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APPLICATION OF ORGANIC FERTILIZERS FOR LAWN ESTABLISHMENT AND MAINTENANCE IN LOUISIANA

A Thesis

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requirements for the degree of
Master of Science

in

The Department of Plant, Environmental, and Soil Sciences

by
Matthew Frank Lambert
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ABSTRACT

Landscape contractors are increasingly interested in organic products for Louisiana's residential and commercial turfgrass areas. However, the use, motivations, and barriers to adopting organic practices in the commercial turfgrass and landscape industry are undocumented. A survey with Louisiana Turfgrass Association (LTA) members to gauge their perceptions on current and future use of organic products in Louisiana was performed; and a field trial was conducted to evaluate organic fertilizers during turfgrass establishment. Substantial majorities of turfgrass professionals are currently applying organic fertilizers and believe organic product use will increase due to consumer demands, potential governmental regulation, and the belief that they are a more environmentally friendly alternative to synthetic products. However, turfgrass professionals’ knowledge of organic definitions and Organic Materials Review Institute (OMRI) labeling were limited. Greater efficacy and access to organic products coupled with increased extension and educational efforts would increase the number of Louisiana turfgrass professionals who adopt organic practices. In the field trial, three organic fertilizers (fish-based, insect-based, and plant-based) and an industry standard synthetic water-soluble fertilizer (WSF) effects on turfgrass establishment were evaluated as a best management practice to reduce surface runoff of nutrients. Organic fertilizers resulted in similar turfgrass groundcovers, cumulative total suspended solids (TSS), and inorganic N losses relative to the synthetic WSF for the 42-day establishment periods. Fertilizer incorporation and initial irrigation most likely muted inorganic N losses among the fertilizers tested. Landscape contractors can successfully establish perennial turfgrass without decreasing runoff resistance or increasing TSS and inorganic losses.

CHAPTER 1. LITERATURE REVIEW

1.1. Introduction

The application of fertilizers and herbicides made from organic sources has captivated the general public's attention in recent years. Over the past 50 years, the general citizen has an increased interest in lawn care management and its impact on the environment. To maintain such high aesthetic lawn care, high inputs of time, money, and chemical applications are implemented. (Robbins et al., 2001). Landscaping practitioners (Homeowners, Park Directors, Landscape Managers, Athletic Field Managers, and Golf Course Superintendents) have examined switching from synthetic sources of products to organic products. Factors behind the interest stems from being more environmentally conscious as well as applying safer products especially in areas of higher population. Growing interest in alternate forms of turf management has led local governing bodies to change public policies limiting or banning the application of synthetic products in favor of alternative options (Alumai et al., 2008). The main problem with using organic products is that there is limited information This research examined current use and barriers to organic product adoption as well as investigated how differently sourced organic fertilizers affect turfgrass establishment and nutrient losses during surface runoff.

1.2. Perennial Ryegrass Characterization

Perennial ryegrass (*Lolium perenne* L.*)* is a cool season turfgrass that is native to Europe and Asia (Thorogood, 2003). Perennial ryegrass is a bunch-type grass that is commonly established in the Southern United States as a temporary groundcover during late fall and winter months on sites where high quality and winter color are desired until more suitable environments for perennial, warm season turfgrasses develop (Yelverton, 2017). Perennial ryegrass can be identified by having a rolled leaf bud, membranous ligule, a small claw-like auricle, dark green coloration on the leaves, and a smooth, glossy appearance on the lower section of the leaf. Perennial ryegrass is best suited for cooler climates due to its lack of heat and drought resistance (Hannaway et al, 1997), but golf courses and athletic fields still use it in the southern United States as winter groundcover for its high tolerance to low mowing heights and rapid recovery growth (Wang et al, 2009).

1.3. Perennial Ryegrass Establishment

Lolium perenne L. is a bunch type turfgrass that spreads through vertical shoots known as tillers (Hunt, 1978). Perennial ryegrass is known for its quick germination rate and ability to perform under cool-season conditions. Seeding perennial ryegrass is a preferred method for some sites due to lower cost of establishment compared to other forms of vegetative establishment (Thorogood, 2003). Since perennial ryegrass is known for having a shallow root system, its appearance can look patchy therefore, it is common for perennial ryegrass to be mixed in with other more aggressive growing types of turfgrasses in seeding mixes (Hannaway et al, 1999). In the southern United States, it is common practice to overseed a warm season turfgrasses plot with perennial ryegrass to keep a vibrant, green color during winter months when environmental conditions are not suitable for warm season turfgrass growth (Daniel, 1978). Once warmer weather conditions occur that favor the growth of warm season grasses, the perennial ryegrass dies off.

1.4. Nitrogen and Turfgrass, General

Nitrogen is the nutrient that is incorporated into the soil more than any other nutrient due to high turfgrass demands (Yu et al., 2014). Nitrogen requirements vary depending on the function and species of turfgrass being used. Turfgrass managers often apply between 150 and 300 kg N ha^{-1} yr^{-1} depending on environmental conditions (Barton and Colmer, 2006; Erickson et al., 2001). Other factors such as clipping management can impact N fertility and therefore, fertilizer application rates and timings (Kopp and Guillard, 2002).

1.5. N Losses Through Water Movement

It has been estimated by Yu et al. (2014) that only 30-40% of N fertilizer applications are taken up by agricultural crops. The remaining amount of N in the soil profile is lost through denitrification, ammonia (NH_3) volatilization, nitrous oxide (N_2O) emissions, and nitrate (NO^{2-}) leaching (Cai et. al., 2002; Cayuela et. al.; 2014). A major contributing factor to coastal eutrophication is excess nitrogen loading into water systems (NRC, 2000). Ribaudo et al. (2001) estimates that approximately 50% of N that enters the Gulf of Mexico via the Mississippi River can be traced back to agricultural sources, with N fertilizers being the major contributor to the cause. Though turfgrass is a smaller source, irrigation rates and frequencies can greatly affect N losses (Barton and Colmer, 2006). For example, Morton et al. (1988) found that use of 244 kg N ha^{-1} yr^{-1} and heavy irrigation on a Kentucky bluegrass (*Poa pratensis*) lawn resulted in annual N losses of 32 kg N ha^{-1} compared to the unfertilized and non-irrigated control which only lost 2 kg N ha^{-1}. Therefore, runoff from overwatered lawns can lead to nitrogen contamination of surface waters (Morton et al., 1988).

1.6. Non-Point Source Pollution

Bricker et al. (2007) found that two-thirds of 58 estuaries in the United States measure moderate to high levels of eutrophication, mostly coming from anthropogenic sources. According to Sonzogni et al. (1980), N and P discharge into the Great Lakes from intensively managed agricultural lands was 10-100 times higher than from forest and idle lands. The Birdfoot Delta of the Mississippi River in Louisiana is home to a productive ecosystem but also to the second largest zone of marine hypoxia in the world (Rabalais et al., 2002), presumably the result of eutrophication by non-point source loads of N and P.

1.7. Surface Runoff

Surface runoff transports sediment, nutrients, (Fierer et al., 2002; Burwell et al., 1975), and pesticides (Gómez et al., 2011; Spencer and Cliath, 1991; Klöppel et al., 1997) that can bring unintended, off-target consequences. P and N loss is a main cause of freshwater pollution (White et al., 2009). Eutrophication with N and P can accelerate algal growth, which can potentially kill aquatic life, clog pipelines, and result in reduced recreational opportunities (USEPA, 1998). Increased algal growth can be caused by P and N concentrations in surface waters as low as 25 mg L^{-1} and 1 mg L^{-1} respectively (Balogh et al.; 1992). Eutrophication appears to be a continuing and increasing problem in coastal waterways and estuaries around the world (Nixon 1995; Boesch 2002). Therefore, efforts must be made to reduce non-point sources of pollution of waterways, estuaries, and aquatic ecosystems through fertilizer applications. A key step is to develop better management practices to reduce nutrient movement into surface waters. Implementing a ground cover, including turfgrass, is important since it is effective in reducing surface runoff. Cole et al. (1997) tested the effectiveness of buffer strips, mowing height, and aerification in reducing surface runoff, and concluded that buffer strips were able to significantly reduce runoff of both pesticides and nutrients compared with no buffer strips; however, mowing height and aerification did not affect surface runoff. Morvan et al. (2014) found that grassed inter-rows of a vineyard had a runoff coefficient of 1% compared to 80% for bare soil. They attribute the difference in runoff coefficient to greater infiltration under grass than bare soil. Even low turf sand densities may greatly reduce runoff and sediment loss compared to bare soil (Gross et al., 1990). Another aspect to stand density is thatch. The heavier thatch under creeping bentgrass (*Agrosis stolonifera*) compared to perennial ryegrass (*Lolium perenne*), for example, slowed runoff and increased infiltration/reduced runoff due to more tortuous flow path (Linde et al., 1995). Similarly, Gutierrez and Hernandez (1996) found that in addition to ground cover, plant type can affect runoff and erosion. They also found that there were significant correlations between the percentage of ground cover and the amount of runoff and erosion. Results from Burwell et al. (2011) was consistent with the following, runoff was decreased up to 84% at a bermudagrass coverage of 90% compared to 10% coverage, and fertilizer N loss decreased over time. As plant density and coverage increase, more protection is provided to the soil from raindrop impact as well and more resistance to surface runoff flow.

CHAPTER 2. PERCEPTIONS OF ORGANIC PRACTICES AMONG TURFGRASS PROFESSIONALS IN LOUISIANA

2.1. Introduction

Turfgrass is a major component of residential and commercial landscapes that has expanded in area as the US shifts demographically from rural to urban and suburban locales (Johsnon et al., 2013; Robbins & Birkenholtz, 2003; Cromartie, 2017). Highly managed urban landscapes enhance property aesthetics and provide recreational spaces. This has led homeowners and those in the turfgrass and landscape industry to rely on conventional fertilizers and pesticides to attain lush groundcover. However, a shift in public concern for human exposure to synthetic chemicals and recognition of well-documented environmental consequences associated with fertilizers and pesticides (Aziz et al, 2015, Motavalli et al, 2008) have contributed to a public perception that organic practices offer a safer alternative to current conventional turfgrass management practices.

Adoption of organic practices has occurred more readily in public spaces versus residential and commercial landscapes in the US (Marshall et al, 2015) due to legislation that limits or prohibits the use of pesticides and fertilizers to assuage public concerns. For example, New York and Connecticut passed legislation limiting pesticide application on school grounds, with New York extending those restrictions to include school athletic field complexes (Bartholomew et al 2015, Haight, 2004). On the other hand, Florida has enacted more encompassing legislation for residential and commercial areas focused on fertilizer applications to protect against water impairment (Hartman et al., 2008; Hochmuth et al., 2009; Tampa Bay

Estuary Program, 2008). Trends in adopting residential and commercial turfgrass organic practices remain nebulous in many regions that lack regulation.

Landscape contractors are increasingly interested in organic products for Louisiana's residential and commercial turfgrass areas. However, the use, motivations, and barriers to adopting organic practices in the commercial turfgrass and landscape industry sector are not well documented. Therefore, a need exists to better understand landscape and turfgrass professionals' perceptions of organic products and practices.

2.2. Theoretical Framework

Rogers' (2003) Diffusion of Innovations (DOI) theory served as the guiding framework for this study. The DOI theory posits that innovations, like organic turfgrass management practices, are diffused among social systems over time through phases of an innovation-adoption process (Rogers, 2003). Padel (2001) concluded that, although organic practices are not a typical innovation, the DOI theory was an appropriate model to understand the adoption process for organic agricultural practices. Similarly, Dearing (2009) stated that societal sectors, often in the form of professional organizations, can facilitate the diffusion process, and targeting professional organizations for intervention aids in communication among the membership. In the context of this study, the Louisiana Turfgrass Association (LTA) served as the societal sector examined by the researchers to determine the level of adoption present among turfgrass professionals in the state. According to Rogers (2003), the rate at which an innovation is adopted among members of a social system is based on five attributes of the innovation perceived by group members: relative advantage, compatibility, complexity, trialability, and observability. Notably, relative advantage, defined by Rogers (2003) as "the degree to which an innovation is perceived as being better than the idea it supersedes” (p. 229), is viewed as one of the most important positive predictors of an innovation’s rate of adoption (Rogers, 2003). Relative advantage has been a primary driving factor in producers' decisions to adopt or reject innovative agricultural practices, especially concerning conservation and environmental concerns (Atwell et al., 2009; Lavoie et al., 2021; Senyolo et al., 2018). Because of the expressed importance of relative advantage to the diffusion of innovation, the design of this study emphasized the need to understand better the perceptions of the relative advantage of organic practices held by turfgrass professionals. By analyzing the prevalence of current organic practices alongside perceptions of their relative advantage, this study seeks to establish an entry point into understanding the innovation/adoption process for organic products in the turfgrass industry to better inform future extension and educational efforts on the subject.

2.3. Methodology

This study employed an online survey instrument delivered via Qualtrics to collect data. The researchers collaborated with the LTA to efficiently communicate with the target population and for their insight on organic landscape and turfgrass practices. The LTA is a non-profit professional organization for adults working in the turfgrass and landscaping industries throughout the state of Louisiana, which frequently provides professional development and industry networking opportunities for its members (Louisiana Turfgrass Association, 2021). LTA membership traditionally includes golf course superintendents, sports field managers, sod producers, landscape contractors, and other professionals related to the turfgrass and landscaping industries (LTA, 2021).

2.4. Instrumentation

The survey instrument utilized in this study was developed by the researchers in collaboration with experts in turfgrass production and agricultural extension education. The instrument was designed to collect data relevant to participants' perceptions of organic practices and demographic information. Content and face validity for the instrument was established by a panel of experts consisting of turfgrass production faculty and social science researchers with experience in survey design. Additionally, Cronbach's alpha was calculated to analyze the post-hoc reliability of the scales measuring knowledge, which yielded alpha values above an acceptable level ($\alpha = .74$).

2.5. Data Collection

The target population for this study consisted of active members of the LTA ($N = 310$) (R. Strahan, personal communication, November 9, 2021). Data collection began late in the Fall semester of 2021 and used a mixed-mode delivery approach using guidelines detailed by Dillman et al. (2014). First, the tailored designed method was used to distribute email invitations containing a description of the study and a link to the survey to LTA members on the current LTA membership roster (Dillman et al., 2014). Two email reminders followed the invitation to LTA members who had not completed the survey instrument, with each email separated by ten days. An alternative mode of data collection was offered during the 2022 LTA Annual Conference. The researchers delivered a presentation during the conference in which attendees were provided with a QR code for the survey instrument and asked to complete the survey if they had not done so via the previous email link. All responses from both delivery modes were quality checked to prevent any duplicates in the data used for analysis. The mixed-mode delivery of the survey instrument yielded 91 usable responses (*n* = 91)*,* for an overall response rate of 29.4%. To address non-response bias, the demographic characteristics of early respondents (*n* = 51) were compared to those of late respondents (*n* = 40) (Lindner et al., 2001). Respondents only displayed significant differences in years of professional experience (*p* = .01, *d* = .55), with late respondents averaging 6.6 fewer years of experience than early respondents. Therefore, the researchers suggest caution in generalizing the findings of this study beyond the respondents represented, as early-career professionals may be underrepresented.

2.6. Data Analysis

IBM SPSS v.27 was utilized to generate descriptive statistics for this study. Additionally, phi coefficients were used to measure the association between dichotomous variables, rank-biserial correlations were calculated for relationships between dichotomous and ordinal variables, and Spearman's rho correlations were used for items with ordinal variables (Field, 2018, Glass, 1965, Hinkle et al., 2003).

2.7. Results and Discussion

The instrument's demographic portion revealed that most respondents identified as male (Table 1). Additionally, nearly three-quarters of respondents were between 31 and 60 years of age, although their years of experience more closely resembled a normal distribution, with the apex at 27.4% of respondents within the range of 16 to 25 years. Differences in position within their respective companies approached an even split between owners (*n* = 47; 52.2%) and employees (*n* = 43; 47.8%). Most companies associated with the respondents had annual sales averaging less than one million dollars (n = 32; 69.1%), with companies with sales <$250,000 having the most representation at 38.1% of the total respondents.

Table 1. Participant Demographics

Item	*f*	%
Gender (*n* = 91)		
Female	8	8.8
Male	82	90.1
Prefer not to answer	1	1.1
Age (*n* = 91)		
18 – 30 years old	7	7.7
31 – 45 years old	28	30.8
46 – 60 years old	36	39.6
More than 60 years old	20	22.0
Experience in the landscaping industry (*n* = 91)		
Five years or fewer	13	14.3
6 -15 years	21	23.1
16 – 25 years	25	27.4
26 – 35 years	19	20.9
More than 35 years	13	14.3
Position within company (*n* = 90)		
Owner	47	52.2
Employee	43	47.8
Company's average annual sales (*n* = 84)		
Less than $250,000	32	38.1
$250,000 - $499,999	13	15.5
$500,000 - $999,999	13	15.5
$1,000,000 – $2,999,999	7	8.3
$3,000,000 - $4,999,999	8	9.5
$5,000,000 - $9,999,999	1	1.2
$10,000,000 - $19,000,000	5	6.0
$20,000,000 or greater	5	6.0

The results from objective two provide insight into respondents' perceptions and knowledge of organic terminology in the turfgrass industry. More than three-quarters of respondents reported slightly positive or positive feelings toward the term organic in relation to turfgrass products (see Table 2).

Additionally, the majority of respondents claimed to be at least moderately knowledgeable about the USDA definition of organic, with 23.1% asserting they were very knowledgeable. However, nearly half of the respondents claimed no knowledge of the Organic Material Review Institute (OMRI), the regulating body for products used in USDA-certified organic production programs (OMRI, 2022).

Examination of the current organic practices and beliefs of turfgrass professionals revealed that the vast majority of respondents (*n* = 64; 70.3%) reported use of organic products within the preceding 12 months as part of their business, with over 90% of current use including organic fertilizers (see Table 3). Alternatively, of the respondents who indicated that they were not currently applying organic products, doubt associated with product efficacy was the most frequently provided reason (*n* = 10; 38.5%), followed closely by a lack of knowledge of available organic products (*n* = 7; 26.9%).

Regarding their belief toward the increased prevalence of organic product use in the turfgrass and landscape industries, over 80% of respondents indicated that they believed these practices would increase in use in the future, with increased customer requests (*n* = 25; 38.5%) and increased governmental regulation (*n* = 16; 24.6%) provided as the most frequent justifications for that belief. Similar to their perceptions of increased use, most respondents believed that organic products were safer than non-organic products, supported by a perception of greater environmental safety held by many participants. Perceptions of increased use and safety were largely in line with an interest in gaining knowledge about organic

Table 2. Perception and Knowledge of Organic Terms

		%			
Item	*n*	NF	SNF	SPF	PF
Perception of the term *Organic*	91	3.3	18.7	38.5	**39.6**
		NK	SK	MK	VK
Knowledge of USDA definition of *Organic*	91	3.3	34.1	**39.6**	23.1
Knowledge of OMRI	91	**47.3**	18.7	24.2	9.9

Note. Perception Scale: 1 = Negative Feelings (NF), 2 = Slightly Negative Feelings (SNF), 3 = Slightly Positive Feelings (SPF), 4 = Positive Feelings (PF); Knowledge Scale: 1 = No Knowledge (NK), 2 = Somewhat Knowledgeable (SK), 3 = Moderately Knowledgeable (MK), 4 = Very Knowledgeable (VK)

products, expressed by over three-quarters of the participants. The preferred learning format to support this interest, however, was near evenly split between in-person (*n* = 31; 48.1%) and web-based methods (*n* = 33; 51.5%).

The analysis aligned with the study's third objective began by examining variables with dichotomous outcomes (current application of organic products, belief in increased use, belief in improved safety, interest in greater information, position within the company, and gender) using the phi coefficient. No significant relationships were identified among these variables at a .05 alpha level. Point biserial correlations were used to examine the relationship between the same dichotomous variables and respondents' years of experience in the landscape and turfgrass industries, which also did not yield correlations significant at the .05 level. Rank biserial and Spearman's ρ correlations were used to analyze relationships, including ordinal variables, which are summarized in Table 4. Davis' (1971) correlation conventions were used to interpret the strength of association between the variables.

Table 3. Use and Perceptions of Organic Products

Item	*f*	%
Do you currently apply organic products? (*n* = 91)		
Yes	64	70.3
No	27	29.7
Organic products applied (*n* = 64)*		
Fertilizer	58	90.6
Herbicide	12	18.8
Insecticide	28	43.8
Fungicide	14	21.9
Other	3	4.7
Primary reason for not applying organic products (*n* = 26)		
Cost prohibitive	5	19.2
Less effective	10	38.5
No knowledge of available products	7	26.9
No products readily available in the local area	4	15.4
Do you believe the use of organic products will increase in the turfgrass/landscape industries in the future? (*n* = 90)		
Yes	74	82.2
No	16	17.8
Primary reason for increased use (*n* = 65)		
Increased customer requests	25	38.5
Increased governmental regulation	16	24.6
Marketing opportunities for landscaping companies	8	12.3
Temporary popularity	5	7.7
Do you believe organic products in the landscaping industry are safer than non-organic products? (*n* = 88)		
Yes	56	63.6
No	32	36.4
Primary reason for believing organic products are safer (*n* = 51)		
Applicator safety	13	25.5
Customer safety	11	21.6
Environmental safety	27	52.9
Are you interested in learning more about organic landscape products? (*n* = 90)		
Yes	69	76.7
No	21	23.3
Preferred method for learning about organic landscape products (*n* = 64)		
Presentations and training at annual meetings	31	48.4
Web-based training videos	18	28.1
Web-based informational pages	15	23.4

**Note*: Percentages total greater than 100% due to the multiple selection nature of this item.

Table 4. Selected Spearman’s *ρ* and Rank Biserial Correlations (*n* = 90)

	Organic Perception	USDA Organic	OMRI	Organic use	Increase in use	Safer	Gender	Sales
Organic Perception	-		.210*	-.281**	-.234*	-.346**		
USDA Organic		-	.578**	-.250*			-.259*	.247*
OMRI	.210*	.578**	-	-.318**				
Organic use	-.281**	-.250*	-.318**	-				
Increase in use	-.234*				-			
Safer	-.346**					-		
Gender		-.259*					-	
Sales		.247*						-

Note. Organic use, Increase in use, & Safer: 1 = Yes, 2 = No; Gender: 1 = Female, 2 = Male
* Correlation is significant at the 0.05 level (2-tailed)
** Correlation is significant at the 0.01 level (2-tailed)

Spearman’s *ρ* correlations revealed a significant, positive, low correlation between the respondents’ perception of the term organic and their knowledge of OMRI (r_s = .210). Additionally, perception of organic also displayed significant, low association with current organic product use (r_s = -.281) and beliefs related to future product use (r_s = -.234), with more positive feelings toward organic products associated with an increase in their current use and a belief that their use will become more prevalent in the future. Similarly, a significant, moderate correlation was displayed between *organic* perception and beliefs about product safety (r_s = -.346), indicating more positive feelings toward the term were associated with the belief that organic products were safer than non-organic products. Knowledge of the USDA definition of *organic* exhibited a substantial positive correlation with knowledge of OMRI (r_s = .578), which the researchers anticipated. USDA knowledge also presented significant, low associations with the current use of organic products (r_s = -.250), indicating a higher perceived knowledge of the USDA definition of *organic* is associated with a greater likelihood of currently using organic products.

Similarly, gender also displayed a low, significant association with USDA knowledge (r_s = -.259). Respondents who identified as female had a greater association with higher perceived knowledge than those who identified as male. A significant, positive low correlation was also present between USDA knowledge and average annual sales for the company the respondent represented ((r_s = .247). In addition to USDA knowledge, a significant, moderate association was displayed between knowledge of OMRI and current use of organic products (r_s = -.318), indicating that increased knowledge of the function of OMRI was associated with a greater chance of a respondent using organic products.

Additional significant correlations were found among demographic characteristics, such as an expected substantial positive correlation between respondents' years of experience in the turf and landscape industries and their age (r_s = .664; p = <.001). Anticipated findings also included a low association between the average annual sales of the respondent's company and their position as an owner or employee (r_s = .298; p = .006), indicating that non-owner respondents were more common from companies with higher annual sales. Average annual sales also exhibited a moderate positive correlation with years of work experience (r_s = .346; p = .001).

2.8. Conclusions and Recommendations

This study aimed to describe the characteristics of LTA members related to their perceptions of organic management practices and determine if relationships were present among those characteristics. The respondents in the study were predominantly male and between 31 and 60 years old. The high participation of males in the turfgrass and landscape industries found in this study was anticipated and in alignment with Carroll et al. (2021) work. They were varied in their career stages, although most worked for companies with average sales totaling less than $1 million and were relatively evenly distributed in their roles as company owners and employees. The narrow comparative number of respondents representing ownership and employees coupled with the distribution of average annual sales indicates a mixture of respondents who manage family-owned businesses and larger regional companies or state agencies with higher non-ownership employee participation. The membership combination of owner-operators and employee-practitioners may provide a potential for further analysis of vantage points regarding organic product usage in the turfgrass and landscape industry.

Among these respondents, the commercial application of organic products, particularly fertilizers, was relatively widespread. This widespread adoption in Louisiana has occurred despite a lack of regulation observed in several other states. The majority application of organic fertilizers is in line with their availability, as animal and plant by-products used as natural fertilizers have a long history of being applied to industrialized agricultural and horticultural lands, bolstered by increased availability in urban environments (Heckman, 2006). A lack of association between current use and age or years of experience aligns with Roger's (2003) generalizations about the socioeconomic characteristics of adopters.

Beyond the current rate of adoption, the variable that held the greatest consensus among respondents was a belief that the use of organic products in the landscape and turfgrass industries will increase in the future, indicating that this notion is held by those with positive *and* those with negative feelings toward organic products.

Despite widespread adoption and moderate knowledge of the USDA definition of organic, an understanding of the role of OMRI in selecting organic products was low. However, significant relationships were present between knowledge of the agencies defining organic products, perceptions of organic products, and the current use of organic products. While the relationships were promising, they were generally low in effect, and inferring causality is not possible from the data. Therefore, the question is raised, is the choice to apply organic products due to increased knowledge, or does knowledge develop following the decision to use the products? Although direct evidence is not present, the knowledge-first scenario is supported by nearly one-quarter of non-adopters who indicated that a lack of knowledge was their primary reason for not adopting organic practices. This barrier is conducive to the knowledge stage of the innovation-adoption process posited by Rogers (2003). Similarly, a felt need can be interpreted from increased customer requests serving as the primary reason for respondents' beliefs that organic product usage will increase in the landscaping industry. Increased customer requests and perceptions of improved safety may also contribute to the relative advantage and compatibility characteristics associated with an innovation-adoption choice (Rogers, 2003).

More research is warranted on landscape and turfgrass professionals' innovation-adoption process regarding organic practices. A better understanding of how those who chose to adopt came to their decision and how long these practices have been in use is needed to provide researchers with a more complete answer on how best to serve practitioners. Additionally, extension specialists in Louisiana should seek to capitalize on the high percentage of respondents who expressed interest in learning more about organic landscape products, the widely held belief that their use will continue to expand, and a lack of knowledge as a barrier to the innovation-adoption process by providing organic product programming for practitioners using both in-person and web-based formats.

CHAPTER 3. INFLUENCE OF ORGANIC FERTILIZERS ON PERENNIAL RYEGRASS GROWTH, EROSION RESISTANCE, AND INORGANIC N TRANSPORT IN SURFACE RUNOFF DURING ESTABLISHMENT

3.1. Introduction

Ryegrass species are often established on disturbed sites as a temporary groundcover in subtropical climates to reduce erosion during late autumn and winter until suitable environmental conditions occur for perennial, warm-season turfgrass species establishment (Zhou and Shangguan, 2007). Synthetic water-soluble fertilizers (WSF) are applied at seeding per construction specifications as a source of readily available nutrients to hasten turfgrass growth. Higher turfgrass coverage and density enhance water infiltration, reduce surface runoff occurrence, and limit erosion (Beard and Green, 1994; Burwell 2011). Application of fertilizer at seeding provides an efficiency to limit the number of input applications.

Alternatives to synthetic WSF such as natural fertilizers are gaining increasing interest from landscape contractors due to concerns with rising energy costs associated with synthetic fertilizer production; as a response to positive public perceptions of natural fertilizers; and potentially as a best management practice (BMP) (Chen, 2018 and Daadi and Latacz-Lohmann, 2021). Prior to the development of synthetic fertilizers in the mid-twentieth century nutrient recycling of animal and plant wastes historically served as primary nutrient sources of fertilizers (Baker, 2005). Modern evaluation of natural fertilizers applied to mature turfgrass swards have generally shown slower sward growth with lower clipping production and paler leaf color compared to swards fertilized using synthetic WSF (Easton and Petrovich, 2004). This is due to the mineralization process of natural fertilizers to release nutrients for plant uptake (Mikkelsen and Hartz, 2008) unlike salt-based water-soluble fertilizers (WSF) that readily disassociate in water. Natural fertilizer composition as well as abiotic factors including soil moisture, temperature, and pH influence soil biological activity (Zech, Wolfgang, et al, 1997, Vilkienė et al, 2016) to affect nutrient availability to regulate plant uptake and growth.

A potential benefit of natural fertilizers is metered nutrient release that is more synchronous with turfgrass emergence and growth (Lee et al, 2003). Application of natural fertilizers in turfgrass areas has been reported to reduce nutrient movement during surface runoff (Cheng et al 2014).This would also conceivably limit excess N available for transport offsite during surface runoff or leaching. The EPA has indicated fertilizers from agriculture are linked to incidents of water impairment (EPA, 2022) and relying solely on synthetic fertilizer composed of highly soluble nutrients at high application rates has the unintended consequence of increasing offsite nutrient movement (Hauck, 1981, Sanders, 2019, and Rice, 2019). Nutrient loss through surface runoff is particularly common in subtropical locations with heavy textured soils and subject to intense rainfall (Michel et al, 2007, Burwell, 2011, Rice, 2019, and Sanders 2019). Therefore, the objectives of this research were to compare turfgrass establishment using commercially available, organic-labeled fertilizers versus an industry standard synthetic WSF and characterize the environmental benefits of organic fertilizers to reduce N movement during surface runoff.

3.2. Field setup and Perennial Ryegrass Establishment

Experiments to examine natural fertilizer during establishment of perennial ryegrass were conducted in 2021 and 2022 for a period of 42 days after planting (DAP). Field research was conducted at the Louisiana State University Agricultural Center Botanic Gardens in Baton Rouge, LA (30°24’25.3’’ N, 91°06’09.5’’ W). Experiments followed much of the setup, field, and laboratory procedures outlined in Rice et al. (2019) examining the effects of N application and bermudagrass sprigging rates on nutrient and sediment movement, and Sanders et al. (2019) which examined fertilizer source effects on nutrient movement. For the experiments, steel runoff trays (1.8 m width X 6.1 m length X 0.35 m depth) inclined at 3° were filled with an A horizon material of an Oprairie silt loam (fine-silty, mixed, semiactive, thermic Fragiaquic Glossudalfs). Experimental units of 1.4-m^2 within each tray were formed using wooden inserts to physically divide areas. Soil samples were submitted for analysis at the LSU AgCenter Soil Testing and Plant Analysis Laboratory for pH (1:1, soil/water; 7.1 ± 0.2) and for Mehlich III concentrations of P (125.7 mg kg^{-1} ± 37.4) and K (196.2 mg kg^{-1} ± 63.5). Seedbeds were prepared by tilling to a depth of 7.5 cm using a hand-operated mini-tiller (Mantis, Southampton, PA) followed by fertilizer application incorporated using a rake to maintain slopes of the experimental units.

Fertilizer treatments included three organic fertilizers compared to an industrial standard synthetic WSF that served as the control. The organic fertilizers included a fish-based organic fertilizer (FOF) (7-7-2; source is unknown fish species, Down to Earth Bio-Fish All-Natural Fertilizer, Down to Earth Distributors, Inc., Eugene, OR), insect-based organic fertilizer (IOF) (3-2-2; source cricket frass, Known Source Farms, Taylor, TX), and plant-based organic fertilizer (POF) (7-1-2; source is soybean meal, Down to Earth Distributors, Inc., Eugene, OR). The synthetic WSF treatment was an ammonium-sulfate (21-0-0; Lesco Inc., Cleveland, OH). All fertilizers were applied at 97.6 kg N ha^{-1} by hand using shaker jars and then incorporated into the soil. Perennial ryegrass (*Lolium perenne* L.) was seeded at 488 kg ha^{-1} using shaker jars for even distribution followed by light raking for better seed-soil contact. Irrigation was applied as needed by hand to prevent inducing surface runoff irrigation the first seven DAP. Daily high temperature averages for the first and second experiments were 19.9 and 20.8 ℃, respectively.

3.3. Rainfall Simulation, Measurements, and Analysis

Runoff from individual experimental units was captured using stainless steel right-angle inserts at the base of the slope that funneled surface runoff into 68-L plastic containers. Surface runoff from natural rainfall in addition to simulated rainfall at 14, 28, and 42 DAP was collected. The rain simulator was composed of two stainless steel nozzles (2HH-SS30WSQ, Spraying Systems Co., Wheaton, Illinois) positioned above each tray to deliver 7.6 cm hr^{-1} for a duration of 30 min per event. Prior to each rainfall simulation, soil moisture and temperature were measured (Field Scout TDR 250, Turf-Tec International, Tallahassee, FL) and perennial ryegrass groundcover was assessed using a 1 cm × 1 cm wire mesh quadrat fitted with 100 pre-marked cross-sections. Post simulation or natural rainfall, runoff water volumes were recorded, and 1-L subsamples collected and stored at 5°C until inorganic N and total suspended solids (TSS) were completed. Total suspended solids analysis was performed following the USEPA Method 106.2. Inorganic N (NH_3 and NO_3) was analyzed following the microplate method outlined by Hood-Nowotny et al. (2010) with NH_3 and NO_3 fractions combined for total N referred to henceforth. At the conclusion of the experiments, tiller density was counted and shoot biomass was collected within 20 cm^2. Shoot biomass was dried for 72 h at 55°C and mass recorded.

3.4. Statistical Analysis

Fertilizer treatments were arranged in a complete randomized design with repeated measures procedure implemented for measurements analyzed over time. This included runoff volume, TSS, inorganic N, and turfgrass groundcover. Data is present for means with standard errors to show variability between fertilizer treatment effects at each runoff date. Additionally, single date measurements per fertilizer treatment including biomass and tiller density along with groundcover at 42 DAP and cumulative runoff volumes, TSS, and inorganic N losses were subjected to post-hoc Tukey's procedure at an alpha level of 0.05.

3.5. Ryegrass Establishment

Ryegrass species typically germinate within 7 to 14 DAP followed by rapid growth under suitable environmental conditions (Nizam, 2011). In this study, ryegrass regardless of fertilizer treatment resulted in increasing groundcovers of 27.5 to 33.7% at 14 DAP, 68.7 to 70.3% at 28 DAP, and 91.0 to 93.2% at 42 DAP (Fig 1. and Table 5). Similarities in ryegrass groundcover among fertilizer treatments also resulted in no statistical differences in shoot biomass (p-value = 0.0646) 42 DAP even though WSF-fertilized ryegrass nearly doubled POF and IOF-ryegrass biomasses and resulted in 20% greater biomass than FOF-ryegrass. The only differences in establishment among the fertilizer treatments was WSF-ryegrass' higher shoot density of 9.4 tillers cm^{-2} compared to 3.1 to 4.1 tillers cm^{-2} for ryegrass fertilized using an organic fertilizer. Increasing N availability is correlated to higher sward densities and biomass in pasture research evaluating ryegrass species (LaFarge and Loiseau, 2011). Nitrogen availability from organic fertilizers is governed by mineralization that is influenced by abiotic factors including temperature and soil moisture (Cassman and Munns, 1980, Choromanska and DeLuca, 2002, and Hartz et al, 2000). Slower mineralization rates of organic fertilizers compared to dissolution of ammonium-sulfate limited initial plant available N to delay biomass accumulation and tillering. This difference in growth is probably more pronounced for a fast-germinating turfgrass

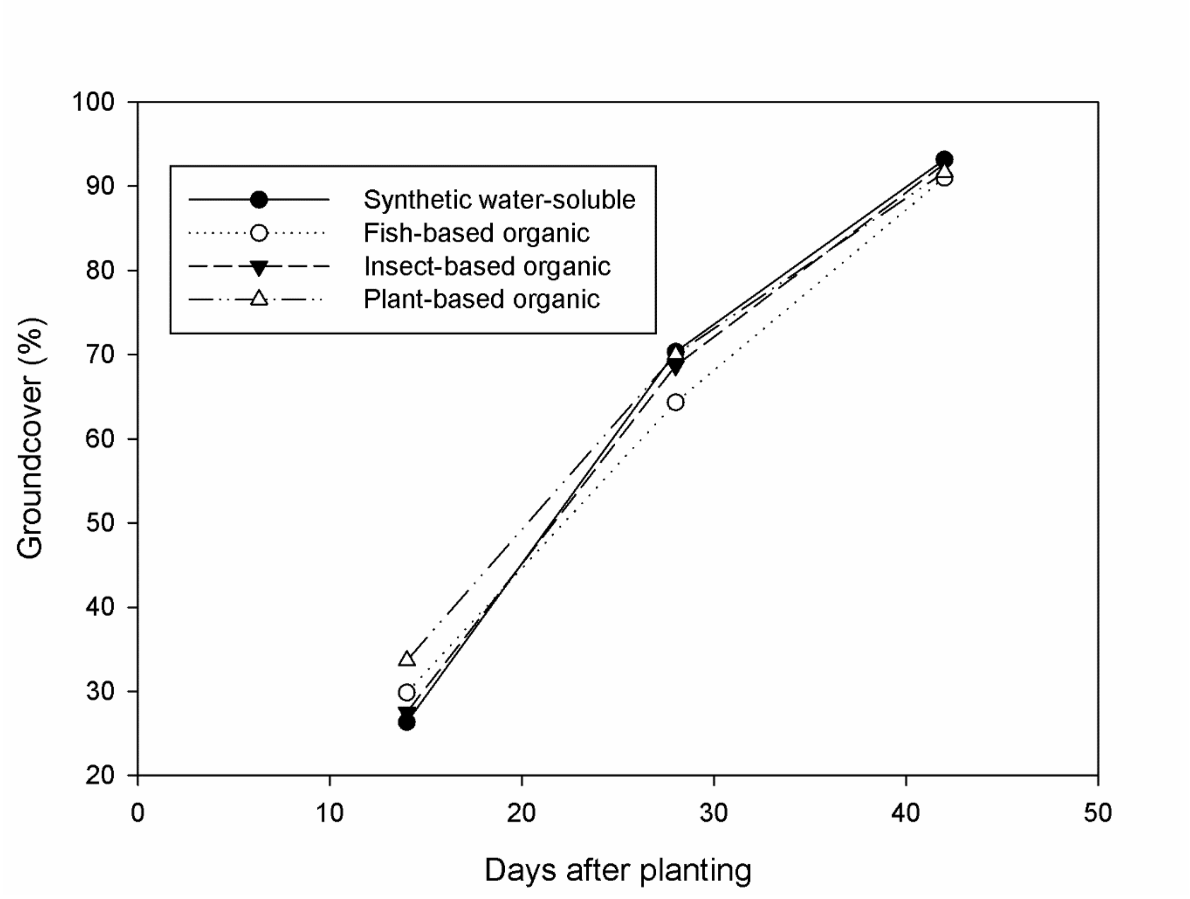

Figure 1. Perennial ryegrass groundcover over a 42 day establishment period fertilized at 97.6 kg N ha^{-1} using three organic fertilizers compared to industry standard synthetic water-soluble fertilizer.

Table 5. Perennial ryegrass establishment for forty-two days using three organic fertilizers and an industry standard synthetic water-soluble fertilizer.

Treatments	Groundcover	Shoot Biomass	Tiller Number
	----%----	-kg ha^{-1}-	-no. cm^{-2}-
Fish-based[†]	91.7[‡] a	6000 a	3.1 a
Insect-based	93.1 a	4500 a	3.1 a
Plant-based	91.0 a	4000 a	4.1 ab
Synthetic water-soluble	92.7 a	7500 a	9.4 b

[†] All fertilizers were applied at 97.6 kg ha^{-1} and incorporated into the soil at planting.

[‡] Means within a column are separated using Tukey's method ($P<0.05$). Means are different if followed by different letters.

species like ryegrass and would be less pronounced for slower germinating species given the physically limitation of developing roots to absorb nutrients. However, incorporation of organic fertilizers into the soil most likely accelerated N mineralization (Chandra, 2005, and Sánchez-García et al, 2015) sufficiently to ameliorate early WSF-ryegrass advantages so that application of organic fertilizers at seeding had no long-term deleterious effects on ryegrass establishment. It is expected the differences in fertilizer stimulated canopy architecture would likely decline beyond the establishment period among the fertilizers tested as N release from organic fertilizer continued.

3.6. Surface Runoff Occurrence and Severity

Turfgrass establishment is an important factor when evaluating surface runoff because higher groundcover and shoot density decrease runoff occurrence and severity (Burwell et al., 2011; Easton and Petrovic, 2004; Soldat and Petrovic, 2008). The lack of differences in groundcover among the fertilizer treatments predicatively resulted in similar cumulative runoff volumes (p-values = 0.3244) and TSS loading (p-value = 0.7246) with ranges of 172.8 to 213.9 L and 855.0 to 1232.1 kg ha^{-1}, respectively, over the establishment periods (Tables 6, 7, and 8). However, runoff volume and TSS losses fluctuated over time depending on rainfall total and runoff date. For example, a lower rainfall depth of 1.27 cm 13 DAP over a 24-hour period in the first experiment resulted in lower runoff volumes and TSS loading compared to a 30-min intense rainfall simulation performed one day later. When ryegrass coverages peaked 42-DAP for the final rainfall simulation, TSS losses consistently declined to the lowest rainfall simulated induced erosion across fertilizer treatments and experiments of 14.4 to 78.5 kg ha^{-1} and 36.7 to

55.6 kg ha^{-1} per experiment. Increasing groundcover delays surface runoff occurrence, impedes overland flow, and filters suspended sediments (Burwell et al, 2011, Easton and Petrovic, 2004).

Table 6. Cumulative total suspended sediment and inorganic N losses from surface runoff of perennial ryegrass established over forty-two days using three organic fertilizers and an industry standard synthetic water-soluble fertilizer.

Treatments	Runoff Depth	Total Suspended Solids	Inorganic N
	----- cm -----	--kg ha^{-1}--	-kg ha^{-1}-
Fish-based†	15.3‡ a	855.0 a	0.5 a
Insect-based	13.0 a	1194.3 a	0.4 a
Plant-based	12.3 a	1232.1 a	0.4 a
Synthetic water-soluble	15.3 a	1019.3 a	0.5 a

† All fertilizers were applied at 97.6 kg ha^{-1} and incorporated into the soil at planting.
‡ Means within a column are separated using Tukey's method ($P<0.05$). Means are different if followed by different letters.

Total suspended solid losses from rainfall simulations performed at 14 and 28 DAP did not decline as expected among fertilizer treatments for the first experiment even though simulated rainfall parameters were constant. One factor that contributed to this discrepancy was timing of natural and simulated rainfalls within the first twenty-one DAP. Low canopy coverage and frequent rainfall in the first experiment allowed water channeling or rills to form through the developing ryegrass swards to create higher variability in erosion 28 DAP compared to a more pronounced and consistent decline in TSS losses in the second experiment. The second experiment had more frequent natural rainfall occur in conjunction with higher groundcover in the latter half of the establishment period that prevented water channeling.

Erect growing species such as ryegrass offer lower runoff resistance versus prostrate growing turfgrass species that weave a filtering canopy architecture to reduce TSS loading

(Beard and Green, 1994; Linde, 1995). Rice et al. (2019) was able to achieve consistent erosion resistance of bermudagrass cv. ‘Latitude’ (*Cynodon dactylon x C. transvaalensis*) at ≥70% groundcover compared to >90% ryegrass groundcover reported in this study. They attributed higher bermudagrass sprig rates with having a mulching effect that shielded the soil during initial rainfall to limit TSS movement until bermudagrass sprig regrowth occurred (Rice et al., 2019), whereas ryegrass established by seed failed to provide soil shielding and was dependent on plant growth and development to deter erosive forces. Regardless of species differences in plant architecture effects on erosion resistance, all organic fertilized ryegrass were able to achieve similar erosion resistance compared to WSF-ryegrass within 42 DAP without requiring higher initial organic fertilizer application rates or applying subsequent fertilizations.

3.7. Nitrogen Losses From Surface Runoff

The fertility of organic fertilizers to support ryegrass establishment and increase erosion resistance to that of synthetic WSF-ryegrass swards lead to a question if organic fertilizers have any additional benefit of limiting nutrient movement. The practice of establishing temporary ryegrass coverage of anthropogenically disturbed sites often includes environmentally sensitive areas (Burwell et al., 2011). In this study, inorganic N losses fluctuated by runoff date due to natural and simulated rainfall patterns in alignment with previously published research examining drainage from turfgrass fertilized using natural or synthetic fertilizers (Easton and Petrovic, 2004). The highest inorganic N losses occurred under intense natural or simulated rainfalls with few differences in inorganic N losses among fertilizer treatments per runoff date. The most notable exception occurred 4 DAP or the first runoff event in the first experiment.

Table 7. Natural and rainfall simulation effects on runoff depth and total sediment loss from three organic fertilizers and an industry standard water-soluble fertilizer during turfgrass establishment over a 42-day establishment period for experiment one.

Day	Treatment	Rainfall Depth	Soil Moisture	Soil Temp.	Runoff Depth		Total Suspended Solids	
		--cm--	--%--	--°C--	--cm--	--SE[†]--	-kg ha^{-1}-	-SE-
4	Synthetic WS	6.4			2.64	0.04	209.2	40.9
	Fish-based				2.65	0.01	197.9	42.0
	Insect-based				2.64	0.04	324.5	45.3
	Plant-based				2.14	0.51	255.5	82.0
13	Synthetic WS	1.3			0.21	0.02	28.8	4.8
	Fish-based				0.18	0.07	40.2	17.9
	Insect-based				0.18	0.09	29.3	11.8
	Plant-based				0.21	0.09	47.5	25.0
14	Synthetic WS	7.6 – RS[‡]	47.7	23.5	5.05	0.94	409.4	262.4
	Fish-based		47.9	23.4	5.32	0.81	352.7	79.2
	Insect-based		48.0	23.5	3.27	0.64	378.0	247.1
	Plant-based		45.8	23.5	4.39	1.16	432.4	262.3
17	Synthetic WS	5.1			2.66	0.01	201.0	21.9
	Fish-based				2.58	0.04	232.9	34.0
	Insect-based				2.53	0.02	179.6	77.4
	Plant-based				2.61	0.05	194.4	11.0
28	Synthetic WS	7.6 – RS	49.0	27.1	4.28	0.17	447.2	247.7
	Fish-based		45.3	27.0	5.79	0.02	335.6	82.7
	Insect-based		46.4	27.4	4.48	0.86	563.6	272.9
	Plant-based		45.8	27.0	4.62	0.86	644.6	305.7
42	Synthetic WS	7.6 – RS	47.9	15.2	3.80	0.49	28.0	6.3
	Fish-based		46.9	15.1	4.31	0.10	14.4	5.8
	Insect-based		46.4	14.4	4.00	0.84	78.5	55.0
	Plant-based		48.9	15.7	2.41	1.62	30.0	18.9

[†] Standard error

[‡] Rainfall Simulation performed at 7.6 cm hr^{-1}

Table 8. Natural and rainfall simulation effects on runoff depth and total sediment loss from three organic fertilizers and an industry standard water-soluble fertilizer during turfgrass establishment over a 42-day establishment period for experiment two.

Day	Treatment	Rainfall Depth	Soil Moisture	Soil Temp.	Runoff Depth		Total Suspended Solids	
		--cm--	--%--	--℃--	--cm--	-SE[†]-	-kg ha^{-1}-	-SE-
14	Synthetic WS	7.6 - RS[‡]	45.8	23.0	4.32	0.84	474.3	91.7
	Fish-based		47.3	23.1	3.51	0.91	385.5	99.6
	Insect-based		44.5	23.0	5.76	3.44	632.5	378.0
	Plant-based		44.5	23.1	6.06	2.60	666.0	285.5
27	Synthetic WS	0.6			0.04	0.03	4.4	3.2
	Fish-based				0.09	0.03	10.1	3.4
	Insect-based				0.29	0.06	31.4	6.9
	Plant-based				0.22	0.10	24.3	11.1
28	Synthetic WS	7.6 – RS	36.3	23.6	1.10	0.44	120.6	48.3
	Fish-based		39.5	23.6	0.95	0.41	104.0	44.8
	Insect-based		40.0	23.5	0.70	0.39	76.6	42.0
	Plant-based		39.8	23.6	0.89	0.31	97.8	33.8
38	Synthetic WS	2.5			0.65	0.24	71.5	25.9
	Fish-based				0.37	0.29	41.0	31.4
	Insect-based				0.44	0.25	47.6	27.3
	Plant-based				0.32	0.14	35.3	15.9
42	Synthetic WS	7.6 - RS	31.4	14.9	0.40	0.31	43.6	34.4
	Fish-based		36.2	15.0	0.51	0.39	55.6	42.8
	Insect-based		39.6	14.8	0.43	0.33	47.3	35.8
	Plant-based		35.7	15.0	0.34	0.24	36.7	26.9

[†] Standard error

[‡] Rainfall Simulation performed at 7.6 cm hr^{-1}

Ryegrass fertilized with WSF or IOF-ryegrass exhibited higher inorganic N losses of 0.14 and 0.13 kg N ha^{-1}, respectively, compared to 0.09 and 0.08 N ha^{-1} for FOF and POF-ryegrass. In the second experiment, inorganic N losses from WSF-ryegrass were again numerically the highest at 14 DAP at 0.13 N ha^{-1}, the first runoff event, but not significantly among all the fertilizer treatments (Figure 2). Initial runoff events typically result in the highest initial nutrient losses particularly for water-soluble nutrient sources (Easton and Petrovic, 2004 and Gaudreau et al, 2002).

The differences in natural and simulated rainfall patterns between experiments does provide insight into the influence runoff timing has on inorganic N transport. Runoff occurred more frequently the first twenty-one DAP in the first experiment versus the second experiment. This higher runoff frequency accounted for 58.2 to 64.4% of the cumulative inorganic N lost compared to 28.3 to 34.5% for the same time period in the second experiment. In fact, inorganic N losses were not only higher in the latter half of the second experiment when runoff occurred more frequently, but ryegrass groundcover increased concurrently. Advantages of higher groundcover on dissolved nutrient transport can be minimized by intense rainfall (Suescún et al, 2017) once the onset of runoff occurs compared to groundcover retention of sediment bound pollutants. However, patterns in inorganic N losses between experiments resulted in similar cumulative inorganic N losses of 0.4 kg N ha^{-1} for insect and plant-based fertilizers and 0.5 kg N ha^{-1} for fish-based and WSF within the establishment period.

Surface water movement from landscape topographical changes is not a pollutant but serves as an important means of drainage (De Wit and Stankiewicz, 2011). It is the transport of dissolved or suspended solids within flowing waters that is the environmental concern. The inability of organic fertilizers to reduce inorganic N losses bring into question their use as a BMP to curb nutrient movement particularly in subtropical environments within the United States where rainfall rates often exceed the national average.

Fertilizer placement and initial supplemental irrigation likely reduced WSF inorganic N loading by moving ammonium deeper into the soil profile and away from the effects of overland flow. Placement of N and irrigation have each been reported to reduce synthetic WSF N losses up to 33 and 14.8%, respectively (Timmons et al, 1974, Siyal et al, 2012, Yu et al, 2021). On the other hand, soil incorporation of organic fertilizers created a conducive environment to accelerate N mineralization (Bernal et al, 1998 and Wu et al, 2019). Cassity-Duffey et al. (2020) reported relatively rapid mineralization rates with high N conversion for several commercially available, organic fertilizers compared to other natural N fertilizer sources and a salt-based WSF control. The combination of mechanical and mineralization processes muted N losses from the WSF while simultaneously increasing organic N availability and susceptibility to transport. Application of current commercially available, organic fertilizers may not be a suitable BMP for reducing nutrient losses during turfgrass establishment from seed. Management practices for incorporating WSF proved effective, but the recalcitrant composition of an organic fertilizer will affect nutrient availability and thus plant establishment and nutrient movement. Organic fertilizers that are quickly mineralized should result in similar patterns of growth and losses presented in this study under the conditions tested. The results of this study support the conclusions of Cassity-Duffey et al. (2020) that new terminology to describe the “high percentage of mineralization and rapid release” of nutrients from commercially available,

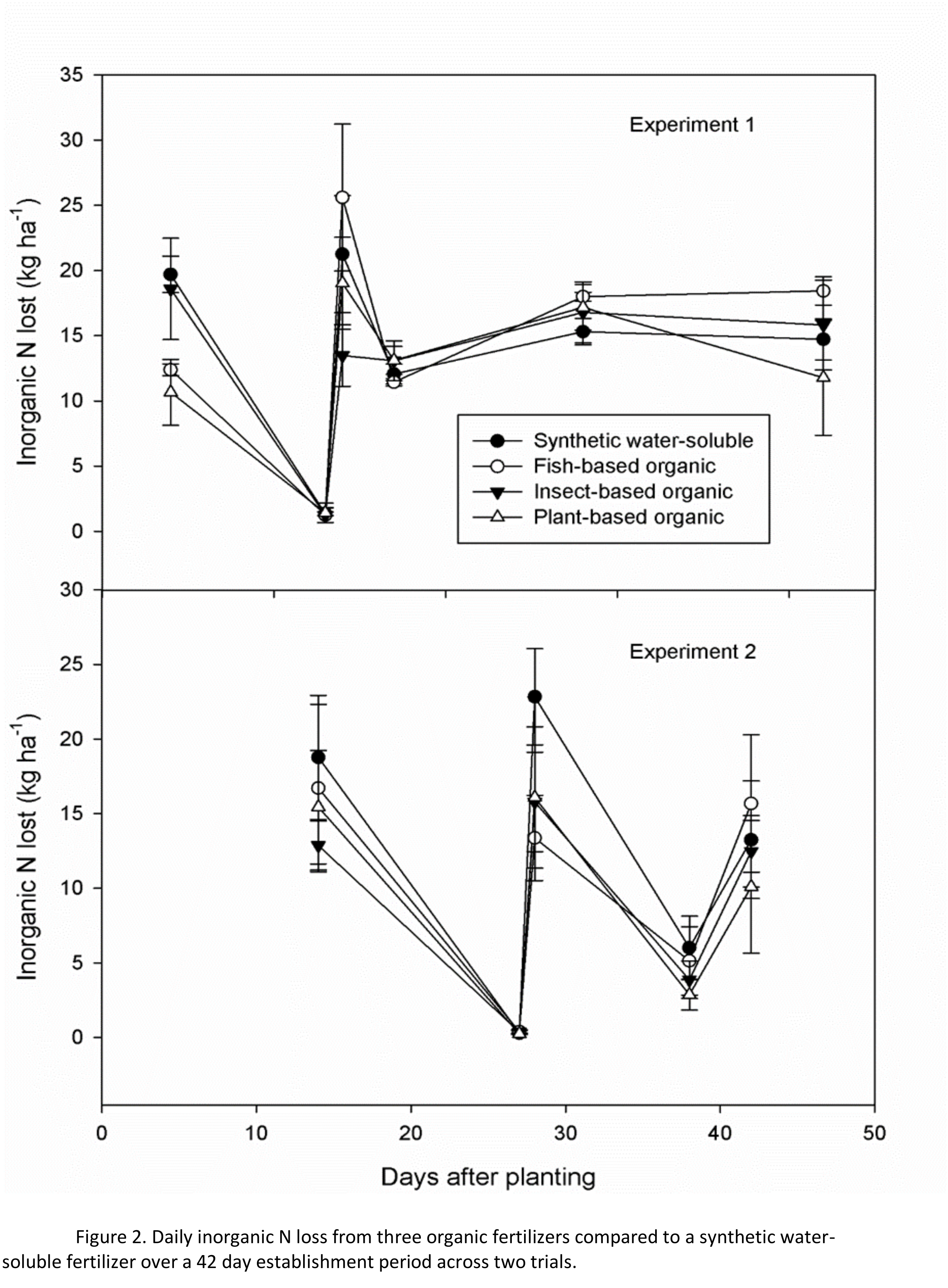

Figure 2. Daily inorganic N loss from three organic fertilizers compared to a synthetic water-soluble fertilizer over a 42 day establishment period across two trials.

organic fertilizers is needed to prevent the use of organic being synonymous with slow-release of nutrients.

3.8. Conclusion

There is increased interest by landscape contractors to use commercially available, organic fertilizers as alternatives to energy-intensive produced synthetic fertilizers during turfgrass establishment. The purpose of this study was to evaluate commercially available, organic-labeled fertilizers effects on ryegrass establishment and TSS and inorganic N movement during surface runoff. The similarity in ryegrass establishment among organic fertilizers across three distinct sources (fish-based, insect-based, and plant-based) indicate landscape contractors are not dependent on one organic source as an alternative to synthetic WSF for successful turfgrass establishment. However, application of organic fertilizers did not reduce cumulative inorganic N losses versus synthetic WSF within the 42-day establishment period. Management practices for incorporating WSF proved an effective BMP while rapid mineralization of organic fertilizers led to greater potential for inorganic N movement during surface runoff. Application of organic fertilizers provides a sustainable repurposing of readily waste streams but understanding timing of N release from organic fertilizers is needed for better BMP implementation.

Literature Cited

Alumai, A., S.O. Salminen, D.S. Richmond, J. Cardina, and P. Grenwal. 2008. Comparative evaluation of aesthetic, biological, and economic effectiveness of different lawn management programs. Urban Ecosyst. 12:127-144.

Anderson, J. R. (2012). Effects of seeding rates of perennial ryegrass (Lolium perenne L.) on sediment loading and nutrient transport via surface runoff.

Atwell, R. C., Schulte, L. A., & Westphal, L. M. (2009). Linking resilience theory and diffusion of innovations theory to understand the potential for perennials in the US Corn Belt. *Ecology and Society*, *14*(1).

Aziz, T., Maqsood, M. A., Kanwal, S., Hussain, S., Ahmad, H. R., & Sabir, M. (2015). Fertilizers and environment: issues and challenges. *Crop production and global environmental issues*, 575-598.

Baker, B. (2005). Brief history of organic farming and the National Organic Program. *Organic farming compliance handbook: A resource guide for western region agricultural professionals*.

Balogh, J. C., and Walker, W. J. (1992). Golf Course Management and Construction: Environmental Issues. pp. 82. WATER ENVIRONMENT FEDERATION.

Bartholomew, C., Campbell, B. L., & Wallace, V. (2015). Factors affecting school grounds and athletic field quality after pesticide bans: The case of Connecticut. *HortScience*, *50*(1), 99-103.

Barton, L., and Colmer, T. D. (2006). Irrigation and fertilizer strategies for minimizing nitrogen leaching from turfgrass. Agricultural Water Management 80, 160-175.

Beard, J. B., & Green, R. L. (1994). The role of turfgrasses in environmental protection and their benefits to humans. *Journal of environmental quality*, *23*(3), 452-460.

Bernal, M. P., Navarro, A. F., Sanchez-Monedero, M. A., Roig, A., & Cegarra, J. (1998). Influence of sewage sludge compost stability and maturity on carbon and nitrogen mineralization in soil. *Soil Biology & Biochemistry, 30*(3), 305–313.

Boesch, D. F. (2002). Challenges and opportunities for science in reducing nutrient overenrichment of coastal ecosystems. Estuaries 25, 886-900.

Bouwman, A. F., & Van Der Hoek, K. W. (1997). Scenarios of animal waste production and fertilizer use and associated ammonia emission for the developing countries. *Atmospheric Environment*, *31*(24), 4095-4102.

Bricker, S. B. (2007). "Effects of nutrient enrichment in the Nation's estuaries [electronic resource]: a decade of change, assessing change in eutrophic condition from the early 1990s to 2004: National Estuarine Eutrophication Assessment update / Authors: Suzanne Bricker ... [et al.]," Silver Spring, Md.: National Centers for Coastal Ocean Science, 2007.

Burwell, R. E., Timmons, D. R., and Holt, R. F. (1975). Nutrient Transport in Surface Runoff as Influenced by Soil Cover and Seasonal Periods1. Soil Science Society of America Journal 39, 523-528.

Burwell Jr, R. W., Beasley, J. S., Gaston, L. A., Borst, S. M., Sheffield, R. E., Strahan, R. E., & Munshaw, G. C. (2011). Losses of surface runoff, total solids, and nitrogen during bermudagrass establishment on levee embankments. *Journal of environmental quality*, *40*(4), 1241-1248.

Cai, G. X., Chen, D. L., Ding, H., Pacholski, A., Fan, X. H., & Zhu, Z. L. (2002). Nitrogen losses from fertilizers applied to maize, wheat and rice in the North China Plain. *Nutrient cycling in Agroecosystems*, *63*(2), 187-195.

Carroll, D. E., Stephens, C. A., Stripling, C. T., Sorochan, J. C., & Brosnan, J. T. (2021). Women in Turf: A Qualitative Study Examining How Women Have Sustained Their Leadership Role in the Turfgrass Industry. *Journal of Agricultural Education*, *62*(4).

Cassity-Duffey, K., Cabrera, M., Gaskin, J., Franklin, D., Kissel, D., & Saha, U. (2020). Nitrogen mineralization from organic materials and fertilizers: Predicting N release. *Soil Science Society of America Journal*, *84*(2), 522-533.

Cassman, K. G., & Munns, D. N. (1980). Nitrogen mineralization as affected by soil moisture, temperature, and depth. *Soil Science Society of America Journal*, *44*(6), 1233-1237.

Cayuela, M. L., Van Zwieten, L., Singh, B. P., Jeffery, S., Roig, A., & Sánchez-Monedero, M. A. (2014). Biochar's role in mitigating soil nitrous oxide emissions: A review and meta-analysis. *Agriculture, Ecosystems & Environment*, *191*, 5-16.

Chandra, K. (2005). Organic manures. *Booklet Released on the Occasion of*, *10*.

Chen, X., Zeng, D., Xu, Y., & Fan, X. (2018). Perceptions, risk attitude and organic fertilizer investment: Evidence from rice and banana farmers in Guangxi, China. *Sustainability*, *10*(10), 3715.

Cheng, Z., McCoy, E. L., & Grewal, P. S. (2014). Water, sediment, and nutrient runoff from urban lawns established on disturbed subsoil or topsoil and managed with inorganic or organic fertilizers. *Urban ecosystems*, *17*(1), 277-289.

Choromanska, U., & DeLuca, T. H. (2002). Microbial activity and nitrogen mineralization in forest mineral soils following heating: evaluation of post-fire effects. *Soil Biology and Biochemistry*, *34*(2), 263-271.

Cliath, W. F. S. M. (1991). Pesticide Losses in Surface Runoff from Irrigated Fields. In "Chemistry for the Protection of the Environment", pp. 277-289.

Cole, J. T., Baird, J. H., Basta, N. T., Huhnke, R. L., Storm, D. E., Johnson, G. V., Payton, M. E., Smolen, M. D., Martin, D. L., and Cole, J. C. (1997). Influence of Buffers on Pesticide and Nutrient Runoff from Bermudagrass Turf. Journal of Environmental Quality 26, 1589-1598.

Cromartie, J. (2017). *Rural areas show overall population decline and shifting regional patterns of population change* (No. 1490-2017-3197).

Daadi, B. E., & Latacz-Lohmann, U. (2021). Organic fertilizer use by smallholder farmers: typology of management approaches in northern Ghana. *Renewable Agriculture and Food Systems*, *36*(2), 192-206.

Daniel, W. H. (1978). MANAGER'S GUIDE TO WARM SEASON GRASSES. *Weeds, Trees, and Turf*, 80–92. https://doi.org/https://archive.lib.msu.edu/tic/wetrt/article/1978mar80.pdf

Davis. J.A. (1971). *Elementary survey analysis*. Prentice-Hall.

De Baets, S., Poesen, J., Meersmans, J., & Serlet, L. (2011). Cover crops and their erosion-reducing effects during concentrated flow erosion. *Catena*, *85*(3), 237-244.

De Wit, M., & Stankiewicz, J. (2006). Changes in surface water supply across Africa with predicted climate change. *Science*, *311*(5769), 1917-1921.

Dearing, J. W. (2009). Applying diffusion of innovation theory to intervention development. *Research on social work practice*, *19*(5), 503-518.

Dillman, D. A., Smyth, J. D., & Christian, L. M. (2014). *Internet, mail, and mixed-mode surveys: The tailored design method* (4th ed.). John Wiley & Sons.

Easton, Z. M., & Petrovic, A. M. (2004). Fertilizer source effect on ground and surface water quality in drainage from turfgrass. *Journal of environmental quality*, *33*(2), 645-655.

Environmental Protection Agency. (n.d.). *Next Gen Fertilizer Challenges*. EPA. Retrieved August 4, 2022, from https://www.epa.gov/

Erickson, J. E., Cisar, J. L., Volin, J. C., and Snyder, G. H. (2001). Comparing Nitrogen Runoff and Leaching between Newly Established St. Augustinegrass Turf and an Alternative Residential Landscape Journal Series No. R-08216 of the Florida Agricultural Experiment Station. Crop Science 41, 1889-1895.

Field, A. (2013). *Discovering statistics using IBM SPSS statistics*. sage.

Fierer, N. G., and Gabet, E. J. (2002). Carbon and Nitrogen Losses by Surface Runoff following Changes in Vegetation. Journal of Environmental Quality 31, 1207-1213.

Gaudreau, J. E., Vietor, D. M., White, R. H., Provin, T. L., & Munster, C. L. (2002). Response of turf and quality of water runoff to manure and fertilizer. *Journal of environmental quality*, *31*(4), 1316-1322.

Glass, G. V. (1965). A ranking variable analogue of biserial correlation: Implications for short-cut item analysis. *Journal of Educational Measurement*, *2*(1), 91-95.

Gómez, S., Gorri, D., and Irabien, Á. (2011). Organochlorine pesticide residues in sediments from coastal environment of Cantabria (northern Spain) and evaluation of the Atlantic Ocean. Environmental Monitoring and Assessment 176, 385-401.

Gross, C. M., Angle, J. S., and Welterlen, M. S. (1990). Nutrient and Sediment Losses from Turfgrass. Journal of Environmental Quality 19, 663-668.

Gutierrez, J., and Hernandez, I. I. (1996). Runoff and interrill erosion as affected by grass cover in a semi-arid rangeland of northern Mexico. Journal of Arid Environments 34, 287-295.

Haight, L. A. (2004). Local Control of Pesticides in New York: Perspectives and Policy Recommendations. *Alb. L. Envtl. Outlook*, *9*, 37.

Hannaway, D. B., Evers, G. W., Fales, S. L., Hall, M. H., Fransen, S. C., Ball, D. M., ... & Young III, W. C. (1997). Perennial ryegrass for forage in the USA. *Ecology, Production, and Management of Lolium for Forage in the USA*, *24*, 101-122.

Hannaway, D. B., Fransen, S., Cropper, J. B., Teel, M., Chaney, M., Griggs, T. D., ... & Lane, W. (1999). Perennial ryegrass (Lolium perenne L.).

Hanson, B., S. R. G., and Fulton, A. (1999). Agricultural salinity and drainage. University of California, Davis, CA, University of California Irrigation Program.

Hartman, R., Alcock, F., & Pettit, C. (2008). The spread of fertilizer ordinances in Florida. *Sea Grant L. & Pol'y J.*, *1*, 98.

Hartz, T. K., Mitchell, J. P., & Giannini, C. (2000). Nitrogen and carbon mineralization dynamics of manures and composts. *HortScience*, *35*(2), 209-212.

Hauck, R. D. (1981). Nitrogen fertilizer effects on nitrogen cycle processes. *Ecological Bulletins*, 551-562.

Heathwaite, A. L., and Dils, R. M. (2000). Characterizing phosphorus loss in surface and subsurface hydrological pathways. Science of The Total Environment 251-252, 523-538.

Heckman, J. (2006). A history of organic farming: Transitions from Sir Albert Howard's War in the Soil to USDA National Organic Program. *Renewable Agriculture and Food Systems*, *21*(3), 143-150.

Hinkle, D. E., Wiersma, W., & Jurs, S. G. (2003). *Applied statistics for the behavioral sciences* (Vol. 663). Houghton Mifflin College Division.

Hochmuth, G., Nell, T., Sartain, J., Unruh, B., Dukes, M., Martinez, C., ... & Cisar, J. (2009). Unintended consequences associated with certain urban fertilizer ordinances. *Univ. Florida Coop. Ext. Serv. SL283*.

Hood-Nowotny, R., Umana, N. H. N., Inselbacher, E., Oswald-Lachouani, P., & Wanek, W. (2010). Alternative methods for measuring inorganic, organic, and total dissolved nitrogen in soil. *Soil Science Society of America Journal*, *74*(3), 1018-1027.

Hunt, W. F., and T. R. O. Field. "Growth characteristics of perennial ryegrass." *Proceedings of the New Zealand Grassland Association*. 1978.

Johnson, P. G., Rossi, F. S., & Horgan, B. P. (2013). Sustainable turfgrass management in an increasingly urbanized world. *Turfgrass: Biology, use, and management*, *56*, 1007-1028.

Klöppel, H., Kördel, W., and Stein, B. (1997). Herbicide transport by surface runoff and herbicide retention in a filter strip — Rainfall and runoff simulation studies. Chemosphere 35, 129-141.

Kopp, K. L., and Guillard, K. (2002). Clipping Management and Nitrogen Fertilization of Turfgrass Contribution no. 1970 of the Storrs Agric. Exp. Stn. Crop Science 42, 1225- 1231.

Kronvang, B. (1990). Sediment-associated phosphorus transport from two intensively farmed catchment areas. In "Soil erosion on agricultural land", pp. 313-330.

Lafarge, M., & Loiseau, P. (2002). Tiller density and stand structure of tall fescue swards differing in age and nitrogen level. *European Journal of Agronomy*, *17*(3), 209-219.

Lavoie, A. L., Dentzman, K., & Wardropper, C. B. (2021). Using diffusion of innovations theory to understand agricultural producer perspectives on cover cropping in the inland Pacific Northwest, USA. *Renewable Agriculture and Food Systems*, *36*(4), 384-395.

Lee, D. J., Bowman, D. C., Cassel, D. K., Peacock, C. H., & Rufty, T. W. (2003). Soil inorganic nitrogen under fertilized bermudagrass turf. *Crop science*, *43*(1), 247-257.

Linde, D. T., Watschke, T. L., Jarrett, A. R., & Borger, J. A. (1995). Surface runoff assessment from creeping bentgrass and perennial ryegrass turf. *Agronomy Journal*, *87*(2), 176-182.

Lindner, J. R., Murphy, T. H., & Briers, G. E. (2001). The handling of nonresponse in agricultural education. *Journal of Agricultural Education*, *42*(4), 43-53.

Louisiana Turfgrass Association. (2021). *About LTA.* https://www.laturf.net/about

Marshall, S., Orr, D., Bradley, L., & Moorman, C. (2015). A review of organic lawn care practices and policies in North America and the implications of lawn plant diversity and insect pest management. *HortTechnology*, *25*(4), 437-446.

Michel, G. A., Nair, V. D., & Nair, P. K. R. (2007). Silvopasture for reducing phosphorus loss from subtropical sandy soils. *Plant and soil*, *297*(1), 267-276..

Mikkelsen, R., & Hartz, T. K. (2008). Nitrogen sources for organic crop production. *Better crops*, *92*(4), 16-19.

Morton, T. G., Gold, A. J., and Sullivan, W. M. (1988). Influence of Overwatering and Fertilization on Nitrogen Losses from Home Lawns. Journal of Environmental Quality 17, 124-130.

Morvan, X., Naisse, C., Malam Issa, O., Desprats, J. F., Combaud, A., and Cerdan, O. (2014). Effect of ground-cover type on surface runoff and subsequent soil erosion in Champagne vineyards in France. Soil Use and Management 30, 372-381.

Motavalli, P. P., Goyne, K. W., & Udawatta, R. P. (2008). Environmental impacts of enhanced-efficiency nitrogen fertilizers. *Crop Management*, *7*(1), 1-15.

Nixon, S. W. (1995). Coastal marine eutrophication: a definition, social causes, and future concerns. *Ophelia*, *41*(1), 199-219.

Nizam, I. (2011). Effects of salinity stress on water uptake, germination and early seedling growth of perennial ryegrass. *African Journal of Biotechnology*, *10*(51), 10418-10424.

NRC (2000). Clean Coastal Waters: Understanding and Reducing the Effects of Nutrient Pollution. National Research Council, National Academies Press, Washington DC.

Organic Materials Review Institute (2022). *Who We Are.* https://www.omri.org/about

Rabalais, N. N., Turner, R. E., & Wiseman Jr, W. J. (2002). Gulf of Mexico hypoxia, aka" The dead zone". *Annual Review of ecology and Systematics*, 235-263.

Ribaudo, M. O., Heimlich, R., Claassen, R., & Peters, M. (2001). Least-cost management of nonpoint source pollution: source reduction versus interception strategies for controlling nitrogen loss in the Mississippi Basin. *Ecological Economics*, *37*(2), 183-197.

Rice, L. A. (2019). *Influence of nitrogen and sprig planting rates on surface runoff losses during'Latitude 36'bermudagrass establishment*. Louisiana State University and Agricultural & Mechanical College.

Robbins, P., & Birkenholtz, T. (2003). Turfgrass revolution: measuring the expansion of the American lawn. *Land use policy*, *20*(2), 181-194.

Robbins, P., Polderman, A., & Birkenholtz, T. (2001). Lawns and toxins: An ecology of the city. *Cities*, *18*(6), 369-380.

Rogers, E. M., Singhal, A., & Quinlan, M. M. (2014). Diffusion of innovations. In *An integrated approach to communication theory and research* (pp. 432-448). Routledge.

Sánchez-García, M., Alburquerque, J. A., Sánchez-Monedero, M. A., Roig, A., & Cayuela, M. L. (2015). Biochar accelerates organic matter degradation and enhances N mineralisation during composting of poultry manure without a relevant impact on gas emissions. *Bioresource technology*, *192*, 272-279.

Sanders, K. R., & Beasley, J. S. (2019). Fertilizer source affects nutrient losses from hybrid bermudagrass during surface runoff. *HortTechnology*, *29*(6), 952-957.

Senyolo, M. P., Long, T. B., Blok, V., & Omta, O. (2018). How the characteristics of innovations impact their adoption: An exploration of climate-smart agricultural innovations in South Africa. *Journal of Cleaner Production*, *172*, 3825-3840.

Singh, T. B., Ali, A., Prasad, M., Yadav, A., Shrivastav, P., Goyal, D., & Dantu, P. K. (2020). Role of organic fertilizers in improving soil fertility. In *Contaminants in agriculture* (pp. 61-77). Springer, Cham.

Siyal, A. A., Bristow, K. L., & Šimůnek, J. (2012). Minimizing nitrogen leaching from furrow irrigation through novel fertilizer placement and soil surface management strategies. *Agricultural Water Management*, *115*, 242-251.

Soldat, D. J., & Petrovic, A. M. (2008). The fate and transport of phosphorus in turfgrass ecosystems. *Crop science*, *48*(6), 2051-2065.

Sonzogni, W. C., Chesters, G., Coote, D. R., Jeffs, D. N., Konrad, J. C., Ostry, R. C., & Robinson, J. B. (1980). Pollution from land runoff. *Environmental Science & Technology*, *14*(2), 148-153.

Suescún, D., Villegas, J. C., León, J. D., Flórez, C. P., García-Leoz, V., & Correa-Londono, G. A. (2017). Vegetation cover and rainfall seasonality impact nutrient loss via runoff and erosion in the Colombian Andes. *Regional Environmental Change*, *17*(3), 827-839.

Thorogood, D. (2003). Perennial ryegrass. *Turfgrass biology, genetics, and breeding. John Wiley and Sons, Hoboken*, 75-106.

Timmons, D. R., Burwell, R. E., & Holt, R. F. (1973). Nitrogen and phosphorus losses in surface runoff from agricultural land as influenced by placement of broadcast fertilizer. *Water Resources Research*, *9*(3), 658-667.

USEPA (1998). National Water Quality Inventory: 1996 Report to Congress. Office of Water, Washington, DC, 521 pp.

Vilkienė, M., Ambrazaitienė, D., Karčauskienė, D., & Dabkevičius, Z. (2016). Assessment of soil organic matter mineralization under various management practices. *Acta Agriculturae Scandinavica, Section B—Soil & Plant Science*, *66*(8), 641-646.

Wang, Y., Bigelow, C. A., & Jiang, Y. (2009). Ploidy level and DNA content of perennial ryegrass germplasm as determined by flow cytometry. *HortScience*, *44*(7), 2049-2052.

White, M. J., Storm, D. E., Busteed, P. R., Stoodley, S. H., & Phillips, S. J. (2009). Evaluating nonpoint source critical source area contributions at the watershed scale. *Journal of environmental quality*, *38*(4), 1654-1663.

Wu, H., Du, S., Zhang, Y., An, J., Zou, H., Zhang, Y., & Yu, N. (2019). Effects of irrigation and nitrogen fertilization on greenhouse soil organic nitrogen fractions and soil-soluble nitrogen pools. *Agricultural Water Management*, *216*, 415-424.

Yelverton, F. (n.d.). *Perennial ryegrass: NC state extension publications*. Perennial Ryegrass | NC State Extension Publications. Retrieved August 8, 2022, from https://content.ces.ncsu.edu/perennial-ryegrass

Yu, Q., Ma, J., Zou, P., Lin, H., Sun, W., Yin, J., & Fu, J. (2015). Effects of combined application of organic and inorganic fertilizers plus nitrification inhibitor DMPP on nitrogen runoff loss in vegetable soils. *Environmental science and pollution research*, *22*(1), 472-481.

Yu, Y., Xu, J., Zhang, P., Meng, Y., & Xiong, Y. (2021). Controlled Irrigation and Drainage Reduce Rainfall Runoff and Nitrogen Loss in Paddy Fields. *International Journal of Environmental Research and Public Health*, *18*(7), 3348.

Zech, W., Senesi, N., Guggenberger, G., Kaiser, K., Lehmann, J., Miano, T. M., ... & Schroth, G. (1997). Factors controlling humification and mineralization of soil organic matter in the tropics. *Geoderma*, *79*(1-4), 117-161.

Zhou, Z. C., & Shangguan, Z. P. (2007). The effects of ryegrass roots and shoots on loess erosion under simulated rainfall. *Catena*, *70*(3), 350-355

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