

CALIFORNIA LEAFY GREENS RESEARCH PROGRAM

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Assessment of N uptake and N removal of leafy greens under different production regimes

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ABSTRACT

Agricultural Discharge Order 4.0 was finalized on April 15, 2021. The order contains limits on the amount of nitrogen (N) loading that can occur in agricultural operations regulated by the Central Coast Regional Water Quality Control Board (CCRWQCB). When targets/ limits take effect in two years, growers will be required to report the amount (A) of N applied to the fields as well as N removed (R) from the fields. The metric used to calculate loading is A-R in relation to the limits set by the board. Calculating the R removed in the harvested portion of the product (R_{harvest}) requires knowledge of the percent moisture and N content of the crop. Crop N removal coefficients have been proposed as a tool to reduce the cost for estimating N removed at harvest. This project evaluates the moisture content and the percent N in the tissue of leafy greens to develop N removal coefficients that growers can use to calculate R_{harvest} over a range of growing conditions and production practices used by the industry. In the production seasons of 2020-21 we completed evaluations of 20 fields of the major lettuce types (including various harvest products), as well as clipped spinach. This information has been entered in a Microsoft Excel spreadsheet and will be converted to a searchable format available to growers to access N removal coefficients.

OBJECTIVES

The main objective of this project is to develop crop N removal coefficients for leafy green vegetables (all lettuces, baby lettuce and spinach). Summaries of the data will be extended to the leafy green industry through blog entries, industry meetings and the annual Irrigation and Nutrient Management Meeting.

PROCEDURES

Commodities sampled are shown in Table 1. We worked with harvest crews to sample harvested product as it is leaving the field. Percent moisture of the product were determined by weighing the fresh product immediately in the field, drying at 149 F for 48 hours (or until completely dry) and weighing again. Samples were sent to the UC Davis Analytical Laboratory for total N content. Over the two years of this project we intend to sample 20 fields of each commodity. Fields sampled were selected on different soil types, planting configurations and geographic locations in the Salinas and surrounding valleys to capture the variability of the N content. The N removal coefficient is calculated by multiplying the percent dry matter (DM) by the N content of

the tissue. The data collected in 2020-21 has been entered in a Microsoft Excel spreadsheet and will be converted to a searchable format available to growers to access N removal coefficients. The database will also be used to develop reports of N removal that can be provided to the leafy green industry upon request.

RESULTS

Calculated N removal coefficients developed for lettuce are shown in Table 1. The N removal coefficients follow general patterns. For instance, green leaf, red leaf and butter generally range from 0.001989 to 0.002240 (Table 1). Head lettuces are have a lower N removal coefficient and generally range from 0.001199 to 0.001285. Fresh market and romaine hearts range from 0.001843 to 0.001882, but overall bulk romaine was 0.001502. The reason for this lower number is not entirely clear. Green and red baby lettuce ranged from 0.003335 to 0.003457 and are higher because they had a higher percent dry matter and nitrogen in their tissue of all the lettuce types (Tables 2 and 3). Baby spinach had the highest N removal coefficient, 0.004838, also because it had the highest percent dry matter and nitrogen in its tissue (Tables 2 and 3).

The following is an example of calculating lbs N removed by a spinach crop:

Spinach yield = 12,000 lbs x spinach N removal coefficient = 0.004838:

$12,000 \times 0.004838 = 58 \text{ lbs N/A}$. This information provides the R_{harvest} number in the A-R equation. It should be mentioned that the amount of N removed by leafy greens is often modest in comparison with the amount of N that is applied. This results in an increase in the load of N in fields which is now regulated by the CCWQCB under Ag Order 4.0. The limits/targets set by the CCRWQCB ratchet down over the next few years, which will put pressure on growers to balance the A-R equation to comply with Ag Order 4.0.

Table 1. Nitrogen removal coefficient and minimum and maximum calculated coefficients

Commodity	Product	Pack type	No. fields sampled	Mean coefficient	Min coefficient	Max coefficient
Butter	Fresh Market	Carton	20	0.001989	0.001416	0.002744
Green Leaf	Fresh Market	Carton	20	0.002070	0.001338	0.003003
Red Leaf	Fresh Market	Carton	20	0.002240	0.001731	0.003196
Head Lettuce	Bulk	Bulk (field cored)	20	0.001199	0.000880	0.001992
Head Lettuce	Fresh Market	Film Wrap	19	0.001269	0.001001	0.001814
Head Lettuce	Fresh Market	Naked (Liner)	21	0.001285	0.000948	0.001754
Romaine	Fresh Market	Naked (Liner)	20	0.001843	0.001316	0.002708
Romaine	Hearts	Carton	21	0.001882	0.001049	0.002518
Romaine	Bulk, average of all	Bulk & RPC	20	0.001502	0.001265	0.002037
Romaine	Bulk Tops & Tails	Bulk & RPC	5	0.001520	0.001265	0.002037
Romaine	Bulk Whole plant	Bulk & RPC	15	0.001496	0.001289	0.001877
Green Baby Lettuce	Bulk	Bulk	19	0.003335	0.002202	0.004780
Red Baby lettuce	Bulk	Bulk	21	0.003457	0.002394	0.005502
Spinach, baby	Bulk	Bulk	21	0.004838	0.003805	0.007311

Table 2. Mean, minimum and maximum percent tissue dry matter (DM)

Commodity	Product	Pack type	No. fields sampled	Mean % DM	Min % DM	Max % DM
Butter	Fresh Market	Carton	20	5.72	4.11	7.60
Green Leaf	Fresh Market	Carton	20	6.80	5.52	8.63
Red Leaf	Fresh Market	Carton	20	5.81	4.61	7.82
Head Lettuce	Bulk	Bulk (field cored)	20	4.02	3.19	6.09
Head Lettuce	Fresh Market	Film Wrap	19	4.31	3.60	6.32
Head Lettuce	Fresh Market	Naked (Liner)	21	4.32	3.55	5.24
Romaine	Fresh Market	Naked (Liner)	20	5.93	4.65	7.88
Romaine	Hearts	Carton	21	5.71	3.98	8.01
Romaine	Bulk, average of all	Bulk & RPC	20	4.93	3.72	6.61
Romaine	Bulk Tops & Tails	Bulk & RPC	5	4.97	4.01	5.90
Romaine	Bulk Whole plant	Bulk & RPC	15	4.92	3.72	6.61
Green Baby Lettuce	Bulk	Bulk	19	6.74	4.91	9.34
Red Baby lettuce	Bulk	Bulk	21	6.85	5.12	9.32
Spinach, baby	Bulk	Bulk	21	8.12	6.43	11.68

Table 3. Mean, minimum and maximum percent N content

Commodity	Product	Pack type	No. fields sampled	Mean % N	Min % N	Max % N
Butter	Fresh Market	Carton	20	3.49	2.84	4.22
Green Leaf	Fresh Market	Carton	20	3.06	2.18	3.84
Red Leaf	Fresh Market	Carton	20	3.85	3.26	4.78
Head Lettuce	Bulk	Bulk (field cored)	20	2.99	2.54	3.84
Head Lettuce	Fresh Market	Film Wrap	19	2.95	2.37	3.88
Head Lettuce	Fresh Market	Naked (Liner)	21	2.98	2.27	3.49
Romaine	Fresh Market	Naked (Liner)	20	3.11	2.33	3.97
Romaine	Hearts	Carton	21	3.33	1.58	4.13
Romaine	Bulk, average of all	Bulk & RPC	20	3.06	2.55	3.75
Romaine	Bulk Tops & Tails	Bulk & RPC	5	3.06	2.56	3.45
Romaine	Bulk Whole plant	Bulk & RPC	15	3.07	2.55	3.75
Green Baby Lettuce	Bulk	Bulk	19	4.96	3.51	5.91
Red Baby lettuce	Bulk	Bulk	21	5.05	4.15	6.13
Spinach, baby	Bulk	Bulk	21	5.97	5.29	6.43

SUMMARY

N removal coefficients have been developed for leafy greens by conducting evaluations in 20 fields of each crop type over the 2020 and 2021 production seasons. The data has been entered in a Microsoft Excel spreadsheet and will be converted to a searchable format available to growers to access N removal coefficients.

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