

Organic Spinach Production, Perspective from an Organic Grower / Shipper

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Earthbound Farm

- **EBF is the largest producers of organic salads in USA. 100% of EBF product lines are organically produced. Earthbound Farm has a lot more competition in organic salad market than in past.**
- **Organic bagged salads continue to increase – nearly 30% of all bagged salads in the US are organically produced. Segment of market continues to grow.**
- **EBF obtains produce from both external growers and from EBF Internal Farming department.**



Earthbound Farm, Internal Farming

- **Produce >40% of raw and commodity volumes for EBF annually.**
- **Grow >13,000 acre (>5200 hectares) organic produce per year.**
- **Grow in Central Coast and Imperial Valley.**

I have worked in organics spinach production for over 17 years.

- **Mission Organics (<12 years)**
- **EBF Internal Farming (~6 years)**
- **Responsible for purchasing all baby crop seed and planning baby crop variety schedules.**
- **Lead EBF Internal Farming Pest/Disease management team.**



Earthbound Farm- Baby Spinach Attributes

- **Baby spinach salads continue to be very popular. Compared to other leafy greens, spinach is favored.**
- **Baby spinach can be eaten fresh, can be cooked, or eaten in other ways (smoothies).**
- **Over 40% of EBF baby leafy greens salad volume is composed of baby spinach.**
- **Spinach can be successfully combined with other leafy greens and generally has strong shelf life.**



Other reasons why organic spinach is so popular?



Environmental Working Group's "Dirty Dozen" list of pesticide residues based on U.S. Department of Agriculture tests of 48 types of produce from USA Today March 10, 2017

1. Strawberries

2. Spinach

3. Nectarines

4. Apples

5. Peaches

6. Pears

7. Cherries

8. Grapes

9. Celery

10. Tomatoes

11. Sweet bell peppers

12. Potatoes



Organic Spinach Production Challenges

Spinach is:

- **Highly susceptible to damping-off diseases (caused by *Pythium*, *Fusarium*, *Rhizoctonia*).**
- **Highly susceptible to downy mildew pathogen *Peronospora effusa*.**
- **Requires higher levels of nitrate-nitrogen and has a smaller root system compared to most baby crops - making it more prone to nitrate deficiency than most crops.**
- **Less tolerant to water saturated soil conditions than most baby crops. Spinach becomes stunted and yellow if exposed to saturated soil conditions for too long.**



Organic Spinach Production Challenges

- **Spinach has a low economic threshold for damaging insect pests –**
 - **Thrips pests (especially Western Flower Thrips *Frankliniella occidentalis*). Damage to leaf primordia will cause mature leaves to be distorted.**
 - **Leaf-miner fly pests (Agromyzidae). Damage including feeding and egg-oviposition marks and ‘mining’ marks.**
 - **Leaf beetle pests (Chrysomellidae). Common leaf beetle pests (western cucumber beetle *Diabrotica undecimpunctata*) and flea beetles can put holes in mature spinach leaves.**
 - **Other pests can be problems in spinach – Leptidopteran worms, Green Peach aphids, springtails, etc. can damage organic spinach crops.**



Organic Spinach Production Challenges

- **Over many years, the largest cause of lost acres, reduced yields, and lost sales has been caused from spinach downy mildew disease.**
- **Crop loss and lost sales is most problematic when we experience regional-level spinach downy mildew outbreaks; when all grower/suppliers experience same problem, same time.**
- **Region-wide outbreaks often occur and emerges of new DM race.**

Recent Regional Downy Mildew Outbreaks in Western US

Region	Year	Months
Central Coast California	2015	September-October
Lower Desert SW USA	2016	January-March
Lower Desert SW USA	2017	January-February

Earthbound Farm Spinach Production

Utilize Multiple Strategies to manage spinach downy mildew

- 1. Host plant resistance (use most downy mildew resistant spinach varieties that are available)**
- 2. Cultural Practices (grow spinach in multiple areas, discing infected crops, etc.)**
- 3. Organic materials (coppers, etc.)**



Earthbound Farm – Spinach Production is Diversified into Many Regions

EBF Internal Farming:

On Central Coast

- **Throughout San Benito County**
- **Throughout Salinas Valley in Monterey County**

In Imperial Valley

- **Throughout Imperial County**

External Growers:

- **Throughout California Central Coast Area**
- **Imperial Valley, Northern Mexico, Arizona, Nevada**



Host Plant Resistance is main tool for controlling downy mildew in organic spinach production

Recent Downy Mildew Races of Major Economic Consequence	Some Spinach Varieties that Helped Organic Spinach Production to Continue
Race 10	Emilia, Lazio, Pelican
Race 11	Flamingo, Carmel, Reflect
Race 12	Tasman, Andromeda
Race 13	Pigeon, Chevelle, Molokai
Race 14	Scorpius*, Caladonia* (*short window)
Race 15	Platypus, Meerkat, Woodpecker
Race 16	Various new varieties

Diversifying Spinach DM Resistance

- **If there is not sufficient amounts of fully resistant spinach seed available, we generally use a mixture of DM resistances so that spinach varieties are not all susceptible to the same DM race.**
- **This strategy helps minimize crop loss if there is few DM races in a region.**
- **This strategy is NOT successful if many co-occurring DM races are in a region.**
- **This strategy also has the bad side-effect of providing hosts to many old DM races, keeping them around over years.**



Host Plant Resistance in Spinach has been successful but for short-term periods

When new spinach downy mildew races emerge it is difficult for everyone in the industry:

- **Seed Companies** – Short opportunity to recuperate invested money used to develop new varieties and to produce seed. Can get stuck with seed inventories.
- **Seed Dealerships** – Dealerships could get stuck with large amounts of highly valuable spinach seed that growers can't use.
- **Growers** – Growers can lose large acreage of very expensive spinach crops and/or see reduced yields. Can get stuck with seed inventories.
- **Shippers** – Loss of crops, reduced yields, and reduce quality can all create large problems with grocery store customers.

There is a Ceiling on Spinach Seed Prices that Organic Growers can Pay.

- **Growers cannot afford to pay much more for spinach seed and still make money or break even on a spinach crop.**
- **Dual pricing for Untreated seed vs. Thiram/Apron treated seed is justifiable but makes organic growers unhappy.**
- **Shippers have difficulty passing increased production costs onto customers.**



Downy Mildew in Organic Spinach Production – Where can we go next?

There will likely NOT be a silver bullet solution.

However, there may be directions that could improve organic spinach production over the long term.

- **Development of organic materials that elicit strong Systemic Acquired Resistance or Induce Resistance.**
- **Development of spinach varieties with high levels of horizontal resistance.**



Systemic Acquired Resistance or Induced Resistance

- **The systemic acquired resistance (SAR) is a "whole-plant" resistance response that occurs following an earlier localized exposure to a pathogen. SAR is analogous to the innate immune response found in animals.**
- **There are compounds that can trigger SAR in plants beside pathogen infection. The active ingredient in the product Actigard (acibenzolar-s-methyl) is a SAR trigger that can effectively control downy mildew in conventional spinach production.**
- **We need more organic materials that are SAR triggers.**
 - **New product Lifeguard (Certis) causes induced resistance in potatoes for many diseases. Can it control downy mildew in spinach?**
 - **Scientific literature shows many biomolecules can trigger SAR, many of which could be acceptable to organic production.**

Systemic Acquired Resistance or Induced Resistance

- **Claim that SAR response in different spinach varieties is variable when exposed to a SAR trigger, leading to mixed results with SAR products. This difference in SAR response is assumed to be due to differences in genetic backgrounds.**

Questions:

Can breeders select for varieties that show a strong SAR response?

Is the SAR response the same across DM races?



Vertical Resistance in Spinach

- **Current Host Plant Resistance in spinach is based on Vertical Resistance (Single Gene Resistance). Vertical Resistance is good because it produced complete resistance to a specific DM race .**
- **BUT if pathogens change genetically via reproductive sex or asexual mutations, resistance breaks down. We've seen this occur many times in the organic spinach industry.**



Horizontal Resistance in Spinach

- **Horizontal resistance is when a plant's resistance to a disease is based on many genes. Horizontal resistance is much harder for a disease to overcome via genetic changes in the pathogen. We see high levels of horizontal resistance in other baby crop species.**
- **Problem: Horizontal resistance is generally partial - not complete, meaning some disease symptoms will be found on plants.**
- **This disease level must be VERY LOW for horizontal resistance to be acceptable for organic spinach production (<5% Leaves showing disease symptoms under DM disease pressure).**



Horizontal Resistance in Spinach

- **CLGRB is funding spinach breeding program done by Charles Brummer, Allen Van Dynes, & Juliana Osorlo-Marin to develop spinach varieties that have a high level of horizontal resistance (OP & Male/Female Parentlines).**
- **Will have be successful?**
 - **Program requires spinach material with A LOT of genetic diversity.**
 - **It is difficult to develop host plant horizontal resistance that will show the same reaction across DM races. Difficult selection process also.**
 - **The payoff would be very big for organic spinach production if the program is successful. It could reduce the volatility of organic spinach production.**
- **Could new varieties be developed with both verticle and horizontal resistances using genetic markers and QTL analysis?**

BIG FEAR – THE SUPER DM RACE

- **When newly emerging DM races attack the newest DM resistant spinach varieties, we often find that older spinach varieties are resistant to new races. (Example: Silverwhale is susceptible to Race 10 but resistant to Races 1-9,11-16).**
- **This phenomenon has allowed us to continue to produce organic spinach using a DMR diversification strategy.**
- **The organic spinach industry could be in COMPLETE JEOPARDY if a new race of DM emerged that infected all known commercially available spinach varieties. This would be a major problem.**



CALIFORNIA LEAFY GREENS

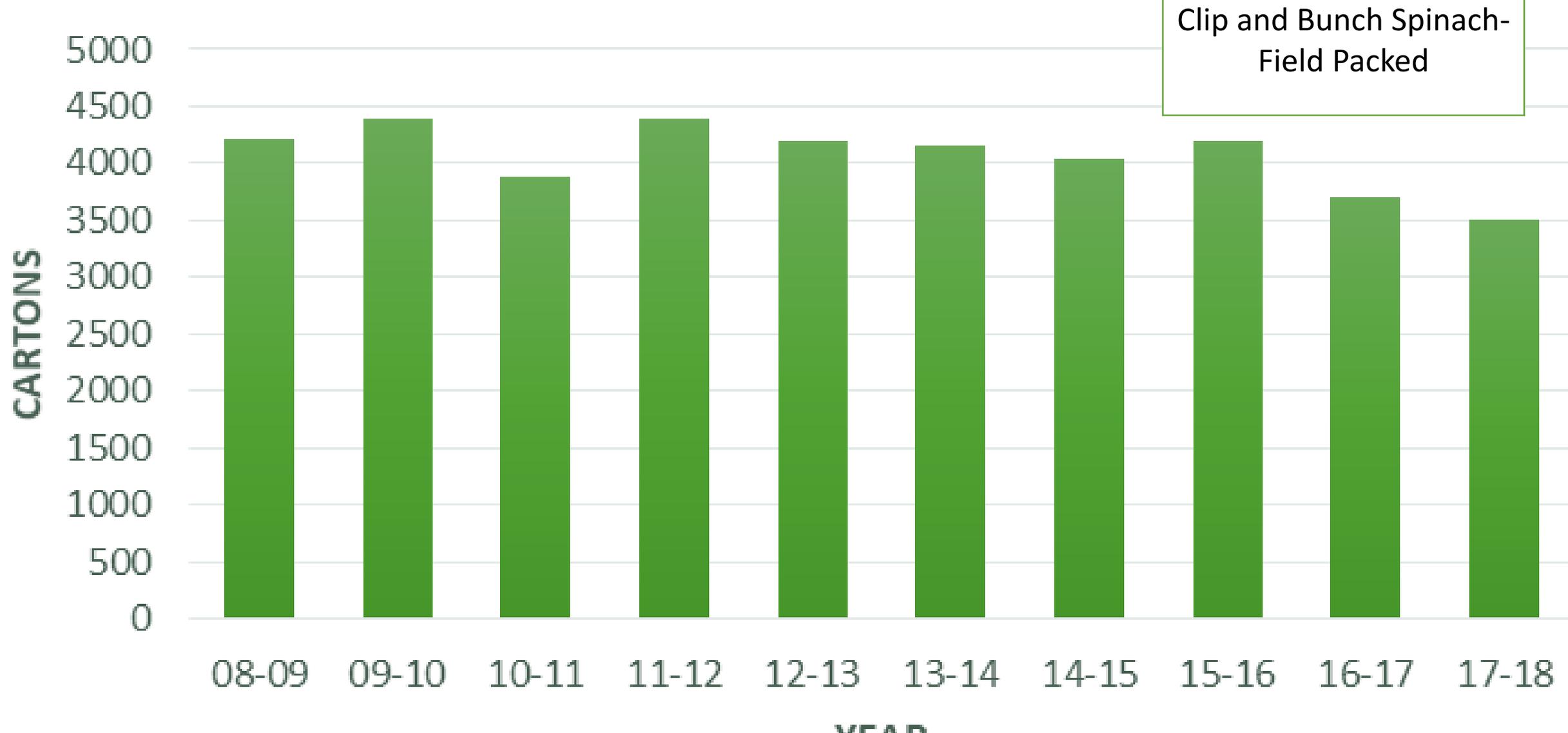
RESEARCH PROGRAM

The California Leafy Greens Research Program was created in March of 2008 to replace the California Lettuce Research Board. Its mission is to provide research programs for iceberg lettuce, leaf lettuces, spinach, and spring mix.



CA Fresh Market Spinach

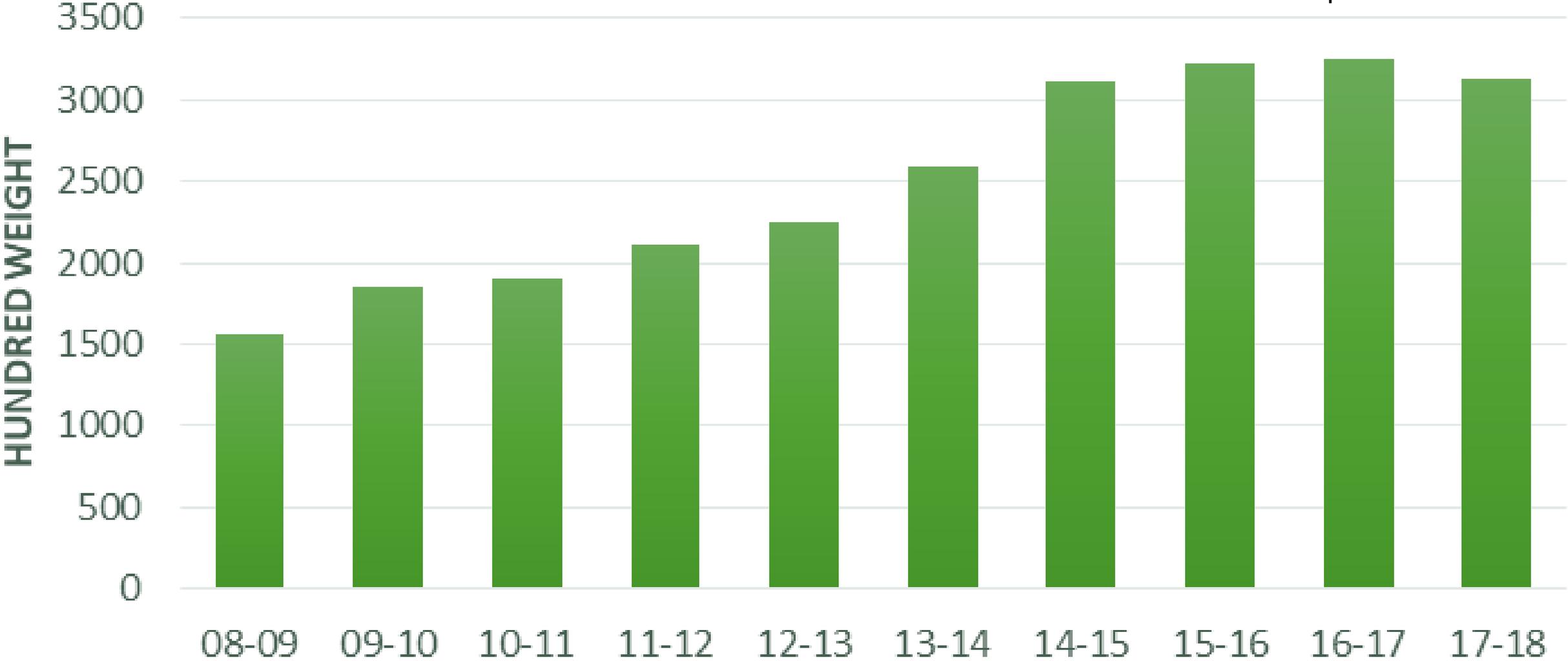
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CA Bulk Spinach

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Baby and Teen Spinach-
Fresh but Processed.
Excludes Freezer and Canned
Spinach



YEAR

CA Spring Mix

(000's omitted)

Baby Leaf Lettuce-
Fresh but Processed

