggot populations has been a serious concern of pest management advisors and producers for several years.

In 2019, the U.S. Environmental Protection Agency (EPA) approved Midac FC for registered use in sugarbeet and potato. Although the current EPA-issued Midac FC label does not specifically list sugarbeet root maggot as a target pest, Vive Crop Protection has issued a Section 2(ee) recommendation for planting-time applications of Midac for SBRM control. The 2(ee) is a legal designation, offered to end-users by the registrant, as permitted by EPA through statutory authority under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) of 1910. The FIFRA 2(ee) designation allows a user to apply "*a pesticide against any target pest not specified on the labeling if the application is to the crop, animal, or site specified on the labeling, unless the Administrator has required that the labeling specifically state that the pesticide may be used only for the pests specified on the labeling after the Administrator has determined that the use of the pesticide against other pests would cause an unreasonable adverse effect on the environment*." This provides legal permission for producers and other applicators to use Midac FC for sugarbeet root maggot management in sugarbeet. However, they must be in physical possession of the published 2(ee) recommendation/product bulletin at the time the product is being applied.

Imidacloprid, the active ingredient in Midac FC, belongs to the neonicotinoid insecticide class, which is an entirely different mode of action in insects (i.e., antagonism of the postsynaptic nicotine acetylcholine receptor in the central nervous system). Although neonicotinoids offer an alternative action mode, insecticides belonging to this class have been widely used as seed treatments for insect management in sugarbeet since 2008.

One purported positive aspect of Midac FC is its compatibility for being tank-mixed with starter fertilizer formulations. That characteristic is beneficial to producers, as it allows for including fertilizer with planting operations. Starter fertilizer is commonly practiced by sugarbeet producers in the Red River Valley growing area, but little is known about its potential impacts, either positive or negative, on agronomic responses such as insecticide performance, plant safety, and resulting crop yield.

The key objective of this experiment was to evaluate the efficacy of Midac FC as an insecticide for sugarbeet root maggot control. Secondarily, this research was conducted to also determine the impacts of combining Midac with 10-34-0 starter fertilizer, and also integrating it with Poncho Beta insecticidal seed treatment and AZteroid fungicide for single-pass insect and disease management in sugarbeet. A third objective was to monitor for potential negative impacts (e.g., phytotoxicity) of dual- and multiple-component combinations of Midac, Poncho Beta, AZteroid, and 10-34-0 starter fertilizer.

Materials and Methods:

This experiment was conducted in a grower-owned field near St. Thomas in rural Pembina County, ND during the 2020 growing season. Betaseed 8524 glyphosate-resistant seed was used for all treatments in the trial. All plots were planted on May 20, 2020 by using a 6-row Monosem NG Plus 4 7x7 planter set to deliver seed at a depth of 1¼ inch and a rate of one seed every 4½ inches of row length. Plots were six rows (22-inch spacing) wide, with the four centermost rows treated. Insecticide was excluded from each of the outside rows (i.e., rows 1 and 6) of the planter, and those "guard rows" served as untreated buffers. Each plot was 35 feet long, and 35-foot alleys between replicates were maintained weed-free by using periodic cultivation throughout the growing season. The experiment was arranged in a randomized complete block design with three replications of the treatments.

Midac FC was applied by both dribble-in-furrow (DIF) and T-band placement. T-bands were achieved by orienting the output fan of each nozzle (TeeJet™ 450067E) directly perpendicular to the row, and nozzle height was adjusted on each row to achieve a 3-inch band over the open seed furrow. Dribble in-furrow applications were made by orienting microtubes (1/4" outside diam.) directly into the open seed furrow. Inline Teejet™ No. 18 orifice plates were used to stabilize the output rate of the spray solutions from the microtubes. Most at-plant treatments included 10-34-0 fertilizer (i.e., 10, 34, and 0% nitrogen, phosphorus, and potassium, respectively), which was diluted to a 3:2 gallon ratio of fertilizer to water. Water used for these solutions was adjusted to pH 6.0 several weeks before use. All planting-time liquid applications were delivered in a finished spray volume output of 5 GPA.

Non-fertilizer entries included Counter 20G at two application rates (i.e., 7.5 and 8.9 lb product/ac), and a true untreated check. However, each of those entries were compared with treatments that included the same base application (i.e., either Counter or a check) with a concurrent application of the fertilizer/water solution. Counter 20G was applied by using band (B) placement (Boetel et al. 2006), which consisted of 5-inch swaths of granules delivered through Gandy™ row banders. Granular application rates were regulated by using a planter-mounted SmartBox™ insecticide delivery system that had been calibrated on the planter before all applications.

Plant Stand Counts: To determine treatment impacts on seedling emergence and survival throughout the growing season, surviving plant stands were conducted on June 25, July 7, and July 20, 2020, which were 37, 49, and 62 days after planting (DAP), respectively. Plant stand assessments involved counting all living plants within each 35-ft-long row. Raw stand counts were then converted to plants per 100 linear row feet for the analysis.

Root injury ratings: Sugarbeet root maggot feeding injury ratings were conducted on July 28. Sampling consisted of randomly collecting ten beet roots per plot (five from each of the outer two treated rows), hand-washing them, and scoring them in accordance with the 0 to 9 root injury rating scale (0 = no scarring, and 9 = over ¾ of the root surface blackened by scarring or dead beet) of Campbell et al. (2000).

Harvest: Plots were harvested on September 22. Immediately (i.e., within one hour) before harvest, all foliage was removed from plots by using a commercial-grade mechanical defoliator. All beets from the center two rows of each plot were then extracted from soil using a mechanical harvester and weighed in the field using a digital scale. A representative subsample of 12-18 beets was collected from each plot and sent to the American Crystal Sugar Company Tare Laboratory (East Grand Forks, MN) for sucrose content and quality analysis.

Data analysis: All data from root injury ratings and harvest samples were subjected to analysis of variance (ANOVA) according to the general linear models (GLM) procedure (SAS Institute, 2012). Treatment means were compared by using Fisher's protected least significant difference (LSD) test. A 0.05 level of significance was used for root injury rating and yield data; however, due to the occurrence of slightly more variability in plant stands within and among replicates in this trial, all stand count data was analyzed and at the 0.10 of significance.

Results and Discussion:

Table 1 includes plant stand counts from three dates. Treatments are listed in descending order of surviving plant stand at the final count. Thus, careful attention is required to assess stand count comparisons from the first two count dates. The highest plant densities at the first stand count (i.e., 37 DAP) were observed in plots protected by Poncho Beta-treated seed and a 3" T-banded application of 10-34-0 starter fertilizer. Most other entries had comparable plant densities, and were not significantly different from that treatment. However, the following had significantly lower plant stands than the treatment that included Poncho Beta and starter fertilizer alone:

1) Poncho Beta-treated seed + a T-banded tank mixture of Midac FC, AZteroid, and 10-34-0;
2) Untreated check (i.e., no insecticide and no fertilizer)
3) Counter 20G banded at 8.9 lb product/ac + a concurrent T-banded application of 10-34-0;
4) 10-34-0 starter fertilizer, 3” T-band; and
5) 10-34-0 starter fertilizer, applied DIF.

Table 1. ***Plant stand counts*** **from from an evaluation of tank-mixed and concurrent applications of planting-time granular, liquid, and seed treatment insecticides with starter fertilizer and azoxystrobin for sugarbeet root maggot control, St. Thomas, ND, 2020**

Treatment/form.[a]	Placement[b]	Rate (product/ac)	Rate (lb a.i./ac)	Stand count[c] (plants / 100 ft)		
				37 DAP	49 DAP	62 DAP
Poncho Beta + Midac FC + 10-34-0	Seed 3” TB	 13.6 fl oz 5 GPA	68 g a.i./ unit seed	190.2 a-d	205.5 abc	209.5 a
Poncho Beta + Midac FC + AZteroid FC + 10-34-0	Seed 3” TB	 13.6 fl oz 5.7 fl oz 5 GPA	68 g a.i./ unit seed 0.18 0.15	183.0 b-e	200.4 abc	200.2 ab
Midac FC + 10-34-0	3” TB	13.6 fl oz 5 GPA	0.18	199.3 ab	209.3 ab	198.2 ab
Poncho Beta + 10-34-0	Seed 3” TB	 5 GPA	68 g a.i./ unit seed	201.1 a	202.3 abc	196.8 ab
Counter 20G	B	8.9 lb	1.8	191.6 abc	213.6 a	191.3 ab
Midac FC + 10-34-0	DIF	13.6 fl oz 5 GPA	0.18	188.0 a-e	194.5 bcd	189.6 bc
Counter 20G + 10-34-0	B DIF	7.5 lb 5 GPA	1.5	184.1 a-e	190.5 cd	189.3 bc
Counter 20G	B	7.5 lb	1.5	185.4 a-e	205.4 abc	187.0 bcd
10-34-0	DIF	5 GPA		171.4 e	189.3 cd	184.1 bcd
Counter 20G + 10-34-0	B DIF	8.9 lb 5 GPA	1.8	173.9 de	178.9 d	182.5 bcd
10-34-0	3” TB	5 GPA		172.3 e	189.6 cd	170.9 cd
Check	---	---	---	175.0 cde	181.3 d	169.1 d
LSD (0.10)				17.48	17.82	19.77

Means within a column sharing a letter are not significantly (*P* = 0.05) different from each other (Fisher’s Protected LSD test).

[a]Carrier for at-plant treatments that included starter fertilizer involved a 3:2 gal. ratio of H_2O to liquid 10-34-0 fertilizer. Output volume was 5 GPA.

[b]Seed = insecticidal seed treatment; B = 5-inch band at planting; 3” TB = 3-inch T-band over open seed furrow at planting; DIF = dribble in-furrow at planting

[c]Surviving plant stands were counted on June 25, and on 7 and 20 July, 2020 (i.e., 37, 49, and 62 days after planting [DAP], respectively).

These early plant stand counts suggest a few concerns. First, these results suggest that combining Midac FC insecticide with azoxystrobin fungicide and 10-34-0 starter fertilizer and using Poncho Beta-treated seed has potential to negatively impact seedling emergence and/or survival. However, further study should be conducted to confirm or rule out this concern. Secondly, the results of this first stand count indicate that banding Counter 20G at its high rate (8.9 lb product/ac) at planting and combining the application with a concurrent (i.e., separate delivery system) application of 10-34-0 could also delay or reduce sugarbeet seedling emergence. Finally, this first series of stand counts suggest that 10-34-0 starter fertilizer itself has potential to reduce or delay sugarbeet seedling emergence, at least under the light-textured soil conditions that characterized this field location.

At the second stand count (49 DAP), the highest surviving plant stand in the trial was observed in plots treated with Counter 20G at 8.9 lb product per acre (without starter fertilizer). The average stand count for that treatment was significantly greater than both Counter treatments (7.5 and 8.9 lb product/ac) when a concurrent application of 10-34-0 starter fertilizer was included at planting. Plots treated with a T-banded application of Midac plus 10-34-0 had the second-highest plant densities at 49 DAP, with an average stand count of 209.3 plants per 100 row ft. Although not significantly different, plots receiving the same Midac FC/10-34-0 tank mixture, but applied via DIF placement, had about 7% fewer plants per 100 row ft than when the mixture was T-banded. Similarly, a slight numerical (i.e., not statistically significant) reduction in stand was observed when AZteroid was tank mixed with Midac and starter fertilizer and applied to plots planted with Poncho Beta-treated seed. However, the difference was only a 3% reduction in plant stand, suggesting that this disparity could have simply been a result of natural variability within and/or between replicates in the experiment.

The third stand count (i.e., 62 DAP) was carried out on July 20, which should have been after nearly all SBRM larvae had ceased feeding behavior. As such, this data should be interpreted for treatment impacts on both crop safety and efficacy at protecting plants from mortality resulting from SBRM feeding injury. At this last count, excellent stands were achieved by using the following treatments, which were not significantly different from each other in respect to surviving plant densities:

1) Poncho Beta-treated seed + a T-banded tank mixture of Midac FC and 10-34-0;
2) Poncho Beta-treated seed + a T-banded tank mixture of Midac FC, AZteroid, and 10-34-0;
3) Midac FC + 10-34-0, T-band;
4) Poncho Beta seed + 10-34-0, T-band; and
5) Counter 20G banded at 8.9 lb product/ac (no fertilizer).

In comparing the tank mixtures that included Midac FC and 10-34-0 starter fertilizer, the trend suggested a slight reduction in surviving stand by adding AZteroid fungicide was also evident at this final count; however, that amounted to a decrease of only 4.5%, and it was not statistically significant. Similarly, in plots treated at planting with Counter 20G at the high labeled rate (8.9 lb/ac), plant densities were reduced by about 5% when a concurrent application of starter fertilizer was included, but the difference was not significant. In comparing placement methods for applying Midac plus starter fertilizer, stands were numerically greater when the mixture was applied by T-band, but the slight difference (4.4%) was not statistically significant.

Results from sugarbeet root maggot feeding injury ratings in this experiment are presented in Table 2. A moderate SBRM infestation was present for the study. This was indicated by the average SBRM feeding injury ratings in the untreated check and the fertilizer-treated controls, which ranged between 5.78 and 5.92 on the 0 to 9 scale of Campbell et al. (2000). Most insecticide treatments provided significant reductions in SBRM feeding injury when compared to that recorded for the untreated check plots. However, the following treatments incurred SBRM feeding injury that was not statistically reduced in comparison to the untreated check: 1) Poncho Beta + 10-34-0 starter fertilizer; 2) Midac FC + 10-34-0 applied in a 3” T-band; and 3) Midac FC + 10-34-0 applied in a 3” T-band.

Table 2. ***Larval feeding injury ratings*** **from an evaluation of tank-mixed and concurrent applications of planting-time granular, liquid, and seed treatment insecticides with starter fertilizer and azoxystrobin for sugarbeet root maggot control, St. Thomas, ND, 2020**				
Treatment/form.[a]	**Placement[b]**	**Rate (product/ac)**	**Rate (lb a.i./ac)**	**Root injury (0-9)**
Counter 20G + 10-34-0	B DIF	8.9 lb 5 GPA	1.8	3.03 e
Counter 20G	B	7.5 lb	1.5	3.08 e
Poncho Beta + Midac FC + AZteroid FC + 10-34-0	Seed 3" TB	 13.6 fl oz 5.7 fl oz 5 GPA	68 g a.i./ unit seed 0.18 0.15	3.65 e
Counter 20G	B	8.9 lb	1.8	3.95 de
Counter 20G + 10-34-0	B DIF	7.5 lb 5 GPA	1.5	4.20 cde
Poncho Beta + Midac FC + 10-34-0	Seed 3" TB	 13.6 fl oz 5 GPA	68 g a.i./ unit seed 0.18	4.25 cde
Midac FC + 10-34-0	DIF	13.6 fl oz 5 GPA	0.18	4.40 b-e
Midac FC + 10-34-0	3" TB	13.6 fl oz 5 GPA	0.18	5.35 a-d
Poncho Beta + 10-34-0	Seed 3" TB	 5 GPA	68 g a.i./ unit seed	5.50 abc
Check	---	---	---	5.78 ab
10-34-0 fertilizer check	DIF	5 GPA		5.83 ab
10-34-0 fertilizer check	3" TB	5 GPA		5.93 a
LSD (0.05)				1.432

Means within a column sharing a letter are not significantly (*P* = 0.05) different from each other (Fisher's Protected LSD test).

[a]Carrier for at-plant treatments that included starter fertilizer involved a 3:2 gal. ratio of H_2O to liquid 10-34-0 fertilizer. Output volume was 5 GPA.

[b]Seed = insecticidal seed treatment; B = 5-inch band at planting; 3" TB = 3-inch T-band over open seed furrow at planting; DIF = dribble in-furrow at planting

It should be noted, however, that the DIF application of Midac with starter fertilizer also was not statistically different from the best-performing treatment in the trial with regard to protection from SBRM feeding injury (i.e., Counter 20G applied at its high labeled rate of 8.9 lb product/ac with a concurrent application of 10-34-0 starter fertilizer. Other treatments that provided excellent levels of protection from SBRM feeding injury included the following:

1) Counter 20G banded at 7.5 lb product/ac (no fertilizer);
2) Poncho Beta-treated seed + a T-banded tank mixture of Midac, AZteroid, and 10-34-0 starter fertilizer;
3) Counter 20G banded at 8.9 lb product/ac (no fertilizer);
4) Counter 20G banded at 7.5 lb product/ac + a concurrent application of 10-34-0; and
5) Poncho Beta-treated seed + a T-banded tank mixture of Midac and 10-34-0

These results suggest that combining at-plant insecticide applications, such as Counter 20G, Poncho Beta seed treatment, or Midac sprayable liquid insecticide, with 10-34-0 starter fertilizer or AZteroid fungicide are not likely to reduce efficacy of the SBRM insecticides evaluated in this trial.

Yield data from this experiment are shown in Table 3. The top-yielding treatment in the trial, with regard to both recoverable sucrose yield and root tonnage, was the planting-time application of Counter 20G, applied at its high labeled rate of 8.9 lb product per acre. Excellent yield was also produced by using a similar treatment involving the same rate of Counter and combining it with a concurrent application of 10-34-0 starter fertilizer.

Table 3. ***Yield parameters*** **from an evaluation of tank-mixed and concurrent applications of planting-time granular, liquid, and seed treatment insecticides with starter fertilizer and azoxystrobin for sugarbeet root maggot control,, St. Thomas, ND, 2020**							
Treatment/form.[a]	**Placement[b]**	**Rate (product/ac)**	**Rate (lb a.i./ac)**	**Sucrose yield (lb/ac)**	**Root yield (T/ac)**	**Sucrose (%)**	**Gross return ($/ac)**
Counter 20G	B	8.9 lb	1.8	10,085 a	29.6 a	18.17 a	1,478
Counter 20G + 10-34-0	B DIF	8.9 lb 5 GPA	1.8	9,768 a	29.3 a	17.89 a	1,397
Poncho Beta + Midac FC + AZteroid FC + 10-34-0	Seed 3" TB	 13.6 fl oz 5.7 fl oz 5 GPA	68 g a.i./ unit seed 0.18 0.15	9,709 ab	28.7 a	18.05 a	1,412
Midac FC + 10-34-0	DIF	13.6 fl oz 5 GPA	0.18	9,577 ab	27.9 ab	18.33 a	1,416
Counter 20G	B	7.5 lb	1.5	9,458 abc	29.2 a	17.38 a	1,303
Poncho Beta + Midac FC + 10-34-0	Seed 3" TB	 13.6 fl oz 5 GPA	68 g a.i./ unit seed 0.18	9,088 abc	28.1 ab	17.50 a	1,251
Counter 20G + 10-34-0	B DIF	7.5 lb 5 GPA	1.5	8,986 abc	26.9 a-d	17.96 a	1,289
Poncho Beta + 10-34-0	Seed 3" TB	 5 GPA	68 g a.i./ unit seed	8,713 a-d	27.4 abc	17.19 a	1,177
Midac FC + 10-34-0	3" TB	13.6 fl oz 5 GPA	0.18	8,378 bcd	24.8 bcd	17.91 a	1,216
10-34-0 fertilizer check	DIF	5 GPA		8,345 bcd	27.2 abc	16.81 a	1,073
Check	---	---	---	8,198 cd	23.7 cd	18.42 a	1,223
10-34-0 fertilizer check	3" TB	5 GPA		7,580 d	23.4 d	17.47 a	1,046
LSD (0.05)				1,373.0	3.69	NS	

Means within a column sharing a letter are not significantly (*P* = 0.05) different from each other (Fisher's Protected LSD test).
[a]Carrier for at-plant treatments that included starter fertilizer involved a 3:2 gal. ratio of H_2O to liquid 10-34-0 fertilizer. Output volume was 5 GPA.
[b]Seed = insecticidal seed treatment; B = 5-inch band at planting; 3" TB = 3-inch band over open seed furrow at planting; DIF = dribble in-furrow at planting

Although the recoverable sucrose yield, root tonnage, and percent sucrose recorded for those plots were slightly lower when the starter fertilizer application was included, none of those yield response variables were significantly reduced in comparison to those recorded for the Counter-only plots. Most other treatments in the trial also produced sucrose and root yields that were not significantly different from the top treatment in the study (Counter 20G only, at the high rate). Exceptions to that, which also failed to provide significant recoverable sucrose and root yield improvements over the unfertilized untreated check, included the following:

1) Counter 20G at 7.5 lb product/ac + a concurrent application of 10-34-0 starter fertilizer;
2) Poncho Beta + 10-34-0 applied in a 3" T-band; and
3) Midac FC tank mixed with 10-34-0 and applied in a 3" T-band;

Despite the fact that few significant yield differences were observed among insecticide-treated plots in this trial, a few general performance patterns suggest careful consideration on deploying the products tested. For instance, in plots treated with Counter 20G, the inclusion of a concurrent application of 10-34-0 starter fertilizer consistently resulted in numerical (i.e., not statistically significant) reductions in recoverable sucrose yield and root tonnage when a concurrent application of 10-34-0 starter fertilizer was included. This was the case for both application rates of Counter (i.e., 7.5 and 8.9 lb product/ac); however, the resulting negative impact on gross revenue was most notable in the case of the high labeled rate of Counter 20G (8.9 lb), which generated $81 less revenue when the starter fertilizer application was included during planting.

One very positive finding was that including AZteroid fungicide in a T-banded tank mixture with Midac FC and 10-34-0 starter fertilizer, and combining the mix with Poncho Beta-treated seed, had no deleterious impact on any of the measured yield parameters. Plots that received that multi-component treatment produced numerically greater recoverable sucrose yield and root yield, and had a numerically greater percent sucrose than comparative plots that included individual or paired components from that combination (i.e., plots protected by only Poncho Beta-treated seed with T-banded 10-34-0 or the T-banded application of the Midac FC plus 10-34-0 tank mixture).

Another helpful result from this trial was that, although placement (i.e., 3" T-band vs. DIF) did not have a significant impact on performance of Midac FC, plots that received this product via DIF placement produced numerically greater recoverable sucrose yield and root tonnage, and roots from DIF-treated Midac plots had numerically greater sucrose content. This is a very positive result, because sugarbeet planters are commonly equipped with DIF delivery technology, and it is also fairly simple to add to a planter.

Overall results of this trial suggest that, for growers intending on applying Counter 20G at planting and also including a concurrent application of 10-34-0 starter fertilizer, it is advisable to at least dilute the fertilizer to the 3:2 gallon (i.e., 3 gallons of fertilizer to 2 gallons of water) ratio if they choose to use the full 8.9-lb rate of Counter. Results also suggest that combining Poncho Beta-treated seed with an application of Midac FC plus 10-34-0 starter fertilizer can improve SBRM control and resulting yield and gross revenue. Additionally, it appears that including AZteroid in a tank mixture with Midac FC and 10-34-0 starter fertilizer, and applying while planting Poncho Beta-treated seed is safe for the crop and is not likely to reduce SBRM control efficacy. Also, growers intending on using Midac FC for SBRM control are advised to apply it by using dribble in-furrow placement. However, it should be noted that data from previous NDSU research suggests that Midac FC performs at a comparable level to that of the moderate rate of Counter 20G (i.e., 7.5 lb product/ac). Thus, if planting-time insecticide protection is limited to Midac FC, the grower should expect the need to add a postemergence rescue insecticide application to augment SBRM control, especially in areas of moderate to high risk of economically damaging root maggot populations.

Finally, it should be noted that most of the treatments tested in this trial need further testing to determine the validity and repeatability of these results. This is especially so for the multi-component treatments tested, for the inclusion of AZteroid fungicide with Midac/10-34-0 tank mixtures, and for the safety of combining Counter 20G applications with concurrent applications of starter fertilizer.

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