Evaluation of an Organic Nitrogen Source in a Yellow Squash- Collard Rotation

by

Charles Zachry Ogles

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Organic Nitrogen Fish Fertilizer Fertigation Rotation

Approved by

Joseph M. Kemble, Professor Horticulture
Amy N. Wright, Professor Horticulture
Elizabeth Guertal, Professor Agronomy and Soils

Abstract

In-season nitrogen (N) management is a common challenge in organic vegetable production. Especially when using polyethylene mulch combined with fertigation. There is a need for a highly soluble quick release N source that is suitable for fertigation in organic vegetable production. Hydrolyzed fish fertilizer (HFF) has been used as a supplemental fertilizer in organic production for many years. Yield with organic N supplied by HFF was compared to that of inorganic N. A crop rotation of yellow squash (*Cucurbita pepo*) and collards (*Brassica oleracea var. acephala*) was used. Three N sources were used in the experiment; HFF, Inorganic N source with secondary and micronutrients (INORGWM), and Inorganic N without secondary or micronutrients (INORGWO). The three N sources were applied at 100%, 80%, and 60% of the recommended N rates for each crop. To evaluate the HFF as an N source it was necessary to equalize other nutrients across all treatments. The experiment was arranged as a randomized complete block design consisting of 10 treatments with 4 replicates. White on black polyethylene mulch was installed along with drip tape. The yellow squash was seeded on 7/6/12 and was harvested 3 times weekly from 8/6 – 8/27. Yellow squash had a 30% higher yield with the inorganic N source treatments compared to the HFF. The collard crop was transplanted on 10/2/12 and harvested 12/12/12. Collards had 21 % higher yield with INORGWM compared to the HFF. However, all collard treatments with secondary and micronutrients yielded significantly higher than the treatments with the micronutrients withheld. The second collard crop was planted on 3/22/13 and harvested on 5/17/13. Yield was significantly reduced across all N treatments.

The highest yields were produced in the INORGWM treatments followed by those grown in the HFF treatments. Overall yield was reduced by 50% from those in the 2012 crop. The final summer squash crop also had greatly reduced yields. The squash grown in the inorganic N treatments produced the highest yields. Those grown in the HFF yielded 16% lower than the two inorganic N sources. Overall yield was reduced by 60% from the yield produced in the 2012 crop. Though yields were reduced in the HFF treatments, the premium price associated with organic products was enough to offset the reduced yield. Upon completion of the rotation, a detailed economic analysis was conducted and determined that over the course of the rotation, the HFF treatments were the most profitable. Total profit from the HFF treatment was 230% greater than the INORGWM treatment and 328% higher than the INORGWO. If growers can obtain the price premiums associated with organic produce, the use of HFF can be an economically feasible option in organic vegetable production.

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List of Abbreviations

HFF Schafer's Liquid Fish- hydrolyzed fish fertilizer at 152, 121, and 91 kg N $\cdot ha^{-1}$

INORGWM Inorganic nitrogen with secondary and micronutrients at 152, 121, and 91 kg N $\cdot ha^{-1}$

INORGWO Inorganic nitrogen without secondary and micronutrients at 152, 121, and 91 kg N $\cdot ha^{-1}$

NON No nitrogen control

I. Literature Review

Introduction

Organic agriculture is one of the fastest growing segments of U.S. agriculture. In 2011, certified organic growers sold more than $3.5 billion in organically grown agricultural commodities (USDA, 2012). The USDA reports a 361 % increase in the number of certified organic operations from 1992 to 2008 (Chapin, 2012). In 2010, the USDA reported a 7.7 % increase in sales over those in 2009 (USDA, 2012). Despite a challenging economy the statistics point to a growing demand for organically produced products (Beyond Pesticides, 2012). In response, there has been an increase in the number of organic growers needed to meet this demand.

In organic production, the use of inorganic fertilizer is largely prohibited. As a result, organic growers must depend on the use of natural sources such as manures, legume cover crops, animal by-products, and naturally formed minerals. Often these nutrient sources are adequate and supply the majority of what is required to produce acceptable yields. This holds true for phosphorous, calcium, sulfur, magnesium, and many of the micronutrients. In most situations these nutrients can be incorporated pre-plant in sufficient quantities to supply a crop throughout the growing season. The pre-plant application of nutrients is an effective practice with a few exceptions. The two most notable are nitrogen and potassium. Both nitrogen and potassium are required in relatively large quantities and often become limited when only applied pre-plant. As a result it is recommended to apply a portion of the nitrogen and potassium pre-plant and the remainder be applied throughout the growing season (Kemble et al., 2012). The management of in-season fertility can be a limiting factor in the production of high nitrogen demanding crops (Hartz and Johnstone,2006).

Use of polyethylene mulch to provide weed control has become a common practice in organic vegetable production. Despite the added cost and negative environmental aspects of their disposal this cultivation method is still the preferred method because of its positive attributes (Rice et al., 2007). The benefits from the use of plastic mulches include earlier and higher yields, reduced weed populations, reduced soil evaporation, reduced fertilizer leaching, greater water use efficiency, reduced soil compaction, control of certain pests, and a cleaner harvested product (Lamont, 1993). Use of polyethylene mulch, restricts the ability to surface apply supplemental fertilizer mid-season. This issue is typically overcome by installing drip irrigation beneath the polyethylene mulch to provide water and nutrients. Previously, organic growers have relied on the use of sodium nitrate for this application. Sodium nitrate, however, has been removed from the National Organic Program's (NOP's) list of allowable synthetic substance, and its use has been banned in organic production (McEvoy, 2012). For organic growers this can poses a serious problem. In the absence of sodium nitrate for organic production, an injectable nitrogen source that is allowable in organic production and proven effective is needed to fill this void. Hydrolyzed fish fertilizer (HFF) has been used as a supplemental fertilizer in organic production for many years (Gaskell and Smith, 2007). HFF is produced through an enzymatic process where fish proteins are broken down into their base amino acids (S.F. Organics, 2013b). This process reduces the particle size and increases the speed of mineralization in the soil. Unfortunately, there has been limited research as to the effectiveness of such products, thus research in this area is greatly needed.

The research that has been conducted with hydrolyzed fish products has reported variable results. Generally, plant response in terms of yield and growth has been quite favorable when compared to that of other plant derived liquid organic fertilizers. In addition to the favorable plant response, hydrolyzed fish fertilizer has not faced the scrutiny that the plant derived sources have as to their acceptability by the NOP. Often plant based fertilizers are byproducts of starch production or derived from genetically modified organisms (GMO's), both of which raise questions as to the appropriateness of their use in organic production (McEvoy,2010).

A common issue in past research with fish derived products is the lack of consistency of the product being evaluated. This lack of homogeneity has resulted in the clogging of drip emitters and filtration equipment commonly used in a fertigation system. The clogging of filtration equipment not only poses a maintenance issue, but is effectively removing nitrogen containing material (Hartz et al., 2010). The issue of clogging is further compounded by the high volumes required to supply the necessary nutrients. The low nitrogen content of hydrolyzed fish requires that large quantities be applied to achieve the same rate that would be supplied by a small amount of inorganic fertilizer.

The cost per unit of available nitrogen has also been a concern as to the profitability of using HFF in organic production (Hartz and Johnstone, 2006). The issue of availability is directly related to the nitrogen mineralization rates. The results of previous studies indicated that hydrolyzed fish fertilizer had one of the fastest and most complete mineralization rates among all liquid organic fertilizers tested. Rapid mineralization rates not only supply the plant with quickly available nitrogen but also insure that the grower receives the full financial and nutritive value of the products applied. Although organically grown products typically command a significant price premium of 60% or more over conventional products, production costs for organic growers are often a limiting factor (Lin et al., 2008). As a result, growers continually search for methods that will maximize profit while reducing overall cost.

The practice of double cropping polyethylene mulch is common among vegetable growers (Rice et al., 2007). This is largely due to the reduction in production cost by splitting the mulch costs over multiple crops. When double cropping growers will typically select a crop that will begin immediately following the termination of the one planted previously. Often this will consist of unrelated crops that will thrive under different seasons and that share few pests. This management system not only reduces overhead costs for growers but it also keeps the land continuously producing a cash crop.

In order to evaluate the HFF as an effective and economically feasible replacement for sodium nitrate, an experiment was developed to exploit the cost savings of double cropping while simultaneously comparing the effects of varying rates of organic and inorganic nitrogen sources. Yellow squash and collards were selected for this experiment to replicate a practical rotation that would thrive in the southeastern United States. To maximize the cost benefits of double cropping, a total of four crops (two of each crop) will be grown utilizing the same polyethylene mulch and drip irrigation. Upon completion of the experiment growth, yield, and nutrient content data will be analyzed to compare the performance of the HFF to that of inorganic nitrogen sources. In addition, an economic analysis will be completed to determine if HFF is an economically feasible alternative to an inorganic nitrogen source.

Organic Fertilizers and Mineralization

Conventional grower's routinely supplement pre-plant fertilizer applications with highly soluble liquid nutrients injected through a drip irrigation system. Injectable options for organic growers are limited in terms of availability and supporting research. Unlike the completely soluble and immediately available inorganic fertilizers, liquid organic fertilizers are often less consistent in particle size and rely largely on mineralization by soil microorganisms to become plant available.

Despite the issues that have been associated with injecting organic liquid fertilizers in the past, the practice still remains a viable option for organic vegetable growers. The rate and timing of these applications has remained uncertain (Gaskell et al., 2009). Although limited research has been conducted on the efficacy of hydrolyzed fish fertilizer and its appropriate rates, there has been research that relates to this subject. One such study evaluated the mineralization rate of four commonly used organic nitrogen sources; seabird guano, hydrolyzed fish powder, blood meal, and feather meal (Hartz and Johnstone, 2006). These dry fertilizer materials were incorporated into the soil for each treatment. Each source was evaluated for its nitrogen mineralization rate at a range of temperatures over an 8- week period. Temperature had only a modest effect on mineralization rates. Hydrolyzed fish powder was the most rapid to mineralize at lower temperatures. This finding supports the use of hydrolyzed fish as a quickly available nitrogen source that should be suited to a wide range of vegetable production. The lack of temperature dependence as noted above is critical in the production of cool-season crops.

These findings (Hartz and Johnstone, 2006) were useful for determining the mineralization rates in controlled conditions. Field conditions, however, vary and as a result mineralization rates may vary as well. In central Alabama it is common for soil temperatures to exceed the highest temperature treatment of 25^{o}C. Although (Hartz and Johnstone, 2006) found only modest differences in mineralization rates based on temperature, we cannot conclude that an increase of 5^{o}C above the highest temperature treatment will not cause a change in mineralization rate (Camberato, 2001).

Cost of available nitrogen is often a limiting factor in organic production. Findings by Hartz (2006) can be used to calculate the cost of available nitrogen applied. Within two weeks of incorporation between 47 and 60 % of the organic nitrogen had been mineralized (Hartz and Johnstone, 2006). At eight weeks after application the total nitrogen mineralized was between 60 and 66 %. Of the four sources evaluated, the cost per kg of available nitrogen varied between $49.10 / kg and $8.90 / kg. Fish powder was the most expensive, followed by blood meal, feather meal, and finally sea bird guano. In some cases the cost per kg from organic sources can be more than 10 times that of conventional sources (Hartz and Johnstone, 2006). The reduced nitrogen availability established in the previous study would increase the fertility cost to a grower by up to 40 %. In organic production, an increase of 40 % in addition to the already elevated price of organic fertilizers would likely be unsustainable for most growers. As a result, a nitrogen source that is quickly and completely available and that is economical is needed in organic production.

In 2010, Hartz conducted additional research that included liquid organic fertilizers. This study focused on three commercially available liquid organic fertilizers and ammonium sulfate. “Phytamine 801” contained fisheries waste and seabird guano while “Phytamine 421” and Biolyzer” were derived from plant based materials. This study evaluated the aforementioned materials for their mineralization rates, plant uptake, and the fraction of particulate matter removed through a filtration system.

The materials were first filtered to remove any particles that would possibly be removed by a high quality media filter. The particles that were greater than 25 μm were removed and analyzed to determine the amount of nitrogen that may be removed in a typical fertigation system. From 8% to 20% of total nitrogen content was associated with particulate matter large enough to be at risk of removal by a drip irrigation filtration system (Hartz et al., 2010). The particulate matter accounted 4.9 g·kg^{-1}, 5.5 g·kg$^{-1,}$ and 7.3 g·kg^{-1} for Phytamine 801, Biolyzer and Phytamine 421 respectively.

Removal of nitrogen containing material was most notable in the plant based products; however, the issue of particulate matter could exist in any liquid organic product. Most products designed to be used in a fertigation system are filtered as part of the production process. Organic liquids intended for use in fertigation are typically passed through a 150 -200 mesh filter prior to introduction into the market (S.F. Organics, 2013b). In Hartz (2010), the percentage of nitrogen containing particles determined too large to pass through a fertigation system were removed using filter paper. Particles greater than 20-25 µm were considered too large and would be subject to removal through filtration. However, most drip irrigation systems use a much larger 150 mesh (112 µm) to 200 mesh (74 µm) filtration system that will allow for passage through the irrigation system (Schultheis, 2005). Most drip irrigation manufactures recommend only a 200 mesh (74µm) filter be installed to avoid the clogging of drip emitters (Haman, 2011). Nonetheless, even small losses of nitrogen containing material through filtration could pose a significant issue in organic fertigation. The resulting losses in efficacy require that the issue of filtration be addressed. By installing the largest mesh filter recommended onto the drip irrigation system combined with the use of a high quality pre-filtered HFF the losses to filtration will be drastically reduced or eliminated. In addition, the continuous flow of water into the system will dilute the HFF further reducing the chance of removal.

In order to determine the mineralization rates of the three organic liquids the materials were applied to 15 g of field soil collected from the top 20 cm of fields under organic management and monitored for one, two, and four weeks at 15^{o}C and 25^{o}C under greenhouse conditions (Hartz et al.,2010). The three fertilizers were applied to each soil at a rate of 100

$mg \cdot kg^{-1}$ in an aqueous solution and sealed. Mineralization was rapid, with up to 93 % mineralization after one week. Phytamine 801, the most rapidly mineralized of the products tested, had a mineralization rate of up to 93% in one week and 99% at four weeks. Results indicated that a liquid organic nitrogen source could not only supply the desired nutrients slowly over a period of time, but that they could be made available at nearly the rate of an inorganic fertilizer (Hartz et al., 2010). Sodium nitrate has long been utilized for its high nitrogen content of 15 % and its rapid availability. In response to the removal of sodium nitrate from organic production, the application of nitrogen containing waste products from agricultural and fisher industries provides a practical alternative (Hartz and Johnstone, 2006).

The findings of Hartz (2010) can help provide the basis for the economic analysis of the fertilizer sources to be explored in the proposed research. The rapid and complete mineralization determined by Hartz (2010) indicates that the nitrogen supplied by the hydrolyzed fish fertilizer is nearly 100% available. This is important when calculating the overall cost to supply a recommended rate of organic nitrogen in comparison to that of an inorganic nitrogen source.

In addition to investigating mineralization rates, an additional study by Hartz (2010) using *Festuca arundinacea* as a bioassay to determine nitrogen uptake was also conducted. *Festuca arundinacea* sod was planted in 1-L pots in soil collected from the top 20 cm of an organically managed field. A small plug of sod was removed from the center of each pot, and the fertilizer was applied to the underlying soil. Each of the three liquid organic fertilizers were applied as $6\ g \cdot L^{-1}$ nitrogen solution. The equivalent rate of ammonium sulfate was applied to additional samples. The samples were allowed to grow under greenhouse conditions for five weeks. Tissue samples were taken at two and four weeks to determine nitrogen uptake between sampling dates. This research showed a significantly higher (P<0.05) nitrogen uptake in the

Phytamine 801 treatments as compared to that of the other organic treatment and the ammonium sulfate.

Hartz's (2010) findings of greater nitrogen uptake from the Phytamine 801 further support the possibility of using hydrolyzed fish fertilizer as a quickly available nitrogen source. The rapid mineralization and uptake determined for the fish- guano blend shows that fish-based products may have potential as a replacement for sodium nitrate. In addition, the potential increase in nitrogen uptake of the organic sources may be an added benefit over the use of an inorganic fertilizer.

In 2012, research by Eaton et al. was conducted to evaluate organic fertilizers in the production of greenhouse- grown marigold (*Tagetes erecta* L.) and calibrachoa (*Calibrachoa x hybrid* Llave & Lex). The calibrachoa was grown using five fertilizer treatments: one inorganic, one organic based (derived from oil seed extracts but supplemented with inorganic fertilizers and therefore not allowed in organic production), and three organic: liquid fish, oilseed extract, and a combination of the two. The marigold was grown with seven fertilizer treatments: one chemical and three organic (liquid fish, oilseed extract, and alfalfa pellets) used either alone or in combination. The four water soluble fertilizers were: chemical (20N-0.5P-6K, organically based (10N-1.8P-2.5K), organic oilseed extract (3N-0.4P-0.8K), and organic liquid fish (2N-1.8P-0.8 K). Fertilizers were applied twice weekly to container grown plants in a 200 mL solution containing 175 $mg \cdot L^{-1}$ N for the first 30 days and 225 $mg \cdot L^{-1}$ N from 30 days until the end of the study. Plants were hand watered any time one of the replicates became dry. Measurements were collected on dry shoot weight, nutrient content using ICAP (inductively coupled argon plasma spectrometry), leaf nitrogen as determined by Kjeldahl analysis, and visual quality ratings.
The results of the study showed that the most visually appealing plants were produced using the

chemical and liquid fish fertilizers. It was also determined that leaf nitrogen content was greatest in the chemical and liquid fish fertilizer treatments ($P<0.05$). The treatments receiving the organic oil seed extract were among the lowest quality.

The source of nitrogen supplied was a significant factor affecting plant growth. The chemical treatments produced the highest dry weights followed by the liquid fish and combinations thereof. The organic oil seed extract treatment ranked the lowest of all treatments in shoot dry weight.

In the same research, ICAP showed variable nutrient content based on fertilizer treatment. Although this is an interesting finding, the differences in nutrients could possibly be attributed to the application of unequal rates of nutrients across the treatments. An example of this is in the potassium content. Potassium content in the chemical treatment was more than twice that of the liquid fish. This could be a result of the forms of the nutrients supplied or the disproportional rates. In the chemical treatment potassium (K_2O) is supplied in equal proportion to nitrogen, however, the analysis of the liquid fish fertilizer did not allow for equal application rates. As a result the liquid fish treatment received less than half the potassium supplied in the chemical treatment.

This research indicated that liquid fish was an effective nitrogen source for marigold and calibrachoa. Among the organic fertilizers evaluated, the liquid fish produced the best results. The study also raises the question of what specifically affects growth and plant nutrient content when comparing organic and inorganic nutrient sources. In order to determine if the nutrient rate or form was a significant influence on growth and nutrient content it would be necessary to equalize all nutrients and only vary the rate and source. In the proposed research every effort will be made to equalize the nutrients between the fertilizer treatments to eliminate any interactions that may exist.

The economic suitability of liquid organic N sources was explored by Gaskell and Smith (2007). This study evaluated potential liquid organic fertilizers for their available nitrogen as well as the cost for each product. The liquid nitrogen sources evaluated were liquid fish and liquid soy bean (*Glycine max*) meal. Several other organic fertilizers were evaluated for their economic value and mineralization rate. They included sea bird guano, blood meal, feather meal, and corn meal (*Zea mays*). The study concluded that liquid fish, seabird guano, and feather meal were the most economical products based on cost per unit N and mineralization rate. As with Hartz (2010), the consistency of the products was critical to the nitrogen they could supply through drip irrigation system. In some cases large particles containing nitrogen could be removed by screen filters used in fertigation thus failing to provide the crop with the correct amount of nitrogen. This problem could be corrected by mixing the material to a uniform particle size and filtering the product (S.F. Organics, 2013b). All of these factors make precise management with organic fertilizers challenging, but despite the challenges, organic vegetable growers are reliant on them to achieve acceptable yield and quality. Despite the filtration and uniformity issues, many of the fish derived products are widely used in organic vegetable production, and many growers report satisfaction overall with these products (Gaskell and Smith, 2007). Though growers report satisfactory results, a better understanding of the proper application rates and the inherent differences between organic and conventional fertigation will provide growers with a more accurate picture of what to expect when choosing to fertigate organically.

In 2003, research by Nakano et al, compared the effects of organic and inorganic nitrogen sources for the production of field-grown tomatoes (*Solanum lycopersicum* L.). In contrast to using animal by-products (Hartz and Johnstone, 2006), this study focuses on the use of corn steep liquor (CSL). CSL is a by-product in the production of corn starch and has been evaluated as a potential organic nitrogen source for use in crop production (Nakano, 2003). Mineralization is necessary for the nitrogen contained in CSL to become available for use by a plant. The study included three fertilizer treatments: basal dressing with granular inorganic fertilizer; inorganic fertigation with liquid chemical fertilizer; and organic fertigation with CSL. Equal nitrogen rates were applied to tomato plants grown in containers filled with a sandy clay loam soil. The fertigation treatments were applied through drip irrigation and the basal dressings were hand applied to the base of each plant. The research evaluated the yield, and the mineral content of the fruit and soil. The findings of this study determined that there were no significant differences between the organic and inorganic treatments in tomato yield at a level of ($P < 0.05$). It did indicate that both fertigation treatments outperformed the basal application treatments.

The data showed that in tomato production, equal yields can be obtained using an organic product at the same rate as an inorganic equivalent. Results further showed the added benefits of nitrogen applied through fertigation as compared to basal-dressing. If similar results were found to be true in yellow squash and collards, the use of hydrolyzed fish fertilizer may be a cost effective option.

An additional finding by Nakano et al. (2003) showed that significantly higher soil nitrogen ($P<0.05$) in the CSL treatment than in the inorganic treatments. This finding was likely due to an increase in soil organic matter resulting from the CSL applications (Nakano et al, 2003). This could be an important factor in a crop rotation such as the yellow squash-collard proposed in this thesis. The increased nutrient holding capacity could impact the performance of subsequent crops in an organic rotation.

It should be noted that the future use of CSL in organic production is in question. The organic integrity of this product has been called into question due to the use of sulfur dioxide in its production (McEvoy, 2010). As of the writing of this thesis, CSL is being reviewed by the National Organic Program to make a final determination as to its future in organic production.

In 2005, a study was conducted to evaluate the performance of Aloe (*A. barbadensis* Mill) as influenced by organic and inorganic fertigation (Saha et al., 2005). This study was conducted using five nitrogen sources and a zero nitrogen control. The treatments consisted of (i) Control (no fertilizer), (ii) Farmyard manure (FYM) to supply 40 $kg \cdot ha^{-1}$ N, (iii) Vermicompost + liquid vermiwash to supply 80 $kg \cdot ha^{-1}$ N, and three concentrations of chemical fertilizer (iv) 120 $kg \cdot ha^{-1}$ N, 26.2 $kg \cdot ha^{-1}$ P, 99.6 $kg \cdot ha^{-1}$ K, (v) 80 $kg \cdot ha^{-1}$ N, 17.4 $kg \cdot ha^{-1}$ P, 66.4 $kg \cdot ha^{-1}$ K , (vi) 40 $kg \cdot ha^{-1}$ N, 8.7 $kg \cdot ha^{-1}$ P, 33.2 $kg \cdot ha^{-1}$ K. The sources of inorganic fertilizers were urea (CH_4N_2O), single super phosphate [$Ca(H_2PO_4)_2$], and muriate of potash (KCl). The vermiwash was derived from a leachate produced by passing water through a column of worm castings and highly degraded organic material. The vermicompost is highly decomposed compost that is produced by microbial breakdown as well as worm activity. The single super phosphate, FYM, and vermicompost were applied and mixed thoroughly in the soil as a basal application. The vermiwash and inorganic nitrogen (CH_4N_2O) and potassium (KCl) were applied at regular intervals through a fertigation system. Data was collected on growth, yield, plant quality parameters (gel and aloin content), chlorophyll content, macro-and micronutrient concentrations (N, P, K, Mg, Zn, Cu, Fe, and Co). Gel and aloin content are important quality components as they are the primary component in the marketability of aloe. Any increase in gel and aloin content would be of economic interest to aloe producers. Both aloe gel and aloin are used as alternative medicines for the treatment of skin and digestive disorders (Saha et al., 2005).

Results of this study found that N and K were influenced by increasing levels of inorganic fertilizers (Saha et al., 2005). Contents of P and Mg and micronutrients like Cu, Zn, Mn and Co were higher under organic-based fertilizer treatments. Similarly, the quality components measured showed that the FYM and vermiwash treatments produced the highest level of aloin of 19.6% and 17.8% respectively. These results indicated that aloe responds differently to the organic and inorganic nutrient sources used in this experiment.

Data collected on yield evaluated the gel content, root weight, and biological yield. Results show a significantly higher yield between the organic vermiwash and the equivalent rate supplied by the inorganic source. At equivalent nutrient levels of 80 $kg{\cdot}ha^{-1}$ N, 17.4 $kg{\cdot}ha^{-1}$ P, 66.4 $kg{\cdot}ha^{-1}$ K the organic sources of fertilizer were superior in yield to the inorganic source. If it could be shown that hydrolyzed fish fertilizer could produce similar results in vegetable production, then it may be possible to achieve equivalent yields while using lower organic nitrogen rates. Even a small reduction in fertilizer would result in substantially lower costs for growers while still producing acceptable yields.

Nutrient Determination and Chlorophyll Content

Plant nutrient concentration and chlorophyll content are commonly used to evaluate the efficacy of fertilizer treatments in vegetable production. Leaf nitrogen content can be used to determine the uptake of nitrogen and can be compared to know sufficiency ranges that are available for most crops (Mills and Jones, 1996). Inductively coupled argon plasma spectrometry (ICAP) can be used to determine the content of many of the critical nutrients in leaf tissue and can likewise be compared to established sufficiency values. The SPAD 502 chlorophyll meter is used to determine the chlorophyll content of leaf tissue and is used as a predictive tool for rapid in-field evaluation of nitrogen content.

Research by Huett and White (1991) attempted to determine the critical nitrogen concentrations in zucchini (*Cucurbita pepo* var. *cylindrica* 'Blackjack') over time in order to accurately predict yield. Zucchini seedlings were transplanted into sand filled containers, and one of five nitrogen rates were applied at 30, 100, 200, 400, or 600 mg $N \cdot L^{-1}$. Nitrate nitrogen was supplied by a greenhouse blend containing K, Ca, Mg, P, Fe, Mn, B, Cu, Zn, and, Mo. The following samples were collected every two weeks; petiole sap, leaf tissue at three stages of leaf development, and a pooled leaf sample containing all three stages. Nitrogen rate had a significant effect on growth rate. Growth rate in the 30 and 100 mg $N \cdot L^{-1}$ treatments were significantly decreased, while plants in the 400 and 600 mg $N \cdot L^{-1}$ treatments expressed toxicity symptoms. Petiole nitrate-N did not differ with age after the first four weeks. The leaf tissue nitrogen concentrations in the first four weeks were significantly higher ($P < 0.01$) than any other time in the study. Critical leaf nitrogen concentrations, the point where 10% yield reduction occurs was determined through laboratory analysis and varied with leaf age. Younger leaves consistently had higher nitrogen content than the older leaves. Less variability was observed in total leaf nitrogen than in petiole sap testing. These findings suggest that more consistent plant nitrogen levels can be obtained through tissue analysis than petiole sap. The end result of the study provided a bi-weekly set of critical leaf nitrogen values for zucchini that can be used to predict growth rate.

Table 2. Critical leaf N concentrations for adequate growth and for toxicity at 90% maximum growth rate at two-week intervals after transplanting

YFOL, youngest fully opened leaf; YFEL, youngest fully expanded leaf; OL, oldest green leaf

	Adequate growth							Toxicity						
Week:	2	4	6	8	10	12	14	2	4	6	8	10	12	14
							Nitrate-N (g/L) in petiole sap							
YFOL	0.85	0.90	1.75	3.15	1.95	3.75	2.80	3.40	1.75	2.90	5.70	3.35	5.25	5.20
YFEL	1.65	1.50	3.50	5.80	3.50	5.85	2.95	5.90	2.60	4.50	6.70	5.90	6.70	6.10
OL	1.40	2.05	2.70	5.30	4.45	4.40	3.40	5.90	6.15	6.20	6.65	6.45	6.65	6.70
							Nitrate-N (%) in leaves							
YFOL	0.20	0.17	0.48	0.40	0.25	0.34	0.28	0.42	0.27	0.51	0.73	0.41	0.36	0.36
YFEL	0.25	0.35	0.95	0.90	0.75	1.00	0.45	0.45	0.60	1.10	1.55	1.00	1.30	0.80
OL	0.25	0.45	0.90	0.65	0.30	1.30	1.70	0.45	0.75	1.15	1.80	0.55	1.30	2.20
							Total N (%) in leaves							
YFOL		5.30	5.10	5.20	5.40	5.25	5.30		5.55	5.15	5.55	5.75	6.15	5.85
YFEL			4.90	4.75	4.65	4.75	4.40			5.00	5.20	5.10	5.10	5.10
OL		3.15	2.90	3.00	2.55	3.15	3.40		3.20	3.35	3.35	3.15	3.75	4.15
Bulked leaf	4.30	4.25	4.00	4.15	4.00	4.15	3.75	4.80	4.45	4.10	4.60	4.75	4.65	4.45

In 2003, Güler and Büyük conducted a series of experiments to attempt to correlate leaf tissue nitrogen content with SPAD meter values (Minolta Camera Co., Ramsey, NJ). As mentioned previously, the SPAD meter uses optical sensors to rapidly determine chlorophyll content in leaf tissue. The sampling process is simple and fast providing immediate results to the user. In some cases a strong correlation can be obtained between leaf tissue nitrogen and chlorophyll readings. This study outlines the sampling techniques that were used to most accurately determine this relationship. The two crops selected for this research were cucumber (*Cucumis satius* L.) and tomato *(Solanum lycopersicum* L.). The cucumber crops were grown in 2000 and 2001, and the tomato crop was grown in 2000 only. Cucumber crops were supplied with 0, 100, 150, or 200 mg $\cdot L^{-1}$ N via drip irrigation. The tomatoes were fertilized with 0, 2, 4, 6, 8, or 10 tonnes $\cdot$ ha^{-1} poultry manure. Measurements (SPAD) were taken for both crops on a newly matured healthy leaf fourth or fifth from the top of each plant. The leaves were sampled using the SPAD meter and the leaves were collected and nitrogen content was determined using the Kjeldahl method.

Güler and Büyük (2003) reported a highly significant correlation between SPAD reading and leaf nitrogen content in the cucumber crop of 2000 ($P<0.05$) and the tomato crop of 2001($P<0.006$). Based on the data it was concluded that regression equations for tomatoes ($y = 1.42+ 0.048x$), and for cucumbers ($y= -7.52 + 0.280x$) can be used to monitor nitrogen status using the SPAD–502 meter. In order to maximize accuracy it is recommended that samples be taken at the same time and from the same part of the leaf.

If a correlation could be established in the two crops chosen for this thesis research, collards and yellow squash, the use of the SPAD-502 meter could be used predict the nitrogen status based on nitrogen source and application rate. A correlation would not only be useful for this research as a quick predictor of nitrogen status, but could also be used by growers to determine the need for additional nitrogen fertilizer applications in a production setting.

In another study leaf chlorophyll content and leaf petiole nitrate content were used to determine the nitrogen fertility levels for field-grown cabbage (*Brassica oleracea* var. *capitata* L.), onions (*Allium cepa* L), and carrots (*Daucus carota* L) (Westerveld, 2004). The study was conducted by applying 0, 50, 100, 150, and 200% of the total recommended nitrogen rates based on recommendations from the Ontario Ministry of Agriculture, Food, and Rural Affairs (Westerveld, 2004). Leaf petiole nitrate readings were taken using a Cardy NO_3^- meter (Horiba Co., Kyoto, Japan) from each crop at three growth stages; early season, mid-season, and late season. Leaf chlorophyll measurements were taken using the method described above by Güler and Büyük (2003). Total leaf nitrogen content was determined via Kjeldahl analysis. In an additional treatment, 50% of the total recommended nitrogen was applied pre-plant, and additional nitrogen was applied any time the leaf chlorophyll reading dropped below 95% of the highest N rate in 2000 and 97% of the highest N rate in 2001.

The results of the study indicated that the SPAD chlorophyll meter has potential as a nitrogen management tool in cabbage and onion. Significant linear relationships ($P < 0.05$) were established during the growing season, however, the location of testing in relation to leaf structures such as edges and veins could alter readings. This was especially important when sampling irregularly shaped leaves such as carrots or leaves with thick veins like cabbage. The Cardy meter showed potential for N analysis of all three crops. Less variability was noted in the results of nitrate testing than were seen in chlorophyll testing. As a result, more frequent and stronger linear relationships were detected between leaf nitrogen and nitrate reading. By using a combination of both techniques, a grower may be able to yield the most accurate and consistent analysis.

In a study by Hochmuth (1994) nitrate levels were determined for several commercial vegetable crops including yellow squash (*Cucurbita pepo* L) and collards (*Brassica oleracea* var. *acephala*) through the use of petiole nitrate sampling (Hochmuth, 1994). The petioles are collected and pressed using a garlic or lemon press to expel the petiole sap. The collected sap is immediately placed into the sampling cup of the calibrated NO_3^- meter and is quickly analyzed (Hochmuth, 1994). Based on the study's finding the most consistently accurate time to sample collards was just before harvest and again at first harvest. The sufficiency range for collars just prior to harvest was determined to be 500-800 (mg· L^{-1}) NO_3-N. At harvest the range was 300 - 500 (mg· L^{-1}) NO_3- N. Similar values were established for yellow squash. The sufficiency range for yellow squash at first boom was determined to be 900-1000 (mg· L^{-1}) NO_3- N. At first harvest the range was 800-900 (mg· L^{-1}) NO_3-N. These values were collected by first collecting 20 leaves from each plot. Similar nitrate values were also presented in the Knott's Handbook (Maynard, 2007).

In previous work, a detailed evaluation of sufficiency values was conducted for cucurbit production (Olson, 2012). This study not only provided sufficiency values but additional plant nutrient analysis as well. Similar to Hochmuth's (1994), their findings indicate that fresh petiole sap should be collected from yellow squash at first bloom and again at harvest. The reported sufficiency values ranged from 900-1000 (mg· L^{-1}) NO_3- N and 800-900 (mg· L^{-1}) NO_3- N at harvest. Included in the study are detailed plant analysis tables containing deficient, adequate, high, and toxic levels for all essential plant nutrients with the exception of carbon, hydrogen and oxygen.

The handling and storage procedure outlined in work by Olson (2012) and Hochmuth (1994) must be closely followed in order to obtain accurate results. Both studies indicate that it is best to analyze samples as quickly as possible, preferably in the field immediately after collection. In some cases mishandling of samples can result in significantly higher readings than would have been observed if taken immediately.

The values determined in these previous studies will be used to estimate the uptake of the nitrogen based on treatment. Total nitrogen will be determined using dry combustion and laboratory analysis. The uptake of secondary and micronutrients will be determined using ICAP analysis.

Economics of Organic Production

An important component of the proposed research will be the economic aspects of organic production using a hydrolyzed fish fertilizer. This aspect of the study will focus on the cost to produce an organic crop in comparison to a conventional one. The economic analysis will be conducted in a manner consistent with work done by Conner (2009).

Research conducted by Lin et al. (2008) examined the pricing premiums of fresh organic produce in the United States. The term “premiums” refer to the percentage by which a product selling price exceeds that of the commonly accepted market price. Their work showed that consumers regularly pay from 13 -86% more to purchase organic fruits and vegetables than conventional. The premiums paid are often based on the amount of market penetration a particular fruit or vegetable has developed. Organic vegetables that are abundant and readily available in most supermarkets often bring a lower price premium. For example, organic carrots (*Daucus carota* L.) have a relatively high market penetration and bring a lower price premium (Lin, 2008). Irish potatoes (*Solanum tuberosum* L.) on the other hand have little market penetration and regularly command a higher premium price (Lin, 2008). This suggests that supplying niche products or less common varieties may bring higher returns for an organic grower than what could be expected for more common ones.

A related study cited that a third of respondents to a survey conducted in New York were willing to pay a 100% premium for organically produced foods (Thompson and Kidwell, 1998). Another study found that price premiums for organic fruits and vegetables ranged from 40 to 175% of their conventional counterparts (Goldman and Clancy, 1991).

The factors that influence a consumer’s willingness to pay a premium price for organic produce in not always clear (Tregear et al., 1994). In a survey conducted in the United Kingdom 45% of respondents claim to have purchased organic products due to health concerns. An additional 9% indicated that their purchases were motivated by concern for the environment (Tregear et al., 1994). In the proposed study the economic focus will be on production costs and the price differential between organic and conventional products.

Zhang (2006) suggested that if large production cost differentials do not exist between a conventional and an organic system then farmers may be able to increase their profitability by allocating more resources to their organic vegetables which have higher profit margins. This research suggested that the fresh organic produce market is still underserved (the highest organic share is less than 4% among the four vegetables in the study) but becoming more standardized and accessible to the public. According to Zhang, we can expect that the market for organic fresh vegetables will continue to grow in the foreseeable future while the organic premiums are not likely to drop much (Zhang et al., 2006).

The market premiums that exist for many organic crops are an attractive incentive for many growers considering adopting organic practices (Conner and Rangarajan, 2009). The economics of this decision may not be so easy to determine. In 2002 and 2003, two case studies were conducted in Pennsylvania to better understand the cost as well as the returns that an organic grower could expect. The difficulty with this type of analysis is that there are no "typical" organic farms to use as a base line. This study determined that enterprise budgets for conventional farms were often not satisfactory when applied to organic farms. This is largely due to the multiple crops that are grown on limited acreage as well as varying practice that are implemented in organic production (Conner and Rangarajan, 2009).

Over the two years these case studies were conducted both farms were able to produce yields that were likely sufficient to achieve their annual income goal (Conner and Rangarajan, 2009). This would be subject to the prices they obtained for the vegetables produced. In a wholesale market, the profits would be significantly reduced as compared to what could be acquired in a direct to consumer market. An example of this can be seen in the field-grown tomatoes produced by one of the farms in this study. The price needed to reach economic goals was $0.64 / kg. This price could easily be reached at a wholesale market; however the retail price could exceed this by 300%. Additionally, the costs associated with organic production were quite different than would be expected in a convention operation (Conner and Rangarajan, 2009). In this particular study they noted a significantly lower need for pest control as compared to a conventional grower; however, the costs associated with the production of compost and nitrogen from cover crops was significant. Costs for fertility were much higher than would be expected in a conventional budget. The use of cover crops not only had the direct cost for seed but also had the loss of revenue during the time it took to establish a cover crop. In this case the cost of production was between 58% and 126% more than that of a conventional budget.

Any reduction in cost that will not negatively affect production would be welcomed by any grower. A reduction in fertility costs could have an even greater effect on organic growers due to the higher percentage of the budget it consumes. The use of a hydrolyzed fish fertilizer in this situation may help reduce the cost of providing nitrogen and free up the land for additional cash crop production. Though the practice of cover cropping will remain an important factor in organic farming, the supplemental application of a hydrolyzed fish fertilizer could extend the time between cover crops. As with many organic growers, nitrogen fertility is a limiting factor in producing adequate yield within a sustainable budget. By slowly applying nitrogen through a drip irrigation system, a grower would be able to apply the nutrients as needed by the crop and have greater predictability in the fertilizer contents. The continuous application of soluble nutrients could be adjusted as needed based on plant growth or through techniques such as leaf nitrogen, nitrate, and chlorophyll analysis. Frequent monitoring and the use of a quickly available organic nitrogen source may improve already respectable yield and eliminate the dependence on cover crop mineralization.

II. Objectives

The objective of this research is to evaluate the performance of a hydrolyzed fish fertilizer in a yellow squash – collard rotation. The evaluation of the fertilizer will be done by comparing various aspects of plant growth, yield, and nutrient content to that of a combination of inorganic fertilizers. In addition to evaluating the performance of the hydrolyzed fish fertilizer, a detailed analysis will be conducted to determine its economic feasibility in organic production.

III. Materials and Methods

Field studies were conducted beginning on 6 July 2012 and continued until 26 Sept. 2013 at the Horticulture Unit of the E.V. Smith Research Center (Shorter, AL), on a Norfolk fine sandy loam (fine-loamy, siliceous thermic Typic Paledult). Prior to the start of the experiment, soil samples were taken to analyze the initial nutrient content of the soil. Based on this test, no nutrient deficiencies or pH issues were detected.

The following experiment compared various rates of organic and inorganic-N employed in a two-year crop rotation scheme with summer squash (*Cucurbita pepo* cv. Conqueror III) followed by collards (*Brassica oleracea* var. *acephala* cv. Blue Max) in the summer and fall of 2012, respectively. 'Conqueror III' was a hybrid, yellow straight-neck summer squash typical of the types grown for the fresh-market throughout the southeastern US (Seminis Seed Co., St. Louis, MO). 'Blue Max' was a hybrid blue-green colored collard also typical of the types of collards grown extensively around the southeastern US (Abbott and Cobb, Feasterville, PA). In 2013, collards were planted in early spring and were followed by a mid-summer crop of summer squash.

This experiment was conducted on 0.15 m raised beds spaced 1.8 m from center. Prior to the installation of the polyethylene mulch, the beds were pre-formed and 17.6% of the total recommended N for the initial summer squash planting was applied pre-plant. The amount of N applied varied between treatments. The required quantity of pre-plant N was calculated by multiplying the total amount to be applied by the recommended 17.6%. The 100% rate received

26.88 kg N ha^{-1}, the 80% received 21.6 kg N ha^{-1}, and the 60% rate received 16.12 kg N ha^{-1}, respectively. All pre-plant fertilizers were applied as an aqueous solution 0.15 m into the center of each bed into a 25 mm x 25 mm pre-formed furrow. Each experimental plot was treated with the same N source, i.e. same treatment, throughout the experiment and no re-randomization of plots occurred.

White on black polyethylene mulch (1.5 m wide x 0.05 mm thick; Berry Plastics Corp. Evansville, IN) was installed immediately after the pre-plant fertilizer was applied. The mulch was installed with drip irrigation (T-Tape; 0.25 mm wall thickness, 0.30 m emitter spacing, San Marcos, CA). The delivery rate of irrigation tape was 5.59 L per 100 m per minute.

This experiment was arranged as a randomized complete block design (RCBD) consisting of 10 treatments with 4 replicates. The plots were regularly scouted to manage irrigation, insect, disease, and weed pressure. Irrigation was applied based on crop requirements. Insect, disease, and weed management were accomplished by following the guidelines set forth in the 2012 SE US Vegetable Crop Handbook (Kemble et al., 2012).

Fertilizer Sources and Treatments

This experiment compared the effect of an organic N source, Schafer's Liquid Fish; a widely available hydrolyzed fish fertilizer hydrolyzed fish fertilizer (HFF) with inorganic-N sources at varying rates with and without the secondary and minor nutrients found in the HFF. The HFF used in this experiment was manufactured by Schafer Fisheries Organics (Schafer Fisheries, Inc., Thomson, IL) with a labeled analysis of 2.6N-0.87P-0.22K. Additional nutrients were inherently present in the HFF and are shown in the following table (Fig. 1). In order to evaluate the HFF as a potential N source for organic production as compared to N sources used in conventional production, it was necessary to equalize all the nutrients present across all treatments with the exception of nitrogen (Table 1). This required the addition of P to all treatments to equal the amount which was present (117 kg P ha^{-1}) in the highest applied rate of the fish fertilizer. The same adjustments were made with K. The amount of K applied was 152 kg P ha^{-1}. In this way, both the P and K rates were the same across all treatments. The full recommended rate for summer squash was 152 kg ha^{-1} for both N and K, while the recommend rates for collards was 90 to 100 kg ha^{-1} for both N and K, respectively (Kemble et al., 2012).

These treatments were developed in order to make comparisons between the inorganic-N sources and the HFF as well as to determine the effect N rate had on each treatment. All treatments are based on 100%, 80%, and 60% of the recommended N rates for summer squash and for collards (Kemble et al., 2012). The inorganic treatments had the additional factor of either having or withholding the secondary and micronutrients found in the HFF (Table 2).

In addition to the equalization in the quantity of nutrients supplied among the inorganic treatments, the form of N supplied was also considered. All treatments were adjusted to supply a rate of 57% NO_3-N and 43% NH_4-N. This adjustment was made for two reasons: (1) to mirror the likely form that the organic-N will be taken up by the plants (Camberato, 2001), and (2) to eliminate any interaction that may be caused due to preferential uptake of one N form versus the other.

Based on the data analysis by the manufacture, the following nutrients were added to the selected inorganic treatments: Ca, Mg, S, Mn, Fe, Zn, Na, and Cl (Fig. 1; Table 2). In order to equalize the nutrient content between the HFF and the inorganic treatments, the following products were used: $Ca(NO_3)_2$, K_2SO_4, K_2CO_3, H_3PO_4, FE EDTA, $(NH_4)_2SO_4$, $CO(NH_2)_2$, NaCl, $NaHCO_3$, Zn chelate, Mn chelate, $MgSO_4$ (Table 2).This group of fertilizers was combined in measured quantities to create a water-soluble blend that was equivalent in nutritional content to the HFF (Table 2). As a control, one treatment (Treatment 10) received no N fertility. This treatment only received the K and P that was common across all treatments.

Treatment Delivery

In order to accurately deliver each fertility treatment across the four replicates, an extensive network of polyethylene pipe (Toro Flex Pipe; 13 mm, Toro Co. Bloomington, MN) was used. The polyethylene pipe interconnected the drip tape from each treatment in each replicate to the water source and a Dosatron D45RE (Dosatron Intl., Clearwater, FL) fertigation injector. A manifold composed of a filter (150 mesh), ball valves, and connectors allowed for each of the ten treatments to have a dedicated connection to an injector (Fig. 2). This system provided an accurate and efficient method for delivering each treatment.

Fertilizer treatments were injected twice weekly during each crop cycle (Tables 3-8). Each of the inorganic treatments was pre-measured and bagged. Once on-site the inorganic fertilizers were dissolved in approximately 1L water and injected. It should be noted that the calcium nitrate was measured and injected separately to avoid issues with precipitants forming. The HFF was measured on-site. It was necessary to inject the HFF and the K_2CO_3 separately due to an acid/base reaction that occurred when the two products were mixed. Treatments were injected after the system was fully pressurized. The complete process is described below in the Irrigation and Fertigation sections under each crop.

Crop Rotation Sequence

The crop rotation consisted of four crops: a summer crop of straight-neck yellow summer squash (July-Aug. 2012), a fall collard crop (Oct.-Dec. 2012), a second early spring collard crop (Mar.-May 2013), and a spring summer squash crop (May-July 2013). Below is description of the data that was collected throughout the experiment. This data provided the basis for the statistical analysis used to determine the effect of N sources, N rates, and the efficacy of each treatment.

Upon completion of the rotation, a detailed economic analysis was conducted. The analysis included developing enterprise budgets for each treatment using cost information from the 2013 Mississippi State Budget Generator 6.0, (Starkville, MS) as well as a budgeting program developed by The University of Florida (Hewitt, 2003) for use in Excel. This data combined with the USDA Terminal Market price for collards and USDA retail price for summer squash was used to determine if the use of a HFF was an economically feasible alternative to the inorganic fertilizer regime.

Crop 1: Summer Squash 2012

On 6 July 2012, the first summer squash crop in the rotation was direct-seeded into the field. Prior to seeding, the beds were irrigated and holes were punched into the plastic mulch at a spacing of 0.45 m centers with a single row per bed. By 13 July nearly 100% of seedlings had emerged. Treatment applications via fertigation began on 18 July and continued until crop termination on 27 Aug. 2012. Fertigation followed the schedule for summer squash provided by the 2012 SE US Vegetable Crop Handbook (Kemble et al, 2012) (Tables 3, 4, 5).

Pest Management: Summer Squash 2012

Pesticides were applied as needed in accordance with recommended standard practices. Insect, weed, and disease pressure was monitored daily through scouting. Fungicides, herbicides, and insecticides were applied as needed to prevent crop damage (Table 9).

Irrigation and Fertigation: Summer Squash 2012

Throughout the experiment, daily water needs were determined based on requirements of the crop, with irrigation initiated any time soil moisture decreased below field capacity (data not shown). The average weekly irrigation throughout the experiment was between 2.50 cm to 3.75 cm. The rate of water application was varied based on weather conditions and growth rate of the crop. Treatments were applied via fertigation twice weekly beginning 18 July and continued until the crop cycle was terminated. Treatment application began with a 30 min pre-wet cycle where the beds were wet with water to help improve the fertilizer movement into the soil as well as to ensure the system was up to full operating pressure (55 to 82 kPa) before injection began. Two fertilizer treatments were injected simultaneously from one of the two injection manifolds (Fig. 2). Each of the inorganic treatments were dissolved in 1 L water and injected into the system. The inorganic-N with minor elements treatments were injected in two stages to prevent precipitants from forming. The first stage was injecting the $Ca(NO_3)_2$ alone or with the K_2CO_3. The next stage of injection continued with the remaining fertilizers.

The procedure for injecting HFF was similar to that of the inorganic with minor elements treatments. It was necessary to avoid mixing the HFF with the K_2CO_3 due to an acid/base reaction. The HFF is strongly acidic (pH 3) and the K_2CO_3 is strongly basic (pH 13). Therefore the HFF was injected first followed by the K_2CO_3. The injection process took approximately 25 min per treatment to inject. After each injection was completed, the irrigation system was allowed to run for an additional 5 min in order to flush the lines and to insure the fertilizer had moved through the irrigation system into each bed. The screen filters were cleaned between each treatment to insure that any un-dissolved particles were removed. This process was repeated until all 10 treatments were injected.

Data Measurements: Summer Squash 2012

Data measurements were collected on the same day treatments were injected. Beginning on 18 July and continuing at 10-day intervals, the above-ground vegetative portion of one plant was harvested from the end of each plot which was designated for destructive harvest use. Each sample was weighed to determine its fresh weight, bagged, and then placed into a convection drying oven at 75^{o}C for a minimum of 48 h. Samples were then removed from the oven and weighed to determine its dry weight. All weights were recorded and later used for growth analysis.

N analysis and ICAP analysis: Summer Squash 2012

Leaf samples were collected weekly for N analysis and ICAP analysis. Approximately 12 leaves from recently expanded and fully matured leaves were collected from each plot. The leaves were collected, bagged, and placed into a convection drying oven at 75^{o}C for 48 h or until fully dry. The leaves were then ground into a fine powder using a Cyclone Sample Mill (UDY Corporation, Fort Collins, CO) in preparation for laboratory analysis.

Total N content was determined from each dried leaf sample by weighing 0.100 g of ground tissue and placing it into foil containers. Total N content was determined via dry combustion techniques (Leco-CHN600, Leco Corporation, St Joseph, MO) (Bremner and Mulvaney, 1986).

Additional leaf tissue samples were taken from each plot. ICAP (inductively coupled argon plasma spectrometry) analysis was performed on these two tissue samples. The first leaf tissue sample was taken at the early bloom stage and the second was taken at the first harvest. These values were compared to established sufficiency values for summer squash (Mills and Jones, 1996). Nutrient content of each relevant element was determined for each sample using the methods for the N analysis and ICAP described above. These results were used during the statistical analysis.

Leaf Chlorophyll Measurements: Summer Squash 2012

Leaf chlorophyll measurements were taken weekly using the SPAD 502 Chlorophyll meter (SPAD 502, Minolta Co. Ltd., Japan) until the final harvest. Beginning 24 July, five readings were taken from random plants with recently expanded, mature leaves in each plot and recorded. The area to the right of the midrib was tested to reduce sampling variation. All readings were recorded for later statistical analysis.

Canopy Height and Width: Summer Squash 2012

Canopy height and canopy width data was collected weekly from five randomly selected plants in each plot. The canopy height was recorded from the soil line to the highest point on the plant. The canopy width was determined by measuring the widest point across the plant. Representative plants from each plot were selected to be measured. All data were recorded for later statistical analysis.

Soil Samples and Testing: Summer Squash 2012

Soil tests were taken from each plot after the summer squash crop of 2012 was terminated. Samples were taken from the surface to a depth of 15 cm. Soil samples were extracted using 25 ml of 2.0 M KCl and NH_4-N and NO_3-N were determined via microtiter plate colorimetric analysis (Sims et al.,1995). The amount of NO_3-N and NH_4-N were recorded to determine if changes in residual N were present among N sources and N rates between crop cycles. Samples were compared to those collected after the previous crop was terminated.

Soil samples were also collected to determine soil pH. This was done to ensure that pH ranges remained equal between treatments. Soil pH was determined by combining 20 ml distilled water into 20 g or soil. The soil was initially mixed distilled water for 15 seconds and allowed to sit for an additional 30 minutes. Immediately prior to inserting the pH probe, the soil was agitated for an additional 15 seconds. Measurements were taken using a HI991001 pH meter (Hanna Instruments, Smithfield, RI)

Leaf Petiole Samples: Summer Squash 2012

Petiole NO_3-N samples were taken from each plot at first flower and again at first harvest to compare these values to established petiole NO_3-N values (Hochmuth, 1994). Petiole NO_3-N was determined in the field using the TwinNO_3 meter (Horiba, Ltd. Kyoto, Japan) using the recommended sampling procedure provided. The meter was calibrated prior to each sampling and again at the half way point of data collection using the provided 5000 ppm NO_3^- solution. Results were recorded for statistical analysis.

Harvest: Summer Squash 2012

Harvest data was collected for each plot. Each plot was harvested three times per week during the crop cycle. The total weight and total fruit number of US #1 grade fruit was determined for all fruit from each plot. The cull weight and cull number of each plot was also determined for each plot. All grading was done according the USDA standards for fresh-market summer squash (USDA, 1984).

All data collected from this experiment was subjected to the appropriate analysis of variance and regression procedures (PROC CORR, PROC MIXED, and PROC REG,) (SAS Institute, Cary, NC). When appropriate, data was combined over years and analyzed together. In cases where interactions occurred between a specific crop and year, data was re-analyzed by year.

Crop 2: Collards 2012

Collard transplants were seeded on 22 Aug. 2012 at the Patterson Greenhouse Complex (Auburn, AL). The transplants were started in standard 72-count trays (37mm x 37mm x 58mm) in an uncharged, soilless media suitable for seed propagation. The seed were sown one seed per cell at a depth of 0.3 cm. The seed were immediately watered and kept at 26^{0}C in a greenhouse under ambient sunlight. The seedlings emerged within five days and were allowed to grow until they had reached an acceptable size for transplanting. This was determined by examining the root structure as well as the size and strength of the above ground portion of the plants. During this time, the transplants were fertilized five times with a 200 ppm N solution (TotalGro 20-20-20, SDT Industries, Winnsboro, LA). On 26 Sept. the transplants were taken to a partially shaded area to harden off prior to planting. On 2 Oct. the transplants were hand-planted into the beds used and into the holes previously punched for the first summer squash crop in the rotation.

Treatment Application: Collards 2012

Treatment applications via fertigation began on 4 Oct. 2012 and continued until the collards were harvested on 12 Dec. 2012. A fertigation schedule was designed to apply the 90 to 100 kg ha^{-1} N recommended in the 2012 SE US Vegetable Growers Handbook (Kemble et al., 2012) (Tables 6, 7, 8). The 100%, 80%, and 60% rates of fertilizer were equal to 2.25 kg, 1.8 kg, and 1.35 kg N ha^{-1} per day respectively. These treatments were developed in order to make comparisons between the inorganic-N sources and the HFF and the effect N rate had on each treatment. These rates were based on a growing season of six to seven weeks. In this case, the season was three weeks longer than expected due to cool temperatures; however, the rate of fertilizer that was injected remained constant continuing through the final harvest.

Irrigation and Fertigation: Collards 2012

Treatments were applied via fertigation twice weekly beginning with a 30 min pre-wet cycle where the beds were wet with water to help improve the fertilizer movement into the soil as well as to ensure the system was up to full operating pressure (55 to 82 kPa) before injection began. Two fertilizer treatments were injected simultaneously from one of the two injection manifolds (Fig. 2). Each of the inorganic treatments was dissolved in 1Lwater and injected into the system. The inorganic-N with minor elements treatments were injected in two stages to prevent precipitants from forming. The first stage was the $Ca(NO_3)_2$ alone or with the K_2CO_3. The next stage of injection continued with the remaining fertilizers.

The procedure for injecting the HFF was similar to that of the inorganic-N with minor elements treatments. It was necessary to avoid mixing the HFF with the K_2CO_3 due to an acid/base reaction. The HFF was strongly acidic (pH 3) and the K_2CO_3 was strongly basic (pH 13). Therefore the HFF was injected first followed by the K_2CO_3. The injection process took approximately 25 min per treatment to inject. After each injection was completed, the irrigation system was allowed to run for an additional 5 min in order to flush the lines and to insure the fertilizer had moved through the system into each bed. The screen filters were cleaned between each treatment to insure that any un-dissolved particles were removed. This process was repeated until all 10 treatments were injected.

Pest Management: Collards 2012

Pesticides were applied as needed in accordance with recommended standard practices. Insect, weed, and disease pressure was monitored daily through scouting. Fungicides, herbicides, and insecticides were applied as needed to prevent crop damage (Table 9).

Data Measurements: Collards 2012

Data were collected on the same day treatments were injected. Beginning 18 Oct. and continuing at 10-day intervals, the above-ground vegetative portion of one collard plant was harvested from the end of each plot which was designated for destructive harvest use. Each sample was weighed to determine its fresh weight, bagged, and then placed into a convection drying oven at 75°C for a minimum of 48 h. Samples were then removed from the oven and weighed to determine its dry weight. All weights were recorded and later used for growth analysis.

N analysis and ICAP analysis: Collards 2012

Leaf samples were collected weekly for both total nitrogen and ICAP analysis. Approximately 12 leaves from recently expanded, mature leaves were collected from each plot. . The leaves were collected, bagged, and then placed in a convection drying oven at 75^{0}C for 48 hours until fully dry. The leaves were then ground into a fine powder using a Cyclone Sample Mill (UDY Corporation, Fort Collins, CO) in preparation for laboratory analysis.

Total N content was determined from each dried leaf sample by weighing 0.100 g of ground tissue and placing it into foil containers which were analyzed for total nitrogen was determined content via dry combustion techniques (Leco-CHN600, Leco Corporation, St Joseph, MO) (Bremner and Mulvaney, 1986).

Additional leaf tissue samples were taken from each plot. ICAP (inductively coupled argon plasma spectrometry) analysis was performed on these two tissue samples from each plot. The first sample leaf tissue was taken at the midpoint of development of the crop and the second was taken at harvest. These values were compared to established sufficiency values for collards (Mills and Jones, 1996). Nutrient content of each relevant element was determined for each sample using the methods for the N analysis and ICAP described above. These results were used during the statistical analysis.

During the midpoint of this experiment, symptoms resembling a nutrient deficiency developed on the collards. The most prominent symptoms were upwardly curled, thickened leaves, reddish coloration, stunted growth, and extremely high petiole nitrate concentrations. The symptoms appeared to be isolated to the inorganic without secondary and minor nutrients

(INORGWO) treatments at 60, 80 and 100% of the recommended N rates, with particularly severe symptoms at the N rate of 121 $kg \cdot ha^{-1}$. Since a nutrient deficiency was the suspected, an additional leaf tissue analysis was conducted to determine the total sulfur content of four of these samples. The samples were taken from two of the most severely affected plots and from two adjacent unaffected plots for comparison. The most severely affected samples were collected from plots 408 and 409, both of which receive no secondary or micro nutrients. The unaffected samples were taken from plots 402 and 403, both receiving secondary and micronutrients (Fig. 3). All four plots received the same rate of N, with the only difference being the supply of secondary and micronutrients. This additional analysis was conducted at the Auburn University Soil Testing Laboratory (Auburn, AL). The results and their significance will be explained in the discussion.

Leaf Chlorophyll Measurements: Collards 2012

Leaf chlorophyll measurements were taken weekly using the SPAD 502 chlorophyll meter (SPAD 502, Minolta Co. Ltd., Japan) until the final harvest. Beginning 23 Oct., five readings were taken from random plants with recently expanded, mature leaves in each plot and recorded. The area to the right of the midrib was tested to reduce sampling variation. All readings were recorded for later statistical analysis.

Canopy Height and Width: Collards 2012

Collard canopy height and canopy width data was collected weekly from five plants in each plot. The canopy height was recorded from the soil line to the highest point on the plant. The canopy width was determined by measuring the widest point across the plant. Representative plants from each plot were selected to be measured. All data were recorded for later statistical analysis.

Soil Samples and Testing: Collards 2012

Soil tests were taken from each plot after the collard crop of 2012 as terminated. Samples were taken from the surface to a depth of 15 cm. Soil samples were extracted using 25 ml of 2.0 M KCl and NH_4-N and NO_3-N were determined via microtiter plate colorimetric analysis (Sims et al.,1995). The amount of NO_3-N and NH_4-N were recorded to determine if changes in residual N were present among N sources and N rates between crop cycles. Samples were compared to those collected after the previous crop was terminated.

Soil samples were also tested to determine soil pH. This was done to ensure that pH ranges remained equal between treatments. Soil pH was determined by combining 20 ml distilled water into 20 g or soil. The soil was initially mixed with distilled water for 15 seconds and allowed to sit for an additional 30 minutes. Immediately prior to inserting the pH probe, the soil was agitated for an additional 15 seconds. Measurements were taken using a HI991001 pH meter (Hanna Instruments, Smithfield, RI)

Leaf Petiole Samples: Collards 2012

Petiole NO_3-N samples were taken from each plot at the mid-point of the crop and again at harvest to compare these values to established petiole NO_3-N values (Hochmuth, 1994). Petiole NO_3-N was determined in the field using the TwinNO_3 meter (Horiba, Ltd. Kyoto, Japan) using the recommended sampling procedure provided. The meter was calibrated prior to each sampling and again at the half way point of data collection using the provided 5000 ppm NO_3^- solution. Results were recorded for statistical analysis.

Harvest: Collards 2012

Harvest data was taken from each of the experimental plots on 12 Dec. 2012. The weight per harvested plant was recorded and the total number of harvested plants per plot recorded. Bunches were size separated into US #1 and the culls and number of each were recorded. The grading was done according the USDA guidelines for collard or broccoli greens (USDA, 1953). All grading was done in the field and recorded.

All data collected from this experiment was subjected to the appropriate analysis of variance and regression procedures (PROC CORR, PROC MIXED, and PROC REG,) (SAS Institute, Cary, NC). All data was combined over years and analyzed together. In cases where interactions occurred between a specific crop and year, data was re-analyzed by year.

Crop 3: Collards 2013

Collard transplants were seeded on 8 Feb. 2013 at the Patterson Greenhouse Complex (Auburn, AL). The transplants were started in standard 72-count (37mm x 37mm x 58mm) trays in an uncharged soilless media suitable for seed propagation. The seed were sown one seed per cell at a depth of 0.3 cm. The seed were immediately watered and kept at 26^{0}C in a greenhouse under ambient sunlight. The seedlings emerged with five days and were allowed to grow until they had reached an acceptable size for transplanting. This was determined by examining the root structure as well as the size and strength of the above ground portion of the plants. During this time the transplants were fertilized five times with a 200 ppm nitrogen solution (TotalGro 20-20-20, SDT Industries, Winnsboro, LA). On 18 Mar. the transplants were taken to a partially shaded area to harden off prior to planting. On 22 March the transplants were hand-planted into the beds used in the same holes used by the previous two crops in the rotation.

Treatment Application: Collards 2013

Fertigation began on 1 April 2013 and continued until the crops were harvested on 17 May 2013. There was a slight delay in the initial fertigation treatment due to rain followed by unseasonably cold temperatures. The same fertigation schedule was followed as described in the previous collard crop above. The schedule was designed to apply the 90 to 100 kg N ha^{-1} as recommended in the 2012 SE US Vegetable Growers Handbook (Kemble et al., 2012) (Tables 6, 7, 8). The 100%, 80%, and 60 % rates of fertilizer were equal to 2.25 kg, 1.8 kg, and 1.35 kg ha^{-1} N per day respectively. These rates were based on a growing season of six to seven weeks. As in 2012, the season went one week longer than expected due to cool temperatures and slower than expected growth; however, the fertilizer injection continued through the final harvest.

Irrigation and Fertigation: Collards 2013

Treatments were applied via fertigation twice weekly beginning with a 30 minute pre-wet cycle where the beds were wet with only water to help improve the fertilizer movement into the soil as well as to ensure the system was up to full operating pressure (55 to 82 kPa) before injection began. Two fertilizer treatments were injected simultaneously from one of the two injection manifolds (Fig. 2). Each of the inorganic treatments was dissolved in 1 L water and injected into the system. The inorganic-N with minor elements treatments were injected in two stages to prevent precipitants from forming. The first stage was the $Ca(NO_3)_2$ alone or with the K_2CO_3. The next stage of injection continued with the remaining fertilizers.

The procedure for injecting HFF was similar to that of the inorganic-N with minor elements treatments. It was necessary to avoid mixing the HFF with the K_2CO_3 due to an acid/base reaction. The HFF was strongly acidic (pH 3) and the K_2CO_3 was strongly basic (pH 13). Therefore the HFF was injected first followed by the K_2CO_3. The injection process took approximately 25 min per treatment to inject. After each injection was completed, the irrigation system was allowed to run for an additional 5 min in order to flush the lines and to insure the fertilizer had moved through the irrigation system into each bed. The screen filters were cleaned between each treatment to insure that any un-dissolved particles were removed. This process was repeated until all 10 treatments were injected.

Pest Management: Collards 2013

Pesticides were applied as needed in accordance with recommended standard practices. Insect, weed, and disease pressure was monitored daily through scouting. Fungicides, herbicides, and insecticides were applied as needed to prevent crop damage (Table 9).

Data Measurements: Collards 2013

Data were collected on the same day treatments were injected. Beginning on 22 April 2013 and continuing at 10-day intervals, the above-ground vegetative portion of one collard plant was harvested from the end of each plot which was designated for destructive harvest use. Each sample was weighed to determine its fresh weight, bagged, and then placed into a convection drying oven at 75^{o}C for a minimum of 48 h. Samples were then removed from the oven and weighed to determine its dry weight. All weights were recorded and later used for growth analysis.

N analysis and ICAP analysis: Collards 2013

Leaf samples were collected weekly for both total nitrogen and ICAP analysis. Approximately 12 leaves from recently expanded, mature leaves were collected from each plot. The leaves were collected, bagged, and then placed in a convection drying oven at 75^{o}C for 48 hours until fully dry. The leaves were then ground into a fine powder using a Cyclone Sample Mill (UDY Corporation, Fort Collins, Colorado) in preparation for laboratory analysis.

Total N content was determined from each dried leaf sample by weighing 0.100 g of ground tissue and placing it into foil containers Total nitrogen was determined content via dry combustion techniques (Leco-CHN600, Leco Corporation, St Joseph, MO) (Bremner and

Mulvaney, 1986).

Additional leaf tissue samples were taken from each plot. ICAP (inductively coupled argon plasma spectrometry) analysis was performed on these two tissue samples from each plot. The first leaf tissue sample was taken at the midpoint of development of the crop and the second was taken at harvest. These values were compared to established sufficiency values for collards (Mills and Jones, 1996). Nutrient content of each relevant element was determined for each sample using the methods for the N analysis and ICAP described above. These results were used during the statistical analysis.

Leaf Chlorophyll Measurements: Collards 2013

Leaf chlorophyll measurements were taken weekly using the SPAD 502 chlorophyll meter (SPAD 502, Minolta Co. Ltd., Japan) until the final harvest. Beginning 22 April, five readings were taken from random plants with recently expanded, mature leaves in each plot and recorded. The area to the right of the midrib was tested to reduce sampling variation. All readings were recorded for later statistical analysis.

Canopy Height and Width: Collards 2013

Collard canopy height and canopy width data was collected weekly from five plants in each plot. The canopy height was recorded from the soil line to the highest point on the plant. The canopy width was determined by measuring the widest point across the plant. Representative plants from each plot were selected to be measured. All data were recorded for later statistical analysis.

Soil Samples and Testing: Collards 2013

Soil tests were taken from each plot after the study was terminated. Samples were taken from the surface to a depth of 15 cm. Soil samples were extracted using 25 ml of 2.0 M KCl and

NH_4-N and NO_3-N were determined via microtiter plate colorimetric analysis (Sims et al.,1995). The amount of NO_3-N and NH_4-N were recorded to determine if changes in residual N were present among N sources and N rates between crop cycles. Samples were compared to those collected after the previous crop was terminated.

Soil samples were also tested to determine soil pH. This was done to ensure that pH ranges remained equal between treatments. Soil pH was determined by combining 20 ml distilled water into 20 g or soil. The soil was initially mixed distilled for 15 seconds and allowed to sit for an additional 30 minutes. Immediately prior to inserting the pH probe, the soil was agitated for an additional 15 seconds. Measurements were taken using a HI991001 pH meter (Hanna Instruments, Smithfield, RI.)

Leaf Petiole Samples: Collards 2013

Petiole NO_3-N samples were taken from each plot at the mid-point of the season and again at harvest to compare these values to established petiole NO_3-N values (Hochmuth, 1994). Petiole NO_3-N was determined in the field using the TwinNO_3 meter (Horiba, Ltd. Kyoto, Japan) using the recommended sampling procedure provided. The meter was calibrated prior to each sampling and again at the half way point of data collection using the provided 5000 ppm NO_3^- solution. Results were recorded for statistical analysis.

Soil tests were taken from each plot after the collard crop of 2013 was terminated. Samples were taken from the surface to a depth of 15 cm. Soil samples were extracted using 25 ml of 2.0 M KCl and NH_4-N and NO_3-N were determined via microtiter plate colorimetric analysis (Sims et al.,1995). The amount of NO_3-N and NH_4-N were recorded to determine if changes in residual N were present among N sources and N rates between crop cycles. Samples were compared to those collected after the previous crop was terminated.

Harvest: Collards 2013

The weight per harvested plant was recorded and the total number of harvested plants per plot recorded. Bunches were size separated into US #1 and the culls and number of each were recorded. The grading was done according the USDA guidelines for kale and greens (beet, broccoli, collard, dandelion, mustard, and turnip) (USDA, 1953). All grading was done in the field and recorded.

All data collected from this experiment was subjected to the appropriate analysis of variance and regression procedures (PROC CORR, PROC MIXED, and PROC REG,) (SAS Institute, Cary, NC). All data was combined over years and analyzed together. In cases where interactions occurred between a specific crop and year, data was re-analyzed by year.

Crop 4: Summer Squash 2014

On 31 May 2013, the final summer squash crop in the rotation was direct-seeded into the field at the Horticulture Unit of E.V. Smith Research Center (Shorter, AL). Over the next five days, over four inches of rain was recorded at this location. As a result of the flooding, germination and emergence percentages were extremely low (data not shown). Additional attempts to direct-seed were made on 14 June and 28 June. Both attempts were unsuccessful due to continuing rain-fall and damage from meadow voles (*Microtus pennsylvanicus*). After three failed attempts to direct-seed, the decision was made to produce transplants.

On 17 July 2013, the second summer squash crop in the rotation was seeded at the Patterson Greenhouse Complex (Auburn, AL). The transplants were started in standard 72-count trays (37mm x 37mm x 58mm) in an uncharged soilless media suitable for seed propagation. The seed were sown one seed per cell at a depth of 1.25 cm. The seed were immediately watered and kept at 26^{o}C in a greenhouse under ambient sunlight. The seedlings emerged within four days and were allowed to grow for two weeks until they had reached an acceptable size for transplanting. This was determined by examining the root structure as well as the size and strength of the above ground portion of the plants. Due to the speed of the transplants to develop, it was not necessary to apply fertilizer prior to transplanting. On 29 July 2013 the transplants were taken to a partially shaded area to harden off prior to planting. On 2 Aug. the transplants were hand- planted into the beds used in the exact holes used for the previous three crops.

Fertigation began on 5 Aug. and continued until crop termination on 20 Sept. 2013. The same fertigation schedule and procedure was followed as was with the first summer squash crop as described above. Fertigation followed the schedule provided by the Southern Vegetable Growers Handbook (Kemble, 2012) (Tables 3, 4, 5).

Pest Management: Summer Squash 2013

Pesticides were applied as needed in accordance with recommended standard practices. Insect, weed, and disease pressure was monitored daily through scouting. Fungicides, herbicides, and insecticides were applied as needed to prevent crop damage (Table 9).

Data Measurements: Summer Squash 2013

Data was collected on the same day fertilizers were injected. Beginning on 20 Aug. and continuing at 10-day intervals, the above-ground vegetative portion of one plant was harvested from the end of each plot designated for destructive harvest. Each sample was weighed to determine its fresh weight, bagged, and then placed into a convection drying oven at 75^{o}C for a minimum of 48 h. Samples were then removed from the oven and weighed to determine its dry weight. All weights were recorded and later used for growth analysis.

N analysis and ICAP analysis: Summer Squash 2013

Leaf samples were collected weekly for both total N and ICAP analysis. Approximately 12 leaves from recently expanded and fully matured leaves were collected from each plot. The leaves were collected, bagged, and then placed in a convection drying oven at 75^{0}C for 48 hours until fully dry. The leaves were then ground into a fine powder using a Cyclone Sample Mill (UDY Corporation, Fort Collins, Colorado) in preparation for laboratory analysis.

Total N content was determined from each dried leaf sample by weighing 0.100 g of ground tissue and placing it into foil containers. Total N content was determined via dry combustion techniques (Leco-CHN600, Leco Corporation, St Joseph, MO) (Bremner and Mulvaney, 1986).

Additional leaf tissue samples were taken from each plot. ICAP (inductively coupled argon plasma spectrometry) analysis was performed on these two tissue samples. The first leaf tissue sample was taken at the early bloom stage and the second was taken at the first harvest. These values were compared to established sufficiency values for summer squash (Mills and Jones, 1996). Nutrient content of each relevant element was determined for each sample using the methods for the N analysis and ICAP described above. These results were used during the statistical analysis.

Leaf Chlorophyll Measurements: Summer Squash 2013

Leaf chlorophyll measurements were taken weekly using the SPAD 502 chlorophyll meter (SPAD 502, Minolta Co. Ltd., Japan) until the final harvest. Beginning 24 July, five readings were taken from random plants with recently expanded, mature leaves in each plot and recorded. The area to the right of the midrib was tested to reduce sampling variation. All readings were recorded for later statistical analysis.

Canopy Height and Width: Summer Squash 2013

Canopy height and canopy width data was collected weekly from five randomly selected plants in each plot. The height was recorded from the soil line to the highest point on the plant. The canopy width was determined by measuring the widest point across the plant. Representative plants from each plot were selected to be measured. All data were recorded for later statistical analysis.

Soil Samples and Testing: Summer Squash 2013

Soil tests were taken from each plot after the study was terminated. Samples were taken from the surface to a depth of 15 cm. Soil samples were extracted using 25 ml of 2.0 M KCl and NH_4-N and NO_3-N were determined via microtiter plate colorimetric analysis (Sims et al.,1995). The amount of NO_3-N and NH_4-N were recorded to determine if changes in residual N were present among N sources and N rates between crop cycles. Samples were compared to those collected after the previous crop was terminated.

Soil samples were also collected to determine soil pH. This was done to ensure that pH ranges remained equal between treatments. Soil pH was determined by combining 20 ml distilled water into 20 g or soil. The soil was initially mixed with distilled for 15 seconds and allowed to sit for an additional 30 minutes. Immediately prior to inserting the pH probe, the soil was agitated for an additional 15 seconds. Measurements were taken using a HI991001 pH meter (Hanna Instruments, Smithfield, RI.)

Leaf Petiole Samples: Summer Squash 2012

Petiole nitrate samples were taken from each experimental plot at first flower and again at first harvest to compare these values to establish petiole NO_3-N values (Hochmuth, 1994). Petiole NO_3-N was determined in the field using the TwinNO_3 meter (Horiba, Ltd. Kyoto, Japan) and using the recommended collection procedure provided. The meter was calibrated prior to each sampling and again at the half way point of data collection using the provided 5000 ppm NO_3^- solution. Results were recorded for later statistical analysis.

Harvest: Summer Squash 2012

Harvest data was collected for each plot. Each plot was harvested three times per week during the crop cycle. The total weight and total fruit number of US #1 grade fruit was determined for all fruit from each plot. The cull weight and cull number of each plot was also determined for each plot. All grading was done according the USDA standards for fresh-market summer squash (USDA, 1984).

All data collected from this experiment was subjected to the appropriate analysis of variance and regression procedures (PROC CORR, PROC MIXED, and PROC REG,) (SAS Institute, Cary, NC). All data was combined over years and analyzed together. In cases where interactions occurred between a specific crop and year, data was re-analyzed by year.

IV. Results and Discussion

Growth Parameters

Summer Squash

During the first summer squash (*Cucurbita pepo* cv. Conqueror III) planting in 2012, the whole plant (minus the root system) fresh and dry weights among all treatments were not affected by N source, N rate, or their interaction (Table 10). This was likely due to residual N from the prior ryegrass cover crop (Shipley et al., 1992). The second crop of summer squash, planted in 2013, did show significant differences among treatments in fresh and dry plant weights due to N source and N rate (Table 10). In 2013, as N rate increased the fresh weight of the summer squash plants increased (Table 10). At the full N rate, on 24 Sept average fresh weight of summer squash receiving N from the hydrolyzed fish fertilizer (HFF), inorganic with secondary and minors (INORGWM), and inorganic without minors (INORGWO) were 237g, 357g, and 388g respectively. Nitrogen rate was not significant in affecting plant fresh weight, therefore all N rates were grouped together.

Plant canopy area of summer squash was not affected by N source among treatments in 2012, although there was a significant N source x N rate interaction at one sampling date, 23 Aug, at the last sampling date at the end of that experiment. Average plant area (cm^2) for summer squash grown with HFF, INORGWM, and INORGWO was 3,743 cm^2, 3,690 cm^2, and 3,536 cm^2, respectively. N source was never significant; while N rate was significant on 9 and 16 Aug. (Table 11, Fig. 4). The 23 Aug. interaction between N source and N rate likely resulted from the delayed availability of N when supplied by the HFF (Fig. 5). Over the cropping period, the organic N source was slower to mineralize and therefore not available for plant uptake immediately becoming available slowly through the end of the crop cycle. The interaction between N rate and N source occurred because the plant canopy area of the summer squash grown at the highest N rate with both inorganic N sources decreased as those plants grown with the HFF increased in size (Fig. 5). This finding suggests that a summer squash crop grown using HFF may need additional time to reach its maturity due to the need for the organic N source to mineralize.

In the 2013 summer squash crop, both N source and N rate significantly affected plant canopy area, with exception of the first sampling date, 20 Aug (Table 11). The interaction of N source and N rate was significant at three dates: 3, 10, and 16 Sept (Table 11). In the 2013 crop, this significant interaction occurred because of a reduction in plant canopy area in the summer squash grown in the INORGWO treatments (Fig. 6). This reduced growth resembled a N deficiency; however; after further investigation this reduced growth was more likely the result of sulfur (S) deprivation (Bennett, 1994). The symptoms first appeared in the collared crop following first summer squash crop in 2012. The suspected S deficiency in these treatments was confirmed by leaf tissue analysis performed by the Auburn University Soil Testing Laboratory using leaf tissue from the next crop (i.e. collards) in the rotation (Table 12). It is unclear as to why the 80% N rate was more severely affected than the 60% N rate by the lack of sulfur (Table 12). Average plant canopy area for squash grown with HFF, INORGWM, and INORGWO on 16 Sept, at the 100% N rate was 2,065 cm^2, 2,466 cm^2, and 2,681 cm^2 respectively.

Leaf Nutrient Content

Summer Squash

Summer squash leaf N content was affected by N source throughout the 2012 and 2013 seasons, while N source and N rate did not interact at any sampling date (Table 13). Nitrogen rate affected summer squash leaf N content only at one sampling date (31 July 2012) in two years. At this date, leaf N content increased as N rate increased (Table 13).

When the main effect of N source was significant, it was because leaf N content was higher in summer squash grown in the inorganic treatments without secondary and micronutrients (INORGWO) as compared to summer squash receiving secondary nutrients (INORGWM) (Fig. 7). Nitrogen source treatments with secondary and micronutrients, hydrolyzed fish fertilizer (HFF), and the inorganic with minors (INORGWM), had no significant differences in leaf N content throughout the 2012 season. The increased N content found in the leaves from the three inorganic without secondary and minors (INORGWO) treatments was likely a result of a sulfur (S) deficiency. The average leaf N content ($g\ N{\cdot}kg^{-1}$) of summer squash grown in the HFF, INORGWM, INORGWO, and NON were 4.75 $g\ N{\cdot}kg^{-1}$, 4.98 $g\ N{\cdot}kg^{-1}$, 5.10 $g\ N{\cdot}kg^{-1}$, and 4.54 $g\ N{\cdot}kg^{-1}$ respectively. In 2012, all of the leaf N values were found to be within the established sufficiency range of 4.0-6.0 $g\ N{\cdot}kg^{-1}$ for summer squash (Mills and Jones, 1996) indicating that adequate N was available for plant uptake. The accumulation of leaf N is related to a reduction in the production of amino acids and subsequent proteins, due to the lack of sulfur (Tabatabai, 1986). Sulfur is an essential component in both methionine and cysteine, necessary for the production of proteins. This finding is consistent with research reported by Tabatabai (1986) on the inhibition of NO_3^- reduction and protein synthesis as a result of S deprivation.

Leaf N content in the 2013 summer squash crop further supports the hypothesis that S deprivation was responsible for the higher leaf N content in the INORGWO treatments. In 2013, the N source significantly affected summer squash leaf N content at every sampling date (Table 13). As in 2012, no differences were detected in leaf N content between the three HFF and the three INORGWM treatments. Leaf N content in the summer squash treatments that received inorganic N without secondary and micronutrients had higher leaf N contents, presumably from the S deprivation discussed previously (Fig. 7). The average leaf N content of summer squash grown in the HFF, INORGWM, INORGWO, and NON were 3.43 g $N \cdot kg^{-1}$, 3.46 g $N \cdot kg^{-1}$, 4.04 g $N \cdot kg^{-1}$, and 3.25 g $N \cdot kg^{-1}$, respectively. Again, the highest leaf N was found in the leaves collected from the summer squash grown in the INORGWO treatments. When these average leaf N values from each treatments were compared to the established sufficiency range of 4.0-6.0 g $N \cdot kg^{-1}$ for summer squash, it was clear that in 2013, nitrogen may have been a limiting factor. The samples that were within the recommended range (INORGWO treatments receiving 100%, 80%, and 60% of the recommended N rate) were likely elevated as a result of a sulfur deficit. Although S deficiencies are rare on vegetables in Alabama, it is probable that plots that received the INORGWO treatment during the second (collards), third (collards), and especially the fourth (summer squash) crop in this intensive rotation would begin to show increasingly severe deficiency symptoms considering the INORGWO treatment(s) did not receive any secondary nutrients for over 12 months.

Petiole Nitrate

Petiole nitrate sampling provided similar results to those observed with leaf N content. In 2012 there were no significant differences in summer squash petiole nitrate due to N source or N rate among any treatments. Average petiole nitrate content for summer squash grown with HFF, INORGWM, and INORGWO at first bloom was 1,531 ppm, 1,795 ppm, and 1,801 ppm, respectively. Petiole nitrate content for summer squash grown with HFF, INORGWM, and INORGWO at first harvest was 805 ppm, 745 ppm, and 1,301 ppm, respectively. Since this was the first crop in the rotation, the lack of differences could again be attributed to the nutrient reserves present in the soil from previous ryegrass cover crop. Ryegrass, having an extensive root system, is capable if recovering fertilizers applied to previous crops and assimilating those nutrients into above ground plant tissue for use in subsequent crops (Shipley et al., 1992).

The 2013 summer squash showed significant differences among treatments in petiole nitrate due to N source (Fig. 8). No effects were found as a result of N rate. High nitrate levels found in the summer squash petioles receiving INORGWO was more than three times that found in the other treatments (Fig. 8). In 2013, the average petiole nitrate content for summer squash grown with HFF, INORGWM, and INORGWO at first bloom was 460 ppm, 571 ppm, and 1,864 ppm, respectively. Average petiole nitrate content for summer squash grown with HFF, INORGWM, and INORGWO at first harvest was 317 ppm, 309 ppm, and 923 ppm, respectively. This finding is similar to the results found in sugar beets (*Beta vulgaris* L.) that were deprived of sulfur (Bennett, 1994). In that study, petiole nitrate was found to be greatly elevated when sulfate was low.

Nitrate concentrations determined for the 2012 summer squash crop were largely within the recommended sufficiency range of 900-1000 ppm at first bloom and 800-900 ppm at first harvest (Olson et al., 2013). During the 2013 crop, only the samples that were believed to be sulfur deficient were within the recommended range. Although no correlation was found between petiole nitrate concentration and leaf N, the substantially lower nitrate levels determined for the 2013 crop may indicate a nitrogen deficit.

Comparison to Established Sufficiency Ranges

In addition to petiole and leaf N content analysis, fresh leaf samples were collected at first flower and at harvest in 2012 and 2013 and were subjected to inductively coupled argon plasma spectrometry testing (ICAP) to determine the levels of the other essential elements. In 2012, few significant differences were noted due to N source or N rate (Tables 14), again likely a factor of reserve nutrients in the soil supplied by previous ryegrass cover crop. Since there were no significant differences as a result of N rate during either summer squash crop, the data was combined. The only significant differences that were found were from the INORGWM and the INORGWO fertility sources (Table 14). In these cases, summer squash receiving micronutrients (INORGWM) had significantly more Fe and Ca their leaf tissue than measured in leaves from summer squash fertilized with INORGWO (Table 14). The Fe content of HFF, INORGWM, INORGWO, and NON was 102 ppm ($p=0.03$), 114ppm ($p=0.17$), 97 ppm ($p=0.85$, and 95ppm ($p=0.85$). The Ca content of HFF, INORGWM, INORGWO, and NON was 2.5 g $N \cdot kg^{-1}$ ($p=0.04$), 2.0 g $N \cdot kg^{-1}$ ($p=0.13$), 2.1 g $N \cdot kg^{-1}$ ($p=0.98$), and 2.5 g $N \cdot kg^{-1}$ ($p=0.95$). Although there were significant differences between the tissue Fe and Ca, content among N sources, none of the levels observed were outside the established sufficiency ranges for summer squash (Mills and Jones, 1996). This indicates that adequate nutrient levels are present in the soil for plant uptake.

Analysis of summer squash leaves from the 2013 crop, yielded different results (Table 15). At first flower and at harvest, summer squash grown in the INORGWO had significantly elevated levels of K when compared to that measured in leaves receiving INORGWM and HFF fertilizer, respectively. The average K content in squash treated with HFF, INORGWM, and INORGWO were 3.8 g $N \cdot kg^{-1}$($p=0.17$), 3.1 g $N \cdot kg^{-1}$ ($p=0.57$), and 4.1 g $N \cdot kg^{-1}$ ($p=0.009$). The potassium content was found to be significantly higher in the summer squash leaves collected from the plots receiving the INORGWO treatment, however, no samples were found to be outside the established sufficiency range of 3.0-4.5 g $N \cdot kg^{-1}$ (Mills and Jones, 1996).

Summer squash leaf samples taken at harvest also had a significantly higher phosphorus (P) content in the INORGWO treatments as compared to those found in the plots receiving HFF and INORGWM treatments (Table 15). The average P content in squash treated with HFF, INORGWM, and INORGWO were 0.76 g $N \cdot kg^{-1}$(p=0.06), 0.68 g $N \cdot kg^{-1}$ (p=0.71), and 0.79 g $N \cdot kg^{-1}$ (p=0.003). Samples slightly exceeded the established sufficiency range values. The inability of the plants to process nutrients and construct proteins is the likely cause for the accumulation of nutrients in the leaf tissue (Tabatabai, 1986).

Leaf Chlorophyll Content

Chlorophyll content has been used to determine correlations with leaf nitrogen content (Güler, S. and G. Büyük, 2007). Weekly chlorophyll meter readings (SPAD) were taken to determine chlorophyll content in the summer squash treatments until the final harvest. In 2012, there was a significant interaction between N source and N rate on 24 July (Table 16). A significant difference in chlorophyll content was observed on 14 Aug due to the significantly lower readings from the NON control (Table 16). As previously stated, residual nutrients present in the soil likely played a role in negating the effect of N source and N rate on the first crop in the rotation. The average SPAD reading for all N sources excluding the control was 34.28. In the control, plants receiving zero nitrogen had an average SPAD reading of 32.83.

In 2013, there were significant differences in chlorophyll content in summer squash leaves due to N source, N rate, and their interaction on 30 Aug, 6 Sept, and 13 Sept (Table 16). The highest SPAD readings were found in the organic and inorganic treatments receiving secondary and micronutrients (Fig. 9). The treatments receiving the highest N rate consistently had higher SPAD readings when also receiving secondary and micronutrients, more specifically the HFF and INORGWM treatments at 152 kg N ha$\cdot^{-1}$. The average SPAD readings for the HFF, INORGWM, and INORGWO were 37.0, 40.1, and 36.5, respectively at the full N rate of 152 kg N ha$\cdot^{-1}$. The significant interaction was due to the lower chlorophyll reading found in the INORGWO treatment at the 121 kg·ha^{-1} (80%) N rate. The effects of sulfur deprivation in the 80% N rate treatments were much more pronounced than in the lower 60% N rate or the higher 100% N rate (Table 16). The reason for this large discrepancy is unknown.

An analysis was performed to correlate SPAD readings with leaf N and petiole nitrate-N content in both the 2012 and 2013 summer squash crops. If a correlation existed between the two values, growers could potentially monitor leaf N status by using a handheld SPAD meter as opposed to costly laboratory analysis. Correlating SPAD reading and petiole nitrate-N with leaf N content has proven to be difficult in some crops. Corn and cotton have been studied extensively due to their economic importance. In corn, chlorophyll meter readings are often site-specific and can vary in their prediction of leaf N (Ziadi et al., 2008). Similar results were found in cotton. Again, weather conditions and location were significant factors in predicting leaf N status (Wood, 1992). Petiole nitrate content can be variable based on plant species and on secondary nutrient status (Bennett, 1994). Research by Huett and White (1991) found that petiole nitrate testing in zucchini squash (*Cucurbita pepo* L.) was variable and not the most accurate predictor of leaf N content. The results of this study found similar results. At no point in the experiment were petiole nitrate concentrations significantly correlated with SPAD readings. Similarly no correlation was made between SPAD readings and leaf N content. The variability of petiole nitrates found in summer squash made the technique of little diagnostic value.

Yield Data - Squash

In 2012, marketable yield of summer squash (USDA, 1984) was only affected by N source (Fig. 10). Nitrogen rate had no effect on overall yield, likely due to the presence of residual nitrogen in the soil from the ryegrass cover crop. Marketable yield was highest in the INORGWM treatment though not statistically significant, producing 9,488 kg ha^{1}followed closely by the INORGWO at 9,157 kg·ha^{-1}, a 3.3% reduction in marketable yield. Modest differences in marketable yield between the two inorganic sources were not statistically different (data not shown). Summer squash grown in the HFF treatment had a statistically significantly lower yield: 7,137 kg·ha^{-1}, 24% less than marketable yield from the INORGWM treatment, and 22% greater than that measured in the unfertilized control which yielded only 4,868 kg·ha^{-1} . The lack of any significant yield differences between the summer squash harvested from the HFF (91 kg·ha^{-1}) and the unfertilized control (0 kg·ha^{-1}) further supports the hypothesis that residual N was present in the soil.

In 2012, yield of culls was significantly affected by N source. The average cull weight for summer squash grown in the HFF, INORGWM, INORGWO, and NON were 1,588 kg·ha^{-1}, 2778 kg·ha^{-1}, 2,183 kg·ha^{-1}, and 1,289 kg·ha^{-1} respectively. More culls were harvested from the two inorganic treatments, the INORGWM and INORGWO. This finding is a magnitude effect. The total yield from the inorganic treatments was greater than the organic (HFF) treatments, and thus a more culls would be expected (Goldy, 2012).

In 2013, the highest marketable yield of summer squash was harvested from the treatments receiving the highest recommended N rate of 152 kg·ha^{-1} regardless of N source being used (Fig. 11). Highest yields (3,634 kg·ha^{-1}) were obtained from the INORGWO treatment at

152 kg·ha^{-1}. The summer squash receiving N as INORGWM had a 15.5% yield reduction of 3,071 kg ha^{-1}. Yield of summer squash grown in the HFF treatments was significantly lower than that observed in either inorganic N treatment at all three N rates which were applied. A yield reduction was measured in summer squash grown in the HFF treatments, when compared to the highest yielding INORGWO treatment. The average yield of summer squash grown at the highest N rate in the INORGWO treatments yielded 3,634 kg·ha^{-1}, as compared to the highest N rate of HFF which yielded 2,310 kg·ha^{-1} , a reduction of 36% (Fig11). The lowest yielding treatment was the zero N rate control (NON) which only produced 182 kg·ha^{-1}, 5% of the yield found in the highest yielding treatment.

Overall, 2013 summer squash yields were lower than those measured in 2012. The highest yielding treatments from the 2013 crop were 60% lower in yield when compared to the highest yielding treatment in 2012. It is possible that this reduction in yield was caused in part by lower nutrient reserves in the soil due to the intensive rotation and further compounded by the high level of soil compaction that was prevalent across all plots (personal observation). The similar summer squash yields found in the INORGWM and INORGWO treatments suggest that summer squash may be less sensitive to sulfur deprivation, and that secondary nutrient may play a less crucial role in their production. The reduced demand for sulfur is likely due to lower levels of glucosinolates produced by cucurbits in comparison to *Brassica* crops (He, 1999). This could also be a function of soil temperature releasing sulfur through increased mineralization during warm, summer months in which the summer squash was grown as compared to the cooler, fall months in which the collards were grown (Warncke, 2007).

Collards

Growth Parameters

In 2012, whole plant (above ground portion of plant cut off at the soil line) fresh and dry weights of collards were never significantly affected by the interaction of N source x N rate. Fresh and dry weights were affected by both N source and N rate on 30 Oct. and 19 Nov., and by N rate alone on 12 Dec. (Table 17). In 2012, there were three dates where increasing N rate increased yield of collards: 30 Oct, 19 Nov, and 12 Dec. At the final sampling date of 12 Dec, the fresh weight of collards harvested from the plots receiving HFF, INORGWM, and INORGWO were 621 g, 776 g, and 686 g, respectively.

In 2013, fresh weight of collards was significantly affected by an interaction between N source and N rate at the last sampling date of 14 May (Fig. 12). This interaction was a result of collards grown in the INORGWO treatments at the 121 $kg \cdot ha^{-1}$ N rate. On 14 May, the fresh weight of collards harvested from the plots receiving the 121 $kg \cdot ha^{-1}$ N rate of HFF, INORGWM, and INORGWO were 276 g, 482 g, and 125 g, respectively. Collards grown in the plots receiving the INORGWO treatments were 75% lighter in fresh weight (125 g) than the heaviest plants harvested from plots receiving the INORGWM treatment (482 g).

As in the previous crops (summer squash and collards in 2012), the sulfur deficiency was most pronounced in the 80% N rate INORGWO treatments. The second crop in the rotation, collards, was likely affected by the nutrient uptake from the previous crop depleting an already limited supply of sulfur, as well as a documented sensitivity to sulfur deprivation (Jez, 2008). This sensitivity to sulfur has been used experimentally in crop rotations by planting *Brassica* crops such as oilseed rape (*Brassica napus*) to aid in the diagnosis of soil sulfur deficiencies (Scherer, 2001).

The size of collards (as determined by their height in cm x width cm) in the 2012 and 2013 seasons was significantly affected by the interaction between N rate and N source. This interaction on 7 May 2013 can be attributed to the reduced growth found in the INORGWO treatments receiving the 121 $kg{\cdot}ha^{-1}$ N rate (Fig. 13). Graphically, it is clear that growth in the INORGWO at 121 $kg{\cdot}ha^{-1}$ N was severely depressed and responsible for the N source x N rate interaction (Fig. 13). The six treatments receiving secondary and micronutrients (HFF and INORGWM at 100, 80, and 60% of the recommended N rate) show a liner response to increasing N rate (Fig. 13). In 2012 and 2013, N source and N rate were significant at nearly all dates that measurements were taken. On the final sample date in 12 Dec 2012, the average plant area for collards grown with HFF, INORGWM, and INORGWO was 2,145 cm^2, 2,452 cm^2, and 2,169 cm^2, respectively.

Leaf Nutrient Content

Collards

Leaf N concentration of collards was affected by a significant interaction between N source and N rate once in 2012 and once again in 2013 (Table 18). The six treatments receiving secondary and micronutrients (HFF and INORGWM at 100, 80, and 60% of the recommended N rate) have similar leaf N content over the dates sampled (Fig. 14 and 15). The samples collected on 8 Dec. 2012 from the plots receiving the 100% rate of HFF, INORGWM, and INORGWO had average leaf N content of 4.10 $g\ N{\cdot}kg^{-1}$, 4.26 $g\ N{\cdot}kg^{-1}$, and 5.44 $g\ N{\cdot}kg^{-1}$, respectively. All treatments receiving the 100% N rate were within the recommended sufficiency range of 4.00-5.00 $g\ N{\cdot}kg^{-1}$(Mills and Jones, 1996) indicating that adequate soil N was present. The zero nitrogen control (NON) had a leaf N content of 2.53, well below the recommended sufficiency range of 4.00-5.0. Among the three N sources, the collards receiving the INORGWO treatments had consistently more leaf N than collards harvested from the HFF, INORGWM, and the zero nitrogen control (NON) treatments (Fig. 16).

In 2013, similar results were found in regards to leaf N as affected by N source. The lowest average leaf N content was found in the NON control, and the highest was again found in the treatments receiving INORGWO. On the last sampling date of 14 May, the plots receiving the 100% rate of HFF, INORGWM, and INORGWO had average leaf N content of 3.63 g $N{\cdot}kg^{-1}$, 4.05 g $N{\cdot}kg^{-1}$, and 5.49 g $N{\cdot}kg^{-1}$ respectively. Unlike in 2012, the plots receiving the HFF had leaf N content below the recommended range. Again, the zero nitrogen control (NON) had a leaf N content of 2.94, well below the recommended sufficiency range of 4.00-5.0 g $N{\cdot}kg^{-1}$. In both these cases, the reduced level of leaf N indicated that a nitrogen deficit was present.

Comparison to Established Sufficiency Ranges

Inductively coupled argon plasma spectrometry (ICAP) analysis was conducted on two samples from each plot at the mid-point of the crop and again at harvest in both the 2012 and 2013 collards crops. At no point in the two crops did N rate significantly in affect leaf nutrient content (Table 19). As a result the treatments were be grouped by N source. Collected data was analyzed to determine if any statistical differences were present among treatments. In the 2012 crop, N source was found to be significant at both the mid-point and at harvest for some of the nutrients: K, Mg, and P were detected in significantly higher quantities in the samples collected from the INORGWO treatments as compared to the treatments receiving secondary and micronutrients (HFF and INORGWM) (Table 19). The average leaf content of K at the mid-point of the season for the collards receiving HFF, INORGWM, INORGWO, and NON was 2.7 g $N{\cdot}kg^{-1}$, 2.9 g $N{\cdot}kg^{-1}$, 3.4 g $N{\cdot}kg^{-1}$, and 2.7 g $N{\cdot}kg^{-1}$, respectively. All treatments with the exception of those receiving INORGWO had K content below the recommended range of 3.0-4.5 g N·kg^{-1}. The leaf content of Mg was below the recommended the values of 0.25-0.75 g N·kg^{-1} in all treatments. The Mg content of the collards grown in plots receiving the HFF, INORGWM, INORGWO, and NON were, 0.18 g N·kg^{-1}, 0.19 g N·kg^{-1}, 0.24 g N·kg^{-1}, and 0.23 g N·kg^{-1}, respectively. Leaf P content was significantly higher in the treatments receiving INORGWO at 0.77 g N·kg^{-1}, which was above the recommended values of 0.30-0.07 g N·kg^{-1}. All other N sources including NON were with the recommended levels of P. Values found to be below the recommended sufficiency values will likely result in reduced yield.

The ICAP analysis of the 2013 collard crop showed many of the same differences as in 2012. At no point in the two crops was N rate or date significant in affecting leaf nutrient content of the ICAP analysis. As a result the treatments will be grouped by N source and date. As with the 2012 crop, leaves collected from collards fertilized with a N source not containing secondary and micronutrients (INORGWO) treatments had the highest nutrient content with respect to K, P, Ca, Mg, Fe, and Mn (Tables 20). Although statistical differences in nutrient content of all the previously listed nutrients were present, values remained within recommended values. Two examples of this are the Mg and Mn content. The Mg content in the HFF, INORGWM, INORGWO, and NON treatments was 0.25, 0.25, 0.29, and 0.33 g N·kg^{-1}, respectively. Though statistically significant, results were within the established sufficiency range of 0.25-0.75 g N·kg^{-1} in all cases (Mills and Jones, 1996). Similarly, the Mn content was statistically different, though within sufficiency ranges. The differences between the HFF and INORGWM treatments receiving secondary and micronutrients and the INORGWO remained insignificant.

The results of the petiole nitrate sampling from 2012 and 2013 further supported the likelihood of sulfur deprivation affecting the treatments receiving no secondary or micronutrients. In 2012 and 2013, N source was the most significant factor affecting petiole nitrate. Nitrogen rate significantly affected petiole nitrate N on 30 Apr. 2013 in the 2013 crop, but never during the 2012 crop (data not shown). It is likely that N rate would have made a significant difference in petiole nitrate content if the sulfur deficiencies were not present. Findings of petiole nitrate concentrations hundreds of times higher in petioles sampled from the INORGWO treatments were so strongly significant that the more subtle effects of N rate were overshadowed. An example of this was found on 21 May 2013, where the average petiole nitrate concentration in the INORGWO treatments was 3,083 ppm while the two treatments receiving secondary and micronutrients (HFF and INORGWM) were 654 ppm and 855 ppm. With the exception of the mid-point sample taken during the 2012 crop, the petiole nitrate concentrations exceeded the recommended sufficiency values of 500-800 ppm at mid-point of growth and 300-500 ppm at harvest at all sample dates (Hochmuth, 1994). Extremely high petiole nitrate concentrations are commonly found in sulfur deficient plants and often used as an in-field diagnostic tool to determine the presence of a sulfur deficiency (Bennett, 1994).

Leaf Chlorophyll Content

Chlorophyll content has been used to determine correlations with leaf nitrogen content in various crops (Güler, S. and G. Büyük, 2007). Weekly chlorophyll meter readings (SPAD) were taken from each collard crop until each crop was terminated and analyzed. At three dates during the 2012 crop a significant N source x N rate interaction occurred (Table 21). In 2012 and 2013, N source and N rate were significant (Table 21). In 2012, SPAD readings had a significant linear response to increasing N rates (Table 21). In 2013, SPAD readings had a significant quadratic response with SPAD readings maximized at an N rate of 175 $kg \cdot ha^{-1}$ (Table 21).

During both years, SPAD readings were similar among N sources, with the exception of the unfertilized control (NON) which consistently produced lower readings (Table 21). The average SPAD reading taken on 8 Dec. 2012 from plots receiving the full N rate of HFF, INORGWM, INORGWO, and NON were 48.7, 51.2, 47.7, and 42.2, respectively. An example of this is shown for the 2012 collard crop (Fig. 17).

An analysis was performed to determine if a correlation existed between N rate and SPAD readings for the collards. If a correlation existed between the two values, growers could potentially monitor leaf N status by using a handheld SPAD meter as opposed to costly laboratory analysis. Correlating SPAD reading with leaf N content has proven to be difficult in some crops. Corn and cotton have been studied extensively due to their economic importance. In corn, chlorophyll meter readings are often site-specific and can vary in their prediction of leaf N (Ziadi et al., 2008). Similar results were found in cotton. Again, weather conditions and location were significant factors in predicting leaf N status (Wood, 1992).

In 2012 and 2013, a significant correlation for the SPAD reading and leaf N content was determined near the mid-point of the crop cycle (Tables 22 and 23). The three sampling dates where a correlation between leaf N and SPAD readings were found had r^2 values of the following, 0.60, 0.30, and 0.40. The 2012 crop had significant correlations at three sampling dates beginning at 35 days after planting (DAP) and again at 42 and 49 (DAP) for the SPAD reading and leaf N content. The 2013 crop showed a significant correlation at 45 (DAP) for the SPAD reading and leaf N content. The correlation data presented here supports the use of SPAD meter readings as a potential method for determining leaf N content without the additional time and cost of laboratory analysis but at specific times during the crop's development. SPAD readings could provide a grower with an additional tool to non-destructively determine N content in collard production. Additionally, the correlations were present at a consistent point in both crops, affording a grower time to make an informed decision as to if additional fertilizer applications are necessary. The time in which the SPAD reading and the leaf N were correlated was the same for both crops (45 DAP). This is significant because it allows a grower to make fertility adjustments during a time where the affects will likely be seen in higher yields.

Petiole N concentrations were compared with actual leaf N to check for the presence of a correlation. As with the two summer squash crops, no correlations were found during either collard crop cycle (Table 24). The lack of correlations found among the four crops in the rotation suggests that petiole N content may not be an accurate predictor of leaf N content.

Yield Data

Marketable yield of collards during both years was significantly affected by an N source by N rate interaction (Fig. 18). Marketable yield increased linearly with increasing nitrogen rates (Fig. 18). Collards grown in the INORGWM and the HFF treatments had a linear response to increasing N (Fig. 18). In 2012 and 2013, collards grown in the INORGWO treatment responded quadratically to increasing nitrogen rates, however, a sever sulfur deficiency resulted in significantly higher numbers of unmarketable plants in the N rate of 121 $kg \cdot ha^{-1}$. In both 2012 and 2013, the minimum yield was determined to be at 38 $kg \cdot ha^{-1}$.

In 2012, the first collard crop in the rotation was harvested and analyzed to determine yield based on both N source and N rate and to determine if there was any interaction between them. An interaction between N source and N rate was a significant factor in affecting marketable yield of collards. At the highest N rate of 152 $kg \cdot ha^{-1}$, marketable yield increased in the INORGWM treatments to 9,689 $kg \cdot ha^{-1}$, a 27% increase over the next highest rate of 121 kg·ha^{-1} which produced 7,640 kg·ha^{-1}. The lowest N rate of 91 kg·ha^{-1} produced 43% less than the highest N rate producing 6,736 kg·ha^{-1}. Collards grown in the HFF treatments followed a similar pattern with the highest N rate of 152 kg·ha^{-1} yielding 6,949 kg·ha^{-1}, 16% higher than the reduced rate of 121 kg·ha^{-1} which produced 5,967 kg·ha^{-1}. The lowest N rate of 91 kg·ha^{-1} produced 36% less than the highest N rate producing 5084 kg·ha^{-1}.

The yield produced in the INORGWO treatments was affected by a high number of culls. The highest N rate of 152 kg·ha^{-1} yielded the highest number of marketable plants producing 5,854 kg·ha^{-1}, however, the reduced rate of 121 kg·ha^{-1} produced no marketable yield due to visual defects and unmarketable size. The lowest rate of 91 kg·ha^{-1} yielded a greater portion of marketable plants than did the 121 kg·ha^{-1} producing 3,774 kg·ha^{-1}. Yield was significantly reduced at all N rates in the INORGWO treatments, as compared to yield from the INORGWM and the HFF treatment. Collards grown in the INORGWO treatments produced 65% and 18% less yield than in the highest nitrogen rate in the INORGWM and HFF treatments, respectively (Fig. 18).

The average yield for collards grown in plots receiving the full N rate from HFF, INORGWM, INORGWO, and NON were 6,949 kg·ha^{-1}, 9,689 kg·ha^{-1}, 5,845 kg·ha^{-1}, and 1,265 kg·ha^{-1}, respectively. In 2013, a similar trend was noted in marketable yield (Fig. 19). Again, the treatments receiving the highest N rate of 152 kg·ha^{-1} yielded the highest number of marketable plants. In both the INORGWM and HFF treatments, the collard yield increased linearly with increasing nitrogen rates (Fig. 19). Collards harvested from the INORGWO treatments followed a quadratic trend due to the high number of culls observed in the treatments receiving 121 kg·ha^{-1} N. At the highest N rate of 152 kg·ha^{-1}, marketable yield increased in the INORGWM treatments to 5123 kg·ha^{-1}, a 11% increase over the next highest rate of 121 kg·ha^{-1} which produced 4611 kg·ha^{-1}. The lowest N rate of 91 kg·ha^{-1} produced 38% less than the highest N rate producing 3706 kg·ha^{-1}. Collards grown in the HFF treatments followed a similar pattern with the highest N rate of 152 kg·ha^{-1} yielding 3,407 kg·ha^{-1}, 24% higher than the reduced rate of 121 kg·ha^{-1} which produced 2,739 kg·ha^{-1}. The lowest N rate of 91 kg·ha^{-1} produced 29% less than the highest N rate producing 2640 kg·ha^{-1}. The yield produced in the INORGWO treatments was again affected by a high number of culls. The highest N rate of 152 kg·ha^{1} yielded the highest number of marketable plants producing 3,167 kg·ha^{-1}, however, the reduced rate of 121 kg·ha^{-1} produced only 177 kg·ha^{-1} marketable yield due to visual defects and unmarketable size. The lowest rate of 91 kg·ha^{-1} yielded a greater portion of marketable plants than did the 121 kg·ha^{-1} producing 1526 kg·ha^{-1}. Yield was significantly reduced at all N rates in the INORGWO treatments, as compared to yield from the INORGWM and the HFF treatment. At the highest N rate of 152 kg·ha^{-1} N, marketable yield increased in the INORGWM treatment by 11% over the next highest rate of 121 kg·ha^{-1} and 38% over the lowest applied rate of 91 kg·ha^{-1}. Collard yield from the HFF treatments followed a similar pattern with the highest rate of 152 kg·ha^{-1} yielding 24% more collard weight than the reduced rate of 121 kg·ha^{-1}, and 29 % more yield than the lowest rate of 91 kg·ha^{-1}.

In 2013, an overall reduction in yield was noted in comparison to the 2012 collard crop. This was true in all treatments regardless of N source or rate. A yield reduction of 47% and 51% was seen in collards harvested from the INORGWM and HFF at 152 kg·ha^{-1} in the 2012 collard crop. Yield from the INORGWO treatments were also reduced from the previous year. A reduction of 45% was observed at the highest N rate, when compared to the 2012 crop. Although the 2013 crop was harvested two weeks earlier, the reduced yields could not be explained by the shorted season. Reduced yields could best be attributed to the overall reduction in reserve soil nutrients from the previous crops and to the time of year the second collard crop was grown.

Soil Analysis

In order to determine if N source or N rate had an effect on soil pH in any treatment, soil samples were collected from each plot throughout the experiment (Table 25.). Soil pH data was analyzed and determined to be non-significant for N source, N rate, and there was no interaction between the two (Table 25). This is an important finding as pH can have significant effects on the availability of nutrients in the soil (Jones, 1998). After finding no significant affects to the soil's pH it is possible to make observations on N source without the concern of pH being an influential factor. The average pH readings from samples collected at the end of the experiment from plots receiving the full N rate of HFF, INORGWM, INORGWO, and NON were 6.46, 6.43, 6.73, and 6.95. In this range, no essential nutrients should be limited due to soil pH.

The idea that soil N may accumulate as a result of using a slower release organic N source was explored in this experiment as well. Soil samples were analyzed to determine total soil nitrogen, NH_4^+-N, and NO_3^--N. Based on the analysis; no significant differences were found among the treatments in this experiment (Table 26). This finding suggests that neither organic nor inorganic N sources persist in the soil for an appreciable amount of time. This finding also suggests that regular soil testing and the application of the recommended nitrogen rates are essential to maximizing crop yield whether using an organic or inorganic N source. In this experiment, no accumulation of nitrogen in any form was found that would facilitate the use of using lower rates of N-containing fertilizer. The equivalent level of residual soil N from both N sources indicates that similar fertigation rates should be used regardless of N source.

Economic Analysis

Upon completion of the field experiments, a detailed analysis was conducted to determine the economic feasibility of Schafer's Liquid Fish fertilizer (HFF) as an alternative N source in this vegetable rotation. In order to do this, it was necessary to develop enterprise budgets for each of the ten treatments used in this experiment. Variable costs were based on the actual inputs used in each of the 10 treatments including such items as seed, fertilizers, plastic mulch, drip tape, pesticides, irrigation, and specialized labor associated with the application of these. Available budgets were based on a single-season use of plastic mulch and drip tape, however, the rotation in this experiment allowed for this cost to be spread across four crops. Because of this, the cost associated with the installation of plastic mulch was added to the budget of the first crop in the rotation. Similarly, the cost associated with the clean-up and removal of mulch was included in the budget of the final crop in the rotation.

Harvest and marketing costs were determined by calculating the labor costs to harvest, sort, grade, and package based on the yield produced from each treatment on a per hectare basis. Costs varied based on the yield produced in each treatment. As yield increased, additional costs were generated due to the extra labor to harvest and more containers needed to market the harvested crops. On the other hand, as yield decreased so did harvest costs. Fixed costs such as management, machinery, and irrigation systems were calculated based on approximate costs per hectare as provided in a budget generating program (Hewitt, 2003).

The return on investment was based on the USDA terminal market price for collards and the USDA retail price for summer squash. The premium price for organically produced products was determined by USDA sales records from the specific date each crop was harvested and would have entered the market (USDA, 2013)

Summer Squash 2012

A series of enterprise budget were created based on the above mentioned criteria and used to determine the profitability of the 2012 summer squash crop (Tables 28-67). Based on these budgets it was possible to determine which of the treatments was the most profitable. In the 2012 summer squash crop, there were few differences in profitability due to treatments (Tables 28-37).Summer squash receiving the highest N rate always had the highest yield, regardless of N source. Lowest yields were found in the NON control. In this case the highest yielding treatment was the INORGWM and was also the most profitable at \$13,962 ha^{-1}, followed closely by HFF at \$13,638 ha^{-1}, and last INORGWO at \$13,410 ha^{-1}. Although the HFF treatments yielded 32% less than the highest yielding treatment and had 121% higher fertilizer costs, the \$1.17 kg^{-1} price premium for organically produced summer squash was nearly high enough to offset both.

Collards Fall 2012

Highest collard yields were harvested from the treatments receiving the highest N rate, regardless of N source (Tables 38-47). The lowest yield was found in the NON control. The most profitable treatment in the first collard crop in the rotation was by far the HFF. This was due to the fact that the plots receiving the HFF treatment produced good yields, combined with the higher price obtained for organically produced collards. The higher profit obtained for the collards grown in the HFF treatment was due to the 262% higher market price for organically produced collards. This price differential was more than enough to offset the additional fertilizer costs and reduced yield measured in the HFF treatment. Collards harvested from the HFF treatment had a profit of \$12,253 ha^{-1}, while the next closest INORGWM had a net loss of \$1,758 ha^{-1}, followed by the lowest yielding and the least profitable of the treatments: INORGWO. Reduced collard yields found in the INORGWO treatment was due to poor yield and unmarketable plants. The INORGWO treatment had a net loss of \$3,517 ha^{1}. As with the 2012 summer squash crop, highest yields and profits came from treatments receiving the highest N rate regardless of N source. It was clear that in order to produce the highest yields it was necessary to supply the secondary and micronutrients as well as the full recommended N rate.

Collards Spring 2013

The budgets for the 2013 collard crop followed much the same trend as in the 2012 crop. This time, however, yields were reduced in all treatments (Fig.18 and19). As a result, none of the treatments were profitable (Tables 48-57). The treatment with the smallest loss during the 2013 season was the HFF treatment, with a loss of \$1,501 ha^{-1}, followed by the INORGWM treatment, with a loss of \$3,935 ha^{-1}, and then the INORGWO with a loss of \$4,979 ha^{-1}. Although all treatments performed below expectations, it was clear that the application of the full N rate and the addition of the secondary and micronutrients were critical to yield.

Summer Squash 2013

The final crop in the rotation, summer squash, had greatly reduced yield from the first crop in 2012. This was due in part to the intensive rotation that had preceded this crop as well as excessive rainfall. During this two month crop cycle, nearly seven inches of rain was recorded at the research station (AWIS, 2013). Extended periods of rain can significantly increase denitrification resulting in nitrogen loss through ammonia volatilization, effecting both plant growth and yield (Mills and Jones 1996). As a result of these factors, all treatments failed to be profitable (Tables 58-67). The overall loss was compounded by the additional cost allocated to this crop due to plastic removal as well as the need to apply additional fungicides to the crop. The additional fungicide applications were needed due to the increased disease pressure resulting from the cool, damp weather conditions that favored disease development. The treatment that lost the least amount was HFF with a loss of \$347 ha^{-1}; following was INORGWM at a loss of \$2,008 ha^{-1}, and finally INORGWO at a loss of \$3,343 ha^{-1}.

Conclusions

The rotation scheme evaluated in this experiment displayed a reduction in yield as the rotation proceeded. Summer squash and collard yields from 2012 were in the range of what would be expected in commercial vegetable production. In Alabama a grower can expect to produce up to 300 cwt. per acre or 14,000 $kg \cdot ha^{-1}$ with slightly lower yields being the norm (Kemble et al,. 1995). Expected collard yield is often hard to quantify due to the variety of methods and plant spacing used in their production. A grower producing collards on bare ground in the southeast would typically expect 165 boxes (25 lb per box) or 4,635 $kg \cdot ha^{-1}$ (Hewitt, 2003). In 2013, yield of both collard and summer squash were significantly reduced. Though neither the summer squash nor collards receiving the full N rate were found to be deficient in leaf N at any time, the leaf N content was closer to the lower limits of the sufficiency range of 3-5 $g \cdot kg^{-1}$ (Mills and Jones, 1996). This could indicate that adjustments to current single crop N recommendations may be necessary when multiple crops will be produced in a plasticulture rotation. Similar results were found in a previous study evaluating N status of spring tomato (*Solanum lycopersicum* L.) followed by fall cucumber (*Cucumis sativus* L.) (Mayfield et al, 2002). The study was conducted in Alabama using plastic mulch and a double -cropping system. It was found that after one crop; N status was negatively affected, thus necessitating an adjustment in single crop N recommendations. The two crops used in this experiment have been shown to be effective when used in a double-cropping rotation (Lamont, 1996). This sequence and selection of crops (summer squash and collards or other Brassicas) is similar to what many organic growers use in Alabama. In this experiment, the use of summer squash and collards in a two-year rotation has been shown to be less economically effective than a two crop rotation.

This experiment has shown that the use of hydrolyzed fish fertilizer HFF is a viable option when used in a plasticulture rotation. This is only true if premium organic prices can be obtained for the crops produced. Though the yield was reduced in the HFF treatments, both crops still produced yields that would compare to that of the two inorganic N treatments (INORGWM and INORGWO). It was clear that the response to N source was dependent on the crop being produced. The summer squash grown in plots receiving N from the HFF consistently yielded lower than the treatments receiving N from the INORGWM and INORGWO sources in this experiment. Lack of response to the organic N source (HFF) was primarily due to the time between N application and availability of that N to the growing plant. The rapid growth rate of summer squash likely caused a slight N deficiency, as shown in the leaf N data (Fig. 5). This could be due to larger N containing particle that are capable of passing through the fertigation system, however, take longer to be mineralized (Hartz, 2010). The particle size of N-containing material is directly proportional to their mineralization rate (Angers and Recous, 1997). The increased surface area of the smallest particles equates to greater exposure to soil microbes facilitating faster mineralization. The same condition was present in the collard crops as well, but the slower growth of the collards lessened this effect. The cooler temperatures reduced growth rates and subsequent demand for nitrogen. Previous studies evaluating the effect of temperature on liquid fish products has shown that temperature has little effect on N availability (Hartz, 2006). Therefore it is likely that the rate of plant growth was more affected by the cool weather than were the mineralization rates.

Over the length of this experiment it was clear that the addition of secondary nutrients in addition to N, P, and K was critical to producing acceptable yield. This was particularly true when considering the increased need for sulfur in the collard crops (Scherer, 2001). By determining the need for these secondary nutrients, growers considering a plasticulture rotation must consider the additional cost of adding these nutrients. In this experiment all the nutrients contained in the organic-N source were evaluated as a single treatment. Although we did not look at each nutrient individually, it was clear that treatments receiving the additional nutrients produced higher yields. Regardless of the N source a grower choses to use, the addition of secondary nutrients should be considered essential.

The determination of N status may be possible in the production of collards. Using data collected in this experiment it was possible to correlate the leaf N content with SPAD meter readings at 45 days after planting (DAP). By simply plugging in SPAD meter reading into the regression equation provided in Tables 7 and 8, a grower could predict the leaf N content without the cost of laboratory analysis. This finding could provide growers with an extra tool when making the costly decision to apply additional N fertilizer. No correlation was found in either summer squash crop.

The use of petiole NO_3- testing was shown to have little correlation with leaf N content in either the summer squash or collard crops. Although petiole NO_3- testing was not successfully correlated with leaf N, it did provide an indication of potential sulfur deficits in both crops. The presence of extremely high NO_3- content could be used as a diagnostic feature associated with sulfur deficiency. This technique could be useful in the prevention of sulfur deficiencies before visual symptoms and yield loss is present. This finding was consistent with previous work in both cotton and corn where petiole nitrate content was a poor predictor of N status (Wood, 1992; Ziadi, 2008).

The economics of Schafer's Liquid Fish HFF in an organic rotation was encouraging. The cost to use the fertilizer was much higher than an inorganic-N source such as urea ($24.68/kg N, $1.11/kg N, respectively). The price per kg N for the Schafer's Liquid Fish would be much higher than what was used for budgeting purposes if purchased in the small containers marketed to home gardeners. For that reason, if a grower is interested in using this product as an N source, it would only be economically feasible to purchase in the largest quantity possible. For a grower farming multiple hectares it would be advantageous to purchase in 5,000 gal. (18,925 L) tankers loads and store it on site.

Although the fertilizer cost is higher when using HFF, it was determined that in order to achieve acceptable results it was necessary to apply full recommended N rates (Kemble et al., 2012). The results of this experiment show that applying any less than the full recommended N rate resulted in lower yield and ultimately lower profits. The idea that a lower N rate of an organic fertilizer would perform as well as a higher rate of an inorganic-N source was not seen in this experiment. Based on the results of this experiment, the extremely low application rates of 2 to 4 gallons per acre (18-37 $L \cdot ha^{-1}$) as recommended by the manufacture would certainly result in severely N deficient plant and a further reduction in yield (S.F. Organics, 2013a). In this experiment, the rate of 560 gallons per acre (5,228 $L \cdot ha^{-1}$) was used to obtain the full recommended 152 kg·ha^{-1} for summer squash. Even at this much higher rate, yield remained lower than the INORGWM treatment.

Even with the higher cost of the HFF included in the budgets of each treatment, the price premiums associated with organically-grown produce were enough to offset those costs. This made the HFF treatment receiving the full recommended N rate the most profitable over the four crops combined. The total profit over the two year experiment for the HFF was \$21,046 ha^{-1}. This was more than 230% higher than the next closest INORGWM treatment and 328% higher than the INORGWO treatment (Table 27).

Overall, the use of a hydrolyzed fish fertilizer (HFF) is a feasible option in vegetable production when using a plasticulture rotation. The premium prices available in the organic food market are the key to profitability. Growers should research the crops that have the highest price premiums and require the lowest N fertility and consider organic production as an economic option.

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VI. Appendix

Table 1. The amount of P_2O_5 and K_2O that is supplied by each of the N sources used in this experiment. In addition, the amounts necessary to equalize the total amount of P_2O_5 and K_2O applied in each treatment is shown.

Treatment	Total N	P_2O_5 Supplied	P_2O_5 to Balance	K_2O Supplied	K_2O to Balance
	----------------------------	----------------------------	*kg/ha^{-1}*	----------------------------	----------------------------
1	152.0	117.0	0.0	15.2	137.0
2	121.6	93.6	23.4	12.1	140.0
3	91.2	70.2	46.8	9.1	142.8
4	152.0	0.0	117.0	152.0	0.0
5	121.6	0.0	117.0	121.6	30.4
6	91.2	0.0	117.0	91.2	60.8
7	152.0	0.0	117.0	152.0	0.0
8	121.6	0.0	117.0	121.6	30.4
9	91.2	0.0	117.0	91.2	60.8
10	0.0	0.0	117.0	0.0	152.0

Table 2. Fertility treatments applied via drip irrigation throughout each of the four crops in the rotation. The table shows the fertilizers contained in each treatment and which nutrients are present.

Treatment	N Source	% of Recommended N	Derived from	Nutrients Contained
1	HFF	100%	Hydrolyzed fish, K_2CO_3	N,P,K, Ca, S, Mg, Fe, Mn, Zn, Na, Cl
2	HFF	80%	Hydrolyzed fish, H_3PO_4, K_2CO_3	N,P,K, Ca, S, Mg, Fe, Mn, Zn, Na, Cl
3	HFF	60%	Hydrolyzed fish, H_3PO_4, K_2CO_3	N,P,K, Ca, S, Mg, Fe, Mn, Zn, Na, Cl
4	Inorganic w/ secondary nutrients	100%	$Ca(NO_3)_2$, K_2SO_4, H_3PO_4, FE EDTA, $(NH_4)_2SO_4$, $CO(NH_2)_2$, NaCl, $NaHCO_3$, Zn chelate, Mn chelate, $MgSO_4$.	N,P,K, Ca, S, Mg, Fe, Mn, Zn, Na, Cl
5	Inorganic w/ secondary nutrients	80%	$Ca(NO_3)_2$, K_2SO_4, K_2CO_3 H_3PO_4, FE EDTA, $(NH_4)_2SO_4$, $CO(NH_2)_2$, NaCl, $NaHCO_3$, Zn chelate, Mn chelate, $MgSO_4$.	N,P,K, Ca, S, Mg, Fe, Mn, Zn, Na, Cl
6	Inorganic w/ secondary nutrients	60%	$Ca(NO_3)_2$, K_2SO_4, K_2CO_3 H_3PO_4, FE EDTA, $(NH_4)_2SO_4$, $CO(NH_2)_2$, NaCl, $NaHCO_3$, Zn chelate, Mn chelate, $MgSO_4$.	N,P,K, Ca, S, Mg, Fe, Mn, Zn, Na, Cl
7	Inorganic w/o secondary nutrients	100%	KNO_3, NH_4NO_3, $CO(NH_2)_2$, H_3PO_4	N, P, K
8	Inorganic w/o secondary nutrients	80%	KNO_3, NH_4NO_3, $CO(NH_2)_2$, H_3PO_4	N, P, K
9	Inorganic w/o secondary nutrients	60%	KNO_3, NH_4NO_3, $CO(NH_2)_2$, H_3PO_4	N, P, K
10	No N	0%	$CO(NH_2)_2$, H_3PO_4	P, K

Table 3. Nitrogen and potassium fertility schedule applied as a drip fertigation over a 9 week summer squash growing season at 100% of the recommended nitrogen and potassium rate.

Days After Planting	**Daily Nitrogen N**	**Daily Potassium K_2O**	**Cumulative**	
-----(Kg/ha^{-1})-----				
			Nitrogen	**Potassium**
Preplant			26.88	26.88
0-7	1.12	1.12	34.72	34.72
8-21	1.68	1.68	58.24	58.24
22-63	2.24	2.24	152.32	152.32

Table 4. Nitrogen and potassium fertility schedule applied as a drip fertigation over a 9 week summer squash growing season at 80% of the recommended nitrogen and potassium rate.

Days After Planting	**Daily Nitrogen N**	**Daily Potassium K_2O**	**Cumulative**	
		(Kg/ha^{-1})		
			Nitrogen	**Potassium**
Preplant			21.60	26.88
0-7	0.90	1.12	27.87	34.72
8-21	1.34	1.68	46.63	58.24
22-63	1.80	2.24	122.23	152.32

Table 5. Nitrogen and potassium fertility schedule applied as a drip fertigation over a 9 week summer squash growing season at 60% of the recommended nitrogen and potassium rate.

Days After Planting	**Daily Nitrogen N**	**Daily Potassium K_2O**	**Cumulative**	
---(Kg/ha^{-1})---			**Nitrogen**	**Potassium**
Preplant			16.12	26.88
0-7	0.67	1.12	20.81	34.72
8-21	1.00	1.68	34.81	58.24
22-63	1.34	2.24	91.10	152.32

Table 6. Nitrogen and potassium fertility schedule applied as a drip fertigation over a 7 week collard growing season at 100% of the recommended nitrogen and potassium rate.

Days After Planting	Daily Nitrogen N	Daily Potassium K_2O	Cumulative	
-----	-----	(Kg/ha^{-1})	-----	-----
			Nitrogen	Potassium
Preplant			0	0
0-49	2.24	2.24	109.76	109.76

Table 7. Nitrogen and potassium fertility schedule applied as a drip fertigation over a 7 week collard growing season at 80% of the recommended nitrogen and potassium rate.

Days After Planting	Daily Nitrogen N	Daily Potassium K_2O	Cumulative	
------------------------------(Kg/ha^{-1})------------------------------				
			Nitrogen	Potassium
Preplant			0	0
0-49	1.80	2.24	87.80	109.76

Table 8. Nitrogen and potassium fertility schedule applied as a drip fertigation over a 7 week collard growing season at 60% of the recommended nitrogen and potassium rate.

Days After Planting	**Daily Nitrogen N**	**Daily Potassium K_2O**	**Cumulative**	
----(Kg/ha^{-1})----				
			Nitrogen	**Potassium**
Preplant			0	0
0-49	1.34	2.24	65.80	109.76

Table 9. Application dates, trade names, common names, EPA registration number, rate applied, crop, and method of application during the 2012 and 2013 seasons.

Date	Brand Name	Active Ingredient	Rate/A	crop	Notes on application
At planting	Curbit EC	ethalfluralin	4.5 pt.	squash	Between plastic rows
At planting	Cornerstone Plus	glyphosate	2 qt.	squash	Between plastic rows
7/27/2012	Bravo WS	chlorothalonil	2 pt.	squash	Air blast
7/27/2012	Tundra EC	bifenthrin	6oz.	squash	Air blast
7/27/2012	Actara	thiamethoxam	5.5 oz.	squash	Air blast
7/27/2012	Bravo WS	chlorothalonil	2 pt.	squash	Air blast
7/27/2012	Tundra EC	bifenthrin	6oz.	squash	Air blast
8/10/2012	Bravo WS	chlorothalonil	2 pt.	squash	Air blast
8/10/2012	Tundra EC	bifenthrin	6oz.	squash	Air blast
8/17/2012	Bravo WS	chlorothalonil	2 pt.	squash	Air blast
8/17/2012	Arctic	permethrin	6 oz.	squash	Air blast
9/28/2013	Gramoxone Interon	paraquat dichloride	2 qt.	collard	over entire tier
10/19/2012	Intrepid 2F	methoxyfenozide	8 oz	collard	Air blast
10/19/2012	Xentari	*B.t. aizawai*	.5 lb.	collard	Air blast
10/26/2013	Dipel 2x	*B. t. kurstaki*	1 lb.	collard	Air blast
10/26/2012	Actara	thiamethoxam	5.5 oz.	collard	Air blast
2/20/2013	Cornerstone Plus	glyphosate	2 qt.	collard	Between plastic rows
2/20/2013	Aim	carfentrazone-ethyl	2 oz.	collard	Between plastic rows
2/20/2013	Cornerstone Plus	glyphosate	2 qt.	collard	Air blast
2/20/2013	Aim	carfentrazone-ethyl	2 oz.	collard	Air blast
4/23/2013	Sevin XLR Plus	carbaryl	2 pt.	collard	Air blast
4/30/2013	Tundra EC	bifenthrin	6oz.	collard	Air blast
5/10/2013	Tundra EC	bifenthrin	6oz.	squash	Air blast
6/7/2013	Sevin XLR Plus	carbaryl	2 pt.	squash	Air blast
6/7/2013	Tundra EC	bifenthrin	6oz.	squash	Air blast
6/27/2013	Aim	carfentrazone-ethyl	2 oz.	squash	Air blast
6/27/2013	Poast	sethoxydim	2 pt.	squash	Air blast
8/24/2013	Quadris	azoxystrobin	15 oz.	squash	Air blast
8/24/2013	Bravo WS	chlorothalonil	3 pt.	squash	Air blast
8/24/2013	Actara	thiamethoxam	5.5 oz.	squash	Air blast
8/30/2013	Bravo WS	chlorothalonil	3 pt.	squash	Air blast
8/30/2013	Tundra EC	bifenthrin	6oz.	squash	Air blast
8/30/2013	Intrepid 2F	methoxyfenozide	8 oz	squash	Air blast
9/6/2013	Quadris	azoxystrobin	15 oz.	squash	Air blast
9/6/2013	Intrepid 2F	methoxyfenozide	8 oz	squash	Air blast

9/14/2013	Bravo WS	chlorothalonil	3 pt.	squash	Air blast
9/14/2013	Topsin 4.5 FL	thiophanate methyl	10 oz.	squash	Air blast
9/14/2013	Arctic 3EC	permethrin	6 oz.	squash	Air blast
9/20/2013	Quadris	azoxystrobin	15 oz.	squash	Air blast
9/20/2013	Arctic 3 EC	permethrin	6 oz.	squash	Air blast

Table 10. Analysis of variance table showing the effects of N source and N rate on whole plant fresh weight of summer squash, Horticulture Unit, Tallassee, AL, 2012 and 2013.

	Fresh Weight Summer Squash Plants							
	----------Summer Squash 2012----------				----------Summer Squash 2013----------			
	----------P > F----------							
	17 July	26 July	6 Aug.	16 Aug.	20 Aug.	30 Aug.	9 Sept.	24 Sept.
N Source	NS†	NS	NS	NS	NS	NS	0.02	NS
N Rate	NS	NS	NS	NS	NS	NS	0.005‡	0.01
N Source x N Rate	NS	NS	NS	NS	NS	NS	NS	NS

†No significant response 2012.
‡For N rate there was a significant linear response on 9 and 24 Sept 2013 (p< 0.001)

Table 11. Analysis of variance table showing plant canopy area (cm^2) as affected by N source and N rate on summer squash Horticulture Unit, Tallassee, AL, 2012 and 2013.

	Summer Squash Plant Area									
	----------Summer Squash 2012----------					----------Summer Squash 2013----------				
	----------P > F----------									
	24 July	2 Aug.	9 Aug.	16 Aug.	23 Aug.	20 Aug.	27 Aug.	3 Sept.	10 Sept.	16 Sept.
N Source	NS	NS	NS	NS	NS	NS	0.03	0.008	0.0001	<0.0001
N Rate	NS	NS	0.01†	0.0001†	NS	NS	0.005‡	0.01‡	< 0.001‡	<0.0001‡
N Source x N Rate	NS	NS	NS	NS	0.009	NS	NS	0.007	0.01	0.01

†For N rate there was a significant linear response on 9 and 16 Aug 2012 (p< 0.001)
‡For N rate there was a significant linear response on all dates except 20 Aug 2013.

Table 12. Leaf tissue analysis of harvested collard plots, May 2013. Data was collected by harvesting whole leaves from selected plots that showed S deficiency (INORGWO) versus those that did not (HFF).

Average sulfur content in selected fertility treatments	
N Source	**S in leaf tissue**
	-----------------------------%---------------------------
Hydrolyzed fish fertilizer @ 80% of the recommended N rate of 88 $kg \cdot ha^{-1}$	1.15 aǂ
Hydrolyzed fish fertilizer @ 60% of the recommended N rate of 66 $kg \cdot ha^{-1}$	1.05 a
Inorganic without secondary and micronutrients @ 80% of the recommended N rate of 88 $kg \cdot ha^{-1}$	0.23 b
Inorganic without secondary and micronutrients @ 60% of the recommended N rate of 66 $kg \cdot ha^{-1}$	0.25 b

ǂMeans followed by the same letter are not significantly different via means separation at α=0.05

Table 13. Analysis of variance table of the effect of N source , N rate and their interaction on leaf N of summer squash, Horticulture Unit, Tallassee, AL, 2012 and 2013.

	Leaf N Content Summer Squash									
	--------------------Summer Squash 2012------------------					---------------------Summer Squash 2013--------------------				
	--P > F--									
	24 July	31 July	9 Aug.	14 Aug.	21 Aug.	23 Aug.	30 Aug.	6 Sept.	13 Sept	20 Sept.
N Source	NSǂ	0.006	0.0004	NS	NS	0.001	0.0002	0.0004	0.002	0.002
N Rate	NS	0.008ǂ	NS	NS	NS	NS	NS	NS	NS	NS
N Source x N Rate	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

ǂNot significant

ǂAt dates in which p-value is listed leaf N content had significant linear response.

Table 14. Nutrient content of harvested leaves of summer squash as affected by N source and N rate, 2012

	Summer Squash											
	Nutrient											
	Summer Squash Crop 2012 @ Mid-point†						Summer Squash Crop 2012 @Harvest					
	------------------------------P > F ------------------------------											
	Ca	Fe	K	Mg	Mn	P	Ca	Fe	K	Mg	Mn	P
N Source	NS	0.02	NS	NS	0.02	NS	0.03	0.02	NS	NS	NS	NS
N Rate	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
N Source x N Rate	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

† = midpoint of vegetative growth in the crop cycle

Table 15. Nutrient content of harvested leaves of summer squash as affected by N source and N rate, 2013

	Summer Squash											
	Nutrient											
	Summer Squash Crop 2013 @ Mid-point†						Summer Squash Crop 2013 @Harvest					
	------------------------------P > F------------------------------											
	Ca	Fe	K	Mg	Mn	P	Ca	Fe	K	Mg	Mn	P
N Source	NS	NS	0.01	0.007	NS	NS	NS	NS	0.008	NS	NS	0.004
N Rate	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
N Source x N Rate	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

† = midpoint of vegetative growth in the crop cycle

Table 16. Analysis of variance table of chlorophyll readings (SPAD) as effected by N source and N rate on summer squash.

	SPAD Readings Squash									
	Squash 2012					Squash 2013				
	P > F									
	24 July	1 Aug	7 Aug	14 Aug	21 Aug	23 Aug	30 Aug	6 Sept	13 Sept	20 Sept
N Source	NS	NS	NS	0.005	NS	<0.0001	<0.0001	<0.0001	<0.0001	NS
N Rate	NS	NS	NS	NS	NS	<0.0001	0.0007	0.0002	0.0003	NS
N Source x N Rate	0.0001	NS	NS	NS	NS	NS	0.008	0.004	0.01	NS

Table 17. Analysis of variance table of the fresh weight of collard as affected by N source and N rate, Horticulture Unit, Tallassee, AL, 2012 and 2013.

	Fresh Weight Collards								
	Collards 2012						Collards 2013		
	P > F								
	18 Oct.	30 Oct.	8 Nov.	19 Nov.	29 Nov.	12 Dec.	22 April	2 May	14 May
N Source	NS	0.003	NS	0.01	NS	NS	NS	NS	NS
N Rate	NS	0.02	NS	0.02	NS	0.0007	NS	NS	NS
N Source x N Rate	NS	NS	NS	NS	NS	NS	NS	NS	0.005

Linear response in both 2012 (p<0.0001) and 2013 (p=0.04)

Table 18. Analysis of variance table of the effect of N source, N rate and their interaction on leaf N of collards, Horticulture Unit, Tallassee, AL, 2012 and 2013.

	Leaf N Content Collards										
	Collards 2012							Collards 2013			
	P > F										
	23 Oct.	30 Oct.	6 Nov.	13 Nov.	20 Nov.	27 Nov.	8 Dec.	25 Apr.	2 May	9 May	14 May
N Source	NS	0.001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.003	<0.0001	<0.0001	<0.0001
N Rate	NS	NS	0.004	0.005	<0.0001	0.002	0.04	NS	NS	NS	NS
N Source x N Rate	NS	NS	NS	0.03	NS	NS	NS	NS	NS	NS	0.02

Leaf N content had a linear response for 2012 (p=0.001) and for 2013 (p<0.0001)

Table 19. Nutrient content of harvested collard leaves as affected by N source and N rate, 2012

	Collard Crop											
	Nutrient											
	Collard Crop 2012 @ Mid-point†						Collard Crop2012 @Harvest					
	P > F											
	Ca	Fe	K	Mg	Mn	P	Ca	Fe	K	Mg	Mn	P
N Source	NS	NS	<0.0001	<0.0001	NS	<0.0001	0.004	NS	0.002	<0.0001	NS	<0.0001
N Rate	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
N Source x N Rate	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

† = midpoint of vegetative growth in the crop cycle

Table 20. Nutrient content of harvested collard leaves as affected by N source and N rate, 2013

	Collard Crop											
	Nutrient											
	Collard Crop 2013 @ Mid-point†						Collard Crop 2013 @Harvest					
	------P > F------											
	Ca	Fe	K	Mg	Mn	P	Ca	Fe	K	Mg	Mn	P
N Source	0.001	0.002	<0.0001	<0.0001	0.002	<0.0001	0.02	NS	NS	<0.0008	NS	<0.0005
N Rate	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
N Source x N Rate	0.02	NS	0.04	0.007	NS	NS	NS	NS	NS	NS	NS	NS

† = midpoint of vegetative growth in the crop cycle

Table 21. Analysis of variance table of chlorophyll readings (SPAD) as effected by N source and N rate of Collard.

	SPAD Readings Collards										
	------Collards 2012------							------Collards 2013------			
	------P > F------										
	23 Oct.	30 Oct.	6 Nov.	13 Nov.	20 Nov.	27 Nov.	8 Dec.	25 Apr.	2 May	9 May	14 May
N Source	NS	0.02	<0.0001	NS	NS	<0.0007	<0.0004	0.008	NS	<0.0001	<0.004
N Rate	NS	0.007	NS	NS	NS	0.03	<0.0001	NS	0.005	NS	NS
N Source x N Rate	0.03	0.02	NS	NS	NS	NS	<0.0001	NS	NS	NS	NS

Table 22. Pearson Correlation coefficients between leaf N and SPAD readings, by sample date, 2012 collard crop.

SPAD/ Leaf Nitrogen Correlation Collard 2012

Sample date	Days after transplanting	Regression equation	R^2	P- Value
10/23/2012	21	Y= 0.65 x + 43.9	0.17	NS
10/30/2012	28	Y= -0.16 x + 41.2	-0.05	NS
11/06/2012	35	Y= 2.26 x + 32.8	0.60	<0.0001
11/13/2012	42	Y= 1.11 x + 43.2	0.31	0.0471
11/20/2012	49	Y= 1.35 x + 46.4	0.40	0.0113
11/27/2012	56	Y= 0.62 x + 51.3	0.14	NS
12/08/2012	63	Y= -0.86 x + 63.3	-0.11	NS

Table 23. Pearson Correlation coefficients between leaf nitrogen and SPAD readings by sample date, 2013 collard crop.

SPAD/ Leaf Nitrogen Correlation Collard Crop 2

Sample Date	Days After Transplanting	Regression equation	R^2	P- Value
4/25/2013	31	Y= 0.57 x + 43.7	0.17	NS
5/02/2013	38	Y= 0.93 x + 43.2	0.18	NS
5/09/2013	45	Y= 2.35 x + 33.9	0.55	0.0003
5/16/2013	52	Y=-0.33 x + 49.1	-0.09	NS

Table 24. Pearson Correlation coefficients between petiole nitrate concentration and SPAD readings by sample date, collard crops 2012 and 2013.

SPAD/ Petiole Nitrate Concentration Correlation Collards 2012 and 2013			
Date		Petiole nitrate (ppm)	SPAD
12/4/12	Petiole nitrate (ppm)	1.0	0.156
	SPAD	0.156	1.0
12/12/12	Petiole nitrate (ppm)	1.0	0.602
	SPAD	0.602	1.0
4/30/13	Petiole nitrate (ppm)	1.0	0.729
	SPAD	0.729	1.0
5/16/13	Petiole nitrate (ppm)	1.0	0.132
	SPAD	0.132	1.0

Table 25. Mean soil pH determined pre-plant and after termination of each crop in the rotation at 100% of the recommended N rate (152 kg·ha^{-1}). No significant differences were seen between N source and N rate at any point in the rotation. Letters represent significance at α =0.05.

Soil pH		
Sample Date	N Rate	pH mean
6/2012	Pre-plant test	6.20 a
9/2012	152 kg·ha^{-1}	5.78 a
12/2012	152 kg·ha^{-1}	6.36 a
5/2013	152 kg·ha^{-1}	6.06 a
9/2013	152 kg·ha^{-1}	6.54 a

Table 26. Analysis of variance table of soil nitrogen content as determined via KCL extraction. Soil samples were collected and analyzed after each crop in the rotation was terminated. Date was not significant in the analysis and therefor all data were combined.

	Soil Nitrogen Content (NH_4) and (NO_3)					
	NH_4^+			NO_3^-		
	d.f.	F Value	P Value	d.f.	F Value	P Value
N Source	2	0.03	0.939	2	0.04	0.965
N Rate	2	0.21	0.850	2	0.07	0.931
N Source *N Rate	4	0.62	0.649	4	0.17	0.952

Table 27. Economic analysis for the 100% N rate treatments in all four crops in the rotation.

	Profit or Loss per ha^{-1}				
N Source	Summer Squash 2012	Collards 2012	Collards 2013	Summer Squash 2013	Profit/Loss for 2012-2013
HFF	$13,638.15	$12,253.08	$-1,501.76	$-3,343.07	$21,046.40
INORGWM	$13,962.84	$-1,758.37	$-3,935.80	$-2,008.95	$6,259.72
INORGWO	$13,410.69	$-3,517.95	$-4,979.08	$-347.97	$4,913.67

Hewitt, T.D. 2003. North Florida research and education center enterprise vegetable budgets. Marianna, FL.

Table 28. Enterprise budget for summer squash 2012, HFF at the 100% N rate (152 kg·ha^{-1})

	Summer Squash HFF 100% 2012						
Estimated Costs of Producing One Acre of Squash on Plastic for Fresh Market,							
Item		Unit	Quantity	Price	Value	Cost/Acre	Cost/ha
Variable Costs							
	Seed	lb.	2	164	328	328	810.16
	Lime, applied	ton	0.15	30	4.5	4.5	11.115
	Fertilizer	N	136	11.22	1525.92	1525.92	3769.022
	Fertilizer	K	122.3	4.2	513.66	513.66	1268.74
	Herbicide Curbit EC	acre	4.5	9.97	44.865	44.87	110.8289
	Herbicide Glyphosate	acre	2	4	8	8	19.76
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide Actara	acre	5.5	10	55	55	135.85
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide permethrin	acre	6	0.33	1.98	1.98	4.8906
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Application Labor	acre	10	11	110	110	271.7
	Plastic	roll	2.2	162	356.4	356.4	880.308
	Drip tape	roll	1.5	145	217.5	217.5	537.225
	Plastic Removal	acre	0	0	0	0	0
	Nematicide	acre	0	0	0	0	0
	Tractor +Machinery+Labor	acre	1	201.3	201.32	201.32	497.2604
	Air blast sprayer+tractor	acre	10	34.09	340.9	340.9	842.023
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land rent	acre	1	70	70	70	172.9
	Irrigation	acre	6	82	492	492	1215.24
	Interest on Oper. Cap.	$	3964.345	0.05	198.2173	198.22	489.6034
Pre-Harvest Variable Costs					4720.962	4720.97	11660.8
Harvest and Marketing Costs							
	Picking and Hauling	bu.	152	0.9	136.8	136.8	337.896
	Grading and Packing	bu.	152	0.75	114	114	281.58
	Containers	ea.	152	1.54	234.08	234.08	578.1776
	Marketing	bu.	152	0.4	60.8	60.8	150.176
Total Harvest and Marketing					545.68	545.68	1347.83
Total Variable Costs					5266.642		
Fixed Costs							
	Machinery	acre	1	74.32	74.32064	74.32	183.5704
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Managemen	$	4162.56	0.1	416.256	416.26	1028.162
Total Fixed Costs					575.5766	575.58	1421.683
Total Budgeted Cost Per Acre					5842.219		14430.28
Total Returns Per Acre/ Hectare					11363.5		28067.85
Profit Per Acre/ Hectare					5521.52		13638.15

Table 29. Enterprise budget for summer squash 2012, INORGWM at the 100% N rate (152 kg·ha^{-1})

	Summer Squash INORGWM 100% 2012						
Estimated Costs of Producing One Acre of Squash on Plastic for Fresh Market,							
Item		Unit	Quantity	Price	Value	Cost/Acre	Cost/Ha
Variable Costs							
	Seed	lb.	2	164	328	328	810.16
	Lime, applied	ton	0.15	30	4.5	4.5	11.115
	Fertilizer	N, P +	136	0	920.98	920.98	2274.821
	Fertilizer	K	136	0	0	0	0
	Herbicide Curbit EC	acre	4.5	9.97	44.865	44.87	110.8289
	Herbicide Glyphosate	acre	2	4	8	8	19.76
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide Actara	acre	5.5	10	55	55	135.85
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide permethrin	acre	6	0.33	1.98	1.98	4.8906
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Application Labor	acre	10	11	110	110	271.7
	Plastic	roll	2.2	162	356.4	356.4	880.308
	Drip tape	roll	1.5	145	217.5	217.5	537.225
	Plastic Removal	acre	0	0	0	0	0
	Nematicide	acre	0	0	0	0	0
	Tractor +Machinery+Labor	acre	1	201.3	201.32	201.32	497.2604
	Air blast sprayer+tractor	acre	10	34.09	340.9	340.9	842.023
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land rent	acre	1	70	70	70	172.9
	Irrigation	acre	6	82	492	492	1215.24
	Interest on Oper. Cap.	$	3964.345	0.05	198.2173	198.22	489.6034
Pre-Harvest Variable Costs					3602.362	3602.37	8897.854
							0
Harvest and Marketing Costs							0
	Picking and Hauling	bu.	201	0.9	180.9	180.9	446.823
	Grading and Packing	bu.	201	0.75	150.75	150.75	372.3525
	Containers	ea.	201	1.54	309.54	309.54	764.5638
	Marketing	bu.	201	0.4	80.4	80.4	198.588
Total Harvest and Marketing					721.59	721.59	1782.327
Total Variable Costs					4323.952		0
							0
Fixed Costs							0
	Machinery	acre	1	74.32	74.32064	74.32	183.5704
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Managemen	$	4162.562	0.1	416.2562	416.26	1028.162
Total Fixed Costs					575.5769	575.58	1421.683
Total Budgeted Cost Per Acre					4899.529		12101.86
Total Returns Per Acre/ Hectare					10552.5		26064.68
Profit Per Acre/ Hectare					5652.97		13962.81

Table 30. Enterprise budget for summer squash 2012, INORGWO at the 100% N rate (152 kg·ha^{-1})

	Summer Squash INORGWO 100% 2012						
Estimated Costs of Producing One Acre of Squash on Plastic for Fresh Market,							
Item		Unit	Quantity	Price	Value	Cost/Acre	Cost/ha
Variable Costs							
	Seed	lb.	2	164	328	328	810.16
	Lime, applied	ton	0.15	30	4.5	4.5	11.115
	Fertilizer	N,P+	136	0	850.56	850.56	2100.883
	Fertilizer	K	136	0	0	0	0
	Herbicide Curbit EC	acre	4.5	9.97	44.865	44.87	110.8289
	Herbicide Glyphosate	acre	2	4	8	8	19.76
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide Actara	acre	5.5	10	55	55	135.85
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide permethrin	acre	6	0.33	1.98	1.98	4.8906
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Application Labor	acre	10	11	110	110	271.7
	Plastic	roll	2.2	162	356.4	356.4	880.308
	Drip tape	roll	1.5	145	217.5	217.5	537.225
	Plastic Removal	acre	0	0	0	0	0
	Nematicide	acre	0	0	0	0	0
	Tractor +Machinery+Labor	acre	1	201.3	201.32	201.32	497.2604
	Air blast sprayer+tractor	acre	10	34.09	340.9	340.9	842.023
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land rent	acre	1	70	70	70	172.9
	Irrigation	acre	6	82	492	492	1215.24
	Interest on Oper. Cap.	$	3964.345	0.05	198.2173	198.22	489.6034
Pre-Harvest Variable Costs					3531.942	3531.95	8723.917
							0
Harvest and Marketing Costs							0
	Picking and Hauling	bu.	195	0.9	175.5	175.5	433.485
	Grading and Packing	bu.	195	0.75	146.25	146.25	361.2375
	Containers	ea.	195	1.54	300.3	300.3	741.741
	Marketing	bu.	195	0.4	78	78	192.66
Total Harvest and Marketing					700.05	700.05	1729.124
Total Variable Costs					4231.992		0
							0
Fixed Costs							0
	Machinery	acre	1	74.32	74.32064	74.32	183.5704
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Managemen	$	4162.562	0.1	416.2562	416.26	1028.162
Total Fixed Costs					575.5769	575.58	1421.683
Total Budgeted Cost Per Acre					4807.569		11874.72
Total Returns Per Acre/ Hectare					10237.5		25286.63
Profit Per Acre/ Hectare					5429.43		13410.69

Table 31. Enterprise budget for summer squash 2012, HFF at the 80% N rate (121 kg·ha^{-1})

	Summer Squash HFF 80% 2012						
Estimated Costs of Producing One Acre of Squash on Plastic for Fresh Market,							
Item		Unit	Quantity	Price	Value	Cost/Acre	Cost/ha
Variable Costs							
	Seed	lb.	2	164	328	328	810.16
	Lime, applied	ton	0.15	30	4.5	4.5	11.115
	Fertilizer	N	108.8	11.22	1220.736	1220.7	3015.129
	Fertilizer	K	125	4.2	525	525	1296.75
	Herbicide Curbit EC	acre	4.5	9.97	44.865	44.87	110.8289
	Herbicide Glyphosate	acre	2	4	8	8	19.76
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide Actara	acre	5.5	10	55	55	135.85
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide permethrin	acre	6	0.33	1.98	1.98	4.8906
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Application Labor	acre	10	11	110	110	271.7
	Plastic	roll	2.2	162	356.4	356.4	880.308
	Drip tape	roll	1.5	145	217.5	217.5	537.225
	Plastic Removal	acre	0	0	0	0	0
	Nematicide	acre	0	0	0	0	0
	Tractor +Machinery+Labor	acre	1	201.3	201.32	201.32	497.2604
	Air blast sprayer+tractor	acre	10	34.09	340.9	340.9	842.023
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land rent	acre	1	70	70	70	172.9
	Irrigation	acre	6	82	492	492	1215.24
	Interest on Oper. Cap.	$	3964.345	0.05	198.2173	198.22	489.6034
Pre-Harvest Variable Costs					4427.118	4427.09	10934.91
							0
Harvest and Marketing Costs							0
	Picking and Hauling	bu.	127	0.9	114.3	114.3	282.321
	Grading and Packing	bu.	127	0.75	95.25	95.25	235.2675
	Containers	ea.	127	1.54	195.58	195.58	483.0826
	Marketing	bu.	127	0.4	50.8	50.8	125.476
Total Harvest and Marketing					455.93	455.93	1126.147
Total Variable Costs					4883.048		0
							0
Fixed Costs							0
	Machinery	acre	1	74.32	74.32064	74.32	183.5704
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Managemen	$	4162.562	0.1	416.2562	416.26	1028.162
Total Fixed Costs					575.5769	575.58	1421.683
Total Budgeted Cost Per Acre					5458.625		13482.74
Total Returns Per Acre/ Hectare					9494.52		23451.46
Profit Per Acre/ Hectare					4035.89		9968.648

Table 32. Enterprise budget for summer squash 2012, INORGWM at the 80% N rate (121 kg·ha^{-1})

	Summer Squash INORGWM 80% 2012						
Estimated Costs of Producing One Acre of Squash on Plastic for Fresh Market,							
Item		Unit	Quantity	Price	Value	Cost/Acre	Cost/ha
Variable Costs							
	Seed	lb.	2	164	328	328	810.16
	Lime, applied	ton	0.15	30	4.5	4.5	11.115
	Fertilizer	N, P +	108.8	0	736.78	736.78	1819.847
	Fertilizer	K	136	0	0	0	0
	Herbicide Curbit EC	acre	4.5	9.97	44.865	44.87	110.8289
	Herbicide Glyphosate	acre	2	4	8	8	19.76
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide Actara	acre	5.5	10	55	55	135.85
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide permethrin	acre	6	0.33	1.98	1.98	4.8906
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Application Labor	acre	10	11	110	110	271.7
	Plastic	roll	2.2	162	356.4	356.4	880.308
	Drip tape	roll	1.5	145	217.5	217.5	537.225
	Plastic Removal	acre	0	0	0	0	0
	Nematicide	acre	0	0	0	0	0
	Tractor +Machinery+Labor	acre	1	201.3	201.32	201.32	497.2604
	Air blast sprayer+tractor	acre	10	34.09	340.9	340.9	842.023
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land rent	acre	1	70	70	70	172.9
	Irrigation	acre	6	82	492	492	1215.24
	Interest on Oper. Cap.	$	3964.345	0.05	198.2173	198.22	489.6034
Pre-Harvest Variable Costs					3418.162	3418.17	8442.88
							0
Harvest and Marketing Costs							0
	Picking and Hauling	bu.	170	0.9	153	153	377.91
	Grading and Packing	bu.	170	0.75	127.5	127.5	314.925
	Containers	ea.	170	1.54	261.8	261.8	646.646
	Marketing	bu.	170	0.4	68	68	167.96
Total Harvest and Marketing					610.3	610.3	1507.441
Total Variable Costs					4028.462		0
							0
Fixed Costs							0
	Machinery	acre	1	74.32	74.32064	74.32	183.5704
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Managemen	$	4162.562	0.1	416.2562	416.26	1028.162
Total Fixed Costs					575.5769	575.58	1421.683
Total Budgeted Cost Per Acre					4604.039		11372
Total Returns Per Acre/ Hectare					8925		22044.75
Profit Per Acre/ Hectare					4320		10670.4

Table 33. Enterprise budget for summer squash 2012, INORGWO at the 80% N rate (121 kg·ha^{-1})

	Summer Squash INORGWO 80% 2012						
Estimated Costs of Producing One Acre of Squash on Plastic for Fresh Market,							
Item		Unit	Quantity	Price	Value	Cost/Acre	Cost/ha
Variable Costs							
	Seed	lb.	2	164	328	328	810.16
	Lime, applied	ton	0.15	30	4.5	4.5	11.115
	Fertilizer	N,P+	108.8	0	680.44	680.44	1680.687
	Fertilizer	K	136	0	0	0	0
	Herbicide Curbit EC	acre	4.5	9.97	44.865	44.87	110.8289
	Herbicide Glyphosate	acre	2	4	8	8	19.76
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide Actara	acre	5.5	10	55	55	135.85
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide permethrin	acre	6	0.33	1.98	1.98	4.8906
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Application Labor	acre	10	11	110	110	271.7
	Plastic	roll	2.2	162	356.4	356.4	880.308
	Drip tape	roll	1.5	145	217.5	217.5	537.225
	Plastic Removal	acre	0	0	0	0	0
	Nematicide	acre	0	0	0	0	0
	Tractor +Machinery+Labor	acre	1	201.3	201.32	201.32	497.2604
	Air blast sprayer+tractor	acre	10	34.09	340.9	340.9	842.023
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land rent	acre	1	70	70	70	172.9
	Irrigation	acre	6	82	492	492	1215.24
	Interest on Oper. Cap.	$	3964.345	0.05	198.2173	198.22	489.6034
Pre-Harvest Variable Costs					3361.822	3361.83	8303.72
							0
Harvest and Marketing Costs							0
	Picking and Hauling	bu.	175	0.9	157.5	157.5	389.025
	Grading and Packing	bu.	175	0.75	131.25	131.25	324.1875
	Containers	ea.	175	1.54	269.5	269.5	665.665
	Marketing	bu.	175	0.4	70	70	172.9
Total Harvest and Marketing					628.25	628.25	1551.778
Total Variable Costs					3990.072		0
							0
Fixed Costs							0
	Machinery	acre	1	74.32	74.32064	74.32	183.5704
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Managemen	$	4162.562	0.1	416.2562	416.26	1028.162
Total Fixed Costs					575.5769	575.58	1421.683
Total Budgeted Cost Per Acre					4565.649		11277.18
Total Returns Per Acre/ Hectare					9187.5		22693.13
Profit Per Acre/ Hectare					4621.8		11415.85

Table 34. Enterprise budget for summer squash 2012, HFF at the 60% N rate (91 kg·ha^{-1})

	Summer Squash HFF 60% 2012						
Estimated Costs of Producing One Acre of Squash on Plastic for Fresh Market,							
Item		Unit	Quantity	Price	Value	Cost/Acre	Cost/ha
Variable Costs							
	Seed	lb.	2	164	328	328	810.16
	Lime, applied	ton	0.15	30	4.5	4.5	11.115
	Fertilizer	N	81.6	11.22	915.552	915.55	2261.409
	Fertilizer	K	128	4.2	537.6	537.6	1327.872
	Herbicide Curbit EC	acre	4.5	9.97	44.865	44.87	110.8289
	Herbicide Glyphosate	acre	2	4	8	8	19.76
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide Actara	acre	5.5	10	55	55	135.85
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide permethrin	acre	6	0.33	1.98	1.98	4.8906
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Application Labor	acre	10	11	110	110	271.7
	Plastic	roll	2.2	162	356.4	356.4	880.308
	Drip tape	roll	1.5	145	217.5	217.5	537.225
	Plastic Removal	acre	0	0	0	0	0
	Nematicide	acre	0	0	0	0	0
	Tractor +Machinery+Labor	acre	1	201.3	201.32	201.32	497.2604
	Air blast sprayer+tractor	acre	10	34.09	340.9	340.9	842.023
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land rent	acre	1	70	70	70	172.9
	Irrigation	acre	6	82	492	492	1215.24
	Interest on Oper. Cap.	$	3964.345	0.05	198.2173	198.22	489.6034
Pre-Harvest Variable Costs					4134.534	4134.54	10212.31
							0
Harvest and Marketing Costs							0
	Picking and Hauling	bu.	109	0.9	98.1	98.1	242.307
	Grading and Packing	bu.	109	0.75	81.75	81.75	201.9225
	Containers	ea.	109	1.54	167.86	167.86	414.6142
	Marketing	bu.	109	0.4	43.6	43.6	107.692
Total Harvest and Marketing					391.31	391.31	966.5357
Total Variable Costs					4525.844		0
							0
Fixed Costs							0
	Machinery	acre	1	74.32	74.32064	74.32	183.5704
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Managemen	$	4162.562	0.1	416.2562	416.26	1028.162
Total Fixed Costs					575.5769	575.58	1421.683
Total Budgeted Cost Per Acre					5101.421		12600.53
Total Returns Per Acre/ Hectare					8148.84		20127.63
Profit Per Acre/ Hectare					3047.42		7527.127

Table 35. Enterprise budget for summer squash 2012, INORGWM at the 60% N rate (91 kg·ha^{-1})

	Summer Squash INORGWM 60% 2012						
Estimated Costs of Producing One Acre of Squash on Plastic for Fresh Market,							
Item		Unit	Quantity	Price	Value	Cost/Acre	Cost/ha
Variable Costs							
	Seed	lb.	2	164	328	328	810.16
	Lime, applied	ton	0.15	30	4.5	4.5	11.115
	Fertilizer	N, P +	81.6	0	552.88	552.88	1365.614
	Fertilizer	K	136	0	0	0	0
	Herbicide Curbit EC	acre	4.5	9.97	44.865	44.87	110.8289
	Herbicide Glyphosate	acre	2	4	8	8	19.76
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide Actara	acre	5.5	10	55	55	135.85
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide permethrin	acre	6	0.33	1.98	1.98	4.8906
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Application Labor	acre	10	11	110	110	271.7
	Plastic	roll	2.2	162	356.4	356.4	880.308
	Drip tape	roll	1.5	145	217.5	217.5	537.225
	Plastic Removal	acre	0	0	0	0	0
	Nematicide	acre	0	0	0	0	0
	Tractor +Machinery+Labor	acre	1	201.3	201.32	201.32	497.2604
	Air blast sprayer+tractor	acre	10	34.09	340.9	340.9	842.023
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land rent	acre	1	70	70	70	172.9
	Irrigation	acre	6	82	492	492	1215.24
	Interest on Oper. Cap.	$	3964.345	0.05	198.2173	198.22	489.6034
Pre-Harvest Variable Costs					3234.262	3234.27	7988.647
							0
Harvest and Marketing Costs							0
	Picking and Hauling	bu.	198	0.9	178.2	178.2	440.154
	Grading and Packing	bu.	198	0.75	148.5	148.5	366.795
	Containers	ea.	198	1.54	304.92	304.92	753.1524
	Marketing	bu.	198	0.4	79.2	79.2	195.624
Total Harvest and Marketing					710.82	710.82	1755.725
Total Variable Costs					3945.082		0
							0
Fixed Costs							0
	Machinery	acre	1	74.32	74.32064	74.32	183.5704
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Managemen	$	4162.562	0.1	416.2562	416.26	1028.162
Total Fixed Costs					575.5769	575.58	1421.683
Total Budgeted Cost Per Acre					4520.659		11166.05
Total Returns Per Acre/ Hectare					10395		25675.65
Profit Per Acre/ Hectare					5874.34		14509.62

Table 36. Enterprise budget for summer squash 2012, INORGWO at the 60% N rate (91 kg·ha^{-1})

	Summer Squash INORGWO 60% 2012						
Estimated Costs of Producing One Acre of Squash on Plastic for Fresh Market,							
Item		Unit	Quantity	Price	Value	Cost/Acre	Cost/ha
Variable Costs							
	Seed	lb.	2	164	328	328	810.16
	Lime, applied	ton	0.15	30	4.5	4.5	11.115
	Fertilizer	N,P+	81.6	0	510.33	510.33	1260.515
	Fertilizer	K	136	0	0	0	0
	Herbicide Curbit EC	acre	4.5	9.97	44.865	44.87	110.8289
	Herbicide Glyphosate	acre	2	4	8	8	19.76
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide Actara	acre	5.5	10	55	55	135.85
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide permethrin	acre	6	0.33	1.98	1.98	4.8906
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Application Labor	acre	10	11	110	110	271.7
	Plastic	roll	2.2	162	356.4	356.4	880.308
	Drip tape	roll	1.5	145	217.5	217.5	537.225
	Plastic Removal	acre	0	0	0	0	0
	Nematicide	acre	0	0	0	0	0
	Tractor +Machinery+Labor	acre	1	201.3	201.32	201.32	497.2604
	Air blast sprayer+tractor	acre	10	34.09	340.9	340.9	842.023
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land rent	acre	1	70	70	70	172.9
	Irrigation	acre	6	82	492	492	1215.24
	Interest on Oper. Cap.	$	3964.345	0.05	198.2173	198.22	489.6034
Pre-Harvest Variable Costs					3191.712	3191.72	7883.548
							0
Harvest and Marketing Costs							0
	Picking and Hauling	bu.	180	0.9	162	162	400.14
	Grading and Packing	bu.	180	0.75	135	135	333.45
	Containers	ea.	180	1.54	277.2	277.2	684.684
	Marketing	bu.	180	0.4	72	72	177.84
Total Harvest and Marketing					646.2	646.2	1596.114
Total Variable Costs					3837.912		0
							0
Fixed Costs							0
	Machinery	acre	1	74.32	74.32064	74.32	183.5704
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Managemen	$	4162.562	0.1	416.2562	416.26	1028.162
Total Fixed Costs					575.5769	575.58	1421.683
Total Budgeted Cost Per Acre					4413.489		10901.35
Total Returns Per Acre/ Hectare					9450		23341.5
Profit Per Acre/ Hectare					5036.51		12440.18

Table 37. Enterprise budget for summer squash 2012, NON at the 0% N rate (0 kg·ha^{-1})

	Summer Squash NON 0% 2012						
Estimated Costs of Producing One Acre of Squash on Plastic for Fresh Market,							
Item		Unit	Quantity	Price	Value	Cost/Acre	Cost/ha
Variable Costs							
	Seed	lb.	2	164	328	328	810.16
	Lime, applied	ton	0.15	30	4.5	4.5	11.115
	Fertilizer	N	0	0	0	0	0
	Fertilizer	P	117		299	299	738.53
	Fertilizer	K	136	0	582.85	582.85	1439.64
	Herbicide Curbit EC	acre	4.5	9.97	44.865	44.87	110.8289
	Herbicide Glyphosate	acre	2	4	8	8	19.76
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide Actara	acre	5.5	10	55	55	135.85
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide permethrin	acre	6	0.33	1.98	1.98	4.8906
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Application Labor	acre	10	11	110	110	271.7
	Plastic	roll	2.2	162	356.4	356.4	880.308
	Drip tape	roll	1.5	145	217.5	217.5	537.225
	Plastic Removal	acre	0	0	0	0	0
	Nematicide	acre	0	0	0	0	0
	Tractor +Machinery+Labor	acre	1	201.3	201.32	201.32	497.2604
	Air blast sprayer+tractor	acre	10	34.09	340.9	340.9	842.023
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land rent	acre	1	70	70	70	172.9
	Irrigation	acre	6	82	492	492	1215.24
	Interest on Oper. Cap.	$	3964.345	0.05	198.2173	198.22	489.6034
Pre-Harvest Variable Costs					3563.232	3563.24	8801.203
							0
Harvest and Marketing Costs							0
	Picking and Hauling	bu.	103	0.9	92.7	92.7	228.969
	Grading and Packing	bu.	103	0.75	77.25	77.25	190.8075
	Containers	ea.	103	1.54	158.62	158.62	391.7914
	Marketing	bu.	103	0.4	41.2	41.2	101.764
Total Harvest and Marketing					369.77	369.77	913.3319
Total Variable Costs					3933.002		0
							0
Fixed Costs							0
	Machinery	acre	1	74.32	74.32064	74.32	183.5704
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Managemen	$	4162.562	0.1	416.2562	416.26	1028.162
Total Fixed Costs					575.5769	575.58	1421.683
Total Budgeted Cost Per Acre					4508.579		11136.22
Total Returns Per Acre/ Hectare					5407.5		13356.53
Profit Per Acre/ Hectare					898.93		2220.357
Profit Per Acre/ Hectare					898.93		2220.357

Table 38. Enterprise budget for collard crop 2012, HFF at the 100% N rate (110 kg·ha^{-1})

	Collard Crop HFF 100% 2012						
Estimated Costs of Producing One Acre of Collard Greens for Fresh Market,							
Item		Unit	Quantity	Price	Value	Cost/Acre	Cost/ha
Cash Expenses, Pre-Harvest:							
	Seedlings	1000	16	16	256	256	632.32
	Lime, applied	ton	0.15	30	4.5	4.5	11.115
	Fertilizer	N	98	11.22	1099.6	1099.6	2716.012
	Fertilizer	K	89	4.28	380.92	380.92	940.8724
	Herbicide Paraquat	acre	2	6.25	12.5	12.5	30.875
	Insecticide Intrepid 2f	acre	8	2.7	21.6	21.6	53.352
	Insecticide Xentari	acre	0.5	20	10	10	24.7
	Insecticide Actara	acre	5.5	10	55	55	135.85
	Insecticide Dipel	acre	1	27	27	27	66.69
	Fungicide	acre	0	0	0	0	0
	Tractor + Sprayer	acre	1	212.54	212.54	212.54	524.9738
	Truck (pickup and atv use)	mi.	20	0.56	11.2	11.2	27.664
	Labor (incl. transplanting)	hr.	12	10	120	120	296.4
	Irrigation	acre	6	82	492	492	1215.24
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land Rent	acre	1	40	40	40	98.8
	Interest on Cash Expenses	$	2702.82	0.05	135.14	135.14	333.7958
Total Pre-Harvest Cash Expenses					3098	3098	7652.06
							0
Fixed Costs, Pre-Harvest:							0
	Tractor + Machinery	acre	1	109.25	109.25	109.25	269.8475
	Truck (pickup)	mi.	20	0.17	3.4	3.4	8.398
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Management	$	406.25	0.1	40.63	40.63	100.3561
Total Pre-Harvest Fixed Costs					238.28		0
							0
Total Pre-Harvest Costs					3336.2	238.28	588.5516
Harvest Costs:							0
	Machinery Labor	acre	1	11	11	11	27.17
	Harvest Labor	box	1	248	248	248	612.56
	Boxes**	each	1.6	248	397	397	980.59
	Marketing	box	0.4	248	99	99	244.53
	Cooling	box	0.25	248	62	62	153.14
	Hauling	box	1.25	248	310	310	765.7
Total Harvest Costs					1127	1127	2783.69
Total Costs					4463.2		11024.3
Total Returns Per Acre/ Hectare					9424		23277.28
Profit Per Acre/ Hectare					4960.8		12253.08

Table 39. Enterprise budget for collard crop 2012, INORGWM at the 100% N rate (110 kg·ha^{-1})

	Collard Crop INORGWM 100% 2012						
Estimated Costs of Producing One Acre of Collard Greens for Fresh Market,							
Item		Unit	Quantity	Price	Value	Cost/Acre	Cost/ha
Cash Expenses, Pre-Harvest:							
	Seedlings	1000	16	16	256	256	632.32
	Lime, applied	ton	0.15	30	4.5	4.5	11.115
	Fertilizer	N,P+	98	0	879.13	879.13	2171.451
	Fertilizer	K	98	0	0	0	0
	Herbicide Paraquat	acre	2	6.25	12.5	12.5	30.875
	Insecticide Intrepid 2f	acre	8	2.7	21.6	21.6	53.352
	Insecticide Xentari	acre	0.5	20	10	10	24.7
	Insecticide Actara	acre	5.5	10	55	55	135.85
	Insecticide Dipel	acre	1	27	27	27	66.69
	Fungicide	acre	0	0	0	0	0
	Tractor + Sprayer	acre	1	212.54	212.54	212.54	524.9738
	Truck (pickup and atv use)	mi.	20	0.56	11.2	11.2	27.664
	Labor (incl. transplanting)	hr.	12	10	120	120	296.4
	Irrigation	acre	6	82	492	492	1215.24
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land Rent	acre	1	40	40	40	98.8
	Interest on Cash Expenses	$	2702.82	0.05	135.14	135.14	333.7958
Total Pre-Harvest Cash Expenses					2496.6	2496.6	6166.602
							0
Fixed Costs, Pre-Harvest:							0
	Tractor + Machinery	acre	1	109.253	109.25	109.25	269.8475
	Truck (pickup)	mi.	20	0.17	3.4	3.4	8.398
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Management	$	406.25	0.1	40.625	40.63	100.3561
Total Pre-Harvest Fixed Costs					238.28		0
							0
Total Pre-Harvest Costs					2734.9	238.28	588.5516
Harvest Costs:							0
	Machinery Labor	acre	1	11	11	11	27.17
	Harvest Labor	box	1	339	339	339	837.33
	Boxes**	each	1.6	339	542.4	542.4	1339.728
	Marketing	box	0.4	339	135.6	135.6	334.932
	Cooling	box	0.25	339	84.75	84.75	209.3325
	Hauling	box	1.25	339	423.75	423.75	1046.663
Total Harvest Costs					1536.5	1536.5	3795.155
Total Costs					4271.4		10550.31
Total Returns Per Acre/ Hectare					3559.5		8791.965
Profit Per Acre/ Hectare					-711.89		-1758.37

Table 40. Enterprise budget for collard crop 2012, INORGWO at the 100% N rate (110 kg·ha^{-1})

	Collard Crop INORGWO 100% 2012						
Estimated Costs of Producing One Acre of Collard Greens for Fresh Market,							
Item		Unit	Quantity	Price	Value	Cost/Acre	Cost/ha
Cash Expenses, Pre-Harvest:							
	Seedlings	1000	16	16	256	256	632.32
	Lime, applied	ton	0.15	30	4.5	4.5	11.115
	Fertilizer	N,P+	98	0	811.51	811.51	2004.43
	Fertilizer	K	98	0	0	0	0
	Herbicide Paraquat	acre	2	6.25	12.5	12.5	30.875
	Insecticide Intrepid 2f	acre	8	2.7	21.6	21.6	53.352
	Insecticide Xentari	acre	0.5	20	10	10	24.7
	Insecticide Actara	acre	5.5	10	55	55	135.85
	Insecticide Dipel	acre	1	27	27	27	66.69
	Fungicide	acre	0	0	0	0	0
	Tractor + Sprayer	acre	1	212.54	212.54	212.54	524.9738
	Truck (pickup and atv use)	mi.	20	0.56	11.2	11.2	27.664
	Labor (incl. transplanting)	hr.	12	10	120	120	296.4
	Irrigation	acre	6	82	492	492	1215.24
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land Rent	acre	1	40	40	40	98.8
	Interest on Cash Expenses	$	2702.82	0.05	135.14	135.14	333.7958
Total Pre-Harvest Cash Expenses					2429	2429	5999.63
							0
Fixed Costs, Pre-Harvest:							0
	Tractor + Machinery	acre	1	109.253	109.25	109.25	269.8475
	Truck (pickup)	mi.	20	0.17	3.4	3.4	8.398
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Management	$	406.25	0.1	40.625	40.63	100.3561
Total Pre-Harvest Fixed Costs					238.28		0
							0
Total Pre-Harvest Costs					2667.3	238.28	588.5516
Harvest Costs:							0
	Machinery Labor	acre	1	11	11	11	27.17
	Harvest Labor	box	1	209	209	209	516.23
	Boxes**	each	1.6	209	334.4	334.4	825.968
	Marketing	box	0.4	209	83.6	83.6	206.492
	Cooling	box	0.25	209	52.25	52.25	129.0575
	Hauling	box	1.25	209	261.25	261.25	645.2875
Total Harvest Costs					951.5	951.5	2350.205
Total Costs					3618.8		8938.387
Total Returns Per Acre/ Hectare					2194.5		5420.415
Profit Per Acre/ Hectare					-1424.3		-3517.95

Table 41. Enterprise budget for collard crop 2012, HFF at the 80% N rate (88 kg·ha^{-1})

	Collard Crop HFF 80% 2012						
Estimated Costs of Producing One Acre of Collard Greens for Fresh Market,							
Item		Unit	Quantity	Price	Value	Cost/Acre	Cost/ha
Cash Expenses, Pre-Harvest:							
	Seedlings	1000	16	16	256	256	632.32
	Lime, applied	ton	0.15	30	4.5	4.5	11.115
	Fertilizer	N	78.4	11.22	879.65	879.648	2172.731
	Fertilizer	K	90.2	4.28	386.06	386.056	953.5583
	Herbicide Paraquat	acre	2	6.25	12.5	12.5	30.875
	Insecticide Intrepid 2f	acre	8	2.7	21.6	21.6	53.352
	Insecticide Xentari	acre	0.5	20	10	10	24.7
	Insecticide Actara	acre	5.5	10	55	55	135.85
	Insecticide Dipel	acre	1	27	27	27	66.69
	Fungicide	acre	0	0	0	0	0
	Tractor + Sprayer	acre	1	212.54	212.54	212.54	524.9738
	Truck (pickup and atv use)	mi.	20	0.56	11.2	11.2	27.664
	Labor (incl. transplanting)	hr.	12	10	120	120	296.4
	Irrigation	acre	6	82	492	492	1215.24
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land Rent	acre	1	40	40	40	98.8
	Interest on Cash Expenses	$	2702.82	0.05	135.14	135.141	333.7983
Total Pre-Harvest Cash Expenses					2883.2	2883.185	7121.467
							0
Fixed Costs, Pre-Harvest:							0
	Tractor + Machinery	acre	1	109.253	109.25	109.25	269.8475
	Truck (pickup)	mi.	20	0.17	3.4	3.4	8.398
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Management	$	406.25	0.1	40.625	40.63	100.3561
Total Pre-Harvest Fixed Costs					238.28		0
							0
Total Pre-Harvest Costs					3121.5	238.28	588.5516
Harvest Costs:							0
	Machinery Labor	acre	1	11	11	11	27.17
	Harvest Labor	box	1	213	213	213	526.11
	Boxes**	each	1.6	213	340.8	340.8	841.776
	Marketing	box	0.4	213	85.2	85.2	210.444
	Cooling	box	0.25	213	53.25	53.25	131.5275
	Hauling	box	1.25	213	266.25	266.25	657.6375
Total Harvest Costs					969.5	969.5	2394.665
Total Costs					4091		10104.68
Total Returns Per Acre/ Hectare					8094		19992.18
Profit Per Acre/ Hectare					4003		9887.509

Table 42. Enterprise budget for collard crop 2012, INORGWM at the 80% N rate (88 kg·ha^{-1})

	Collard Crop INORGWM 80% 2012						
Estimated Costs of Producing One Acre of Collard Greens for Fresh Market,							
Item		Unit	Quantity	Price	Value	Cost/Acre	Cost/ha
Cash Expenses, Pre-Harvest:							
	Seedlings	1000	16	16	256	256	632.32
	Lime, applied	ton	0.15	30	4.5	4.5	11.115
	Fertilizer	N,P+	78.4	0	703.3	703.3	1737.151
	Fertilizer	K	98	0	0	0	0
	Herbicide Paraquat	acre	2	6.25	12.5	12.5	30.875
	Insecticide Intrepid 2f	acre	8	2.7	21.6	21.6	53.352
	Insecticide Xentari	acre	0.5	20	10	10	24.7
	Insecticide Actara	acre	5.5	10	55	55	135.85
	Insecticide Dipel	acre	1	27	27	27	66.69
	Fungicide	acre	0	0	0	0	0
	Tractor + Sprayer	acre	1	212.54	212.54	212.54	524.9738
	Truck (pickup and atv use)	mi.	20	0.56	11.2	11.2	27.664
	Labor (incl. transplanting)	hr.	12	10	120	120	296.4
	Irrigation	acre	6	82	492	492	1215.24
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land Rent	acre	1	40	40	40	98.8
	Interest on Cash Expenses	$	2702.82	0.05	135.14	135.141	333.7983
Total Pre-Harvest Cash Expenses					2320.8	2320.781	5732.329
							0
Fixed Costs, Pre-Harvest:							0
	Tractor + Machinery	acre	1	109.253	109.25	109.25	269.8475
	Truck (pickup)	mi.	20	0.17	3.4	3.4	8.398
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Management	$	406.25	0.1	40.625	40.63	100.3561
Total Pre-Harvest Fixed Costs					238.28		0
							0
Total Pre-Harvest Costs					2559.1	238.28	588.5516
Harvest Costs:							0
	Machinery Labor	acre	1	11	11	11	27.17
	Harvest Labor	box	1	273	273	273	674.31
	Boxes**	each	1.6	273	436.8	436.8	1078.896
	Marketing	box	0.4	273	109.2	109.2	269.724
	Cooling	box	0.25	273	68.25	68.25	168.5775
	Hauling	box	1.25	273	341.25	341.25	842.8875
Total Harvest Costs					1239.5	1239.5	3061.565
Total Costs					3798.6		9382.446
Total Returns Per Acre/ Hectare					2866.5		7080.255
Profit Per Acre/ Hectare					932.06		2302.188

Table 43. Enterprise budget for collard crop 2012, INORGWO at the 80% N rate (88 kg·ha^{-1})

	Collard Crop INORGWO 80% 2012						
Estimated Costs of Producing One Acre of Collard Greens for Fresh Market,							
Item		Unit	Quantity	Price	Value	Cost/Acre	Cost/ha
Cash Expenses, Pre-Harvest:							
	Seedlings	1000	16	16	256	256	632.32
	Lime, applied	ton	0.15	30	4.5	4.5	11.115
	Fertilizer	N,P+	78.4	0	646.2	649.2	1603.524
	Fertilizer	K	98	0	0	0	0
	Herbicide Paraquat	acre	2	6.25	12.5	12.5	30.875
	Insecticide Intrepid 2f	acre	8	2.7	21.6	21.6	53.352
	Insecticide Xentari	acre	0.5	20	10	10	24.7
	Insecticide Actara	acre	5.5	10	55	55	135.85
	Insecticide Dipel	acre	1	27	27	27	66.69
	Fungicide	acre	0	0	0	0	0
	Tractor + Sprayer	acre	1	212.54	212.54	212.54	524.9738
	Truck (pickup and atv use)	mi.	20	0.56	11.2	11.2	27.664
	Labor (incl. transplanting)	hr.	12	10	120	120	296.4
	Irrigation	acre	6	82	492	492	1215.24
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land Rent	acre	1	40	40	40	98.8
	Interest on Cash Expenses	$	2702.82	0.05	135.14	135.141	333.7983
Total Pre-Harvest Cash Expenses					2266.7	2266.681	5598.702
							0
Fixed Costs, Pre-Harvest:							0
	Tractor + Machinery	acre	1	109.253	109.25	109.25	269.8475
	Truck (pickup)	mi.	20	0.17	3.4	3.4	8.398
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Management	$	406.25	0.1	40.625	40.63	100.3561
Total Pre-Harvest Fixed Costs					238.28		0
							0
Total Pre-Harvest Costs					2505	238.28	588.5516
Harvest Costs:							0
	Machinery Labor	acre	1	0	0	0	0
	Harvest Labor	box	0	0	0	0	0
	Boxes**	each	0	0	0	0	0
	Marketing	box	0	0	0	0	0
	Cooling	box	0	0	0	0	0
	Hauling	box	0	0	0	0	0
Total Harvest Costs					0	0	0
							0
Total Costs					2505		6187.254
Total Returns Per Acre/ Hectare					0		0
Profit Per Acre/ Hectare					-2505		-6187.28

Table 44. Enterprise budget for collard crop 2012, HFF at the 60% N rate (66 kg·ha^{-1})

	Collard Crop HFF 60% 2012						
Estimated Costs of Producing One Acre of Collard Greens for Fresh Market,							
Item		Unit	Quantity	Price	Value	Cost/Acre	Cost/ha
Cash Expenses, Pre-Harvest:							
	Seedlings	1000	16	16	256	256	632.32
	Lime, applied	ton	0.15	30	4.5	4.5	11.115
	Fertilizer	N	58.8	11.22	659.74	659.736	1629.548
	Fertilizer	K	92.12	4.28	394.27	394.2736	973.8558
	Herbicide Paraquat	acre	2	6.25	12.5	12.5	30.875
	Insecticide Intrepid 2f	acre	8	2.7	21.6	21.6	53.352
	Insecticide Xentari	acre	0.5	20	10	10	24.7
	Insecticide Actara	acre	5.5	10	55	55	135.85
	Insecticide Dipel	acre	1	27	27	27	66.69
	Fungicide	acre	0	0	0	0	0
	Tractor + Sprayer	acre	1	212.54	212.54	212.54	524.9738
	Truck (pickup and atv use)	mi.	20	0.56	11.2	11.2	27.664
	Labor (incl. transplanting)	hr.	12	10	120	120	296.4
	Irrigation	acre	6	82	492	492	1215.24
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land Rent	acre	1	40	40	40	98.8
	Interest on Cash Expenses	$	2702.82	0.05	135.14	135.141	333.7983
Total Pre-Harvest Cash Expenses					2671.5	2671.491	6598.582
							0
Fixed Costs, Pre-Harvest:							0
	Tractor + Machinery	acre	1	109.253	109.25	109.25	269.8475
	Truck (pickup)	mi.	20	0.17	3.4	3.4	8.398
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Management	$	406.25	0.1	40.625	40.63	100.3561
Total Pre-Harvest Fixed Costs					238.28	238.28	588.5516
							0
Total Pre-Harvest Costs					2909.8	238.28	588.5516
Harvest Costs:							0
	Machinery Labor	acre	1	11	11	11	27.17
	Harvest Labor	box	1	182	182	182	449.54
	Boxes**	each	1.6	182	291.2	291.2	719.264
	Marketing	box	0.4	182	72.8	72.8	179.816
	Cooling	box	0.25	182	45.5	45.5	112.385
	Hauling	box	1.25	182	227.5	227.5	561.925
Total Harvest Costs					830	830	2050.1
Total Costs					3739.8		9237.233
Total Returns Per Acre/ Hectare					6916		17082.52
Profit Per Acre/ Hectare					3176.2		7845.288

Table 45. Enterprise budget for collard crop 2012, INORGWM at the 60% N rate (66 kg·ha^{-1})

	Collard Crop INORGWM 60% 2012						
Estimated Costs of Producing One Acre of Collard Greens for Fresh Market,							
Item		Unit	Quantity	Price	Value	Cost/Acre	Cost/ha
Cash Expenses, Pre-Harvest:							
	Seedlings	1000	16	16	256	256	632.32
	Lime, applied	ton	0.15	30	4.5	4.5	11.115
	Fertilizer	N,P+	58.8	0	527.5	527.5	1302.925
	Fertilizer	K	98	0	0	0	0
	Herbicide Paraquat	acre	2	6.25	12.5	12.5	30.875
	Insecticide Intrepid 2f	acre	8	2.7	21.6	21.6	53.352
	Insecticide Xentari	acre	0.5	20	10	10	24.7
	Insecticide Actara	acre	5.5	10	55	55	135.85
	Insecticide Dipel	acre	1	27	27	27	66.69
	Fungicide	acre	0	0	0	0	0
	Tractor + Sprayer	acre	1	212.54	212.54	212.54	524.9738
	Truck (pickup and atv use)	mi.	20	0.56	11.2	11.2	27.664
	Labor (incl. transplanting)	hr.	12	10	120	120	296.4
	Irrigation	acre	6	82	492	492	1215.24
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land Rent	acre	1	40	40	40	98.8
	Interest on Cash Expenses	$	2702.82	0.05	135.14	135.141	333.7983
Total Pre-Harvest Cash Expenses					2145	2144.981	5298.103
							0
Fixed Costs, Pre-Harvest:							0
	Tractor + Machinery	acre	1	109.253	109.25	109.25	269.8475
	Truck (pickup)	mi.	20	0.17	3.4	3.4	8.398
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Management	$	406.25	0.1	40.625	40.63	100.3561
Total Pre-Harvest Fixed Costs					238.28		0
							0
Total Pre-Harvest Costs					2383.3	238.28	588.5516
Harvest Costs:							0
	Machinery Labor	acre	1	11	11	11	27.17
	Harvest Labor	box	1	240	240	240	592.8
	Boxes**	each	1.6	240	384	384	948.48
	Marketing	box	0.4	240	96	96	237.12
	Cooling	box	0.25	240	60	60	148.2
	Hauling	box	1.25	240	300	300	741
Total Harvest Costs					1091	1091	2694.77
Total Costs					3474.3		8581.425
Total Returns Per Acre/ Hectare					2520		6224.4
Profit Per Acre/ Hectare					-954.26		-2357.02

Table 46. Enterprise budget for collard crop 2012, INORGWO at the 60% N rate (66 kg·ha^{-1})

	Collard Crop INORGWO 60% 2012						
Estimated Costs of Producing One Acre of Collard Greens for Fresh Market,							
Item		Unit	Quantity	Price	Value	Cost/Acre	Cost/ha
Cash Expenses, Pre-Harvest:							
	Seedlings	1000	16	16	256	256	632.32
	Lime, applied	ton	0.15	30	4.5	4.5	11.115
	Fertilizer	N,P+	58.8	0	486.9	486.9	1202.643
	Fertilizer	K	98	0	0	0	0
	Herbicide Paraquat	acre	2	6.25	12.5	12.5	30.875
	Insecticide Intrepid 2f	acre	8	2.7	21.6	21.6	53.352
	Insecticide Xentari	acre	0.5	20	10	10	24.7
	Insecticide Actara	acre	5.5	10	55	55	135.85
	Insecticide Dipel	acre	1	27	27	27	66.69
	Fungicide	acre	0	0	0	0	0
	Tractor + Sprayer	acre	1	212.54	212.54	212.54	524.9738
	Truck (pickup and atv use)	mi.	20	0.56	11.2	11.2	27.664
	Labor (incl. transplanting)	hr.	12	10	120	120	296.4
	Irrigation	acre	6	82	492	492	1215.24
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land Rent	acre	1	40	40	40	98.8
	Interest on Cash Expenses	$	2702.82	0.05	135.14	135.141	333.7983
Total Pre-Harvest Cash Expenses					2104.4	2104.381	5197.821
							0
Fixed Costs, Pre-Harvest:							0
	Tractor + Machinery	acre	1	109.253	109.25	109.25	269.8475
	Truck (pickup)	mi.	20	0.17	3.4	3.4	8.398
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Management	$	406.25	0.1	40.625	40.63	100.3561
Total Pre-Harvest Fixed Costs					238.28		0
							0
Total Pre-Harvest Costs					2342.7	238.28	588.5516
Harvest Costs:							0
	Machinery Labor	acre	1	11	11	11	27.17
	Harvest Labor	box	1	135	135	135	333.45
	Boxes**	each	1.6	135	216	216	533.52
	Marketing	box	0.4	135	54	54	133.38
	Cooling	box	0.25	135	33.75	33.75	83.3625
	Hauling	box	1.25	135	168.75	168.75	416.8125
Total Harvest Costs					618.5	618.5	1527.695
Total Costs					2961.2		7314.068
Total Returns Per Acre/ Hectare					1417.5		3501.225
Profit Per Acre/ Hectare					-1543.7		-3812.84

Table 47. Enterprise budget for collard crop 2012, NON at the 0% N rate (0 kg·ha^{-1})

	Collard Crop NON 0% 2012						
Estimated Costs of Producing One Acre of Collard Greens for Fresh Market,							
Item		Unit	Quantity	Price	Value	Cost/Acre	Cost/ha
Cash Expenses, Pre-Harvest:							
	Seedlings	1000	16	16	256	256	632.32
	Lime, applied	ton	0.15	30	4.5	4.5	11.115
	Fertilizer	N	0	0	0	0	0
	Fertilizer	P	117	0	299	299	738.53
	Fertilizer	K	98	0	420	420	1037.4
	Herbicide Paraquat	acre	2	6.25	12.5	12.5	30.875
	Insecticide Intrepid 2f	acre	8	2.7	21.6	21.6	53.352
	Insecticide Xentari	acre	0.5	20	10	10	24.7
	Insecticide Actara	acre	5.5	10	55	55	135.85
	Insecticide Dipel	acre	1	27	27	27	66.69
	Fungicide	acre	0	0	0	0	0
	Tractor + Sprayer	acre	1	212.54	212.54	212.54	524.9738
	Truck (pickup and atv use)	mi.	20	0.56	11.2	11.2	27.664
	Labor (incl. transplanting)	hr.	12	10	120	120	296.4
	Irrigation	acre	6	82	492	492	1215.24
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land Rent	acre	1	40	40	40	98.8
	Interest on Cash Expenses	$	2702.82	0.05	135.14	135.14	333.7958
Total Pre-Harvest Cash Expenses					2336.5	2336.5	5771.155
							0
Fixed Costs, Pre-Harvest:							0
	Tractor + Machinery	acre	1	109.253	109.25	109.25	269.8475
	Truck (pickup)	mi.	20	0.17	3.4	3.4	8.398
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Management	$	406.25	0.1	40.625	40.63	100.3561
Total Pre-Harvest Fixed Costs					238.28		0
							0
Total Pre-Harvest Costs					2574.8	238.28	588.5516
Harvest Costs:							0
	Machinery Labor	acre	1	11	11	11	27.17
	Harvest Labor	box	1	45	45	45	111.15
	Boxes**	each	1.6	45	72	72	177.84
	Marketing	box	0.4	45	18	18	44.46
	Cooling	box	0.25	45	11.25	11.25	27.7875
	Hauling	box	1.25	45	56.25	56.25	138.9375
Total Harvest Costs					213.5	213.5	527.345
Total Costs					2788.3		6887.052
Total Returns Per Acre/ Hectare					472.5		1167.075
Profit Per Acre/ Hectare					-2315.8		-5719.93

Table 48. Enterprise budget for summer squash 2013, HFF at the 100% N rate (152 $kg \cdot ha^{-1}$)

	Summer Squash HFF 100% 2013						
Estimated Costs of Producing One Acre of Squash on Plastic for Fresh Market,							
Item		Unit	Quantity	Price	Value	Cost/Acre	Cost/ha
Variable Costs							
	Seed	lb.	2	164	328	328	810.16
	Lime, applied	ton	0	0	0	0	0
	Fertilizer	N	136	11.22	1525.92	1525.9	3768.973
	Fertilizer	K	122.3	4.2	513.66	513.66	1268.74
	Herbicide Aim	acre	2	1.67	3.34	3.34	8.2498
	Herbicide Poast	acre	2	24.5	49	49	121.03
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide Intrepid 2f	acre	8	2.7	21.6	21.6	53.352
	Insecticide Actara	acre	5.5	10	55	55	135.85
	Insecticide Intrepid 2f	acre	8	2.7	21.6	21.6	53.352
	Insecticide permethrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide permethrin	acre	6	0.33	1.98	1.98	4.8906
	Fungicide Quadris	acre	15	2.72	40.9	40.9	101.023
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Quadris	acre	15	2.72	40.9	40.9	101.023
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Topsin 4.5f	acre	10	1.17	11.71	11.71	28.9237
	Fungicide Quadris	acre	15	2.72	40.9	40.9	101.023
	Application Labor	acre	15	11	165	165	407.55
	Plastic	roll	0	0	0	0	0
	Drip tape	roll	0	0	0	0	0
	Plastic Removal	acre	1	135	135	135	333.45
	Mulch lifter	acre	1	21.72	21.72	21.72	53.6484
	Nematicide	acre	0	0	0	0	0
	Tractor +Machinery+Lal	acre	1	118.9	118.9	118.9	293.683
	Air blast sprayer+tracto	acre	15	34.09	511.35	511.35	1263.035
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land rent	acre	1	70	70	70	172.9
	Irrigation	acre	6	82	492	492	1215.24
	Interest on Oper. Cap.	$	3964.35	0.05	198.217	198.22	489.6034
Pre-Harvest Variable Costs					4617.42	4617.4	11404.98
Harvest and Marketing Costs							
	Picking and Hauling	bu.	48	0.9	43.2	43.2	106.704
	Grading and Packing	bu.	48	0.75	36	36	88.92
	Containers	ea.	48	1.54	73.92	73.92	182.5824
	Marketing	bu.	48	0.4	19.2	19.2	47.424
Total Harvest and Marketing					172.32	172.32	425.6304
Total Variable Costs					4789.74		
Fixed Costs							
	Machinery	acre	1	74.321	74.3206	74.32	183.5704
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Manager	$	4162.56	0.1	416.256	416.26	1028.162
Total Fixed Costs					575.577	575.58	1421.683
Total Budgeted Cost Per Acre					5365.31		13252
Total Returns Per Acre/ Hectare					4011.84		9909.245
Profit Per Acre/ Hectare					-1353.47		-3342.76

Table 49. Enterprise budget for summer squash 2013, INORGWM at the 100% N rate (152 $kg \cdot ha^{-1}$)

	Summer Squash INORGWM 100% 2013						
Estimated Costs of Producing One Acre of Squash on Plastic for Fresh Market,							
Item		Unit	Quantity	Price	Value	Your Cost	Cost/ha
Variable Costs							
	Seed	lb.	2	164	328	328	810.16
	Lime, applied	ton	0	0	0	0	0
	Fertilizer	N, P +	136	0	920.98	920.98	2274.821
	Fertilizer	K	136	0	0	0	0
	Herbicide Aim	acre	2	1.67	3.34	3.34	8.2498
	Herbicide Poast	acre	2	24.5	49	49	121.03
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide Intrepid 2f	acre	8	2.7	21.6	21.6	53.352
	Insecticide Actara	acre	5.5	10	55	55	135.85
	Insecticide Intrepid 2f	acre	8	2.7	21.6	21.6	53.352
	Insecticide permethrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide permethrin	acre	6	0.33	1.98	1.98	4.8906
	Fungicide Quadris	acre	15	2.72	40.9	40.9	101.023
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Quadris	acre	15	2.72	40.9	40.9	101.023
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Topsin 4.5f	acre	10	1.17	11.71	11.71	28.9237
	Fungicide Quadris	acre	15	2.72	40.9	40.9	101.023
	Application Labor	acre	15	11	165	165	407.55
	Plastic	roll	0	0	0	0	0
	Drip tape	roll	0	0	0	0	0
	Plastic Removal	acre	1	135	135	135	333.45
	Mulch lifter	acre	1	21.72	21.72	21.72	53.6484
	Nematicide	acre	0	0	0	0	0
	Tractor +Machinery+Lab	acre	1	118.9	118.9	118.9	293.683
	Air blast sprayer+tracto	acre	15	34.09	511.35	511.35	1263.035
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land rent	acre	1	70	70	70	172.9
	Irrigation	acre	6	82	492	492	1215.24
	Interest on Oper. Cap.	$	3964.35	0.05	198.217	198.22	489.6034
Pre-Harvest Variable Costs					3498.82	3498.8	8642.036
							0
Harvest and Marketing Costs							0
	Picking and Hauling	bu.	65	0.9	58.5	58.5	144.495
	Grading and Packing	bu.	65	0.75	48.75	48.75	120.4125
	Containers	ea.	65	1.54	100.1	100.1	247.247
	Marketing	bu.	65	0.4	26	26	64.22
Total Harvest and Marketing					233.35	233.35	576.3745
Total Variable Costs					3732.17		0
							0
Fixed Costs							0
	Machinery	acre	1	74.321	74.3206	74.32	183.5704
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Manage	$	4162.56	0.1	416.256	416.26	1028.162
Total Fixed Costs					575.577	575.58	1421.683
Total Budgeted Cost Per Acre					4307.74		10640.12
Total Returns Per Acre/ Hectare					3494.4		8631.168
Profit Per Acre/ Hectare					-813.34		-2008.95

Table 50. Enterprise budget for summer squash 2013, INORGWO at the 100% N rate (152 kg·ha^{-1})

	Summer Squash INORGWO 100% 2013						
Estimated Costs of Producing One Acre of Squash on Plastic for Fresh Market,							
Item		Unit	Quantity	Price	Value	Your Cost	Cost/ha
Variable Costs							
	Seed	lb.	2	164	328	328	810.16
	Lime, applied	ton	0	0	0	0	0
	Fertilizer	N,P+	136	0	850.56	850.56	2100.883
	Fertilizer	K	136	0	0	0	0
	Herbicide Aim	acre	2	1.67	3.34	3.34	8.2498
	Herbicide Poast	acre	2	24.5	49	49	121.03
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide Intrepid 2f	acre	8	2.7	21.6	21.6	53.352
	Insecticide Actara	acre	5.5	10	55	55	135.85
	Insecticide Intrepid 2f	acre	8	2.7	21.6	21.6	53.352
	Insecticide permethrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide permethrin	acre	6	0.33	1.98	1.98	4.8906
	Fungicide Quadris	acre	15	2.72	40.9	40.9	101.023
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Quadris	acre	15	2.72	40.9	40.9	101.023
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Topsin 4.5f	acre	10	1.17	11.71	11.71	28.9237
	Fungicide Quadris	acre	15	2.72	40.9	40.9	101.023
	Application Labor	acre	15	11	165	165	407.55
	Plastic	roll	0	0	0	0	0
	Drip tape	roll	0	0	0	0	0
	Plastic Removal	acre	1	135	135	135	333.45
	Mulch lifter	acre	1	21.72	21.72	21.72	53.6484
	Nematicide	acre	0	0	0	0	0
	Tractor +Machinery+Lal	acre	1	118.9	118.9	118.9	293.683
	Air blast sprayer+tracto	acre	15	34.09	511.35	511.35	1263.035
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land rent	acre	1	70	70	70	172.9
	Irrigation	acre	6	82	492	492	1215.24
	Interest on Oper. Cap.	$	3964.35	0.05	198.217	198.22	489.6034
Pre-Harvest Variable Costs					3428.4	3428.4	8468.148
Harvest and Marketing Costs							
	Picking and Hauling	bu.	77	0.9	69.3	69.3	171.171
	Grading and Packing	bu.	77	0.75	57.75	57.75	142.6425
	Containers	ea.	77	1.54	118.58	118.58	292.8926
	Marketing	bu.	77	0.4	30.8	30.8	76.076
Total Harvest and Marketing					276.43	276.43	682.7821
Total Variable Costs					3704.83		
Fixed Costs							
	Machinery	acre	1	74.321	74.3206	74.32	183.5704
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Manageı	$	4162.56	0.1	416.256	416.26	1028.162
Total Fixed Costs					575.577	575.58	1421.683
Total Budgeted Cost Per Acre					4280.4		10572.59
Total Returns Per Acre/ Hectare					4139.52		10224.61
Profit Per Acre/ Hectare					-140.88		-347.974

Table 51. Enterprise budget for summer squash 2013, HFF at the 80% N rate (121 kg·ha^{-1})

	Summer Squash HFF 80% 2013						
Estimated Costs of Producing One Acre of Squash on Plastic for Fresh Market,							
Item		Unit	Quantity	Price	Value	Your Cost	Cost/ha
Variable Costs							
	Seed	lb.	2	164	328	328	810.16
	Lime, applied	ton	0	0	0	0	0
	Fertilizer	N	108.8	11.22	1220.7	1220.7	3015.129
	Fertilizer	K	125	4.2	525	525	1296.75
	Herbicide Aim	acre	2	1.67	3.34	3.34	8.2498
	Herbicide Poast	acre	2	24.5	49	49	121.03
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide Intrepid 2f	acre	8	2.7	21.6	21.6	53.352
	Insecticide Actara	acre	5.5	10	55	55	135.85
	Insecticide Intrepid 2f	acre	8	2.7	21.6	21.6	53.352
	Insecticide permethrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide permethrin	acre	6	0.33	1.98	1.98	4.8906
	Fungicide Quadris	acre	15	2.72	40.9	40.9	101.023
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Quadris	acre	15	2.72	40.9	40.9	101.023
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Topsin 4.5f	acre	10	1.17	11.71	11.71	28.9237
	Fungicide Quadris	acre	15	2.72	40.9	40.9	101.023
	Application Labor	acre	15	11	165	165	407.55
	Plastic	roll	0	0	0	0	0
	Drip tape	roll	0	0	0	0	0
	Plastic Removal	acre	1	135	135	135	333.45
	Mulch lifter	acre	1	21.72	21.72	21.72	53.6484
	Nematicide	acre	0	0	0	0	0
	Tractor +Machinery+Lal	acre	1	118.9	118.9	118.9	293.683
	Air blast sprayer+tracto	acre	15	34.09	511.35	511.35	1263.035
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land rent	acre	1	70	70	70	172.9
	Irrigation	acre	6	82	492	492	1215.24
	Interest on Oper. Cap.	$	3964.3	0.05	198.22	198.22	489.6034
Pre-Harvest Variable Costs					4323.6	4323.5	10679.05
Harvest and Marketing Costs							
	Picking and Hauling	bu.	30	0.9	27	27	66.69
	Grading and Packing	bu.	30	0.75	22.5	22.5	55.575
	Containers	ea.	30	1.54	46.2	46.2	114.114
	Marketing	bu.	30	0.4	12	12	29.64
Total Harvest and Marketing					107.7	107.7	266.019
Total Variable Costs					4431.3		
Fixed Costs							
	Machinery	acre	1	74.321	74.321	74.32	183.5704
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Managei	$	4162.6	0.1	416.26	416.26	1028.162
Total Fixed Costs					575.58	575.58	1421.683
Total Budgeted Cost Per Acre					5006.8		12366.8
Total Returns Per Acre/ Hectare					2507.4		6193.278
Profit Per Acre/ Hectare					-2499.4		-6173.52

Table 52. Enterprise budget for summer squash 2013, INORGWM at the 80% N rate (121 kg·ha^{-1})

	Summer Squash INORGWM 80% 2013						
Estimated Costs of Producing One Acre of Squash on Plastic for Fresh Market,							
Item		Unit	Quantity	Price	Value	Your Cost	Cost/ha
Variable Costs							
	Seed	lb.	2	164	328	328	810.16
	Lime, applied	ton	0	0	0	0	0
	Fertilizer	N, P +	108.8	0	736.78	736.78	1819.847
	Fertilizer	K	136	0	0	0	0
	Herbicide Aim	acre	2	1.67	3.34	3.34	8.2498
	Herbicide Poast	acre	2	24.5	49	49	121.03
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide Intrepid 2f	acre	8	2.7	21.6	21.6	53.352
	Insecticide Actara	acre	5.5	10	55	55	135.85
	Insecticide Intrepid 2f	acre	8	2.7	21.6	21.6	53.352
	Insecticide permethrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide permethrin	acre	6	0.33	1.98	1.98	4.8906
	Fungicide Quadris	acre	15	2.72	40.9	40.9	101.023
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Quadris	acre	15	2.72	40.9	40.9	101.023
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Topsin 4.5f	acre	10	1.17	11.71	11.71	28.9237
	Fungicide Quadris	acre	15	2.72	40.9	40.9	101.023
	Application Labor	acre	15	11	165	165	407.55
	Plastic	roll	0	0	0	0	0
	Drip tape	roll	0	0	0	0	0
	Plastic Removal	acre	1	135	135	135	333.45
	Mulch lifter	acre	1	21.72	21.72	21.72	53.6484
	Nematicide	acre	0	0	0	0	0
	Tractor +Machinery+Lal	acre	1	118.9	118.9	118.9	293.683
	Air blast sprayer+tracto	acre	15	34.09	511.35	511.35	1263.035
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land rent	acre	1	70	70	70	172.9
	Irrigation	acre	6	82	492	492	1215.24
	Interest on Oper. Cap.	$	3964.3	0.05	198.22	198.22	489.6034
Pre-Harvest Variable Costs					3314.6	3314.6	8187.062
Harvest and Marketing Costs							
	Picking and Hauling	bu.	56	0.9	50.4	50.4	124.488
	Grading and Packing	bu.	56	0.75	42	42	103.74
	Containers	ea.	56	1.54	86.24	86.24	213.0128
	Marketing	bu.	56	0.4	22.4	22.4	55.328
Total Harvest and Marketing					201.04	201.04	496.5688
Total Variable Costs					3515.7		
Fixed Costs							
	Machinery	acre	1	74.321	74.321	74.32	183.5704
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Manager	$	4162.6	0.1	416.26	416.26	1028.162
Total Fixed Costs					575.58	575.58	1421.683
Total Budgeted Cost Per Acre					4091.2		10105.26
Total Returns Per Acre/ Hectare					3010.56		7436.083
Profit Per Acre/ Hectare					-1080.64		-2669.18

Table 53. Enterprise budget for summer squash 2013, INORGWO at the 80% N rate (121 kg·ha^{-1})

	Summer Squash INORGWO 80% 2013						
Estimated Costs of Producing One Acre of Squash on Plastic for Fresh Market,							
Item		Unit	Quantity	Price	Value	Your Cost	Cost/ha
Variable Costs							
	Seed	lb.	2	164	328	328	810.16
	Lime, applied	ton	0	0	0	0	0
	Fertilizer	N,P+	108.8	0	680.44	680.44	1680.687
	Fertilizer	K	136	0	0	0	0
	Herbicide Aim	acre	2	1.67	3.34	3.34	8.2498
	Herbicide Poast	acre	2	24.5	49	49	121.03
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide Intrepid 2f	acre	8	2.7	21.6	21.6	53.352
	Insecticide Actara	acre	5.5	10	55	55	135.85
	Insecticide Intrepid 2f	acre	8	2.7	21.6	21.6	53.352
	Insecticide permethrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide permethrin	acre	6	0.33	1.98	1.98	4.8906
	Fungicide Quadris	acre	15	2.72	40.9	40.9	101.023
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Quadris	acre	15	2.72	40.9	40.9	101.023
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Topsin 4.5f	acre	10	1.17	11.71	11.71	28.9237
	Fungicide Quadris	acre	15	2.72	40.9	40.9	101.023
	Application Labor	acre	15	11	165	165	407.55
	Plastic	roll	0	0	0	0	0
	Drip tape	roll	0	0	0	0	0
	Plastic Removal	acre	1	135	135	135	333.45
	Mulch lifter	acre	1	21.72	21.72	21.72	53.6484
	Nematicide	acre	0	0	0	0	0
	Tractor +Machinery+Lal	acre	1	118.9	118.9	118.9	293.683
	Air blast sprayer+tracto	acre	15	34.09	511.35	511.35	1263.035
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land rent	acre	1	70	70	70	172.9
	Irrigation	acre	6	82	492	492	1215.24
	Interest on Oper. Cap.	$	3964.3	0.05	198.22	198.22	489.6034
Pre-Harvest Variable Costs					3258.3	3258.3	8048.001
Harvest and Marketing Costs							
	Picking and Hauling	bu.	39	0.9	35.1	35.1	86.697
	Grading and Packing	bu.	39	0.75	29.25	29.25	72.2475
	Containers	ea.	39	1.54	60.06	60.06	148.3482
	Marketing	bu.	39	0.4	15.6	15.6	38.532
Total Harvest and Marketing					140.01	140.01	345.8247
Total Variable Costs					3398.3		
Fixed Costs							
	Machinery	acre	1	74.321	74.321	74.32	183.5704
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Manager	$	4162.6	0.1	416.26	416.26	1028.162
Total Fixed Costs					575.58	575.58	1421.683
Total Budgeted Cost Per Acre					3973.9		9815.533
Total Returns Per Acre/ Hectare					2096.6		5178.602
Profit Per Acre/ Hectare					-1877.3		-4636.93

Table 54. Enterprise budget for summer squash 2013, HFF at the 60% N rate (91 kg·ha^{-1})

	Summer Squash HFF 60% 2013						
Estimated Costs of Producing One Acre of Squash on Plastic for Fresh Market,							
Item		Unit	Quantity	Price	Value	Your Cost	Cost/ha
Variable Costs							
	Seed	lb.	2	164	328	328	810.16
	Lime, applied	ton	0	0	0	0	0
	Fertilizer	N	81.6	11.22	915.55	915.55	2261.409
	Fertilizer	K	128	4.2	537.6	537.6	1327.872
	Herbicide Aim	acre	2	1.67	3.34	3.34	8.2498
	Herbicide Poast	acre	2	24.5	49	49	121.03
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide Intrepid 2f	acre	8	2.7	21.6	21.6	53.352
	Insecticide Actara	acre	5.5	10	55	55	135.85
	Insecticide Intrepid 2f	acre	8	2.7	21.6	21.6	53.352
	Insecticide permethrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide permethrin	acre	6	0.33	1.98	1.98	4.8906
	Fungicide Quadris	acre	15	2.72	40.9	40.9	101.023
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Quadris	acre	15	2.72	40.9	40.9	101.023
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Topsin 4.5f	acre	10	1.17	11.71	11.71	28.9237
	Fungicide Quadris	acre	15	2.72	40.9	40.9	101.023
	Application Labor	acre	15	11	165	165	407.55
	Plastic	roll	0	0	0	0	0
	Drip tape	roll	0	0	0	0	0
	Plastic Removal	acre	1	135	135	135	333.45
	Mulch lifter	acre	1	21.72	21.72	21.72	53.6484
	Nematicide	acre	0	0	0	0	0
	Tractor +Machinery+Lab	acre	1	118.9	118.9	118.9	293.683
	Air blast sprayer+tracto	acre	15	34.09	511.35	511.35	1263.035
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land rent	acre	1	70	70	70	172.9
	Irrigation	acre	6	82	492	492	1215.24
	Interest on Oper. Cap.	$	3964.3	0.05	198.22	198.22	489.6034
Pre-Harvest Variable Costs					4031	4031	9956.57
Harvest and Marketing Costs							
	Picking and Hauling	bu.	20	0.9	18	18	44.46
	Grading and Packing	bu.	20	0.75	15	15	37.05
	Containers	ea.	20	1.54	30.8	30.8	76.076
	Marketing	bu.	20	0.4	8	8	19.76
Total Harvest and Marketing			20		71.8	71.8	177.346
Total Variable Costs					4102.8		
Fixed Costs							
	Machinery	acre	1	74.321	74.321	74.32	183.5704
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Manager	$	4162.6	0.1	416.26	416.26	1028.162
Total Fixed Costs					575.58	575.58	1421.683
Total Budgeted Cost Per Acre					4678.4		11555.65
Total Returns Per Acre/ Hectare					1671.6		4128.852
Profit Per Acre/ Hectare					-3006.8		-7426.8

Table 55. Enterprise budget for summer squash 2013, INORGWM at the 60% N rate (91 $kg \cdot ha^{-1}$)

	Summer Squash INORGWM 60% 2013						
Estimated Costs of Producing One Acre of Squash on Plastic for Fresh Market,							
Item		Unit	Quantity	Price	Value	Your Cost	Cost/ha
Variable Costs							
	Seed	lb.	2	164	328	328	810.16
	Lime, applied	ton	0	0	0	0	0
	Fertilizer	N, P +	81.6	0	552.88	552.88	1365.614
	Fertilizer	K	136	0	0	0	0
	Herbicide Aim	acre	2	1.67	3.34	3.34	8.2498
	Herbicide Poast	acre	2	24.5	49	49	121.03
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide Intrepid 2f	acre	8	2.7	21.6	21.6	53.352
	Insecticide Actara	acre	5.5	10	55	55	135.85
	Insecticide Intrepid 2f	acre	8	2.7	21.6	21.6	53.352
	Insecticide permethrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide permethrin	acre	6	0.33	1.98	1.98	4.8906
	Fungicide Quadris	acre	15	2.72	40.9	40.9	101.023
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Quadris	acre	15	2.72	40.9	40.9	101.023
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Topsin 4.5f	acre	10	1.17	11.71	11.71	28.9237
	Fungicide Quadris	acre	15	2.72	40.9	40.9	101.023
	Application Labor	acre	15	11	165	165	407.55
	Plastic	roll	0	0	0	0	0
	Drip tape	roll	0	0	0	0	0
	Plastic Removal	acre	1	135	135	135	333.45
	Mulch lifter	acre	1	21.72	21.72	21.72	53.6484
	Nematicide	acre	0	0	0	0	0
	Tractor +Machinery+Lal	acre	1	118.9	118.9	118.9	293.683
	Air blast sprayer+tracto	acre	15	34.09	511.35	511.35	1263.035
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land rent	acre	1	70	70	70	172.9
	Irrigation	acre	6	82	492	492	1215.24
	Interest on Oper. Cap.	$	3964.3	0.05	198.22	198.22	489.6034
Pre-Harvest Variable Costs					3130.7	3130.7	7732.829
Harvest and Marketing Costs							
	Picking and Hauling	bu.	52	0.9	46.8	46.8	115.596
	Grading and Packing	bu.	52	0.75	39	39	96.33
	Containers	ea.	52	1.54	80.08	80.08	197.7976
	Marketing	bu.	52	0.4	20.8	20.8	51.376
Total Harvest and Marketing					186.68	186.68	461.0996
Total Variable Costs					3317.4		
Fixed Costs							
	Machinery	acre	1	74.321	74.321	74.32	183.5704
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Manager	$	4162.6	0.1	416.26	416.26	1028.162
Total Fixed Costs					575.58	575.58	1421.683
Total Budgeted Cost Per Acre					3893		9615.71
Total Returns Per Acre/ Hectare					2795.52		6904.934
Profit Per Acre/ Hectare					-1097.48		-2710.78

Table 56. Enterprise budget for summer squash 2013, INORGWO at the 60% N rate (91 kg·ha^{-1})

	Summer Squash INORGWO 60% 2013						
Estimated Costs of Producing One Acre of Squash on Plastic for Fresh Market,							
Item		Unit	Quantity	Price	Value	Your Cost	Cost/ha
Variable Costs							
	Seed	lb.	2	164	328	328	810.16
	Lime, applied	ton	0	0	0	0	0
	Fertilizer	N,P+	81.6	0	510.33	510.33	1260.515
	Fertilizer	K	136	0	0	0	0
	Herbicide Aim	acre	2	1.67	3.34	3.34	8.2498
	Herbicide Poast	acre	2	24.5	49	49	121.03
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide Intrepid 2f	acre	8	2.7	21.6	21.6	53.352
	Insecticide Actara	acre	5.5	10	55	55	135.85
	Insecticide Intrepid 2f	acre	8	2.7	21.6	21.6	53.352
	Insecticide permethrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide permethrin	acre	6	0.33	1.98	1.98	4.8906
	Fungicide Quadris	acre	15	2.72	40.9	40.9	101.023
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Quadris	acre	15	2.72	40.9	40.9	101.023
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Topsin 4.5f	acre	10	1.17	11.71	11.71	28.9237
	Fungicide Quadris	acre	15	2.72	40.9	40.9	101.023
	Application Labor	acre	15	11	165	165	407.55
	Plastic	roll	0	0	0	0	0
	Drip tape	roll	0	0	0	0	0
	Plastic Removal	acre	1	135	135	135	333.45
	Mulch lifter	acre	1	21.72	21.72	21.72	53.6484
	Nematicide	acre	0	0	0	0	0
	Tractor +Machinery+Lal	acre	1	118.9	118.9	118.9	293.683
	Air blast sprayer+tracto	acre	15	34.09	511.35	511.35	1263.035
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land rent	acre	1	70	70	70	172.9
	Irrigation	acre	6	82	492	492	1215.24
	Interest on Oper. Cap.	$	3964.3	0.05	198.22	198.22	489.6034
Pre-Harvest Variable Costs					3088.2	3088.2	7627.854
Harvest and Marketing Costs							
	Picking and Hauling	bu.	38	0.9	34.2	34.2	84.474
	Grading and Packing	bu.	38	0.75	28.5	28.5	70.395
	Containers	ea.	38	1.54	58.52	58.52	144.5444
	Marketing	bu.	38	0.4	15.2	15.2	37.544
Total Harvest and Marketing					136.42	136.42	336.9574
Total Variable Costs					3224.6		
Fixed Costs							
	Machinery	acre	1	74.321	74.321	74.32	183.5704
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Manager	$	4162.6	0.1	416.26	416.26	1028.162
Total Fixed Costs					575.58	575.58	1421.683
Total Budgeted Cost Per Acre					3800.2		
Total Returns Per Acre/ Hectare					2042.88		5045.914
Profit Per Acre/ Hectare					-1757.32		5045.914

Table 57. Enterprise budget for summer squash 2013, NON at the 0% N rate (0 kg·ha^{-1})

	Summer Squash NON 0% 2013						
Estimated Costs of Producing One Acre of Squash on Plastic for Fresh Market,							
Item		Unit	Quantity	Price	Value	Your Cost	Cost/ha
Variable Costs							
	Seed	lb.	2	164	328	328	810.16
	Lime, applied	ton	0	0	0	0	0
	Fertilizer	N	0	0	0	0	0
	Fertilizer	P	117		299	299	738.53
	Fertilizer	K	136	0	582.85	582.85	1439.64
	Herbicide Aim	acre	2	1.67	3.34	3.34	8.2498
	Herbicide Poast	acre	2	24.5	49	49	121.03
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide Intrepid 2f	acre	8	2.7	21.6	21.6	53.352
	Insecticide Actara	acre	5.5	10	55	55	135.85
	Insecticide Intrepid 2f	acre	8	2.7	21.6	21.6	53.352
	Insecticide permethrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide permethrin	acre	6	0.33	1.98	1.98	4.8906
	Fungicide Quadris	acre	15	2.72	40.9	40.9	101.023
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Quadris	acre	15	2.72	40.9	40.9	101.023
	Fungicide Bravo WS	acre	2	4.46	8.92	8.92	22.0324
	Fungicide Topsin 4.5f	acre	10	1.17	11.71	11.71	28.9237
	Fungicide Quadris	acre	15	2.72	40.9	40.9	101.023
	Application Labor	acre	15	11	165	165	407.55
	Plastic	roll	0	0	0	0	0
	Drip tape	roll	0	0	0	0	0
	Plastic Removal	acre	1	135	135	135	333.45
	Mulch lifter	acre	1	21.72	21.72	21.72	53.6484
	Nematicide	acre	0	0	0	0	0
	Tractor +Machinery+Lab	acre	1	118.9	118.9	118.9	293.683
	Air blast sprayer+tracto	acre	15	34.09	511.35	511.35	1263.035
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land rent	acre	1	70	70	70	172.9
	Irrigation	acre	6	82	492	492	1215.24
	Interest on Oper. Cap.	$	3964.35	0.05	198.217	198.22	489.6034
Pre-Harvest Variable Costs					3459.69	3459.7	
Harvest and Marketing Costs							0
	Picking and Hauling	bu.	4	0.9	3.6	3.6	8.892
	Grading and Packing	bu.	4	0.75	3	3	7.41
	Containers	ea.	4	1.54	6.16	6.16	15.2152
	Marketing	bu.	4	0.4	1.6	1.6	3.952
Total Harvest and Marketing					14.36	14.36	
Total Variable Costs					3474.05		
Fixed Costs							0
	Machinery	acre	1	74.321	74.3206	74.32	183.5704
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Manager	$	4162.56	0.1	416.256	416.26	1028.162
Total Fixed Costs					575.577	575.58	
Total Budgeted Cost Per Acre					4049.62		10002.56
Total Returns Per Acre/Hectare					215.04		531.1488
Profit Per Acre/Hectare					-3834.58		-9471.41

Table 58. Enterprise budget for collard crop 2013, HFF at the 100% N rate (110 kg·ha^{-1})

	Collard Crop HFF 100% 2013						
Estimated Costs of Producing One Acre of Collard Greens for Fresh Market,							
Item		Unit	Quantity	Price	Value	Your Cost	Cost/ha
Cash Expenses, Pre-Harvest:							
	Seedlings	1000	16	16	256	256	632.32
	Lime, applied	ton	0.15	30	4.5	4.5	11.115
	Fertilizer	N	98	11.22	1099.56	1099.6	2716.012
	Fertilizer	K	89	4.28	380.92	380.92	940.8724
	Herbicide Glyphosate	acre	2	4	8	8	19.76
	Herbicide Aim	acre	2	1.67	3.34	3.34	8.2498
	Herbicide Glyphosate	acre	2	4	8	8	19.76
	Herbicide Aim	acre	2	1.67	3.34	3.34	8.2498
	Insecticide Sevin xlr	acre	2	14	28	28	69.16
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide Sevin xlr	acre	2	14	28	28	69.16
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Fungicide	acre	0	0	0	0	0
	Tractor + Sprayer	acre	1	382.57	382.57	382.57	944.9479
	Truck (pickup and atv u	mi.	20	0.56	11.2	11.2	27.664
	Labor (incl. transplantir	hr.	12	10	120	120	296.4
	Irrigation	acre	6	82	492	492	1215.24
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land Rent	acre	1	40	40	40	98.8
	Interest on Cash Expen	$	2702.82	0.05	135.141	135.14	333.7958
Total Pre-Harvest Cash Expenses					3226.511	3226.5	7969.455
							0
Fixed Costs, Pre-Harvest:							0
	Tractor + Machinery	acre	1	109.25	109.2527	109.25	269.8475
	Truck (pickup)	mi.	20	0.17	3.4	3.4	8.398
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Managei	$	406.25	0.1	40.625	40.63	100.3561
Total Pre-Harvest Fixed Costs					238.2777		0
							0
Total Pre-Harvest Costs					3464.789	238.28	588.5516
Harvest Costs:							0
	Machinery Labor	acre	1	11	11	11	
	Harvest Labor	box	1	122	122	122	
	Boxes**	each	1.6	122	195.2	195.2	482.144
	Marketing	box	0.4	122	48.8	48.8	120.536
	Cooling	box	0.25	122	30.5	30.5	75.335
	Hauling	box	1.25	122	152.5	152.5	376.675
Total Harvest Costs					560	560	1383.2
Total Costs					4024.789		9941.229
Total Returns Per Acre/ Hectare					3416		8437.52
Profit Per Acre/Hectare					-608.789		-1503.71

Table 59. Enterprise budget for collard crop 2013, INORGWM at the 100% N rate (110 kg·ha^{-1})

	Collard Crop INORGWM 100% 2013						0
Estimated Costs of Producing One Acre of Collard Greens for Fresh Market,							0
Item		Unit	Quantity	Price	Value	Your Cost	Cost/ha
Cash Expenses, Pre-Harvest:							
	Seedlings	1000	16	16	256	256	632.32
	Lime, applied	ton	0.15	30	4.5	4.5	11.115
	Fertilizer	N,P+	98	0	879.13	879.13	2171.451
	Fertilizer	K	98	0	0	0	0
	Herbicide Glyphosate	acre	2	4	8	8	19.76
	Herbicide Aim	acre	2	1.67	3.34	3.34	8.2498
	Herbicide Glyphosate	acre	2	4	8	8	19.76
	Herbicide Aim	acre	2	1.67	3.34	3.34	8.2498
	Insecticide Sevin xlr	acre	2	14	28	28	69.16
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide Sevin xlr	acre	2	14	28	28	69.16
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Fungicide	acre	0	0	0	0	0
	Tractor + Sprayer	acre	1	382.57	382.57	382.57	944.9479
	Truck (pickup and atv u	mi.	20	0.56	11.2	11.2	27.664
	Labor (incl. transplantir	hr.	12	10	120	120	296.4
	Irrigation	acre	6	82	492	492	1215.24
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land Rent	acre	1	40	40	40	98.8
	Interest on Cash Expen	$	2702.82	0.05	135.141	135.14	333.7958
Total Pre-Harvest Cash Expenses					2625.161	2625.2	6484.244
							0
Fixed Costs, Pre-Harvest:							0
	Tractor + Machinery	acre	1	109.25	109.2527	109.25	269.8475
	Truck (pickup)	mi.	20	0.17	3.4	3.4	8.398
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Managei	$	406.25	0.1	40.625	40.63	100.3561
Total Pre-Harvest Fixed Costs					238.2777		0
							0
Total Pre-Harvest Costs					2863.439	238.28	588.5516
Harvest Costs:							0
	Machinery Labor	acre	1	11	11	11	
	Harvest Labor	box	1	183	183	183	
	Boxes**	each	1.6	183	292.8	292.8	723.216
	Marketing	box	0.4	183	73.2	73.2	180.804
	Cooling	box	0.25	183	45.75	45.75	113.0025
	Hauling	box	1.25	183	228.75	228.75	565.0125
Total Harvest Costs					834.5	834.5	2061.215
Total Costs					3697.939		9133.909
Total Returns Per Acre/ Hectare					2104.5		5198.115
Profit Per Acre/Hectare					-1593.44		-3935.79

Table 60. Enterprise budget for collard crop 2013, INORGWO at the 100% N rate (110 kg·ha^{-1})

	Collard Crop INORGWO 100% 2013						
Estimated Costs of Producing One Acre of Collard Greens for Fresh Market,							
Item		Unit	Quantity	Price	Value	Your Cost	Cost/ha
Cash Expenses, Pre-Harvest:							
	Seedlings	1000	16	16	256	256	632.32
	Lime, applied	ton	0.15	30	4.5	4.5	11.115
	Fertilizer	N,P+	98	0	811.51	811.51	2004.43
	Fertilizer	K	98	0	0	0	0
	Herbicide Glyphosate	acre	2	4	8	8	19.76
	Herbicide Aim	acre	2	1.67	3.34	3.34	8.2498
	Herbicide Glyphosate	acre	2	4	8	8	19.76
	Herbicide Aim	acre	2	1.67	3.34	3.34	8.2498
	Insecticide Sevin xlr	acre	2	14	28	28	69.16
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide Sevin xlr	acre	2	14	28	28	69.16
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Fungicide	acre	0	0	0	0	0
	Tractor + Sprayer	acre	1	382.57	382.57	382.57	944.9479
	Truck (pickup and atv u	mi.	20	0.56	11.2	11.2	27.664
	Labor (incl. transplantir	hr.	12	10	120	120	296.4
	Irrigation	acre	6	82	492	492	1215.24
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land Rent	acre	1	40	40	40	98.8
	Interest on Cash Expen	$	2702.82	0.05	135.141	135.14	333.7958
Total Pre-Harvest Cash Expenses					2557.541	2557.5	6317.025
							0
Fixed Costs, Pre-Harvest:							0
	Tractor + Machinery	acre	1	109.25	109.2527	109.25	269.8475
	Truck (pickup)	mi.	20	0.17	3.4	3.4	8.398
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Manager	$	406.25	0.1	40.625	40.63	100.3561
Total Pre-Harvest Fixed Costs					238.2777		0
							0
Total Pre-Harvest Costs					2795.819	238.28	588.5516
Harvest Costs:							0
	Machinery Labor	acre	1	11	11	11	
	Harvest Labor	box	1	113	113	113	
	Boxes**	each	1.6	113	180.8	180.8	446.576
	Marketing	box	0.4	113	45.2	45.2	111.644
	Cooling	box	0.25	113	28.25	28.25	69.7775
	Hauling	box	1.25	113	141.25	141.25	348.8875
Total Harvest Costs					519.5	519.5	1283.165
Total Costs					3315.319		8188.838
Total Returns Per Acre/ Hectare					1299.5		3209.765
Profit Per Acre/Hectare					-2015.82		-4979.07

Table 61. Enterprise budget for collard crop 2013, HFF at the 80% N rate (88 kg·ha^{-1})

	Collard Crop HFF 80% 2013						
Estimated Costs of Producing One Acre of Collard Greens for Fresh Market,							
Item		Unit	Quantity	Price	Value	Your Cost	Cost/ha
Cash Expenses, Pre-Harvest:							
	Seedlings	1000	16	16	256	256	632.32
	Lime, applied	ton	0.15	30	4.5	4.5	11.115
	Fertilizer	N	78.4	11.22	879.65	879.65	2172.736
	Fertilizer	K	90.2	4.28	386.06	386.06	953.5682
	Herbicide Glyphosate	acre	2	4	8	8	19.76
	Herbicide Aim	acre	2	1.67	3.34	3.34	8.2498
	Herbicide Glyphosate	acre	2	4	8	8	19.76
	Herbicide Aim	acre	2	1.67	3.34	3.34	8.2498
	Insecticide Sevin xlr	acre	2	14	28	28	69.16
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide Sevin xlr	acre	2	14	28	28	69.16
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Fungicide	acre	0	0	0	0	0
	Tractor + Sprayer	acre	1	382.57	382.57	382.57	944.9479
	Truck (pickup and atv u	mi.	20	0.56	11.2	11.2	27.664
	Labor (incl. transplantir	hr.	12	10	120	120	296.4
	Irrigation	acre	6	82	492	492	1215.24
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land Rent	acre	1	40	40	40	98.8
	Interest on Cash Expen	$	2702.8	0.05	135.14	135.14	333.7958
Total Pre-Harvest Cash Expenses					3011.7	3011.7	7438.899
							0
Fixed Costs, Pre-Harvest:							0
	Tractor + Machinery	acre	1	109.25	109.25	109.25	269.8475
	Truck (pickup)	mi.	20	0.17	3.4	3.4	8.398
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Manager	$	406.25	0.1	40.625	40.63	100.3561
Total Pre-Harvest Fixed Costs					238.28		0
							0
Total Pre-Harvest Costs					3250	238.28	588.5516
Harvest Costs:							0
	Machinery Labor	acre	1	11	11	11	
	Harvest Labor	box	1	98	98	98	
	Boxes**	each	1.6	98	156.8	156.8	387.296
	Marketing	box	0.4	98	39.2	39.2	96.824
	Cooling	box	0.25	98	24.5	24.5	60.515
	Hauling	box	1.25	98	122.5	122.5	302.575
Total Harvest Costs					452	452	1116.44
Total Costs					3702		9143.94
Total Returns Per Acre/ Hectare					2744		6777.68
Profit Per Acre/Hectare					-958		-2366.26

Table 62. Enterprise budget for collard crop 2013, INORGWM at the 80% N rate (88 kg·ha^{-1})

	Collard Crop INORGWM 80% 2013						
Estimated Costs of Producing One Acre of Collard Greens for Fresh Market,							
Item		Unit	Quantity	Price	Value	Your Cost	Cost/ha
Cash Expenses, Pre-Harvest:							
	Seedlings	1000	16	16	256	256	632.32
	Lime, applied	ton	0.15	30	4.5	4.5	11.115
	Fertilizer	N,P+	78.4	0	703.3	703.3	1737.151
	Fertilizer	K	98	0	0	0	0
	Herbicide Glyphosate	acre	2	4	8	8	19.76
	Herbicide Aim	acre	2	1.67	3.34	3.34	8.2498
	Herbicide Glyphosate	acre	2	4	8	8	19.76
	Herbicide Aim	acre	2	1.67	3.34	3.34	8.2498
	Insecticide Sevin xlr	acre	2	14	28	28	69.16
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide Sevin xlr	acre	2	14	28	28	69.16
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Fungicide	acre	0	0	0	0	0
	Tractor + Sprayer	acre	1	382.57	382.57	382.57	944.9479
	Truck (pickup and atv u	mi.	20	0.56	11.2	11.2	27.664
	Labor (incl. transplantir	hr.	12	10	120	120	296.4
	Irrigation	acre	6	82	492	492	1215.24
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land Rent	acre	1	40	40	40	98.8
	Interest on Cash Expen	$	2702.8	0.05	135.14	135.14	333.7958
Total Pre-Harvest Cash Expenses					2449.3	2449.3	6049.771
							0
Fixed Costs, Pre-Harvest:							0
	Tractor + Machinery	acre	1	109.25	109.25	109.25	269.8475
	Truck (pickup)	mi.	20	0.17	3.4	3.4	8.398
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Manager	$	406.25	0.1	40.625	40.63	100.3561
Total Pre-Harvest Fixed Costs					238.28		0
							0
Total Pre-Harvest Costs					2687.6	238.28	588.5516
Harvest Costs:							0
	Machinery Labor	acre	1	11	11	11	
	Harvest Labor	box	1	165	165	165	
	Boxes**	each	1.6	165	264	264	652.08
	Marketing	box	0.4	165	66	66	163.02
	Cooling	box	0.25	165	41.25	41.25	101.8875
	Hauling	box	1.25	165	206.25	206.25	509.4375
Total Harvest Costs					753.5	753.5	1861.145
Total Costs					3441.1		8499.517
Total Returns Per Acre/ Hectare					1897.5		4686.825
Profit Per Acre/Hectare					-1543.6		-3812.69

Table 63. Enterprise budget for collard crop 2013, INORGWO at the 80% N rate (88 kg·ha^{-1})

	Collard Crop INORGWO 80% 2013						
Estimated Costs of Producing One Acre of Collard Greens for Fresh Market,							
Item		Unit	Quantity	Price	Value	Your Cost	Cost/ha
Cash Expenses, Pre-Harvest:							
	Seedlings	1000	16	16	256	256	632.32
	Lime, applied	ton	0.15	30	4.5	4.5	11.115
	Fertilizer	N,P+	78.4	0	646.2	649.2	1603.524
	Fertilizer	K	98	0	0	0	0
	Herbicide Glyphosate	acre	2	4	8	8	19.76
	Herbicide Aim	acre	2	1.67	3.34	3.34	8.2498
	Herbicide Glyphosate	acre	2	4	8	8	19.76
	Herbicide Aim	acre	2	1.67	3.34	3.34	8.2498
	Insecticide Sevin xlr	acre	2	14	28	28	69.16
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide Sevin xlr	acre	2	14	28	28	69.16
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Fungicide	acre	0	0	0	0	0
	Tractor + Sprayer	acre	1	382.57	382.57	382.57	944.9479
	Truck (pickup and atv u	mi.	20	0.56	11.2	11.2	27.664
	Labor (incl. transplantir	hr.	12	10	120	120	296.4
	Irrigation	acre	6	82	492	492	1215.24
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land Rent	acre	1	40	40	40	98.8
	Interest on Cash Expen	$	2702.8	0.05	135.14	135.14	333.7958
Total Pre-Harvest Cash Expenses					2392.2	2395.2	5916.144
							0
Fixed Costs, Pre-Harvest:							0
	Tractor + Machinery	acre	1	109.25	109.25	109.25	269.8475
	Truck (pickup)	mi.	20	0.17	3.4	3.4	8.398
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Managei	$	406.25	0.1	40.625	40.63	100.3561
Total Pre-Harvest Fixed Costs					238.28		0
							0
Total Pre-Harvest Costs					2630.5	238.28	588.5516
Harvest Costs:							0
	Machinery Labor	acre	1	11	11	11	
	Harvest Labor	box	1	6	6	6	
	Boxes**	each	1.6	6	9.6	9.6	23.712
	Marketing	box	0.4	6	2.4	2.4	5.928
	Cooling	box	0.25	6	1.5	1.5	3.705
	Hauling	box	1.25	6	7.5	7.5	18.525
Total Harvest Costs					38	38	93.86
Total Costs					2668.5		6591.195
Total Returns Per Acre/ Hectare					69		170.43
Profit Per Acre/Hectare					-2599.5		-6420.77

Table 64. Enterprise budget for collard crop 2013, HFF at the 60% N rate (66 kg·ha^{-1})

	Collard Crop HFF 60% 2013						
Estimated Costs of Producing One Acre of Collard Greens for Fresh Market,							
Item		Unit	Quantity	Price	Value	Your Cost	Cost/ha
Cash Expenses, Pre-Harvest:							
	Seedlings	1000	16	16	256	256	632.32
	Lime, applied	ton	0.15	30	4.5	4.5	11.115
	Fertilizer	N	58.8	11.22	659.74	659.74	1629.558
	Fertilizer	K	92.12	4.28	394.27	394.27	973.8469
	Herbicide Glyphosate	acre	2	4	8	8	19.76
	Herbicide Aim	acre	2	1.67	3.34	3.34	8.2498
	Herbicide Glyphosate	acre	2	4	8	8	19.76
	Herbicide Aim	acre	2	1.67	3.34	3.34	8.2498
	Insecticide Sevin xlr	acre	2	14	28	28	69.16
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide Sevin xlr	acre	2	14	28	28	69.16
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Fungicide	acre	0	0	0	0	0
	Tractor + Sprayer	acre	1	382.57	382.57	382.57	944.9479
	Truck (pickup and atv u	mi.	20	0.56	11.2	11.2	27.664
	Labor (incl. transplantir	hr.	12	10	120	120	296.4
	Irrigation	acre	6	82	492	492	1215.24
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land Rent	acre	1	40	40	40	98.8
	Interest on Cash Expen	$	2702.8	0.05	135.14	135.14	333.7958
Total Pre-Harvest Cash Expenses					2800	2800	6916
							0
Fixed Costs, Pre-Harvest:							0
	Tractor + Machinery	acre	1	109.25	109.25	109.25	269.8475
	Truck (pickup)	mi.	20	0.17	3.4	3.4	8.398
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Manage	$	406.25	0.1	40.625	40.63	100.3561
Total Pre-Harvest Fixed Costs					238.28		0
							0
Total Pre-Harvest Costs					3038.3	238.28	588.5516
Harvest Costs:							0
	Machinery Labor	acre	1	11	11	11	
	Harvest Labor	box	1	94	94	94	
	Boxes**	each	1.6	94	150.4	150.4	371.488
	Marketing	box	0.4	94	37.6	37.6	92.872
	Cooling	box	0.25	94	23.5	23.5	58.045
	Hauling	box	1.25	94	117.5	117.5	290.225
Total Harvest Costs					434	434	1071.98
Total Costs					3472.3		8576.581
Total Returns Per Acre/ Hectare					2632		6501.04
Profit Per Acre/Hectare					-840.3		-2075.54

Table 65. Enterprise budget for collard crop 2013, INORGWM at the 60% N rate (66 kg·ha^{-1})

	Collard Crop INORGWM 60% 2013						
Estimated Costs of Producing One Acre of Collard Greens for Fresh Market,							
Item		Unit	Quantity	Price	Value	Your Cost	Cost/ha
Cash Expenses, Pre-Harvest:							
	Seedlings	1000	16	16	256	256	632.32
	Lime, applied	ton	0.15	30	4.5	4.5	11.115
	Fertilizer	N,P+	58.8	0	527.5	527.5	1302.925
	Fertilizer	K	98	0	0	0	0
	Herbicide Glyphosate	acre	2	4	8	8	19.76
	Herbicide Aim	acre	2	1.67	3.34	3.34	8.2498
	Herbicide Glyphosate	acre	2	4	8	8	19.76
	Herbicide Aim	acre	2	1.67	3.34	3.34	8.2498
	Insecticide Sevin xlr	acre	2	14	28	28	69.16
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide Sevin xlr	acre	2	14	28	28	69.16
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Fungicide	acre	0	0	0	0	0
	Tractor + Sprayer	acre	1	382.57	382.57	382.57	944.9479
	Truck (pickup and atv u	mi.	20	0.56	11.2	11.2	27.664
	Labor (incl. transplantir	hr.	12	10	120	120	296.4
	Irrigation	acre	6	82	492	492	1215.24
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land Rent	acre	1	40	40	40	98.8
	Interest on Cash Expen	$	2702.8	0.05	135.14	135.14	333.7958
Total Pre-Harvest Cash Expenses					2273.5	2273.5	5615.545
							0
Fixed Costs, Pre-Harvest:							0
	Tractor + Machinery	acre	1	109.25	109.25	109.25	269.8475
	Truck (pickup)	mi.	20	0.17	3.4	3.4	8.398
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Manageı	$	406.25	0.1	40.625	40.63	100.3561
Total Pre-Harvest Fixed Costs					238.28		0
							0
Total Pre-Harvest Costs					2511.8	238.28	588.5516
Harvest Costs:							0
	Machinery Labor	acre	1	11	11	11	
	Harvest Labor	box	1	132	132	132	
	Boxes**	each	1.6	132	211.2	211.2	521.664
	Marketing	box	0.4	132	52.8	52.8	130.416
	Cooling	box	0.25	132	33	33	81.51
	Hauling	box	1.25	132	165	165	407.55
Total Harvest Costs					605	605	1494.35
Total Costs					3116.8		7698.496
Total Returns Per Acre/ Hectare					1518		3749.46
Profit Per Acre/Hectare					-1598.8		-3949.04

Table 66. Enterprise budget for collard crop 2013, INORGWO at the 60% N rate (60 kg·ha^{-1})

	Collard Crop INORGWO 60% 2013						
Estimated Costs of Producing One Acre of Collard Greens for Fresh Market,							
Item		Unit	Quantity	Price	Value	Your Cost	Cost/ha
Cash Expenses, Pre-Harvest:							
	Seedlings	1000	16	16	256	256	632.32
	Lime, applied	ton	0.15	30	4.5	4.5	11.115
	Fertilizer	N,P+	58.8	0	486.9	486.9	1202.643
	Fertilizer	K	98	0	0	0	0
	Herbicide Glyphosate	acre	2	4	8	8	19.76
	Herbicide Aim	acre	2	1.67	3.34	3.34	8.2498
	Herbicide Glyphosate	acre	2	4	8	8	19.76
	Herbicide Aim	acre	2	1.67	3.34	3.34	8.2498
	Insecticide Sevin xlr	acre	2	14	28	28	69.16
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide Sevin xlr	acre	2	14	28	28	69.16
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Fungicide	acre	0	0	0	0	0
	Tractor + Sprayer	acre	1	382.57	382.57	382.57	944.9479
	Truck (pickup and atv u	mi.	20	0.56	11.2	11.2	27.664
	Labor (incl. transplantir	hr.	12	10	120	120	296.4
	Irrigation	acre	6	82	492	492	1215.24
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land Rent	acre	1	40	40	40	98.8
	Interest on Cash Expen	$	2702.8	0.05	135.14	135.14	333.7958
Total Pre-Harvest Cash Expenses					2232.9	2232.9	5515.263
							0
Fixed Costs, Pre-Harvest:							0
	Tractor + Machinery	acre	1	109.25	109.25	109.25	269.8475
	Truck (pickup)	mi.	20	0.17	3.4	3.4	8.398
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Manager	$	406.25	0.1	40.625	40.63	100.3561
Total Pre-Harvest Fixed Costs					238.28		0
							0
Total Pre-Harvest Costs					2471.2	238.28	588.5516
Harvest Costs:							0
	Machinery Labor	acre	1	11	11	11	
	Harvest Labor	box	1	55	55	55	
	Boxes**	each	1.6	55	88	88	217.36
	Marketing	box	0.4	55	22	22	54.34
	Cooling	box	0.25	55	13.75	13.75	33.9625
	Hauling	box	1.25	55	68.75	68.75	169.8125
Total Harvest Costs					258.5	258.5	638.495
Total Costs					2729.7		
Total Returns Per Acre/ Hectare					632.5		1562.275
Profit Per Acre/Hectare					-2097.2		-5180.08

Table 67. Enterprise budget for collard crop 2013, NON at the 0% N rate (0 kg·ha^{-1})

	Collard Crop NON 0% 2013						
Estimated Costs of Producing One Acre of Collard Greens for Fresh Market,							
Item		Unit	Quantity	Price	Value	Your Cost	Cost/ha
Cash Expenses, Pre-Harvest:							
	Seedlings	1000	16	16	256	256	632.32
	Lime, applied	ton	0.15	30	4.5	4.5	11.115
	Fertilizer	N	0	0	0	0	0
	Fertilizer	P	117	0	299	299	738.53
	Fertilizer	K	98	0	420	420	1037.4
	Herbicide Glyphosate	acre	2	4	8	8	19.76
	Herbicide Aim	acre	2	1.67	3.34	3.34	8.2498
	Herbicide Glyphosate	acre	2	4	8	8	19.76
	Herbicide Aim	acre	2	1.67	3.34	3.34	8.2498
	Insecticide Sevin xlr	acre	2	14	28	28	69.16
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Insecticide Sevin xlr	acre	2	14	28	28	69.16
	Insecticide bifenthrin	acre	6	0.33	1.98	1.98	4.8906
	Fungicide	acre	0	0	0	0	0
	Tractor + Sprayer	acre	1	382.57	382.57	382.57	944.9479
	Truck (pickup and atv u	mi.	20	0.56	11.2	11.2	27.664
	Labor (incl. transplantir	hr.	12	10	120	120	296.4
	Irrigation	acre	6	82	492	492	1215.24
	Fertigation Labor	hr.	20	11	220	220	543.4
	Land Rent	acre	1	40	40	40	98.8
	Interest on Cash Expen	$	2702.82	0.05	135.141	135.14	333.7958
Total Pre-Harvest Cash Expenses					2465.031	2465	6088.55
							0
Fixed Costs, Pre-Harvest:							0
	Tractor + Machinery	acre	1	109.25	109.2527	109.25	269.8475
	Truck (pickup)	mi.	20	0.17	3.4	3.4	8.398
	Irrigation	acre	1	85	85	85	209.95
	Overhead and Manager	$	406.25	0.1	40.625	40.63	100.3561
Total Pre-Harvest Fixed Costs					238.2777		0
							0
Total Pre-Harvest Costs					2703.309	238.28	588.5516
Harvest Costs:							
	Machinery Labor	acre	1	11	11	11	
	Harvest Labor	box	1	11	11	11	27.17
	Boxes**	each	1.6	11	17.6	17.6	43.472
	Marketing	box	0.4	11	4.4	4.4	10.868
	Cooling	box	0.25	11	2.75	2.75	6.7925
	Hauling	box	1.25	11	13.75	13.75	33.9625
Total Harvest Costs					60.5	60.5	
Total Costs					2763.809		6826.608
Total Returns Per Acre/ Hectare					126.5		312.455
Profit Per Acre/Hectare					-2637.31		-6514.15

Fig. 1. Nutrient content was determined via dry ash and subsequent analysis via ICAP. Results were used to adjust inorganic fertility treatments so as to mirror the nutrient content present in Schafer's Liquid Fish fertilizer. (Data obtained from S.F. Organics website on 9 May 2012. http://schaferfish.com/theSite/liquid-fish/)

Midwest Laboratories, Inc.

13611 B Street • Omaha, Nebraska 68144-3693 • (402) 334-7770 • FAX (402) 334-9121 • www.midwestlabs.com

Report #: 09-021-2038

Report To: MIKE SCHAFER
SCHAFER FISHERIES INC
PO BOX 399
THOMSON IL 61285-

Lab #: 1527709

Date Reported: 21-Jan-09
Date Received: 13-Jan-09
Date Sampled:
Sample ID: FERTILIZER
Account #: 13468

FERTILIZER ANALYSIS

Organic Solid Report

Parameters	Analysis As Received	Dry Weight	Units	Nutrients Lbs./Ton As Received	Detection Limit
Ammonium Nitrogen (N)	0.080	0.20	%	1.6	0.001
Organic Nitrogen (N)	2.34	5.76	%	46.8	Calculated
Total Nitrogen (N)	2.42	5.96	%	48.4	0.01
Phosphorus (P205)	2.04	5.02	%	40.8	0.10
Potassium (K2O)	0.22	0.54	%	4.4	0.10
Sulfur (S)	1.81	4.46	%	36.2	0.05
Calcium (Ca)	1.81	4.46	%	36.2	0.01
Magnesium (Mg)	0.04	0.10	%	0.8	0.01
Sodium (Na)	0.13	0.32	%	2.6	0.01
Copper (Cu)	n.d.	n.d.	ppm	0.0	20.0
Iron (Fe)	141	347	ppm	0.3	50.0
Manganese (Mn)	417	1027	ppm	0.8	20.0
Zinc (Zn)	54	133	ppm	0.1	20.0
Moisture	59.40		%		0.10
Total Solids	40.60		%	812	
Total Salts				92.4	
pH	2.80				
Total Carbon	12.20	30.05	%		0.050
C/N Ratio	5:1				
Chloride	0.13	0.32	%		0.02
Nitrate Nitrogen (N)	n.d.	n.d.	%		0.01

n.d. = Not Detected

Total salts should not exceed 500 lbs/acre.
Salt contributions from commercial fertilizer applications must also be considered.

Soil test yearly to monitor phosphorus levels, organic matter, pH, and micronutrients.

Matt Stukenholtz

Matt Stukenholtz

Fig. 2. Fertilizer injection manifold used for applying irrigation and the ten fertility treatments evaluated in this experiment. Injectors are Dosatron D45RE (Dosatron Intl., Clearwater, FL) and inject 5 fertility treatments each. This allows for two treatments to be injected simultaneously.

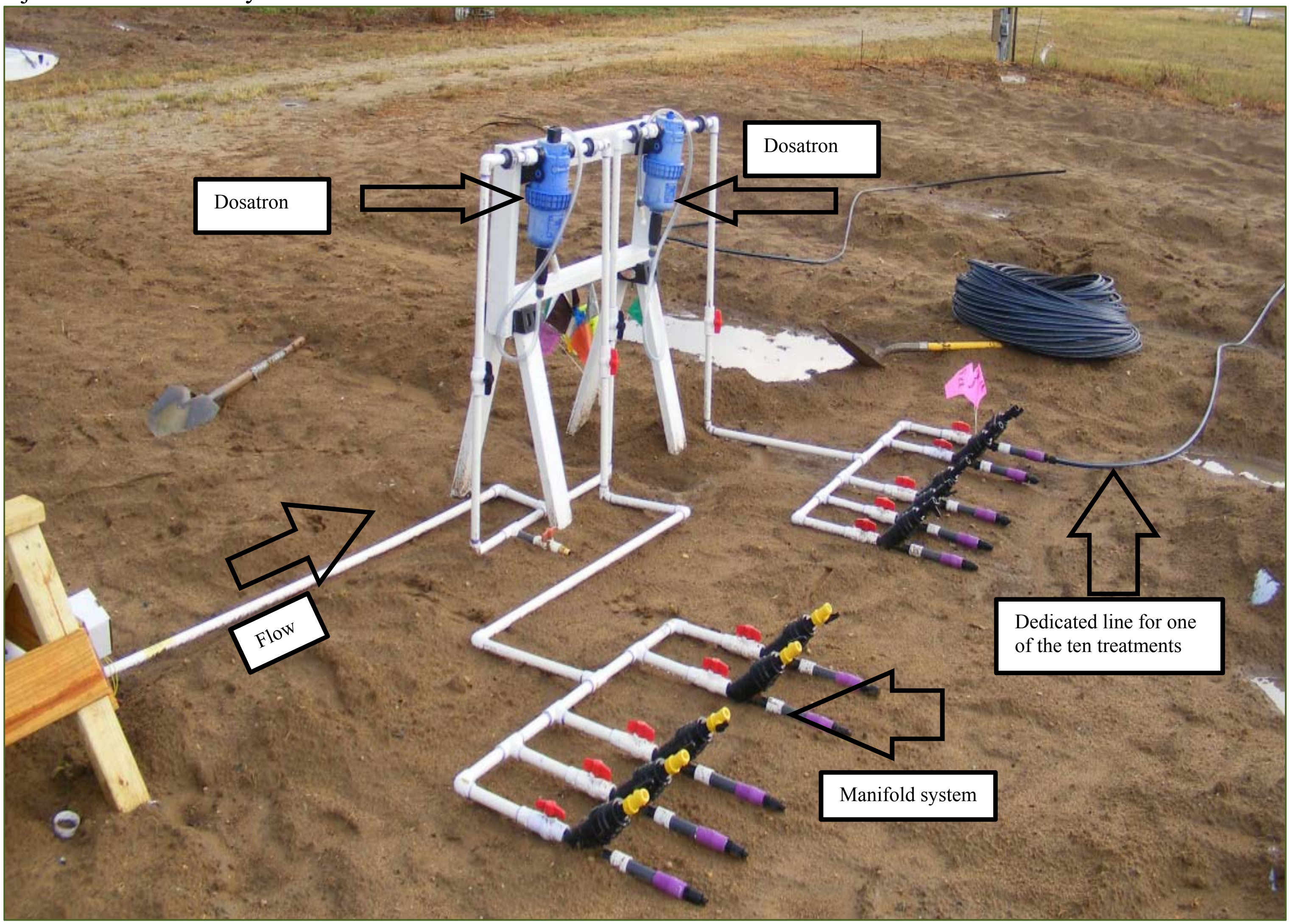

Fig. 3. Plot diagram showing the location of each experimental plot, the treatment that each plot received, and the method for interconnecting the same treatments from block to block.

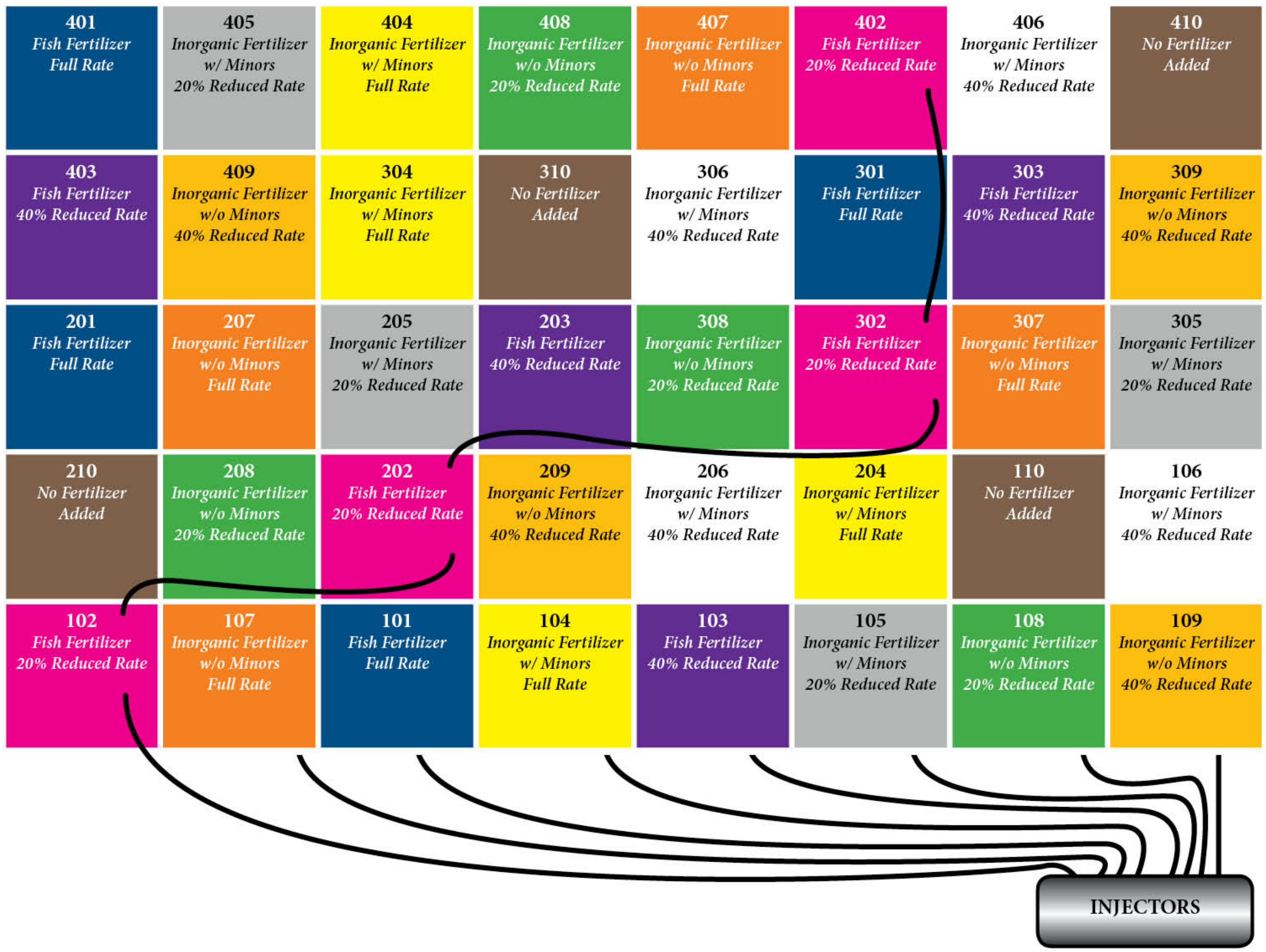

Fig. 4. Plant canopy area (cm^2) as affected by N rate, summer squash, Horticulture Unit, Tallassee, AL , 9 Aug. and 16 Aug. 2012. Vertical lines on each marker are standard error about the mean.

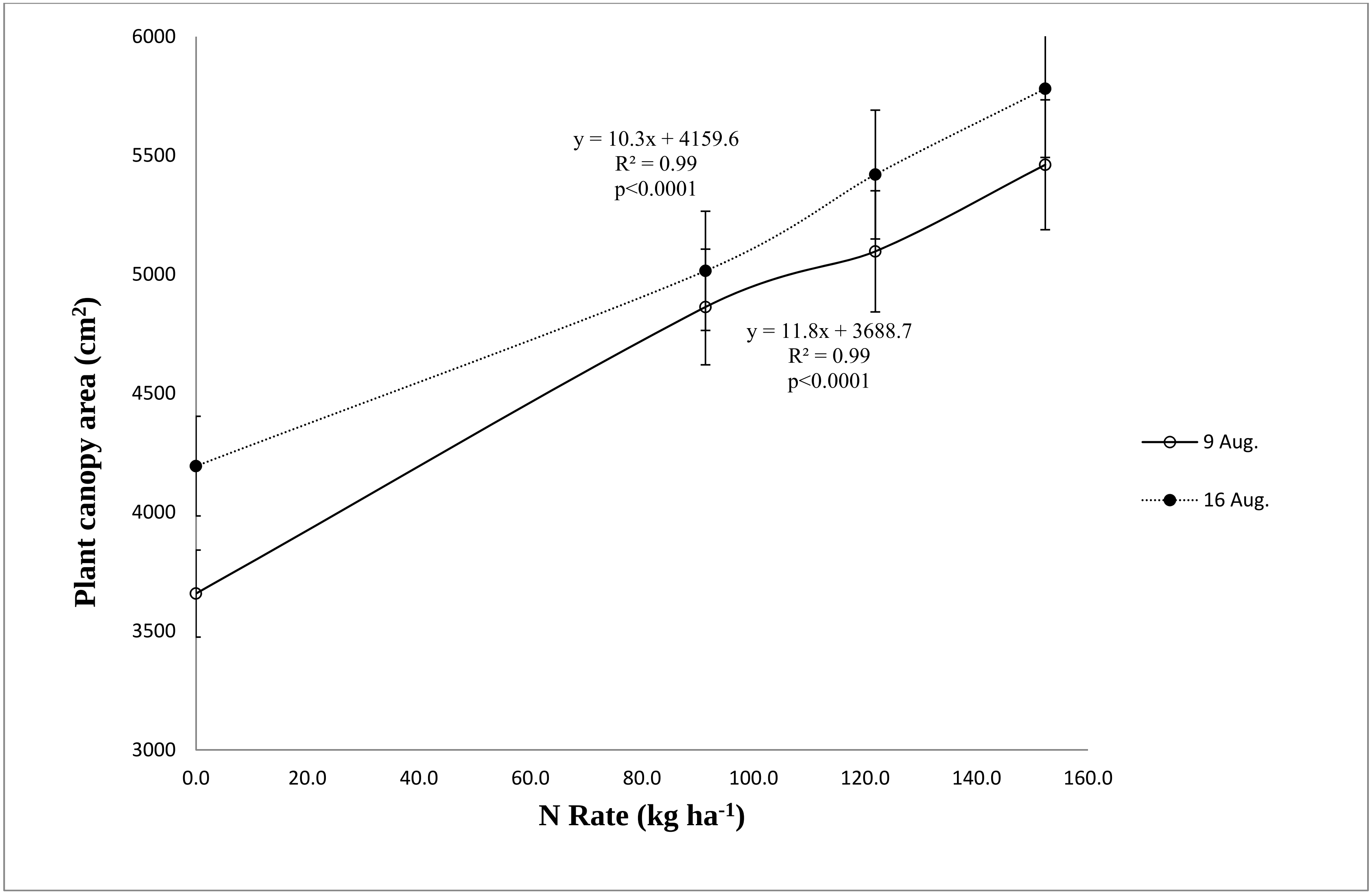

Fig. 5. Plant canopy area (cm^2) showing the interaction of N source and N rate on summer squash, Horticulture Unit, Tallassee, AL 23 Aug. 2012. Vertical lines on each marker are the standard error about the mean.
HFF: Schafer's Liquid Fish, INORGWM: Inorganic N without secondary and micronutrients, INORGWO: Inorganic without secondary and micronutrients.

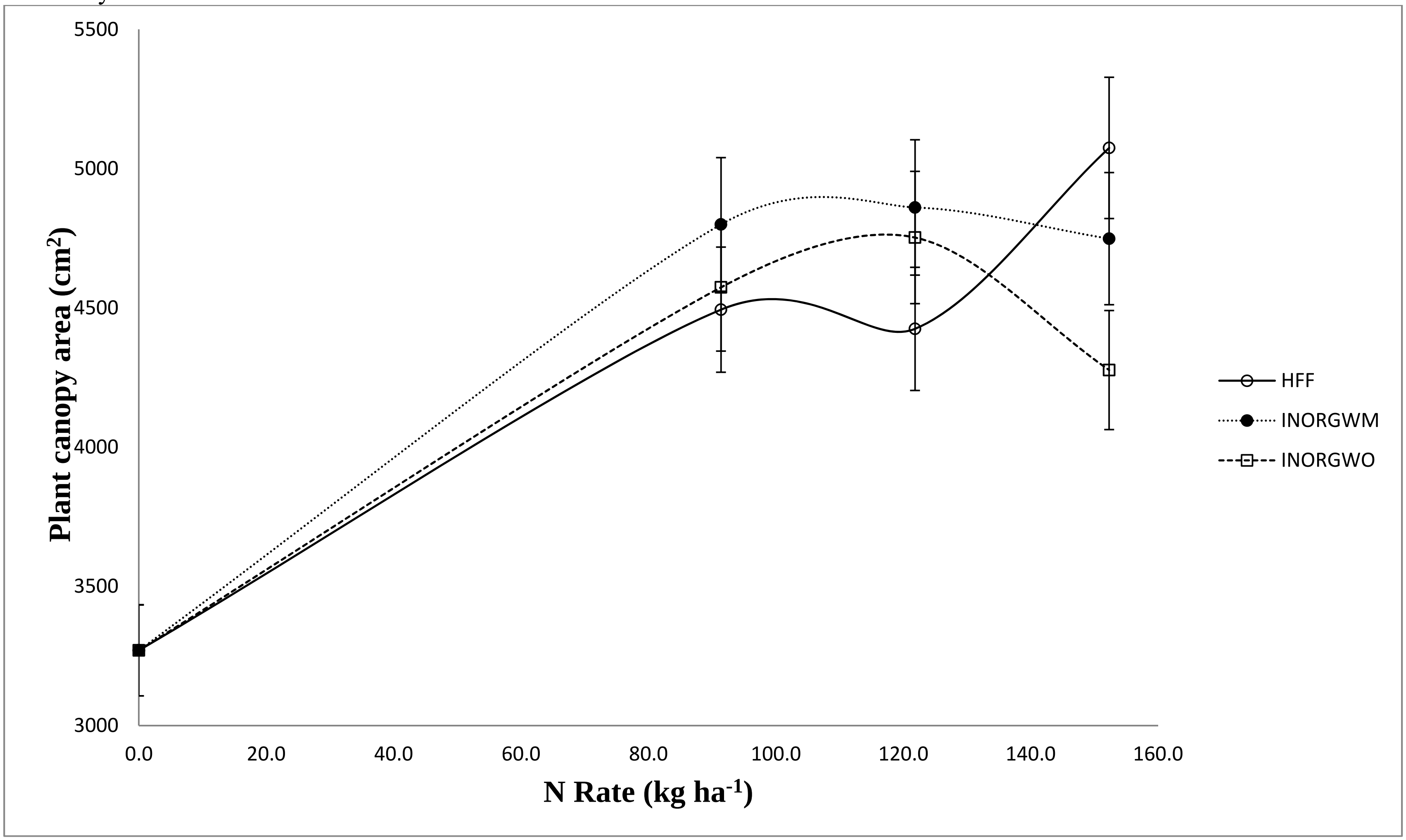

Fig. 6. Plant canopy area (cm^2) showing the interaction of N source and N rate on summer squash, Horticulture Unit, Tallassee, AL 16 Sept. 2013. Vertical lines on each marker are the standard error about the mean.
HFF: Schafer's Liquid Fish, INORGWM: Inorganic N without secondary and micronutrients, INORGWO: Inorganic without secondary and micronutrients.

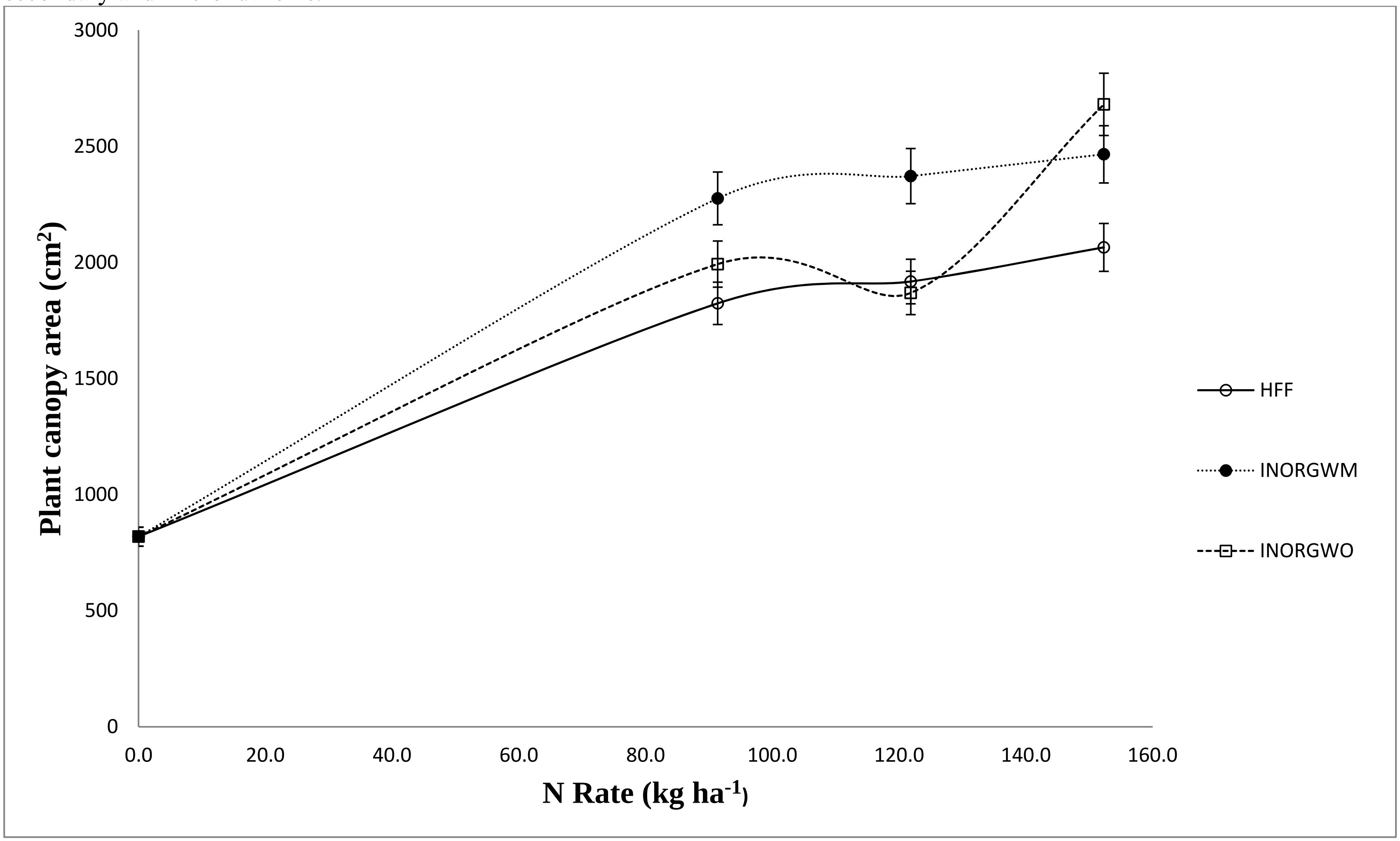

Fig. 7. Leaf N content in summer squash as affected by N source and N rate, 2013. Vertical lines on each marker are the standard error about the mean.

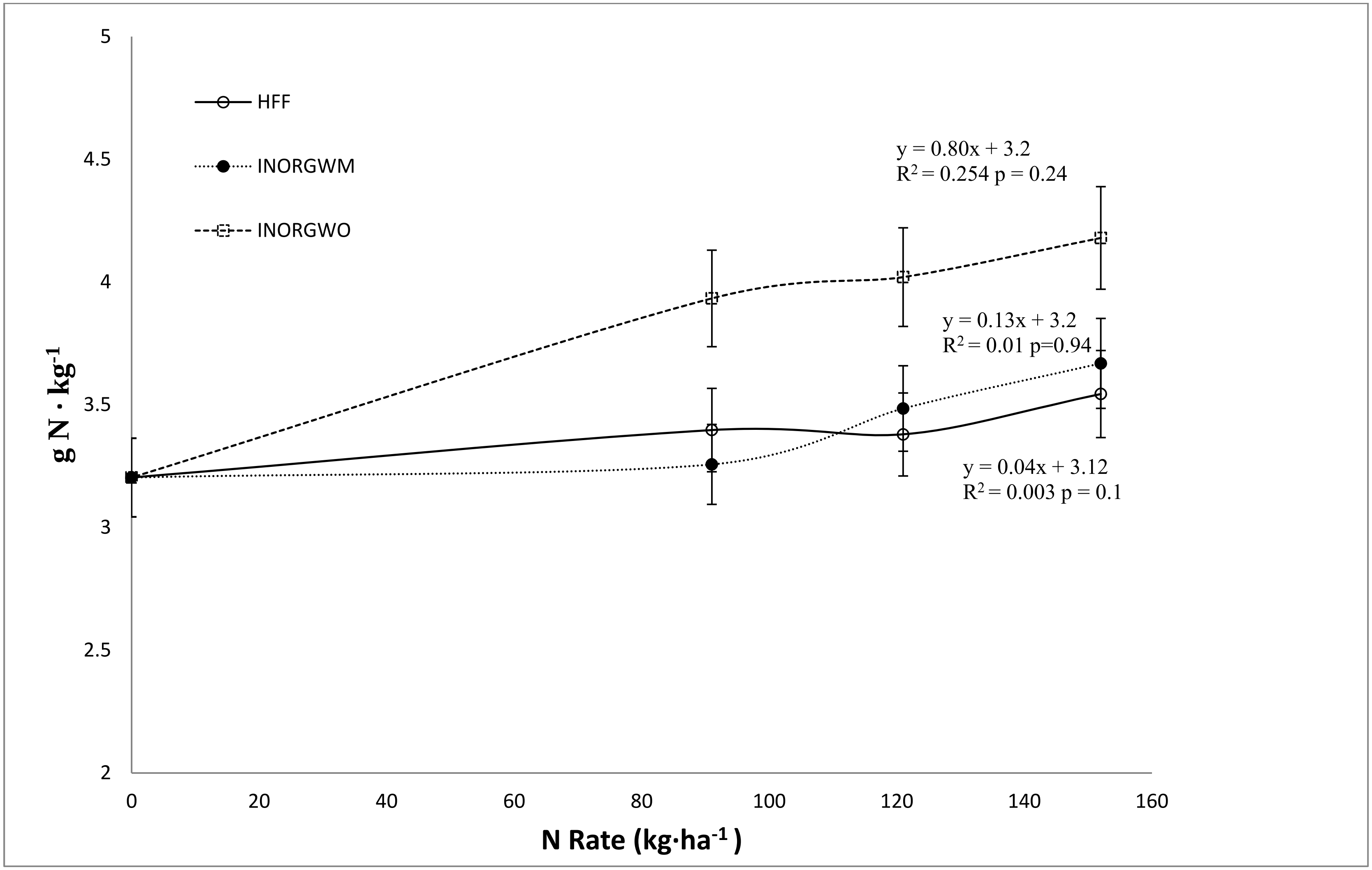

Fig. 8. Petiole nitrate concentration in summer squash as affected by N source, 2013. Letters indicate differences between means at α = 0.05.

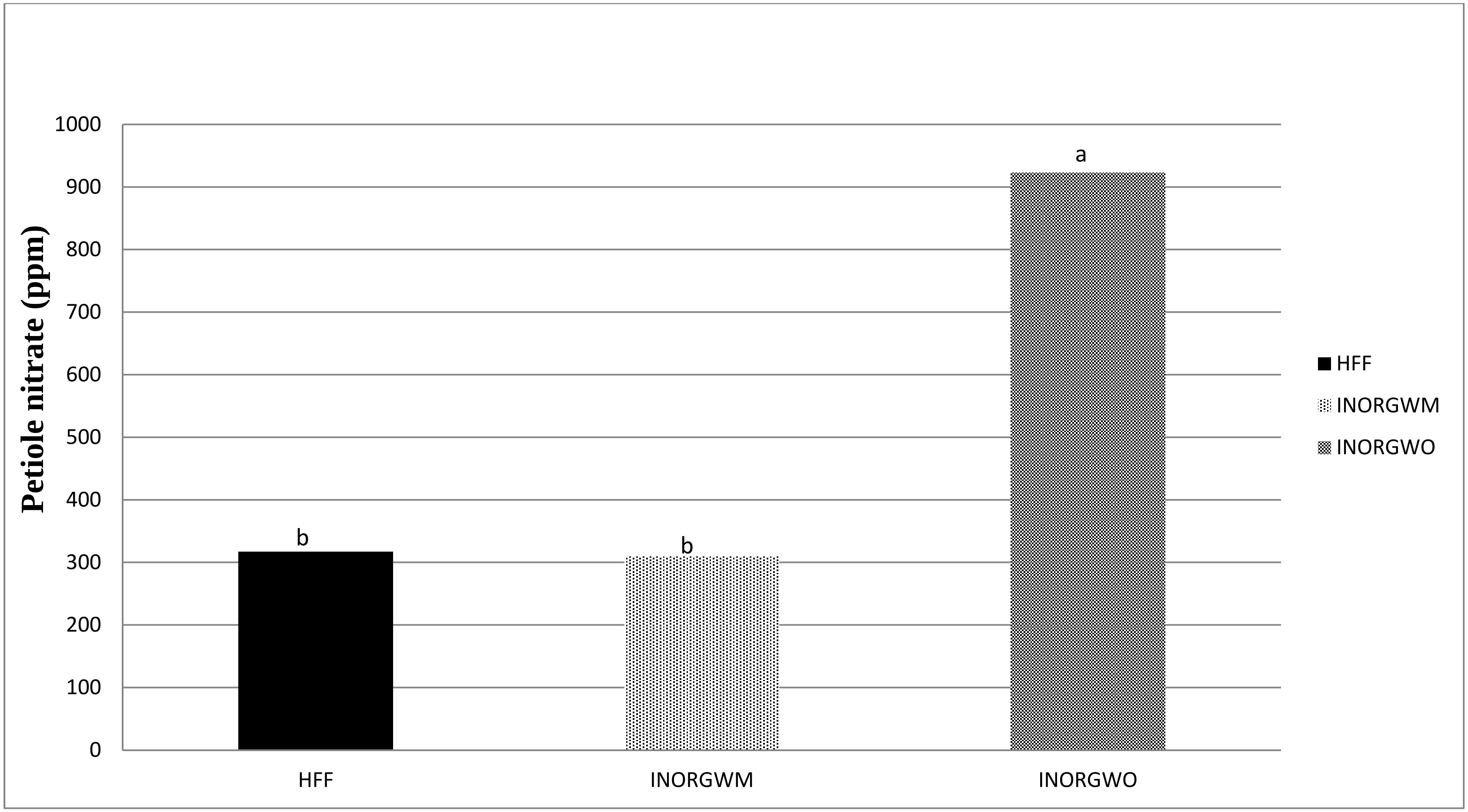

Fig. 9. The interaction of N rate and N source on chlorophyll content of squash as measured via SPAD meter, 6 Sept, 2013. Vertical lines on each marker are the standard error about the mean.

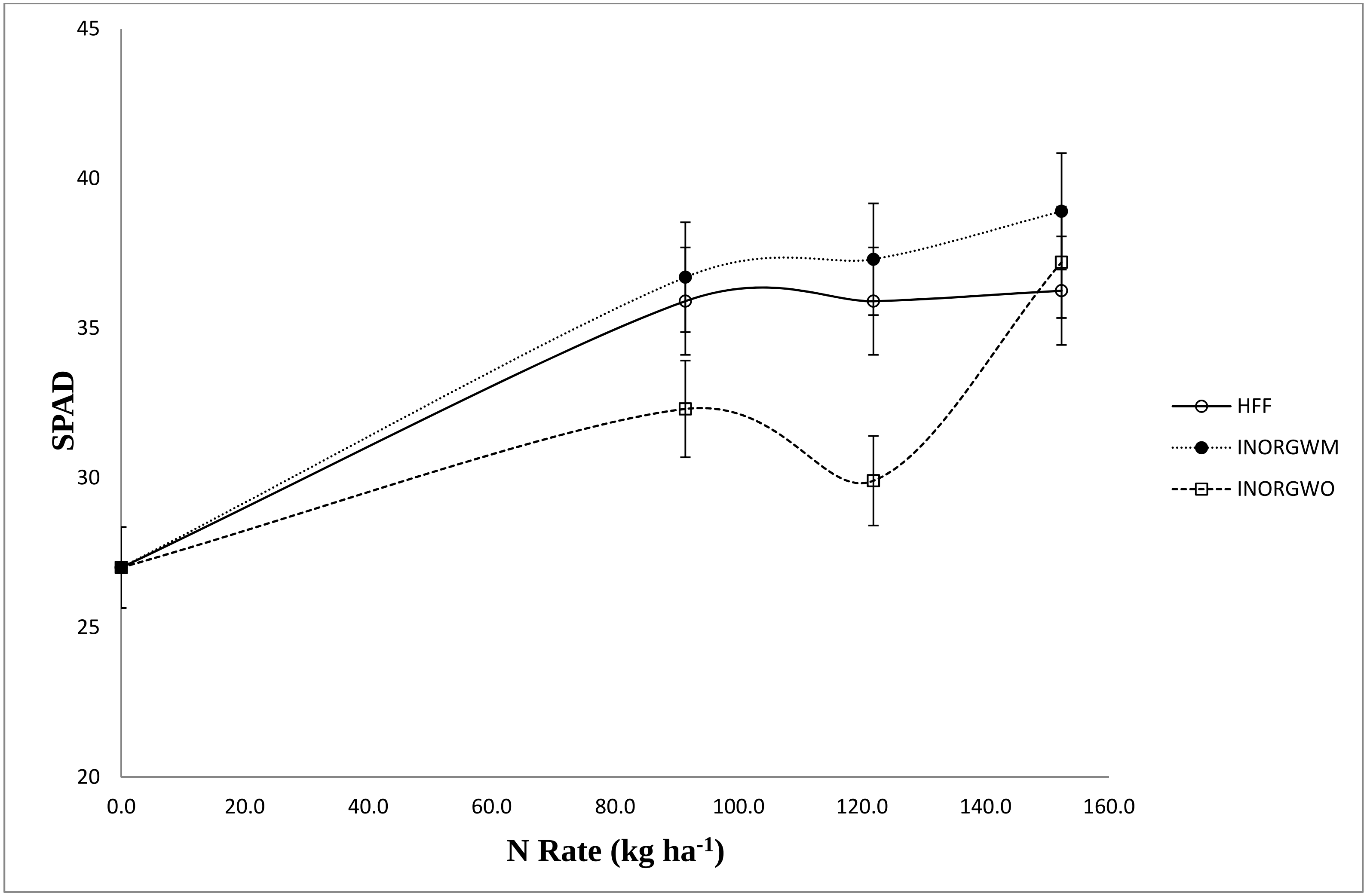

Fig. 10. Marketable yield of summer squash as affected by N rate and N source, 2012. Vertical lines on each marker are the standard error about the mean.

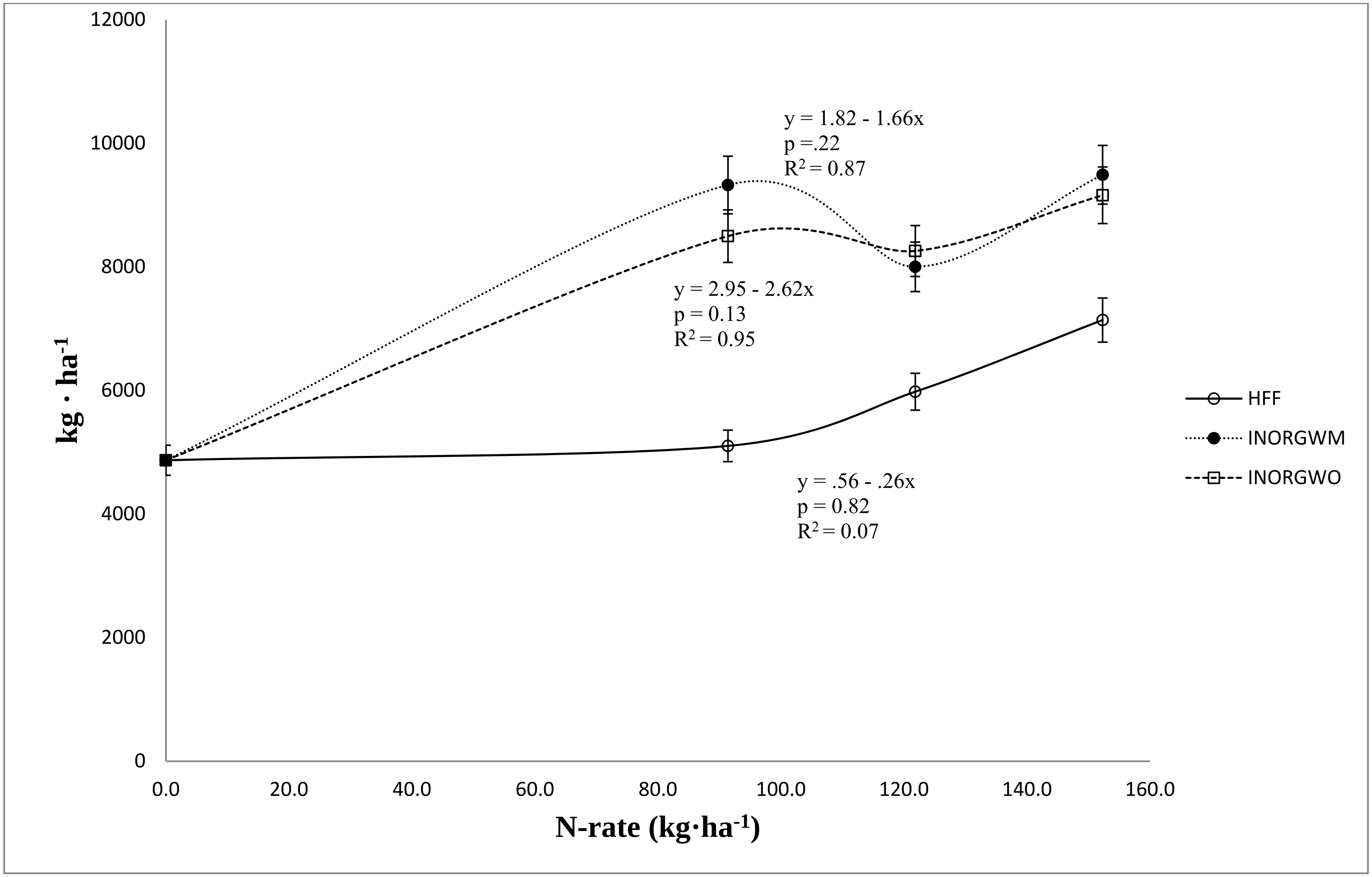

Fig. 11. Marketable yield of summer squash as affected by N rate and N source, 2013. Vertical lines on each marker are the standard error about the mean.

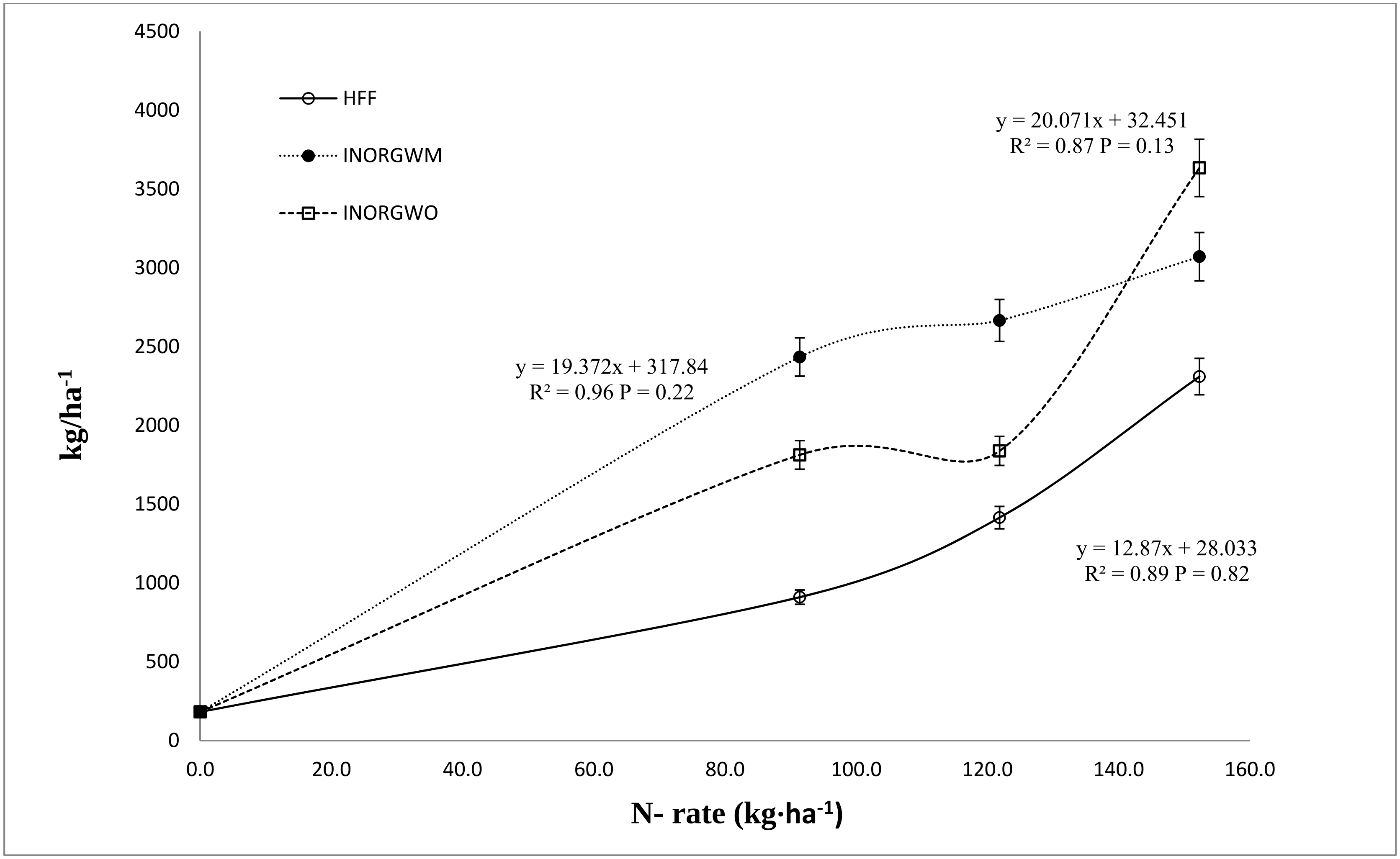

Fig. 12. The interaction of N source and N rate of fresh weight of collards, 14 May, 2013. Collard fresh weight interaction 14 May 2013. Vertical lines are standard error about the mean.

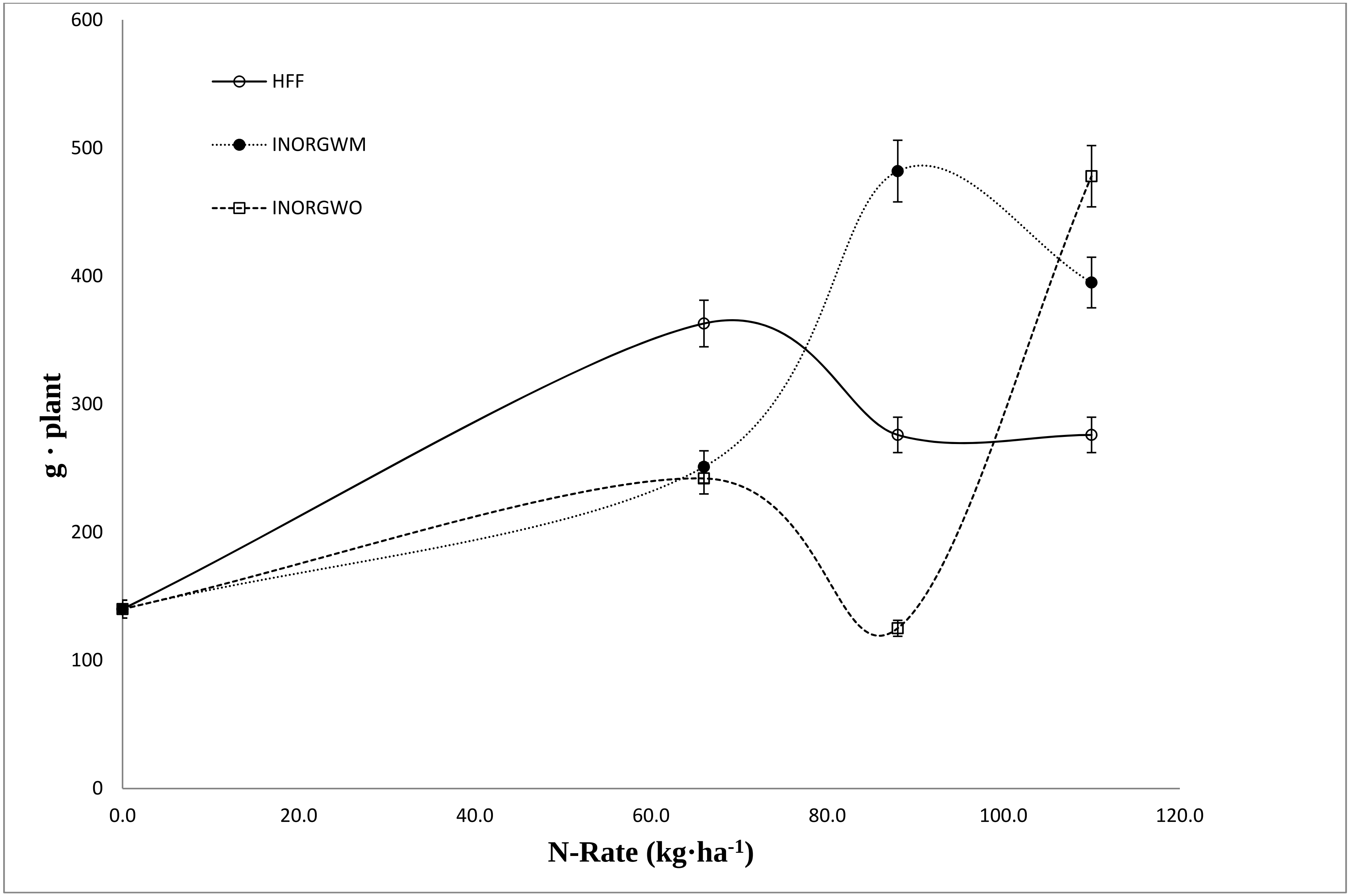

Fig.13. The interaction of N rate and N source on the leaf area of collards, 7 May, 2013. Vertical lines are standard error about the mean.

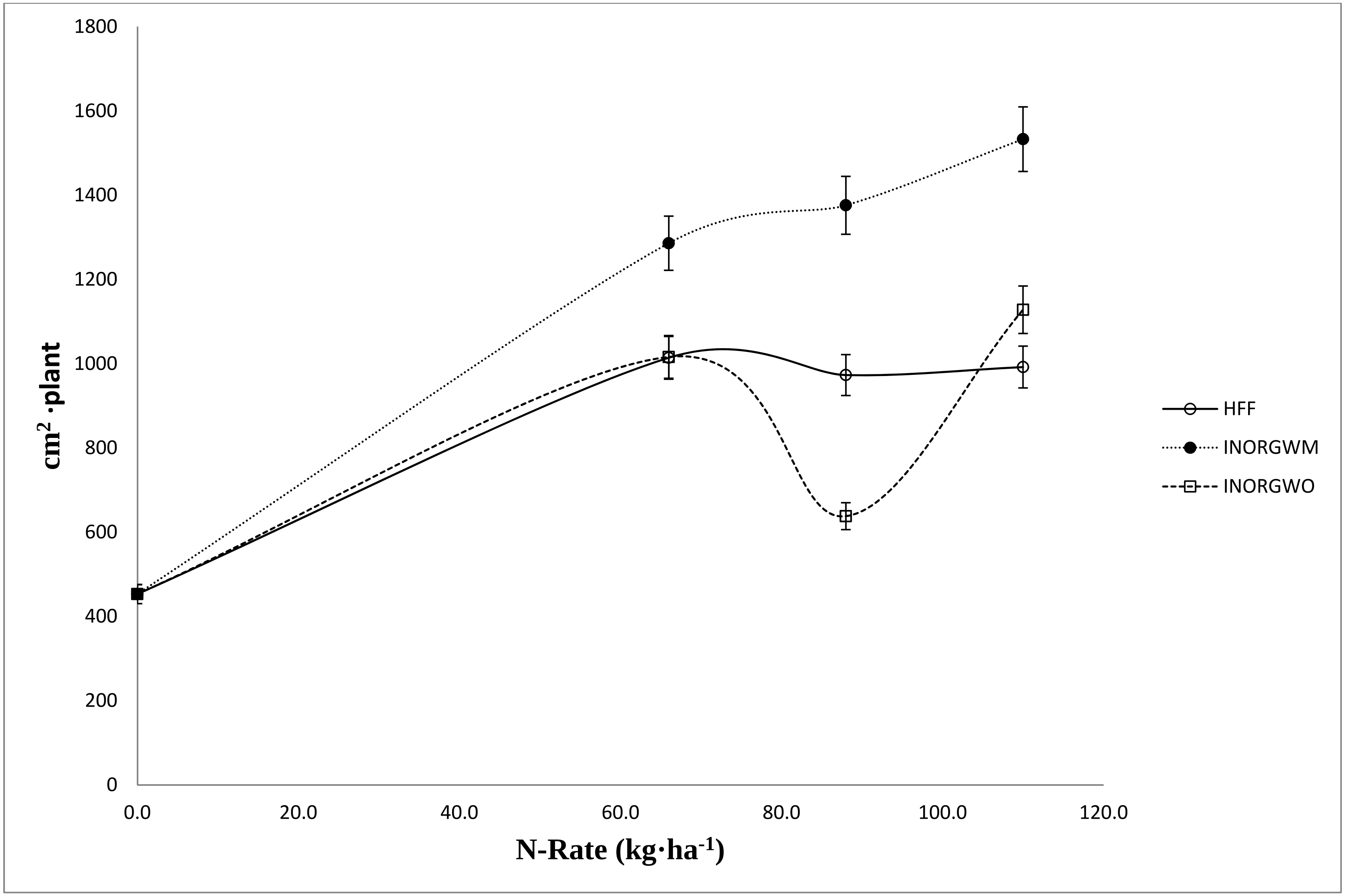

Fig. 14. Leaf nitrogen content as affected by N source and sample date in collard crop 2012. Vertical lines are standard error about the mean.

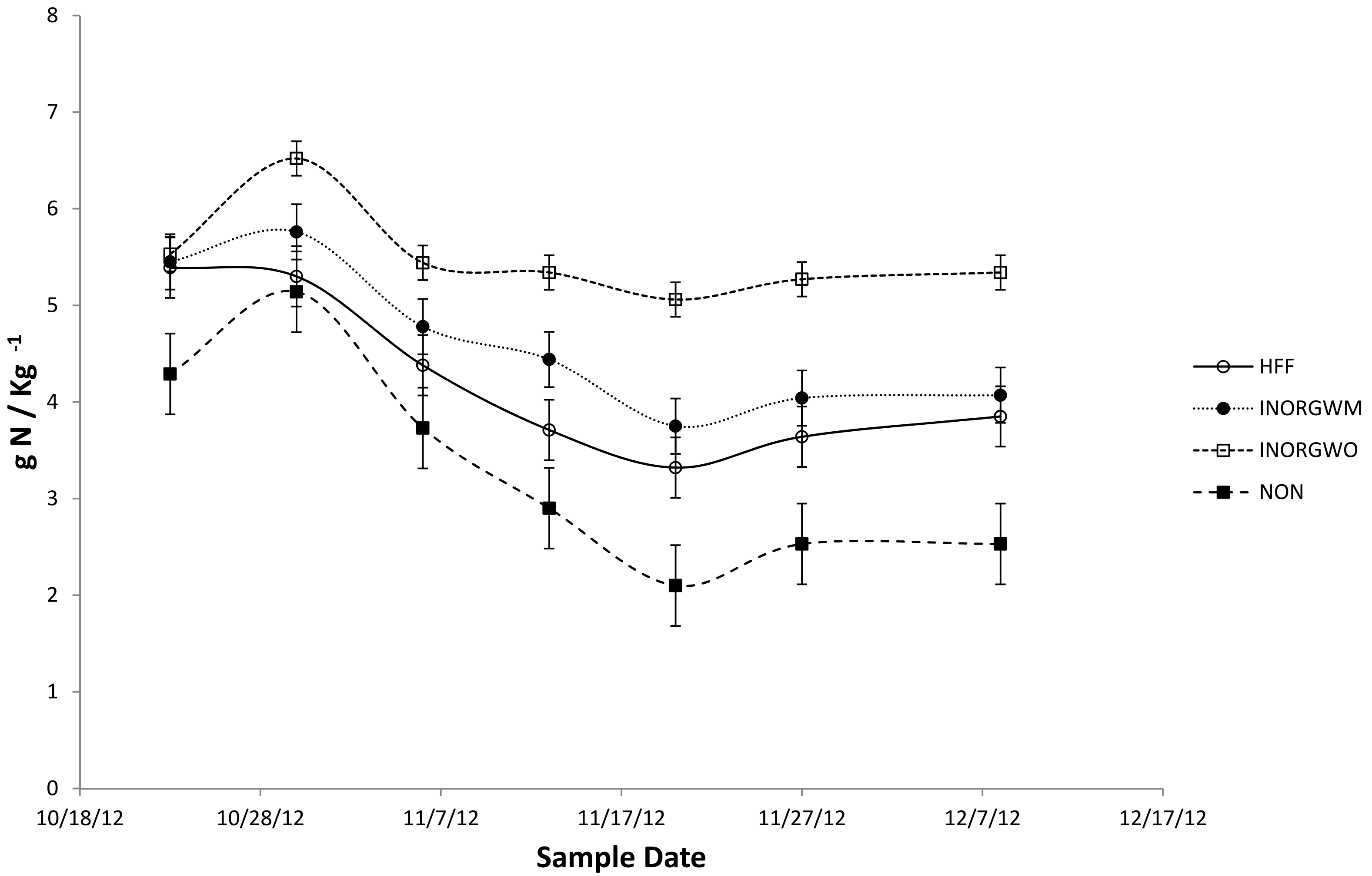

Fig. 15. Leaf nitrogen content as affected by N source and sample date in collard crop 2013. Vertical lines are standard error about the mean.

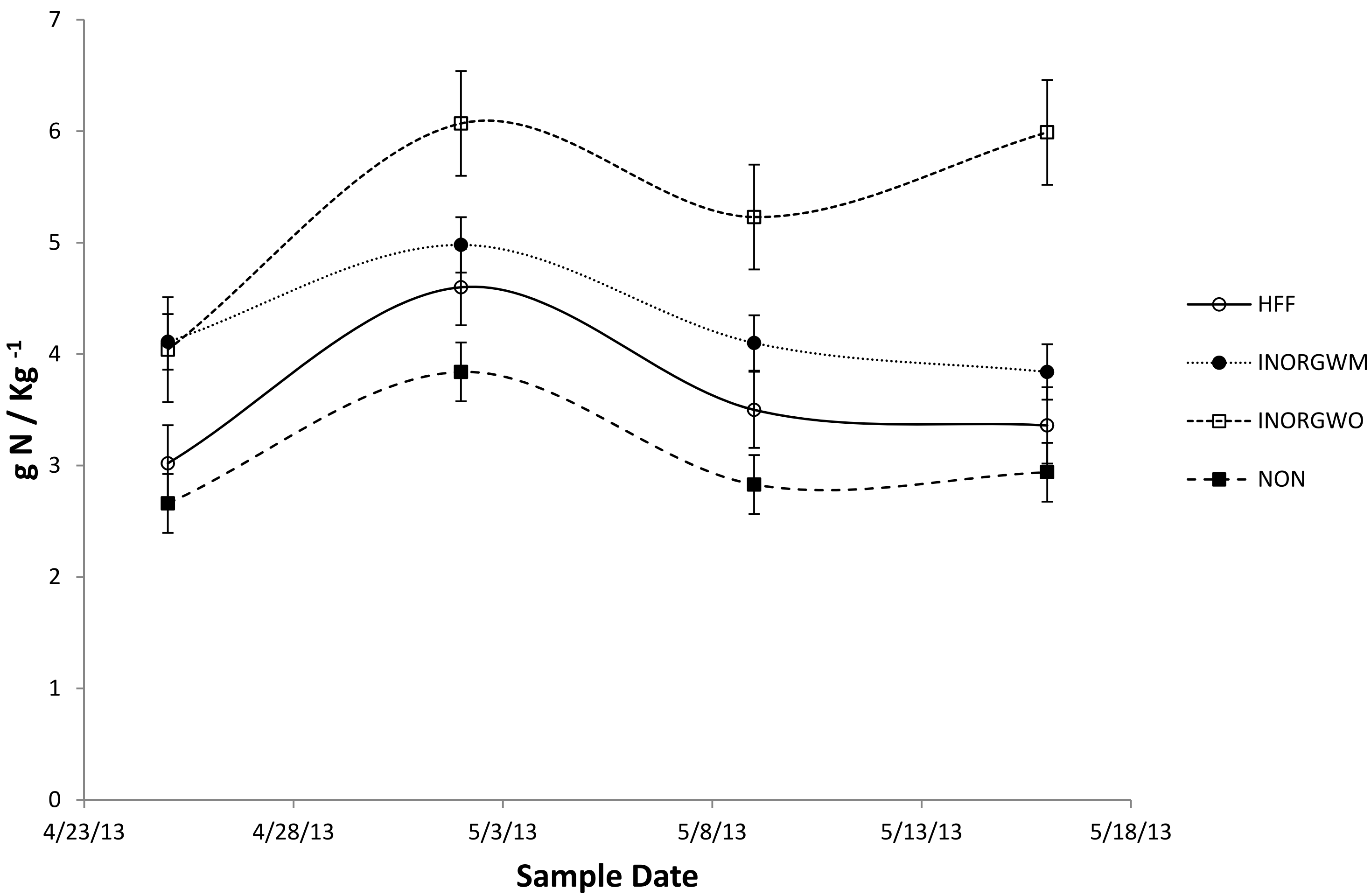

Fig. 16. Leaf nitrogen content as affected by N source and N rate in collard crop 2012. Vertical lines on each marker are the standard error about the mean.

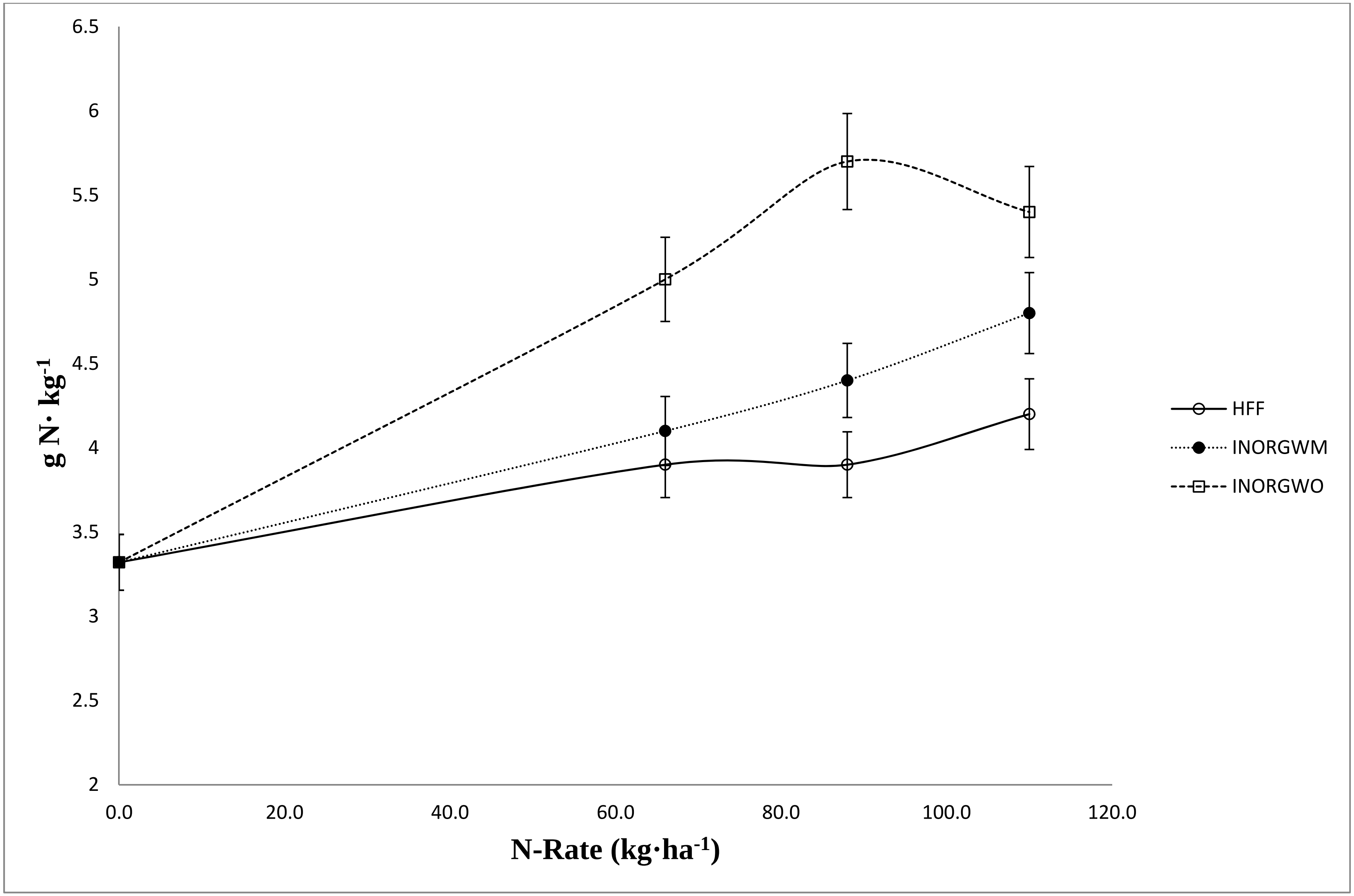

Fig. 17. Chlorophyll readings as measured by a SPAD meter as affected by N source and sampling date collards 2012. Vertical lines on each marker are the standard error about the mean.

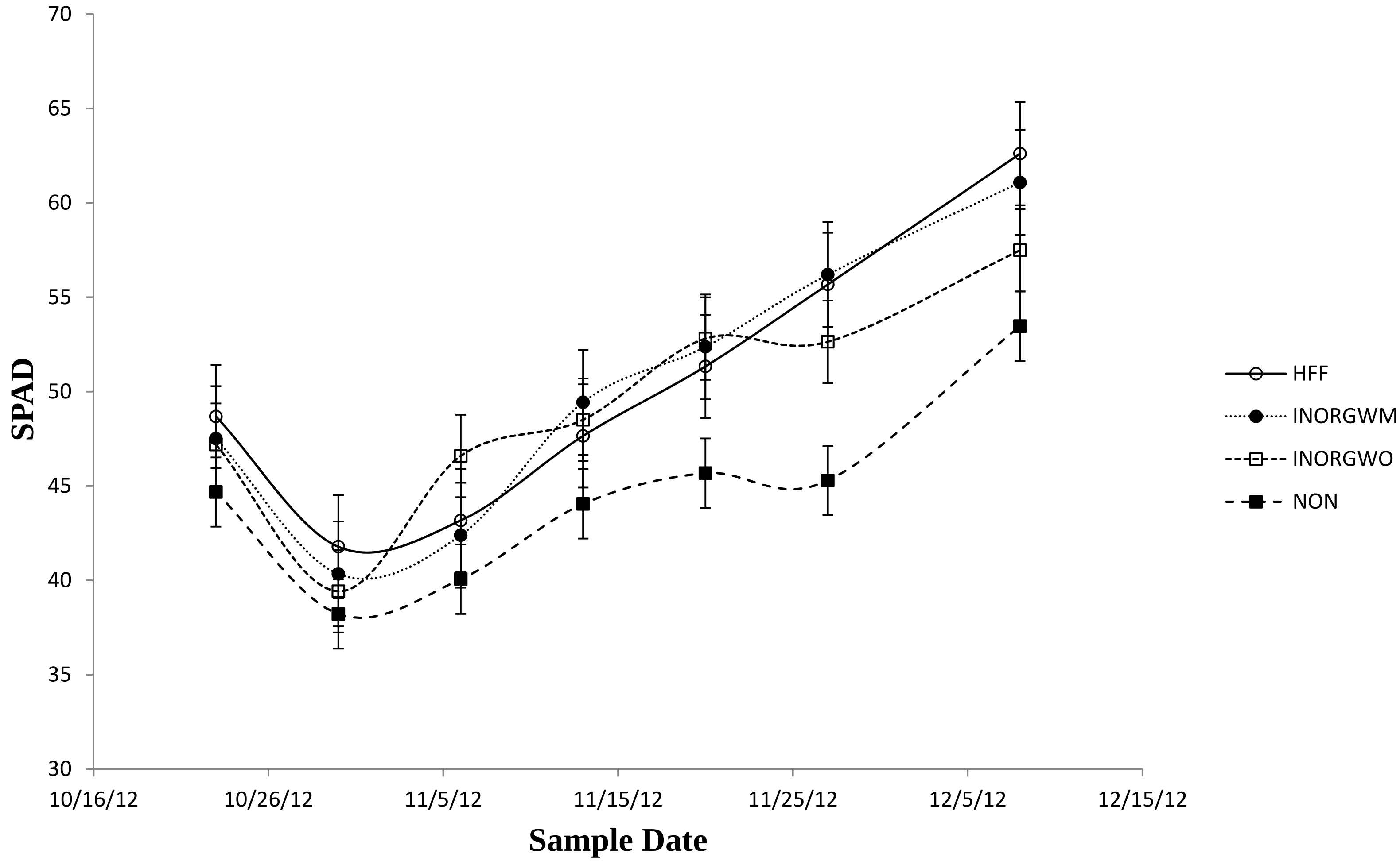

Fig. 18. Marketable yield Collards 2012. Vertical lines on each marker are the standard error about the mean.

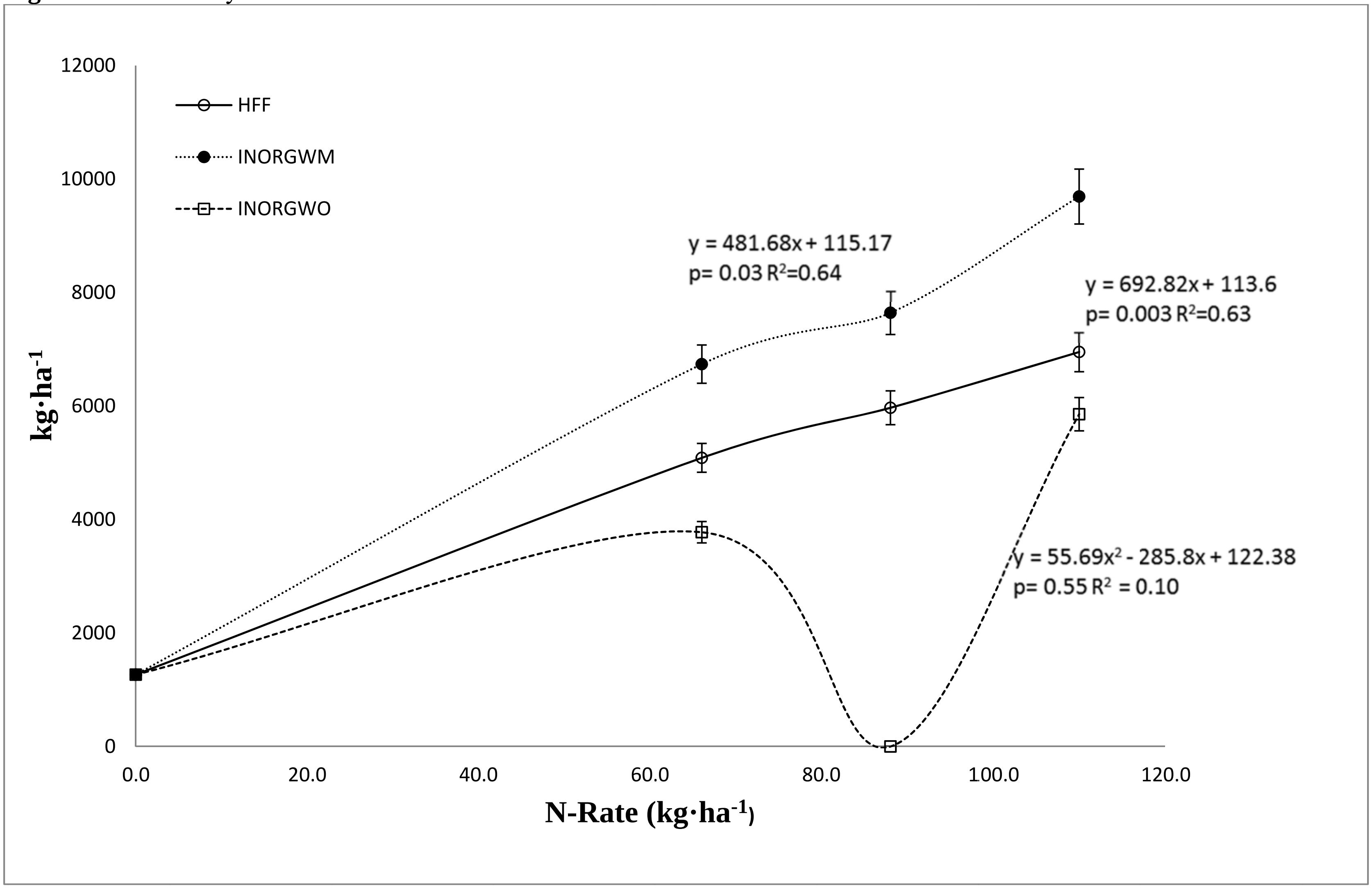

Fig. 19. Marketable yield of collard, 2013. Vertical lines on each marker are the standard error about the mean.