

What's Cropping Up?

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Whole Farm Nutrient Mass Balance Calculator For New York Dairy Farms

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Whole Farm Nutrient Mass Balance

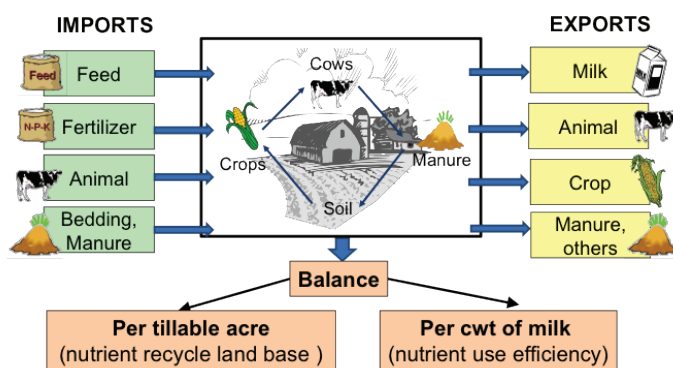


Fig. 1: Whole farm nutrient mass balance assessment.

Striking a whole farm balance

Environmental awareness and the desire for social, economic and environmental sustainability have led to more proactive management of farm nitrogen (N), phosphorus (P) and potassium (K) balances. Nutrient accumulation is when the amount of imported nutrients on farm exceeds the amount of nutrients exported from the farm. The implications of nutrient accumulation include degradation of water and air quality, which is reason for increased pressure on animal agriculture by the public, litigators and state and federal regulators. Similarly negative consequences can result from whole farm nutrient losses, when exported nutrients exceed the amount of nutrients imported on the farm. In these situations, the soil can be mined of nutrients, decreasing soil fertility and, when deficiencies start to occur, also crop yields. Thus, a clear understanding of the imbalances between farm nutrient exports and imports, and how they relate to farm management practices, is key to developing long-term, sustainable solutions for individual farms, and the animal industry in general.

Adaptive management

Sustainable solutions require improved nutrient use efficiency across the whole farm, balancing the nutrient flows of both the animals and the land. However, when it comes to whole farm nutrient management, it can feel like there are more questions for producers than time to evaluate and answer. Is cropland being fertilized

at the proper times in sufficient quantities to supply nutrients to crops without accumulating nutrients? What nutrients need to be supplied in purchased fertilizer and feed this year to prevent nutrient loss? And once all those questions have been dealt with for the year, a new year comes around and the process begins anew. This is where a method of keeping track of nutrient management records from year to year in a systematic way can save time, money and conserve nutrients. The idea behind the adaptive management concept is to maintain nutrient management records in such a way that one can assess the nutrient status of the whole farm (Fig. 1), pinpoint the areas where improvements can be made, and then track the progress of those improvements year to year. The whole farm nutrient mass balance (NMB) calculator is a tool that was developed to help in the assessment.

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Nutrient Management

A whole farm assessment tool

The whole farm NMB calculator was first developed by Stuart Klausner at Cornell University, and modified and reprogrammed in Microsoft Visual Basic in more recent years. The software and supporting information (manual etc.) are downloadable from the whole farm nutrient mass balance project page of the Cornell Nutrient Management Spear Program (NMSP): <http://nmsp.cals.cornell.edu/projects/massbalance.html>. The NMB calculator is targeted for use by dairy farms, though it can be used to determine NMBs of any type of livestock operation. A data questionnaire was developed to help gather the data listed in Table 1.

Within the NMB calculator, there are four basic pools where nutrients can be allocated on a farm: (1) they are imported to the farm in the form of purchased products; (2) they are exported from the farm as products sold/exported; (3) they remain on the farm to be recycled; or (4) they are lost to the environment. The NMB program calculates N, P, and K imported onto and exported from the farm in the form of feed, fertilizer, animals, crops,

milk, manure and bedding. The difference between nutrients imported and nutrients exported is expressed as N, P and K balance per acre of cropland, and per unit (cwt or hundred weight) of milk produced (Fig. 1). Negative values are not sustainable over time, as they indicate that more nutrients are being taken off the farm than are replaced. However, large positive balances are not desirable either, as they indicate nutrient inefficiencies and increased risk for environmental losses.

To demonstrate how the NMB calculator assists producers in evaluating best management practices, data from a central New York dairy farm were analyzed over the course of 8 consecutive years (2003-2010). In the initial assessments, NMB values were high, and 76, 69 and 64% of the imported N, P, and K remained on the farm (Fig. 2). However, by gradually matching feed and fertilizer purchases with animal and crop needs, the farm reduced its nutrient imbalances, and only 45, 34 and 31% of the imported N, P, and K remained on the farm in recent years. Moreover, the improvements made resulted in a milk production per cow increase from a little less than 23,000 to more than 24,000 lbs of milk over the same time period.

Table 1: Information needed to complete a whole farm nutrient mass balance assessment.

Category	Data Collected
Farm Characteristics	
Farm contact info	Name, address, phone, email
Balance year	Year
Farm land base	Total and tillable acres Acres in legumes and receiving manure
Animals	Group, average number, weight
Farm Produced Feed	
Farm produced crops	Acres and yield (tons/acre), %DM CP, P, and K (%DM) Acres in legume, % legume in stand Beginning and end year inventories (tons)
Imports (Purchases)	
Feed	Tons/yr, %DM, CP, P, and K (%DM) Beginning and end year inventories (tons)
Fertilizer	Tons, %N, %P ₂ O ₅ , %K ₂ O
Animals	Number, weight (lbs)
Bedding	Tons/year, N, P, and K (%DM)
Exports (Sales)	
Milk sold	Lbs/year, milk protein (%)
Animals sold	Number, weight (lbs)
Crops sold	Tons/year, %DM, CP, P, and K (%DM)
Other sold	Tons/year, % DM, N, P and K (%DM)

Farmer feedback

Farmers and their advisors can utilize the NMB calculator to increase nutrient use efficiency on the farm and monitor progress over time. They can also compare their farm's nutrient balance to those of peers in the dairy industry with similar milk production. Comments of participating farmers included:

"Pulling together the information is useful in itself and it gets me to look at numbers in a different way."

"Participating in the NMB is one way to show that we are doing our best to comply with regulations; it demonstrates that we are good environmental stewards."

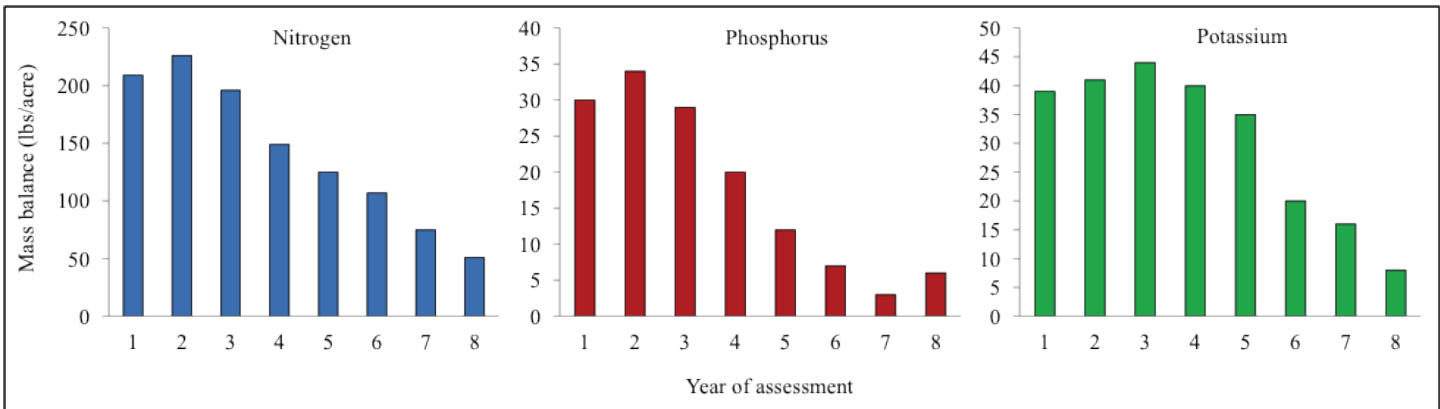


Fig. 2. Nitrogen, phosphorus and potassium mass balances (lbs/acre) measured by a New York case study dairy farm over 8 years.

In summary

Whole farm adaptive management approaches to nutrient management have been recognized by the Natural Resources Conservation Service (NRCS) in its new national NRCS590 standard and many states are currently discussing approaches for implementation. The NMB calculator generates an overall summary of N, P and K balance of a particular farm using recorded imports and exports; these annual summaries can assist producers in making management changes that lead to more efficient production and resource conservation.

York Agricultural Development Program (NNYADP), Northeast Sustainable Agriculture Research and Extension (NESARE), Federal-Formula Funds, and a USDA-NRCS Conservation Innovation Grant. For questions about these results contact Quirine M. Ketterings at 607-255-3061 or gmk2@cornell.edu, and/or visit the Cornell Nutrient Management Spear Program website at: <http://nmsp.cals.cornell.edu/>.

Additional resources

- Soberon, M.A., Q.M. Ketterings, C.N. Rasmussen, and K.J. Czymmek. 2013. Whole Farm Nutrient Balance Calculator for New York Dairy Farms. *Nat. Sci. Educ.* 42:57–67.



Acknowledgments

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Feasible Whole Farm Nutrient Mass Balances For New York Dairy Farms

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Nutrient mass balances for New York dairies

A whole-farm nutrient mass balance (NMB) is the difference between the amounts of N, P, and K imported onto dairy farms as feed, fertilizer, animals, and bedding, and exported via milk, animals, crops, and manure. We can express a NMB per tillable acre to indicate the potential for recycling nutrients in the land base, an environmental indicator, or per cwt milk, a milk production efficiency indicator.

The importance of measuring nutrient mass balances

Large positive NMBs per acre suggest high risk of nutrient losses to the environment, while large positive NMBs per hundred weight (cwt) reflect low nutrient use efficiencies, and potential economic loss for the farm as well. Negative NMBs (resulting from exports exceeding imports) reflect mining of soil P and K resources, and will eventually reduce crop yields. Annual NMB assessments give farmers a chance to compare the farm against peers in the same milk production group, and to evaluate the impact of management changes on nutrient use efficiency and production.

Distribution of nutrient mass balances across New York dairy farms

In 2006, NMBs for 102 dairy farms from 26 different New York counties showed a range from -35 to 211 lbs N/acre, from -7 to 45 lbs P/acre, and from -45 to 132 lbs K/acre (Fig. 1). Also the NMBs per cwt of milk varied widely among New York dairies: from -1.3 to 2.6 lbs N/cwt, from -0.11 to 0.47 lbs P/cwt, and from -0.73

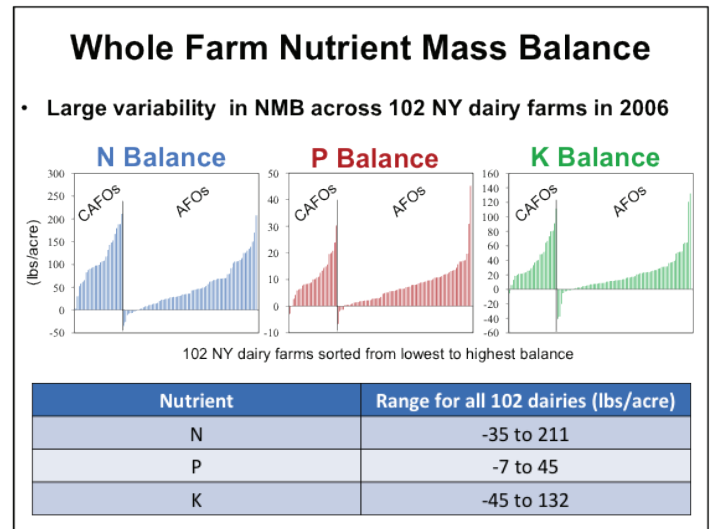


Fig. 1: Distribution of N, P, and K mass balances (lbs/acre) for concentrated animal feeding operations (CAFOs) and animal feeding operations (AFOs) based on 102 NY dairy farms.

to 1.69 lbs K/cwt. Ranges in NMB were similar when comparing CAFOs and AFOs.

How do nutrient mass balances relate to milk production per cow?

Dairy farms in our database averaged 19,600 lbs milk/cow per year, slightly higher than the average milk production of New York dairies in 2006 (18,900 lbs/cow per year). Dairy production does not depend on large positive balances (Fig. 2); we found high producing dairies (>20,000 lbs milk/cow per year) with negative NMBs per acre as well as high producing dairies with large positive NMBs per acre.

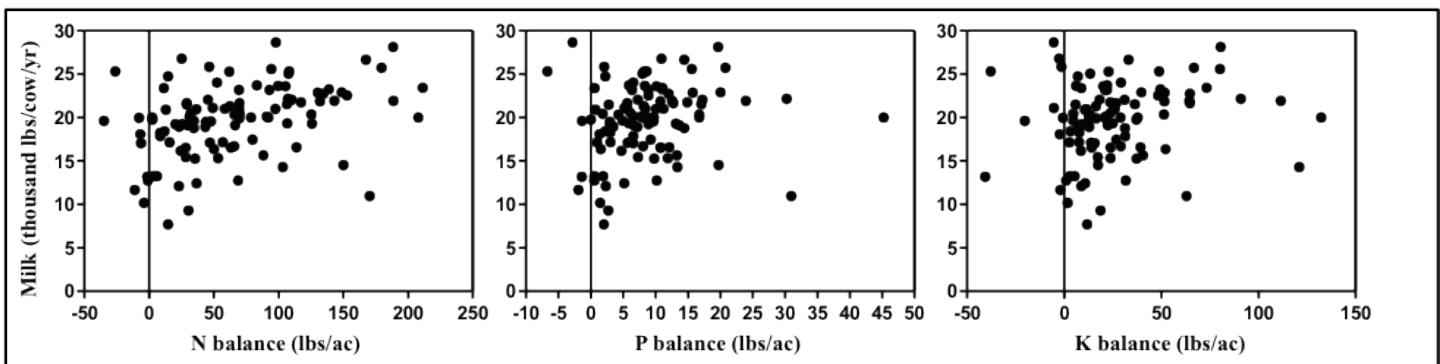


Fig. 2: Relationships between milk production per cow and nutrient mass balances per acre show that highly productive farms can operate within the feasible balances.

Table 1. Feasible nutrient mass balances for NY.

NMB	N	P	K
Per acre (lbs/acre)	<105	<12	<37
Per cwt milk (lbs/cwt)	<0.88	<0.11	<0.30

Combining both indicators, the most efficient farms have balances in the green area in Fig. 3. Although the current assessment of feasible balances for New York can change over time as more farms join the study, evaluations so far have shown that farms that

What's a "feasible" nutrient mass balance?

The data showed large ranges in NMBs among the 102 farms, but this does not tell us what is reasonably achievable, or "feasible". A feasible NMB should allow dairy farms to be economically profitable, environmentally sustainable, and flexible enough to allow for the many variations among farms. Based on the largest dairy farm database we had for one individual year (2006), we defined "feasible" NMBs per acre as those at or below which 75% of the dairy farms in our database were operating: ≤ 105 lbs N/acre, ≤ 12 lbs P/acre, and ≤ 37 lbs K/acre (Table 1). We also defined a "feasible" NMB per cwt of milk produced as those at or below which 50% of the dairies were operating in 2006: ≤ 0.88 lbs N/cwt, ≤ 0.11 lbs P/cwt, and ≤ 0.30 lbs K/cwt (Table 1).

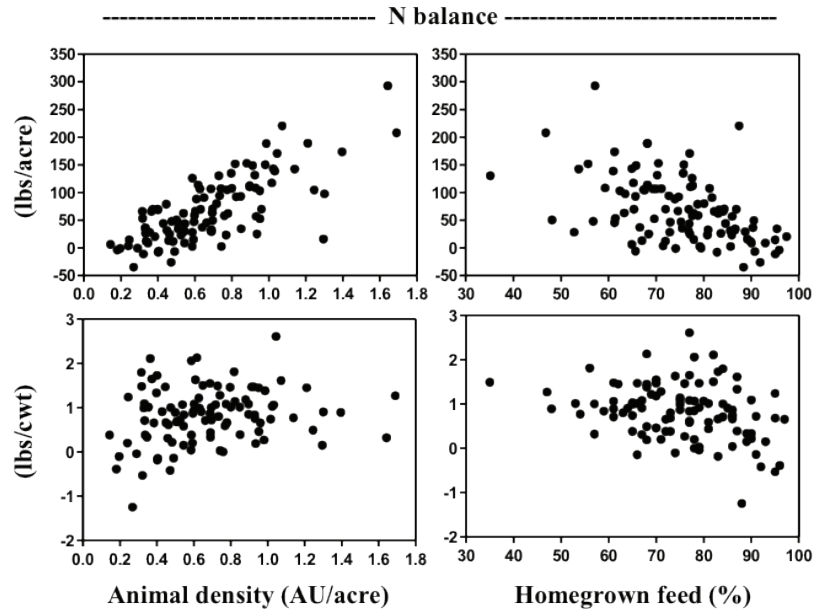


Fig. 4: Relationship between the N mass balances per acre and per cwt (without manure export) and animal density and farm produced feed.

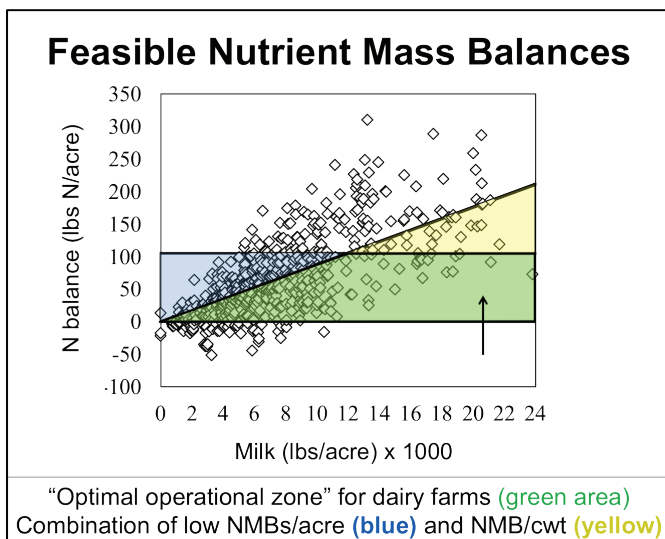


Fig. 3: Feasible balances (optimal operational zone) based on 102 dairy farms in New York.

operate outside of the green area (Fig. 3) might have opportunities for improvements in nutrient use.

Drivers of nutrient mass balances

Farms with high animal densities (more cows per acre) tend to have higher NMBs per acre than low density farms, and therefore higher risk of nutrient losses to the environment. However, NMBs per cwt are unrelated to animal density, except at very low density farms (Fig. 4). This suggests that high density farms need to operate with high nutrient use efficiencies to reduce the risk of nutrient losses. Farms that grow a high proportion of the feed in the farm itself tend to have lower NMBs per acre and similar NMBs per cwt than farms that purchase much of the feed (Fig. 4).

Opportunities to improve nutrient mass balances

Experiences with a large number of farms over the past ten years has shown that opportunities exist for some dairy farms to improve NMBs by producing more feed on the farm, implementing precision feeding, adjusting fertilizer use, exporting crops (in farms with low animal densities) and exporting manure (in farms with high animal densities). Farms with less than 1 animal unit per acre (about 2 acres per cow plus her replacement) were typically able to stay below the feasible balances, whereas on higher density farms, export of manure and/or crops was needed to lower balances.

Additional resources

- Cela, S., Q. Ketterings, K. Czymmek, M. Soberon, and C. Rasmussen. 2014. Characterization of nitrogen, phosphorus, and potassium mass balances of dairy farms in New York State. *Journal of Dairy Science* 97:1-19.
- Soberon, M.A., Q.M. Ketterings, C.N. Rasmussen, and K.J. Czymmek. 2013. Whole Farm Nutrient Balance Calculator for New York Dairy Farms. *Natural Sciences Education* 42:57-67.

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Control Glyphosate-Resistant Horseweed in Zone/No-Tillage Corn and Soybeans

Weed Management

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Fig. 1: Over-wintering horseweed rosette. From: *Weeds of the Northeast*. Photo by J. Neal.

Horseweed, also known as marestail, is a winter or summer annual weed which reproduces by seed that germinates in spring or late summer. Seed that germinate in late summer over-winter as rosettes or basal clusters of leaves not separated by stem elongation (Figure 1). These over-wintering rosettes rapidly elongate (bolt) to produce erect flowering stems in the spring and early summer. Mature plants are unbranched at the base and may be 6 feet tall with many small flowering branches near the top as shown in Figure 2. Seeds are about 1/16 inch long with many white bristles on the end. These bristles allow for wind dispersal of the seed.

Zone/No-Tillage Problem

Horseweed is native to North America and is commonly found in fallow fields, pastures, roadsides, and wasteland. Although not common in conventionally tilled and planted fields, it is common where zone/no-tillage cropping is practiced. Many of the states reporting glyphosate-resistant (GR) horseweed have a long history of no-tillage cropping. In these areas, over-wintering horseweed rosettes have likely been subjected to glyphosate selection pressure since the 1970s when growers started using Roundup (glyphosate) for burndown in no-tillage fields. With repeated glyphosate use over the years, susceptible horseweed plants were likely

controlled while glyphosate tolerant plants flowered and set seed. This resulted in a shift to a horseweed population dominated by the resistant biotypes.

GR Horseweed is Widespread in U.S.

The International Survey of Herbicide Resistant Weeds, <http://www.weedscience.org>, shows that 24 states in the U.S. have documented GR horseweed populations. It appears that the increasing popularity of zone/no-tillage cropping in NY, along with the widespread use of GR crops and repeated use of glyphosate herbicides has led to the development of GR horseweed populations here as well. Greenhouse trials with horseweed seed from two locations in Central NY are being conducted to confirm this. In one case, glyphosate was applied for burndown prior to planting no-tillage soybeans and again for postemergence weed control. As can be seen in Figure 3, horseweed



Fig. 2: Horseweed plant showing the lower part of the leafy stem, upper part of the stem with flowers, and seed with slender bristles on one end. From: *Weeds of the North Central States*, North Central Regional Research Publication No. 281.

Weed Management



Fig. 3: Horseweed population that survived burndown and postemergence glyphosate applications. Photo by R.J. Richtmyer III.

survived both glyphosate applications. Although field experiments to evaluate control programs for GR horseweed have not been conducted in NY State, conversations with weed science colleagues on the Delmarva, where GR horseweed was first confirmed in 2000, have been helpful in formulating control recommendations for GR horseweed in zone/no-tillage corn and soybeans. Effective control programs target the rosette stage shown in Figure 1 as part of the burndown herbicide application prior to planting zone/no-tillage crops. Once stem elongation begins, horseweed becomes increasingly difficult to control. The other key element of an effective control program is to incorporate herbicides with sites of action that are different from glyphosate, which is a Group 9 herbicide.

Burndown/Control Recommendations

The recommendations shown in Table 1 are a first

Table 1. Burndown/control recommendations for GR horseweed in zone/no-tillage corn and soybeans.

GR Horseweed burndown/control for zone/no-tillage corn.		
Weed Situation	Amount of Product(s) Per Acre	Remarks and Limitations
Problem Weed Glyphosate-resistant horseweed	22 fl. oz. Roundup PowerMax + 1 pt. of 3.8 lb./gal. 2,4-D LVE + 1 qt. Atrazine 4L	GROUP 4, 5, AND 9 HERBICIDES • Apply Roundup or other glyphosate product with 2,4-D LVE and atrazine to horseweed rosettes at least 7 days before planting corn. Follow with an appropriate preemergence or postemergence program for control of other weeds.
	22 fl. oz. Roundup PowerMax + 1 pt. of 3.8 lb./gal. 2,4-D LVE + 13-15 fl. oz. Verdict	GROUP 4, 9, 14, AND 15 HERBICIDES • Apply Roundup or other glyphosate product with 2,4-D LVE and Verdict to horseweed rosettes at least 7 days before planting corn. Follow with an appropriate postemergence program if needed.
GR Horseweed burndown/control for zone/no-tillage soybeans.		
Weed Situation	Amount of Product(s) Per Acre	Remarks and Limitations
Problem Weed Glyphosate-resistant horseweed	22 fl. oz. Roundup PowerMax + 1 pt. of 3.8 lb./gal. 2,4-D LVE + 2 oz. OpTill	GROUP 2, 4, 9, AND 14, HERBICIDES • Apply Roundup or other glyphosate product with 2,4-D LVE and OpTill to horseweed rosettes in spring at least 14 days before planting soybeans. Follow with an appropriate postemergence program if needed.
	22 fl. oz. Roundup PowerMax + 1 pt. of 3.8 lb./gal. 2,4-D LVE + 2.5 oz. Valor XLT	GROUP 2, 4, 9, AND 14, HERBICIDES • Apply Roundup or other glyphosate product with 2,4-D LVE and Valor XLT to horseweed rosettes in spring at least 14 days before planting soybeans. Follow with an appropriate postemergence program if needed.

attempt to make written recommendations for GR horseweed in zone/no-tillage corn and soybeans. They have not been incorporated into the Cornell Guide for Integrated Field Crop Management. They emphasize the importance of controlling horseweed early in the season when the plants are still in the rosette stage, and they incorporate herbicides with sites of action that are different from glyphosate (Group 9). For both corn and soybeans, 2,4-D LVE (synthetic auxin or growth regulator Group 4 herbicide) makes a significant contribution to horseweed burndown/control. For corn, residual herbicides like atrazine (photosynthesis inhibitor Group 5 herbicide), or Verdict a premix of Kixor (cell membrane disrupter Group 14 herbicide) and Outlook (seedling shoot inhibitor Group 15 herbicide), have proven helpful in controlling horseweed, and

provide residual for control of summer annual weeds. In the soybean recommendations, OpTill or Valor XLT help control the horseweed and provide residual weed control. OpTill is a premix of Kixor and Pursuit (ALS inhibitor Group 2 herbicide), while Valor XLT combines Classic (ALS inhibitor Group 2 herbicide) with Valor, (cell membrane disrupter Group 14 herbicide).

At this time, it seems prudent that NY farmers scout zone/no-tillage acreage for horseweed that is not readily controlled with glyphosate, and that they employ an aggressive herbicide resistance management plan. Key elements of such a plan involve rotating herbicides with different sites of action, and using tank mixes/premixes or sequential applications that include herbicides with different sites of action.

Cornell FIELD CROPS



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Calendar of Events

Jun. 4	Small Grains Management Field Day , Aurora, NY
July 15	New York Weed Science Field Day , Aurora, NY
July 16	Aurora Farm Field Day, Aurora, NY (Tentative)
Aug. 5-8	2015 Soil Health Train-the-Trainer Workshop , Ithaca, NY

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