PRODUCTION AND PERFORMANCE OF *Gaillardia* CULTIVARS AND ECOTYPES

By

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A THESIS PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT
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This document is dedicated to every student who gave up before finishing. With a little support and dedication, anything is possible.

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Blanket flower (*Gaillardia pulchella* Foug.) and related species are wildflowers native to much of the US. Cultivated varieties, as well as native ecotypes, are widely available from growers and seed companies.

Horticultural grade composts of sufficient quantity and quality are now being produced by private enterprises and public municipalities and marketed at economical values. Our study evaluated blanket flower grown in peat or compost-based media, and found compost to be a viable alternative to peat use in containerized nursery media, while maintaining sufficient plant growth, development, and plant quality.

Many blanket flower cultivars and ecotypes are characterized by having long internodes, thus having a leggy appearance. Plant growth regulators (PGRs) are often used to control internode length, resulting in decreased overall plant size. The PGRs ethephon and uniconazole effectively controlled the size of *Gaillardia pulchella* 'Torch,' but not for a north Florida *Gaillardia pulchella* ecotype.

Cultivar trials are useful tools for introducing new plants to the public and private sectors, and for testing performance in a particular climate. Several *Gaillardia* cultivars and ecotypes were planted in a trial garden in north central Florida. There were no general trends among *Gaillardia* species, though uniformity was higher in vegetatively propagated types as compared to those grown from seed.

Differences among separate populations within a species (ecotypes) have been noted in several species, including *Gaillardia pulchella*. Several ecotypes were collected, germinated, and transplanted to three locations in Florida. Generally, plants performed better in north Florida than in north central or central south Florida. Survival rate varied widely by ecotype and planting location, thus emphasizing the value of ecotype selection and use.

CHAPTER 1
INTRODUCTION AND LITERATURE REVIEW

The floriculture industry is growing. Between 2003 and 2004, there was a two percent rise in floriculture sales, bringing the total wholesale greenhouse and nursery receipts to $15.7 billion (floriculture's share of this is $6 billion) (Jerardo, 2005). The USDA Economic Research Service reported that most of the economic growth in floriculture in 2004 came from bedding and garden plant sales (Jerardo, 2005). The costs of transporting and storage have gone up, resulting in increasing prices on imported ornamental crops, while domestic prices have remained unchanged (Jerardo, 2005). These circumstances could provide an opportunity for domestic growers to capture more market share with the introduction of new, affordable crops that can be produced within this country.

Increasing native plant production may be profitable for the floriculture industry. As the value of using indigenous species is recognized, and native plant marketing is emphasized, consumer interest in native plants is rising (Hamill, 2005). Consumers often view native plants as easier to maintain since they are well-suited to the soils and climate of their native environment. Native plants are being used in land restoration projects, as well as in home gardens, along roadsides, and in city landscaping.

Though most nurseries sell some native plants, natives do not make up the majority of sales. As reported by respondents to a survey by Hodges and Haydu (2002), 58% of nurseries sell plants native to Florida. One quarter of all respondents said that natives represented over 20% of their sales.

With a household annual consumption of floriculture crops up to $54 in 2004 (Jerardo, 2005), and a greater interest in using natives, it is clear that the native plant industry has great potential for gaining a greater portion of the market share. There are dozens of marketable native plants that have yet to move into broad-scale production, not to mention the unending possibilities in cultivars of native species. It has been said that natives will be the "next big growth area for the industry" (Hamill, 2005).

People may be surprised to know that there are several popular landscaping plants that are native, but are not always labeled as such. Many popular flowers, grasses, and trees are native to the US. Marketing of these native plants is beginning to take off. One example of this is a native plant collection called 'American Beauties,' which will soon be available in retail garden centers (Hamill, 2005). This could be a big step toward mainstreaming great numbers of native plants.

Blanket flower (*Gaillardia* spp. Foug.), also known as firewheel or Indian blanket, is a native plant that has found its way into the realm of cultivation and extensive production. The *Gaillardia* genus is in the class Magnoliopsida, the order Asterales, and the family Asteraceae (United States Department of Agriculture [USDA], 2004). The genus was named after the 18^{th} century patron of botany, M. Gaillard de Charentonneau (Armitage, 2001). *G. aestivalis* (Walt. H. Rock) and *G. pulchella* (Foug.) are the two *Gaillardia* species native to Florida (Figure 1-1A and B). *G. pulchella* is native to the continental US and Hawaii, with a wide growing range stretching from the northernmost to southernmost contiguous states (Figure 1-2). *G. aestivalis* has a narrower range, with Kansas as its northwestern reach, south to Texas and Florida, and as far north as South Carolina on the east coast (USDA, 2004). An apparent physical difference between these species is in the spacing of ray florets; *G. aestivalis* has gaps between ray florets, while those of *G. pulchella* tend to grow abutting, or slightly overlapping.

At least nine cultivars are in production under the parentage of *G. aristata* and *G. pulchella* (Michigan State University Extension [MSU], 1999), and can be found in most seed catalogs and in many nurseries. Several other cultivars of diverse parentage are also widely available. Many *Gaillardia* cultivars are grown from seed, and hybrids may be propagated by root cuttings (Floridata, 2003) or stem cuttings (Ball FloraPlant, 2005).

Blanket flower is an annual or short-lived perennial (Floridata, 2003). Leaves may be basal and linear to lanceolate with a grayish green appearance. The disk florets are generally red to brown. Ray florets may be solid yellow or red, but most are red with yellow tips. They will bloom from late spring to fall, longer if spent heads are removed (Floridata, 2003).

Blanket flower plants and flowers can be used to fit a variety of niches. Cut flowers can last up to a week in water (Floridata, 2003), but flower heads may tend to droop due to thin pedicels. It is often used in wildflower plantings, along borders, roadsides, and in containers. Some of the more compact cultivars can accent walkways and embellish other formal environments. Improved production practices, assessment of cultivar performance, and determination of ecotype use in distinct geographic areas will ultimately broaden the availability and use of blanket flower in various landscapes. These issues have been investigated in the following chapters.

There are four studies featured in this thesis, covering production and evaluation aspects that address growth of blanket flower and its use in the landscape. The overall objectives of this thesis are to determine optimal production practices involving medium composition and plant growth regulator applications, to evaluate landscape performance of several blanket flower cultivars, and to evaluate performance of five different blanket flower seed sources when growing in north, north central, and central south Florida.

Compost Usage in Blanket Flower Growing Medium

There is an abundance of composting material in the US. In 1998, Americans generated 6.9 million dry tons of biosolids (United States Environmental Protection Agency [USEPA], 1999), which, along with yard waste, makes up the bulk of many composts. Twenty-one states have banned the dumping of at least some forms of yard trimmings in their landfills (Kaufman et al., 2004). Some waste management facilities have begun using these forms of waste to create compost. As of 1997, Florida had 12 permitted composting facilities, including some of the largest in the country, yet production is far from meeting the potential demand for compost (Shiralipour and Smith, 1998). Studies demonstrating the benefits and lack of negative consequences of compost use in ornamental production media may serve to encourage wider use of compost and help develop the market.

It has been suggested that if producers of compost were to control production methods and make a consistent and stable product, growers might be more willing to use compost in their growing medium (Raviv, 2005). The composition of composted material varies depending on the source of materials, the ratio of constituents used, and the length and type of maturing process. These factors vary by facility and age of compost. Some countries have adopted standards for compost quality. Australia has listed standards of rates of compost to use based on the electrical conductivity (EC) of the compost and salt tolerance of the plant (Woods End Research Laboratory, 2000). EC describes the concentration of soluble salts, which is important when growing containerized plants because an EC above 3.5 mS/cm (milliSiemens per centimeter) can be too high to support growth (Hicklenton, 1998). Having standards could increase consumers' willingness to use compost because they would be assured of its quality and consistency.

Since few researchers have investigated the use of compost for native herbaceous plant production, Wilson et al. (2001a) conducted a series of experiments addressing a multitude of factors influencing containerized perennial plant response to compost, including media composition, species specificity (Wilson et al., 2002), plant nutrition (Wilson et al., 2003), and irrigation (Wilson et al., 2003). Commercial soilless mixes amended with up to 50% compost (biosolids and yard trimmings) did not adversely affect size, appearance, or flowering. Plants grown in media with higher percentages of compost (75% or 100%) were still considered marketable, but were reduced in size and appeared to have abnormal root distribution.

The wealth of literature documenting the beneficial effects of compost on containerized plant growth emphasizes that results vary by species and source of compost. Previous research has largely focused on non-native ornamental plants without post-performance field assessments. There is rising interest and applications for native plant use in the landscape. Subsequently, containerized media compositions are being continually modified to optimize native plant production. Canadian sphagnum peat is one of the primary components of many substrate blends used by the nursery industry, but up to 40% Florida peat (sedge peat) is used by some native nurseries in Florida. As a product consisting mainly of sedges and grasses of wetland ecosystems, Florida peat is not considered by some as renewable at the level at which it is harvested (Barkham, 1993; Buckland, 1993). Florida ranks in the top five states nationally in the production of horticultural peat, with an annual mining industry value estimated at $8.18 million in 1999 (National Mining Association, 2001). Although the lower cost may make Florida peat an attractive substitute for sphagnum peat, Florida peat is reportedly inconsistent in pH and quality (Alexander, 2001). To address this, we conducted a study that evaluated blanket flower grown with or without compost-based media.

Growth Regulator Use on Blanket Flower

In many situations, growers want to control the growth of crops. While growth and development are desired, the amount of space a plant takes up affects shipping and holding capacity. A greater number of plants that can be placed on a truck and in a retail area translates into lower costs and greater potential for sales. More compact plants also have a greater aesthetic appeal (McMahon and Pasian, 2004). There are several methods that growers utilize to manage plant size during production. Altering quality and quantity of light, lowering temperature and DIF (day temperature minus night temperature), mechanical stimulation (moving plants), and applying plant growth regulating chemicals are all methods growers use to control plant growth (McMahon and Pasian, 2004).

Plant growth regulators (PGRs) are used for controlling many aspects of plant growth and development, including height, flower initiation, and fruit set. Several PGRs interrupt physiological pathways of hormones and enzymes, which disrupts normal growth. Many of these modes of action are far less obvious and understood than are the results that they produce.

There are three broad categories of growth retardants: ethylene releasers, gibberellin (GA) translocation inhibitors, and GA biosynthesis inhibitors (Rademacher, 1991). One of the most important ethylene releasers is ethephon, which, among other effects, retards shoot growth in plants, especially graminaceous plants such as wheat, oat, and barley (Rademacher, 1991).

Florel is a trade name for ethephon, and it is used on many horticultural crops. Other ethephon-containing products are Pistill and Ethrel (Barrett, 2001). Ethephon is often used to eliminate undesired fruit on ornamental trees. It has been used on apple trees to encourage flower bud formation and control growth (Jones et al., 1989). It is used on ornamental crops to abort and delay flowers, abscise leaves, strengthen stems and reduce stem elongation. It does this by releasing ethylene when it is absorbed by cells and exposed to pH greater than four (Rajala and Peltonen-Sainio, 2000). Auxin, which is a class of growth hormones, is involved in cell elongation and growth (Graham et al., 2003). It is made less available in the presence of ethylene (Rademacher, 1991). Cell elongation can be reduced when auxin is made less available, resulting in shorter internodes and smaller plants.

Another benefit of using Florel is to increase branching, which is good for stock plants and making plants appear more compact (Barrett, 1999). It has been recommended that growers spray Florel on liners as a substitute for pinching to develop a uniform crop (Styer, 2004).

Ethephon is commonly used to prevent flowering in stock plants, and even prevent flowering in cuttings taken from that plant (Barrett, 1999). While this is beneficial for stem cutting health, the reduction in flowering could be detrimental to the marketability of flowering plants in a nursery. It can take up to 8 weeks for plants to flower after treatment with ethephon, though the time can vary depending on rate (Barrett, 2001).

The common rate at which Florel is applied is 500 mg·L^{-1} (ppm), though a rate of up to 5,000 mg·L^{-1} is recommended for some crops (Latimer, 2004). However, the leaves of some plants can be damaged as a result of a high rate of Florel application (Barrett, 2001). The rate of application varies depending on environmental conditions and crop (Barrett, 1999).

Time of application can greatly alter the effects ethephon has on a crop. When applied to young pea plants, it reduced final height and caused a thickening of basal stems (Andersen, 1979). This could be an effect which growers would want to initiate in blanket flower plants to make plants stronger and easier to handle.

The triazoles, which are GA biosynthesis inhibitors, inhibit the oxidation of *ent*-kaurene to *ent*-kaurenoic acid, which is a part of the second step in GA biosynthesis (Gausman, 1991). This lowers the content of biologically active GAs (Gausman, 1991). Many of the intermediates produced during GA synthesis are used in other biotic functions, so inhibiting their production can further arrest growth by preventing the action of the processes for which the substances are required (Gausman, 1991).

In the 1960's, triazoles were developed for controlling fungal diseases in plants and animals (Fletcher et al., 2000). The method by which they work in fungi is to inhibit conversion of lanosterol to ergosterol (Fletcher et al., 2000). When being used for this purpose, it was found that treatments also reduce stem elongation. They reduce GA biosynthesis, ABA, ethylene, indole-3-acetic acid, inhibit sterol biosynthesis, and increase cytokinins content (Arteca, 1996).

It is apparent that triazoles work by lowering levels of GA because the growth retarding effects are reversed when GAs are applied (Fletcher et al., 2000). Triazoles cause a decrease in plant height by inducing a decrease in cell number and causing cortical cells to be shorter (Fletcher et al., 2000). For packing and shipping, it is often better to have shorter stems to reduce the chance of them breaking, and increase the number of plants that can fit into the shipping containers and retail displays.

Though plant growth regulator sales comprised a small fraction of the $20 billon industry of crop-protecting chemicals in 1988 (Gausman, 1991), they still are very important in agriculture. Along with being the largest group of systemic compounds, triazoles are also the most important growth inhibitors (Fletcher et al., 2000). Their importance can be partially attributed to the fact that they are effective at low doses and are not phytotoxic at low rates (Fletcher et al., 2000). Uniconazole, triapenthenol, BAS 11, LAB 150 978, and paclobutrazol are all triazoles. The most commercially used are uniconazole and paclobutrazol, which differ by one carbon bond (Gausman, 1991).

The concentration and method of application of the chemical greatly influence PGR effects on plants. The plant itself has a great deal to do with the outcome as well. Results will vary among species, and even among varieties and cultivars. Triazoles are primarily translocated via xylem. This has been shown using ^{14}C-tracers in *Malus* (Fletcher et al., 2000). Since there is little movement out of the leaves via the xylem, a triazole will not have any effect when applied to leaves, which is why foliar sprays are less effective than soil drenches or trunk injections (Fletcher et al., 2000).

Landscape Evaluations of *Gaillardia* Cultivars and Ecotypes

Trial gardens are places where a variety of plants are grown alongside one another and evaluated based on a range of qualities. There are several benefits to trialing plants. As the Pennsylvania State University trial garden mission statement puts it, their trial gardens "advance ornamental horticulture by providing plant growers, plant breeders and selectors, and the gardening public with unbiased evaluations of cultivar performance" (Shumac, 2004). For these same reasons, trial gardens are found in every corner of the US and in all seasons.

There are several reasons for conducting trials. One reason is to test plants in a certain climate or time of year. Different cultivars of the same species may bloom at different times of year and have longer or shorter seasons of flowering (Kelly and Harbaugh, 2002). It is important to know these differences, especially in marketing and production. Plants must be made available to consumers at the best time of year for planting, and this date will vary across climates. Performance of one cultivar can differ based on environmental elements such as soil, temperature, rainfall, day length and a number of other factors. Growers want to supply their customers with plants that will do well in their area, which is information they can obtain from local trial gardens (Schoellhorn, 2005).

Another reason for having plant trials is to showcase new products. Growers can view new plant performance at local trials and base future crops on what they like in the trials. They are then able to provide the newest and best of what is available to their customers (Schoellhorn, 2005). Trials also allow consumers to see plant performance in the landscape, giving a better idea of how they would look once planted at home.

Trials can instigate further research on cultivars. Investigations such as looking at why certain cultivars of the same species perform so differently or deciding which traits should be bred into a new cultivar may begin after seeing cultivars together in a trial. The outstanding showing of blanket flower in trials at the University of Florida prompted the studies presented in this thesis. It was apparent that certain cultivars or native species of blanket flower could be great garden performers, and further research of this plant could expand our knowledge base about it and increase its marketability.

Blanket Flower Ecotype Evaluations

Turesson is credited with coining the term “ecotype” and describing the ecotype concept (1922). Ecotype is defined as “a genetically induced variety within a single species, adapted for local ecological conditions” (Meyers et al., 2005), though there have been dissenters to the approval of such a definition. Quinn (1978) wrote that such units should be referred to as “populations,” or described by words such as “clinal variation.” Whatever the terminology, diversity exists within many plant species which can be characterized by genetic, morphological, physiological, and life cycle differences (Daehler et al., 1999).

Studies comparing ecotypes of a species have been conducted with spruce (*Picea glauca* Voss.) (Chanway and Holl, 1993), blue grama grass [*Bouteloua gracilis* (Willd. Ex Kunth) Lag. ex Griffiths] (Pitterman and Sage, 2000), ryegrass (*Lolium perenne* L.) (Schmidt, 2003), vetiver grass (*Bouteloua gracilis* Lag.) (Pitterman and Sage, 2000), black-eyed susan (*Rudbeckia hirta* L.) (Norcini et al., 2001), as well as many other plant species. Most studies have found significant differences among traits of ecotypes. Included among these differences are flowering time, height, performance, and even disease resistance (Czembor et al., 2001).

Phenotypic differences among ecotypes can be brought about by certain environmental factors (McCully, 2000). Environmental factors such as substrate texture can affect survival rate of various ecotypes of one species (McCully, 2000). Differences among ecotypes in their ability to tolerate environmental stresses have also been noted (Duncan, 2001).

Today, region-specific plants, commonly referred to as ecotypes or regional seed sources, are often the preferred type of plant material used in restoration projects. This is because ecotypes have genetically-evolved adaptations to certain environmental factors which help them to survive region-specific conditions (Heywood, 1986). Bringing in non-local plant material introduces novel genes which can alter the adaptive traits of future generations (McKay et al., 2005). Lesica and Allendorf (1999) proposed that it is preferable to use local plants when the restoration site has experienced a low amount of disturbance, but if the degree of disturbance is high, using a mixture of local and non-local plants would be preferred. Local plants would not be adapted to the much-altered environment, so introducing plants from outside populations would increase genetic variation, resulting in the capacity for more rapid adaptation to the disturbed site (Lesica and Allendorf, 1999).

Certain adaptations of ecotypes can make them more desirable in ornamental landscape applications and in production. For example, in turf production, an ecotype with lower seed production and a longer life cycle is preferred (Duncan, 2001). For a flowering annual plant such as blanket flower, an ecotype with a longer flowering season may be preferred. If seed production is of interest, it would be important to be familiar with seed differences among ecotypes. In a study of wiregrass (*Aristida beyrichiana* Trin & Rupr.), seed weight and seedling emergence differed among ecotypes (Gordon and Rice, 1998). The authors concluded that due to the significant differences among ecotypes, it is important to use local seed sources which were growing in similar soil and hydrological conditions (Gordon and Rice, 1998).

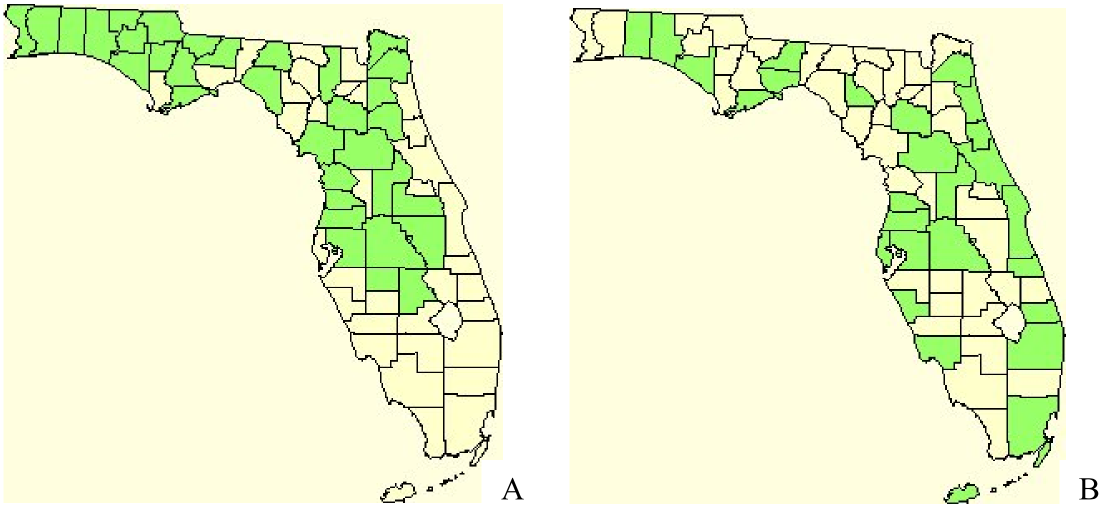

Figure 1-1. Counties in Florida with vouchered specimens (in green) of (A) *Gaillardia aestivalis* and (B) *Gaillardia pulchella* (in green) (Wunderlin and Hansen, 2002).

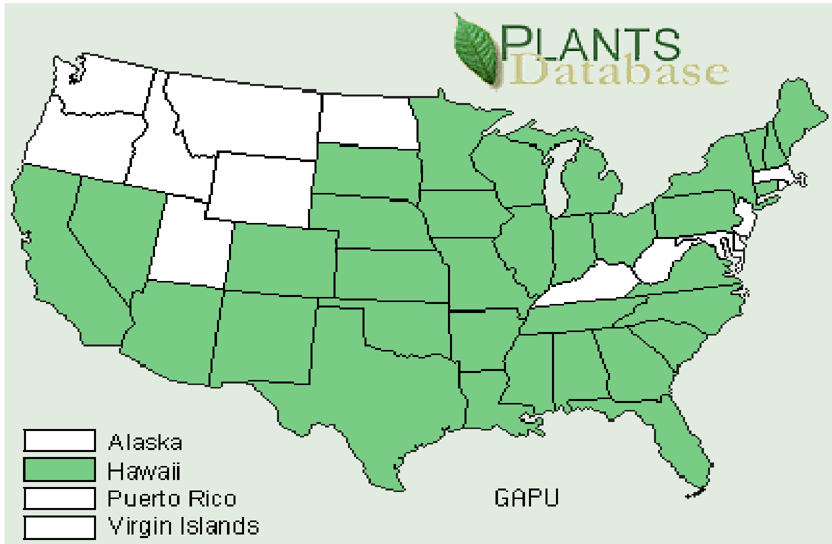

Figure 1-2. States which have vouchered specimens of *Gaillardia pulchella* (in green) (USDA, 2004).

CHAPTER 2

CONTAINER AND FIELD-EVALUATION OF BLANKET FLOWER (*Gaillardia pulchella* FOUG.) PRODUCED IN COMPOST-BASED MEDIA

Introduction

Though the physical properties of peat make it an excellent component of container media for ornamental plant production, environmental and economical implications of peat usage have led to the development of new substrate substitutes worldwide. Compost may be one of these peat alternatives. Compost is described by Raviv (2005) as “organic matter that has undergone partial thermophilic, aerobic decomposition.” The source of this organic matter can come from a number of places, such as agricultural and municipal wastes.

In the US, the amount of municipal solid waste recovered for composting has greatly increased to nearly 17 million tons (about 7% of generated waste) from 1980 to 2003 (USEPA, 2005). As composting activities increase, the amount of processed compost available for use by businesses and homeowners will continue to increase. Compost is commonly used to amend soils for growing vegetable and fruit crops (Raviv, 2005), but a market for container use of compost is growing.

Composts can provide a valuable source of nutrients within a nursery substrate (Hue and Sobieszczyk, 1999). In addition, composts have soil-borne disease suppression properties (Hoitink et al., 1991), and generally improve the physical, chemical, and biological properties of substrates (Inbar et al., 1993). Fitzpatrick (2001) has reviewed and cited numerous investigations illustrating the beneficial growth responses of compost utilization in ornamental and nursery crop production systems including temperate woody ornamentals, bedding plants, foliage plants, and subtropical or tropical trees. There have not, however, been many studies of native plants produced in composted media.

The objectives of this study were to compare peat- and compost-based media for container production and landscape performance of a popular US native, blanket flower (*Gaillardia pulchella* Foug.). This plant has earned notoriety by providing copious blooms throughout the summer and into fall, while being able to withstand harsh conditions. It performs well in low moisture, sandy soils, and has some salt tolerance, as shown by the populations growing on salty sand dunes adjacent to the Atlantic Ocean.

Abstract

Seed propagated blanket flower (*Gaillardia pulchella* Foug.) were container grown in a peat- or compost-based medium under greenhouse conditions for 10 weeks. The formulated compost-based medium had lower initial moisture, pH, total porosity, and container capacity; and higher bulk and particle density than the other media. The compost-based medium and un-amended compost both had higher levels of N, P, K, Zn, Cu, Mn, and Fe than the peat-based medium. At 10 weeks, plant height and shoot dry weight were greater for plants grown in the compost-based medium or compost alone than for plants grown in the peat-based medium. Incorporation of compost in the medium did not affect growth index, leaf greenness, flowering, or root mass. In addition, when transferred and planted out in the landscape for 16 weeks, initial container medium did not affect subsequent plant height, growth index, or visual quality.

Materials and Methods

Plant Material and Media Composition

Uniform blanket flower plugs grown from seed (D.R. Bates Nursery, Loxahatchee, FL) were transplanted into 1-gallon (3.8 L) plastic pots filled with a compost-based medium formulated on site (50% pine bark, 40% compost, and 10% coarse sand) (by volume). Additional containers were filled with compost alone or a peat-based commercial soilless mix (50% pine bark, 40% Florida peat, and 10% coarse sand) (v:v:v) (Atlas 3000, Atlas Peat and Soil Inc., Boynton, FL). Compost was generated by the Palm Beach County Solid Waste Authority (West Palm Beach, FL) using a 1:1 ratio (w:w) of biosolids and yard trimmings (screened to 0.64 cm). All plants were topdressed at a manufacturer-recommended rate of 15 g per pot of 15N:9P:12K Osmocote Plus ®.

Percent moisture, air-filled porosity (AFP), total porosity (TP), container capacity (CC), bulk density (BD), and particle density (PD) were determined on five samples from each medium. Percent moisture was calculated by drying a known weight of media at 105C for 24 h and weighing before and after drying. The AFP was determined in 500 mL containers using the Wolverhampton submersion method of measuring the volume of drainage water in relation to the substrate volume (Bragg and Chambers, 1998). Standard drying procedures were then used after volume displacement methods to determine TP, CC, BD, and PD [see (Niedziela and Nelson, 1992), for equations].

Electrical conductivity (EC), pH, and chemical and nutrient composition were determined on three samples from each medium prior to adding controlled-release fertilizer. Total C and N concentrations were determined by a CNS analyzer (Carlo-Erba Na-1500; BICO, Burbank, California). The Environmental Protection Agency (EPA) method 3050 (USEPA, 1998) was used to determine total P, K, Ca, Mg, Fe, Zn, Cu, Mn, and B. An acid digestion procedure was used to prepare the samples for analysis by Inductively Coupled Argon Plasma Spectroscopy (ICP) (Model 61E, Thermo Jarrell Ash Corp, Franklin, MA). Samples were air-dried for 2 days and ground to a powder with a ball mill grinder. A 1-g portion of the sample was digested in nitric acid then treated with 30% hydrogen peroxide. The sample was then refluxed with nitric acid, filtered through Whatman filter paper (no. 41), and diluted to 100 mL for analysis.

Growth and Development

Plant height and perpendicular widths were measured bi-weekly. After ten weeks, leaf greenness, dry shoot weight, and dry root weight of five plants from each treatment were measured. SPAD readings were measured on the fifth, sixth, and seventh leaves of the predominant stem using a SPAD-502 handheld chlorophyll meter (Minolta, Mahwah, NJ). Stems were separated from the roots at soil level and the roots were rinsed to remove media prior to oven drying at 74C for 7 days. For subsequent field evaluations, the remaining plants were transplanted (13 April 2004) 0.91 m on center on raised beds covered with landscape fabric. Plants were watered by seep irrigation as needed. Field conditions were as follows: 2.5% organic matter, pH 5.3, average monthly rainfall 3.31 cm, mean minimum and maximum temperatures 14.9C and 34.9C, respectively. The soil was Ankona series, which is sandy, siliceous, and hyperthermic (National Resources Conservation Survey [NRCS], 1999). Flowering and visual quality were evaluated bi-weekly for 16 weeks after planting. Flowering was based on a scale of 1-5, where 1=no flowers or buds present, 2=flower buds present, 3=several open flowers, 4=many open flowers, and 5=abundant open flowers. Visual quality (color and form) ratings were based on a scale of 1 to 5 with 1 indicating very poor quality and 5 indicating excellent quality.

Statistical Analysis

In the greenhouse study, a randomized complete block experimental design was used with 5 single plant replications for each medium. The field study utilized a randomized complete block experimental design with 3 replications (3 single plant samples per treatment per block). All data were subjected to an analysis of variance (ANOVA) and means separated at $P \leq 0.05$ by Duncan's Multiple Range Test.

Results and Discussion

Physical, Chemical, and Nutrient Characteristics of the Media

The formulated compost-based medium had lower initial moisture, pH, total porosity, and container capacity than the other media, with higher bulk and particle density (Table 2-1). Higher bulk density generally corresponds to a lower porosity (Poole et al., 1981). Passioura (2002) found that high bulk density caused a decrease in shoot and root weight in young barley (*Hordeum vulgare* L.) plants. Air filled porosity (6.7%) and container capacity (44.0%) were within the optimal range reported as suitable for use as a substrate for container-grown plants (Rynk et al., 1992). Inbar et al. (1993) have reviewed physical, chemical, and biological properties of compost used as a containerized media. More recently, Raviv (2005) reviewed the criteria necessary to produce high quality composts for horticultural purposes.

While it is not unusual for composts to have pH values slightly above the desirable range (Nappi and Barberis, 1993), the compost used in this study had a pH value (6.53) similar to that of the peat-based commercial mix (6.58). The EC of the compost-based medium was three times higher than that of the peat-based medium. High EC content, which has been reported for other composts made of biosolids and yard waste (Vavrina, 1994), often limits the exclusive use of compost without amendments, particularly for salt sensitive species. However, blanket flower thrives in coastal areas and did not appear to have been affected by the higher EC.

Compost or compost-based media had higher N content than the peat-based medium (Table 2-2). Organic waste has been reported as a valuable source of N (Sims, 1995). Composts with C:N ratios less than 20 are considered stable and optimum for plant growth (Davidson et al., 1994), while those with ratios greater than 30 may result in plant phytotoxicity and N immobilization (Zucconi et al., 1981). The compost-based medium had substantially more P and K than the peat-based medium (Table 2-2), which could lessen the need for additional P and K fertilizer. Phosphorus and K are often present at higher levels in compost media, which correlates with higher EC (McLachlan et al., 2004). Although this study only investigated nutrients within the media, a previous compost study analyzing nutrient content of leaf tissue showed that plants grown in media amended with compost generally had higher leaf K, P, and Mn; similar N and Ca; and lower Mg, Fe, and Al content than plants grown in the peat-based medium (Wilson et al., 2003). Heavy metal contents did not exceed EPA acceptable levels for biosolids application (USEPA, 1994) for any substrate.

Growth and Development

Regardless of the medium, at 10 weeks all plants were considered marketable (Figure 2-1). The average heights of plants grown in the compost or compost-based medium were consistently greater than the average heights of plants grown in the peat-based medium (Figure 2-2). Compost had no effect on growth index, leaf color, flower number, root dry weight, or shoot:root ratio. Shoot dry weight was 45% greater in compost-based media than in peat-based media (Table 2-3). This was consistent with Wilson et al. (2004) who found that at 8 weeks after transplanting in 100% compost, shoot dry weights of butterfly sage (*Cordia globosa* (Jacq.) Kunth), firebush (*Hamelia patens* Jacq.), scorpions tail (*Heliotropium angiospermum* Murray), tropical sage (*Salvia coccinea* Buc'hoz ex Etl.), climbing aster (*Symphyotrichum carolinianum* (Walter) Wunderlin & B.F. Hansen), narrowleaf sunflower (*Helianthus angustifolius* L.), pineland lantana (*Lantana depressa* Small), spotted beebalm (*Monarda punctata* L.), black-eyed susan (*Rudbeckia hirta* L.), and Carolina wild petunia (*Ruellia caroliniensis* (J.F. Gmel.) Steud.) were 1.5 to 8.0 times greater than that of plants grown in a peat-based medium. Interestingly, plant growth response of native plants grown in compost-based media was generally greater than that of non-native species. In seven out of the ten non-native perennial species evaluated, shoot dry weight was reduced when grown in media with more than 50% compost (Wilson et al., 2001b).

Subsequent to field transplanting, plants received similar flower and visual quality ratings regardless of the initial container medium used (Figure 2-3A and B). Visual quality ratings peaked for all treatments between weeks four and ten. After the week 10 evaluation, quality began to diminish, though flower ratings remained relatively high. Flower ratings for all treatments peaked around week 6, but continued to receive relatively high ratings throughout the remainder of the evaluation period (Figure 2-3A). Verifying field establishment of Florida natives is particularly warranted if they are not native to soils with high organic matter. In a study exploring nursery and field establishment techniques to improve seedling growth of three Costa Rican hardwoods, Wightman et al. (2001) reported varying results among ecologically distinct species. Pilon (*Hyeronima alchorneoides* Fr. Allemao), grown initially in compost, retained its size advantage after a year in the field. However, for other species such as Spanish elm

[*Cordia alliodora* (R.P.) Cham] and santa maria (*Calophyllum brasiliense* Cambess), container use of compost did not affect subsequent field growth.

Conclusions

Blanket flower grown in compost or compost-based media grew as well as or better than those in peat-based media. More importantly, media composition did not affect subsequent field establishment or landscape performance. However, container-grown blanket flower (particularly those with compost in the medium) could benefit from PGR application to control legginess.

In the past, variation within and among commercial compost facilities reduced the quality and consistency of compost, which are necessary for use in horticultural enterprises. Horticultural grade composts of sufficient quantity and quality are now being produced by private enterprises and public municipalities and marketed at economical values. Therefore, composts may be an alternative to peat in containerized nursery media for blanket flower, while maintaining sufficient plant growth, development, and ultimately, plant quality.

Table 2-1. Chemical and physical properties of compost and peat-based media[z].

Medium[y]	pH	EC (mmho/cm)	Air filled porosity	Total porosity	Container capacity	Bulk density	Particle density
			--------(% by vol)--------			--------($g \cdot cm^{-3}$)--------	
Peat-based	6.58 a[x]	1.63 c	5.08 a	48.0 a	43.0 a	0.23 b	0.46 b
Compost-based	5.97 b	5.73 b	4.06 a	41.6 b	38.0 b	0.33 a	0.57 a
Compost	6.53 a	11.20 a	6.67 a	50.8 a	44.0 a	0.20 c	0.42 b

[z] Data measured prior to transplanting.
[y] Peat-based commercial mix consists of 4:5:1 peat:pine bark:coarse sand (v:v:v).
Compost-based mix consists of 4:5:1 compost:pine bark:coarse sand (v:v:v).
Compost consists of yard waste : biosolids 1:1 (w:w).
[x] Means separation by Duncan's Multiple Range Test, 5% level.

Table 2-2. Elemental contents of compost and peat-based media[z].

Medium[y]	N	C	C/N	P	K	Ca	Mg
	--------(%)-------		ratio	-----------Concentration ($mg \cdot kg^{-1}$) ----------			
Peat-based	0.52 c[x]	31.8 a	60.7 a	103 c	267 c	13300 b	3660 a
Compost-based	0.84 b	24.3 b	28.9 b	3540 b	1937 b	13940 b	1105 c
Compost	2.43 a	30.7 a	12.7 c	10410 a	7150 a	47143 a	3096 b
Medium	**Zn**	**Cu**	**Mn**	**Al**	**Fe**	**B**	
	----------Concentration ($mg \cdot kg^{-1}$)----------						
Peat-based	5.4 c	3.6 c	20.1 c	1326 c	1174 c	11.0 b	
Compost-based	40.9 b	58.0 b	48.4 b	1703 b	4162 b	15.6 b	
Compost	102.3 a	166.4 a	115.6 a	3749 a	10557 a	34.8 a	

[z] Data measured prior to transplanting.
[y] Peat-based commercial mix consists of 4:5:1 peat:pine bark:coarse sand (v:v:v).
Compost-based mix consists of 4:5:1 compost:pine bark:coarse sand (v:v:v).
Compost consists of yard waste : biosolids 1:1 (w:w).
[x] Means separation by Duncan's Multiple Range Test, 5% level.

Table 2-3. Mean plant growth, leaf color, flowering, and dry weight of blanket flower (*Gaillardia pulchella*) grown in peat and compost-based media for 10 weeks[z].

Medium[z]	Growth index[y]	Leaf color (SPAD)	Flower (no.)	Shoot dry weight (g)	Root dry weight (g)	Shoot: root
Peat-based	36.8 a[x]	36.4 a	10.6 a	14.1 b	2.7 a	6.2 a
Compost-based	41.7 a	35.4 a	11.0 a	20.4 a	3.7 a	5.7 a
Compost	39.6 a	36.8 a	12.6 a	19.4 a	3.0 a	6.6 a

[z] Peat-based commercial mix consists of 4:5:1 peat:pine bark:coarse sand (v:v:v).
Compost-based mix consists of 4:5:1 compost:pine bark:coarse sand (v:v:v).
Compost consists of yard waste : biosolids 1:1 (w:w).
[y] Measured as [(plant height + width 1 + width 2)÷3].
[x] Means separation by Duncan's Multiple Range Test, 5% level.

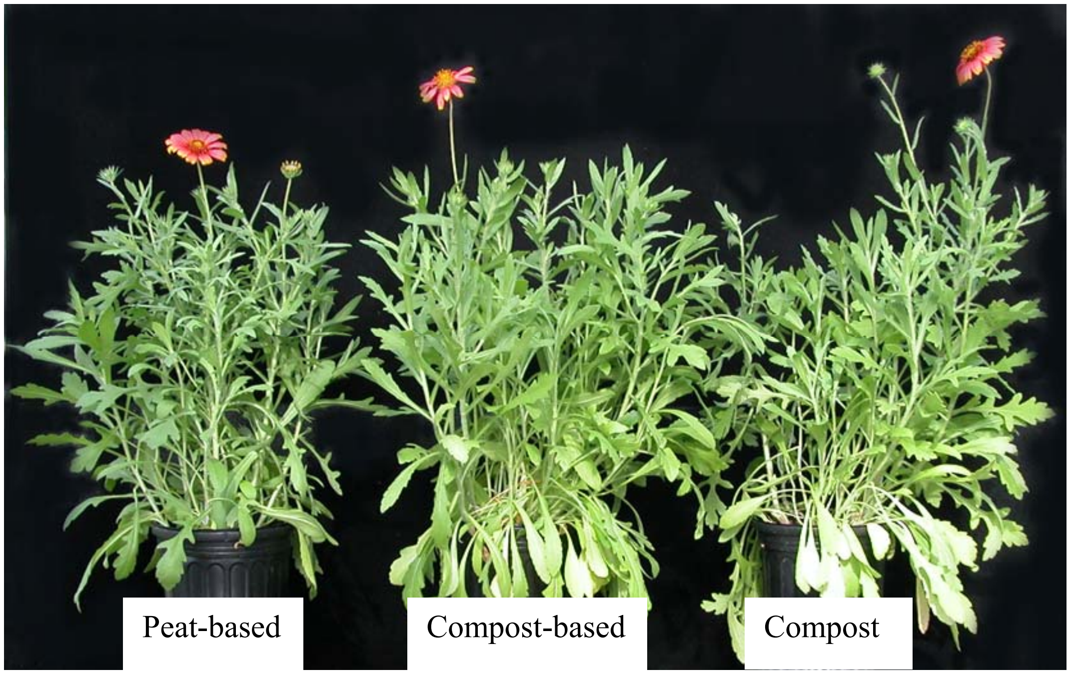

Figure 2-1. Blanket flower (*Gaillardia pulchella*) grown in peat-based, compost-based and compost media for 10 weeks.

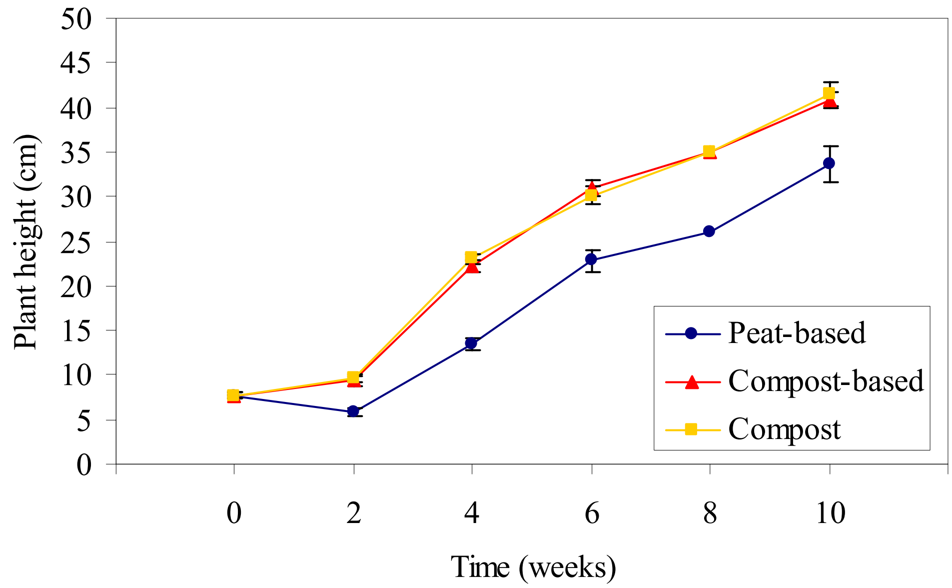

Figure 2-2. Bi-weekly plant height of blanket flower (*Gaillardia pulchella*) grown in peat-based, compost-based and compost media during container production. Vertical bars represent standard error for each treatment at each time interval.

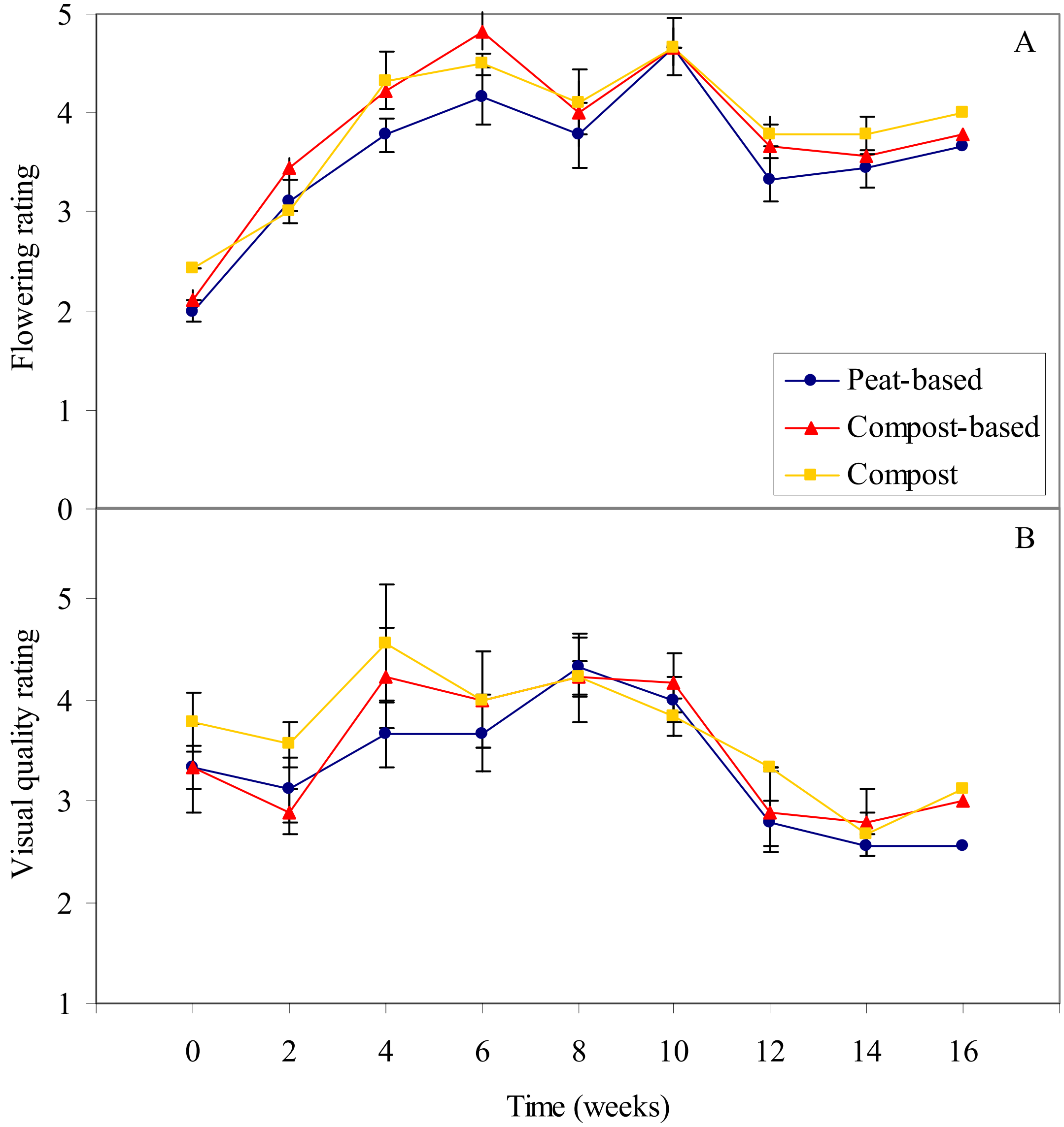

Figure 2-3. Flowering (A) and visual quality (B) of blanket flower (*Gaillardia pulchella*) that were transferred to the field following greenhouse container production in peat- or compost-based media. Flower ratings were based on a scale of 1-5, where 1=no flowers, 2=few flowers, 3=some flowers, 4=many flowers, and 5=peak flowering. Visual quality (color and form) was based on a scale of 1-5, where 1=very low quality, 2=low quality, 3=medium quality, 4=high quality, and 5=very high quality. Vertical bars represent standard error for each treatment at each time interval.

CHAPTER 3
USE OF PLANT GROWTH REGULATORS FOR PRODUCING MORE COMPACT BLANKET FLOWER (*Gaillardia pulchella* FOUG.)

Introduction

Blanket flower (*Gaillardia pulchella* Foug.) is an herbaceous annual in the Aster family. It is native throughout most of the US (Wunderlin and Hansen, 2002), and cultivated varieties are grown world-wide. In the right conditions, these plants are fast-growing and can quickly reach a cumbersome size for handling and shipping. The use of plant growth regulators (PGRs) may help extend the amount of time these plants can be held before distribution and sale.

There are many PGRs available for use on ornamental crops. They work through various biological systems in plants, and their effectiveness differs by plant. PGRs regulate growth by preventing lengthening of stems, resulting in a more compact plant with stronger stems (Whitman et al., 2005).

Uniconazole is a growth retardant related to paclobutrazol (Bonzi), but with greater efficacy (Gent and McAvoy, 2000). Uniconazole-P is the active ingredient in Sumagic (0.055%), which is used on many ornamental crops. It has been reported that growth restrictions induced by uniconazole persist for 28 to 40 days in Mandevilla (*Mandevilla splendens* Hook.) (Deneke et al., 1992), but persistence data for blanket flower have not been published.

Ethephon [(2-chloroethyl) phosphonic acid] is the active ingredient in Florel at 3.9% by weight. It is applied as a spray, generally at 250 to 500 $mg \cdot L^{-1}$ (ppm) (Barrett, 1999), but rates as high as 5,000 mg·L^{-1} can be applied to azalea (*Rhododendron* L. sp.) (Latimer, 2004). Ethephon can be used to initiate flower drop via the release of ethylene, however, some plants in Asteraceae have ethylene-insensitive flowers (Serek and Reid, 2000). When exposed to pH above 4.0, ethephon decomposes to release ethylene (Goudy et al., 1987). Ethylene reduces availability of auxin (Rademacher, 1991). Auxin is a class of growth hormones which affects stem elongation. The lack of useable auxin can decrease overall stem length, and therefore plant size, because of a reduction in internode length. This results in plants that are more compact, easier to ship, and more attractive to consumers (McMahon and Pasian, 2004).

A preliminary study was conducted by applying B-Nine (Uniroyal Chemical, Middlebury, Conn.) as a spray, Cycocel (Olympic Horticultural Products, Mainland, Pa.) as a spray, a tank mix of B-Nine/Cycocel as a spray, and Bonzi (Syngenta, Greensboro, N.C.) as a drench on a blanket flower cultivar (‘Torch’), and on an uncultivated blanket flower ecotype native to north Florida. The native blanket flower was chosen for these studies because of its large habit and leggy growth. While the ‘Torch’ cultivar has a more branching and less leggy habit than the native ecotype, it is not very compact.

During the preliminary studies, it was noted that the two types of blanket flower have very different growth habits and could not be compared directly. Therefore, later studies were separated by plant type. Regardless of blanket flower type, none of the PGR treatments were effective in controlling stem elongation (Table 3-1). Subsequently, additional growth regulators were tested: Florel (Southern Agricultural Insecticides, Inc., Palmetto, FL), which is an ethylene-releasing compound (Rademacher, 1991); and Sumagic (Valent U.S.A. Corporation, Walnut Creek, CA), which is a triazole like B-

Nine, but is more active (Barrett, 1999). The objective of this study was to determine if the PGRs uniconazole and ethephon, used at varying rates, could reduce stem elongation in *Gaillardia pulchella* 'Torch' and a blanket flower ecotype, resulting in more compact, marketable plants.

Abstract

Growth regulators are used on ornamental crops often to reduce stem elongation, resulting in more compact plants. Blanket flower (*Gaillardia pulchella*) is generally characterized by having long internodes, giving plants a leggy appearance. Two plant growth regulators were applied to 'Torch' and native blanket flower plants to try to reduce final production size. Florel (ethephon) was applied as a spray at a rate of 500 and 1,000 $mg \cdot L^{-1}$ (ppm) one and two times per plant. Sumagic (uniconazole) was applied as a soil drench at rates of 6, 12, and 24 $mg \cdot L^{-1}$ one and two times per plant. Regardless of application rate, 'Torch' plants that were sprayed twice with ethephon were the most compact. Regardless of whether plants were drenched once or twice, Uniconazole treatments of 24 $mg \cdot L^{-1}$ resulted in the smallest 'Torch' plants. No treatments effectively reduced the size of the blanket flower ecotype.

Materials and Methods

Unrooted 'Torch' stem cuttings (Ball FloraPlant, West Chicago, IL) were stuck in Fafard #2 medium (Fafard Inc., Apopka, FL) in 72-cell trays. Seeds of blanket flower from a source in Crestview, Florida were sown in Fafard #2 medium in 128-cell trays. Seed trays and cuttings were kept under intermittent mist (10 seconds per 20 minutes) for 10 days, then moved to a greenhouse where they were watered with 150 $mg \cdot L^{-1}$ 20-10-20

(N-P-K) liquid fertilizer (The Scotts Company, Marysville, OH). Rooted cuttings were transplanted into 3.8 L containers with Fafard #2 medium. Drip tubes delivered fertilized irrigation as needed throughout the study.

Growth Regulators

All solutions were prepared using deionized water (pH 7.0). Uniconazole was applied with a CO_2 sprayer at 2 quarts per 100 square feet, or as a drench using 180 milliliters per container at rates of 6, 12, and 24 $mg \cdot L^{-1}$ (Table 3-2). Ethephon was applied using a CO_2 sprayer at 3 quarts per 100 square feet at rates of 500 and 1,000 $mg \cdot L^{-1}$. The spray adjuvant Capsil (Aquatrols, Cherry Hill, NC) was added to ethephon solutions at a rate of 0.5 ml per liter. The second application for treatments which received 2 applications was applied 1 week following the initial treatment for both uniconazole and ethephon treatments.

Measurements

On the day of the first treatment, the height and widths of all plants were measured. Height was measured from the soil level to the highest vegetative point. Width was measured first at the widest vegetative point passing through the center of the plant, and a second measurement was taken perpendicular to the first. These same measurements were taken at the end of each study, before plants were harvested to determine dry weight. At harvest, all plant material above soil level was put into separate paper bags and dried in an oven at 70C for 1 week, after which dry weights were recorded.

Statistical Design and Analysis

The treatments were arranged in a completely randomized block design with three blocks and three replications per treatment. Means were separated using the Waller-

Duncan K-ratio t Test. This is a non-conservative test and allowed for missing data points.

Results and Discussion

Visual ratings of each plant were recorded for how compact the plant looked at the end of the study. Compactness ratings were based on a scale from one to three, where 1=not compact, 2=somewhat compact, and 3=highly compact. These ratings were made by looking through the center of each plant from the side and estimating the amount of open space visible compared to total area taken up by the plant. A highly compact plant had less than 10% of open space when looking through the plant. In a somewhat compact plant, more than 10% but less than 30% of the area was open space. If greater than 30% of the area was open, the plant was not compact. An example of compactness ratings of 1, 2, and 3 are can be seen in Figure 3-1A, where the control plant (left) was rated a 1, the center plant was rated a 2, and the plant on the right was rated a 3 for compactness.

Ethephon

Regardless of spray number or spray rate, ethephon applications did not affect the native blanket flower, so data has not been presented. A reason for the lack of affect could be that ethephon breaks down quickly, and not enough chemical may have been present to affect stem elongation when bolting began (J.E. Barrett, personal communication, 2005). To be effective, ethephon should be applied at the point when plants are beginning to bolt out of the rosette stage. Growth is not uniform in a seed-produced crop, so bolting times vary, making proper application for each plant extremely difficult. Other options for reducing stem elongation include restricting fertilizer and water, increasing light intensity, and mechanically stimulating plants.

Ethephon did have a significant effect on growth of ‘Torch.’ All treated plants were more compact than control, and were of saleable quality at the end of the study (Figure 3-1). Plants treated with 500 mg·L^{-1} ethephon twice and with 1,000 mg·L^{-1} ethephon once or twice received the highest rating (3.0) for compactness (Table 3-3). This compactness was due to reduction of internode lengths. This is consistent with results of Hansen and Grossman (2000) in which shoot growth of catchweed bedstraw (*Galium aparine* L.) and tomato (*Lycopersicon esculentum* Mill.) were reduced after exposure to ethephon.

Plants with the smallest growth index (GI) and least change in size were those which received two applications of ethephon (Table 3-3). The number of applications was significant, while the rate of ethephon was not significant (Table 3-4). Therefore, two applications of 500 mg·L^{-1} ethephon was just as effective in controlling GI as two applications of 1,000 mg·L^{-1} ethephon. Ethephon did not affect dry weights. This is noteworthy because though the GI of plants treated twice were smaller than plants treated once, the weight of vegetation was not less. This meant that the same amount of growth occurred among treatments, but the growth was more dense when two applications were administered. There were significant differences among treatments in compactness ratings, though only average ratings above 2.0 would be considered marketable. Thus, the treatment of 500 mg·L^{-1} applied twice and both 1,000 mg·L^{-1} Ethephon treatments resulted in very compact, marketable plants (Figure 3-1).

Flowering was affected by ethephon. At the time of final measurements, (3 weeks after initial application and 2 weeks after second application), only the untreated plants had flowers (Table 3-3). One week later, no open flowers were present on plants treated with two ethephon applications. With one application, the 500 ppm treatment showed about 7 flowers, and the 1,000 ppm treatment showed less than one flower. Untreated plants exhibited about 12 flowers per plant. Rate, number of applications, and their interaction had an effect on flowering at four weeks after initial treatment (Table 3-5).

All ethephon-treated plants had many flower buds at both 3 and 4 weeks after initial application. Plants treated with one application had many large buds; plants treated with two applications had many small buds (data not shown). The plants that had only one ethephon application flowered first, which is better for marketing since plants with flowers or flower buds sell more readily than those without (Keever and McGuire, 1991). Since the 1,000 $mg \cdot L^{-1}$ single application resulted in plants of marketable size similar to the double application treatment plants, it would be better to use the high rate single application for plants of marketable size and earlier flowering. This would also reduce on labor needed for a second application. However, flowering will still be delayed until about 5 weeks after ethephon application. By this time, plants will have begun to grow out of the effects of the growth regulator and internode lengthening will occur. If plants must be in flower before this, uniconazole may be a more desirable option for growth regulation, as it did not impact flowering in this study. Additionally, growth-controlling effects of ethephon do not last very long compared to effects of uniconazole, which may be important to growers wanting to hold plants longer.

Uniconazole

Regardless of application number or rate, uniconazole applied as a spray or as a drench had no effect on the blanket flower ecotype so final harvest data is not presented (Table 3-2). It is possible that plant size was not affected because during bolting, growth is mostly due to auxin (J.E. Barrett, personal communication, 2005). Bolting, or the elongation of flowering stems may be mediated by a shift in the control of elongation to auxins as well as gibberlic acid. Since the elongation process at this time may be controlled by both auxin and gibberellin pathways uniconazole would offer less control over the process. No research has been done to evaluate the family Asteraceae in this regard. Additionally, there are several GA pathways which could be utilized by the plant, essentially working around those that are blocked by uniconazole.

Uniconazole applied as a foliar spray had no significant effect on 'Torch' plants. In unpublished studies, high rates of uniconazole foliar spray were required for control in some Asteraceae plants (J.E. Barrett, personal communication, 2005).

Soil drenches of uniconazole were effective in controlling growth of 'Torch' *Gaillardia*. The rate of uniconazole drench had a significant effect on the GI and change in size (Table 3-6), though the number of times treatment was applied (once or twice) and the interaction of rate and number of treatments was not significant (Table 3-7). All treated plants were of saleable quality at the end of the study (Figure 3-2). Compactness was greatest when two applications of the 12 $mg{\cdot}L^{-1}$ drench was applied, and with either one or two applications of 24 $mg{\cdot}L^{-1}$ drench. Since there were no differences between GI, change in size, dry weight or compactness for single and double applications of the 24 $mg{\cdot}L^{-1}$ rate, one 24 $mg{\cdot}L^{-1}$ application on 'Torch' is sufficient for optimum size control.

A notable risk of using PGRs is a delay in flowering. However, this effect varies by species. For example, uniconazole has induced an increase in flower number of Camellia (*Camellia sasanqua* Thunb.) (Keever and McGuire, 1991) and delayed flowering in Mandevilla (Deneke et al., 1992). Changes in flowering may depend on time of application. In a study by Keever and Oliver (1994), time to flower decreased when azalea plants were treated at an early stage of development and increased when application occurred at a later stage. In our study, uniconazole treatments had no significant affect on flowering (Table 3-6).

Conclusions

Plant growth regulators (B-Nine, Cycocel, Bonzi, Uniconazole, and Ethephon) were not effective in controlling growth of a north Florida blanket flower ecotype, regardless of delivery method, application number or application rate. However, either ethephon spray or uniconazole drench can be used to effectively control growth of cultivated *Gaillardia pulchella* 'Torch.' It should be noted that these experiments were conducted during late summer in Florida. In more northern states, growth regulators are often needed in lower amounts than in the south (Latimer et al., 2003), so the recommended rates in this study may need to be adjusted for growers outside of Florida.

Table 3-1. Summary of preliminary plant growth regulator studies and resulting size comparisons of a cultivar and north Florida ecotype of *Gaillardia pulchella*.

PGR	Rate (mg·L^{-1})	No. of applications	Application method	*Gaillardia* type	% of growth index of control
B-Nine	5000	1	Spray	'Torch'	ND[z]
B-Nine/Cycocel	5000/1200	1	Spray	'Torch'	ND
Cycocel	1200	1	Spray	'Torch'	ND
Bonzi	30	1	Spray	'Torch'	ND
Bonzi	60	1	Spray	'Torch'	ND
Bonzi	120	1	Spray	'Torch'	ND
Bonzi	3	1	Drench	'Torch'	ND
Bonzi	6	1	Drench	'Torch'	ND
Bonzi	12	1	Drench	'Torch'	ND
B-Nine	5000	1	Spray	ecotype	ND
B-Nine/Cycocel	5000/1200	1	Spray	ecotype	ND
Cycocel	1200	1	Spray	ecotype	ND
Bonzi	30	1	Spray	ecotype	ND
Bonzi	60	1	Spray	ecotype	ND
Bonzi	120	1	Spray	ecotype	ND
Bonzi	3	1	Drench	ecotype	ND
Bonzi	6	1	Drench	ecotype	ND
Bonzi	12	1	Drench	ecotype	ND

[z] ND=Not visually different in size compared to untreated controls, thus measurements were not recorded.

Table 3-2. Summary of PGR applications and resulting size comparisons for *Gaillardia pulchella* 'Torch' and a north Florida ecotype.

PGR	Rate	No. of applications	Application method	*Gaillardia* type	% reduction of growth[z]
Florel	500	1	Spray	'Torch'	14.1
Florel	500	2	Spray	'Torch'	20.9
Florel	1000	1	Spray	'Torch'	15.6
Florel	1000	2	Spray	'Torch'	26.3
Sumagic	6	1	Drench	'Torch'	8.2
Sumagic	6	2	Drench	'Torch'	16.0
Sumagic	12	1	Drench	'Torch'	18.9
Sumagic	12	2	Drench	'Torch'	18.5
Sumagic	24	1	Drench	'Torch'	31.1
Sumagic	24	2	Drench	'Torch'	29.2
Sumagic	60	1	Spray	'Torch'	NS[y]
Sumagic	60	2	Spray	'Torch'	NS
Sumagic	120	1	Spray	'Torch'	NS
Sumagic	120	2	Spray	'Torch'	NS
Sumagic	180	1	Spray	'Torch'	NS
Sumagic	180	2	Spray	'Torch'	NS
Florel	500	1	Spray	ecotype	NS
Florel	500	2	Spray	ecotype	NS
Florel	1000	1	Spray	ecotype	NS
Florel	1000	2	Spray	ecotype	NS
Sumagic	6	1	Drench	ecotype	NS
Sumagic	6	2	Drench	ecotype	NS
Sumagic	12	1	Drench	ecotype	NS
Sumagic	12	2	Drench	ecotype	NS
Sumagic	24	1	Drench	ecotype	NS
Sumagic	24	2	Drench	ecotype	NS
Sumagic	60	1	Spray	ecotype	NS
Sumagic	60	2	Spray	ecotype	NS
Sumagic	120	1	Spray	ecotype	NS
Sumagic	120	2	Spray	ecotype	NS
Sumagic	180	1	Spray	ecotype	NS
Sumagic	180	2	Spray	ecotype	NS

[z] Growth calculated as one minus the growth index of treated plants divided by the growth of untreated control plants.

[y] There were not significant differences in size among 'Torch' plants treated with uniconazole spray and control (untreated) plants, nor among any treatments of the blanket flower ecotype and control.

Table 3-3. Growth index, size change, dry weight, compactness rating, flower number at week 3, and flower number at week 4 of *Gaillardia pulchella* 'Torch' treated with ethephon.

Rate ($mg \cdot L^{-1}$)	# of sprays	Growth index[z]	Size change[y]	Dry weight (g)	Compactness rating[x]	Flower no. at 3 weeks	Flower no. at 4 weeks
Control	-	26.3 a[w]	16.6 a	8.9 a	1.2 c	2.3 a	12.3 a
500	1	22.6 b	14.1 b	6.1 bc	2.0 b	0.0 b	7.3 b
1000	1	22.2 bc	12.9 bc	7.5 b	3.0 a	0.0 b	0.7 c
500	2	20.8 cd	12.1 c	6.5 bc	3.0 a	0.0 b	0.0 c
1000	2	19.4 d	10.2 d	5.9 c	3.0 a	0.0 b	0.0 c

[z] Growth index (GI) was calculated by the equation: (height+(width 1+width 2)/2)/2.
[y] Size change=final GI – initial GI.
[x] Compactness rating was a visual assessment based on a scale of 1-3, where 1=not compact, 2=somewhat compact, and 3=highly compact.
[w] Mean separation by Waller-Duncan with p=0.05.

Table 3-4. Anova table data for growth index at three weeks after initial treatment for *Gaillardia pulchella* 'Torch' treated with ethephon. Size was calculated by the equation: (height+(width 1+width 2)/2)/2.

Rate ($mg \cdot L^{-1}$)	One ethephon application	Two ethephon applications	Mean rate
500	22.6 b[z]	20.8 cd	21.7 a
1,000	22.2 bc	19.4 d	20.8 a
Untreated	26.3 a		
Mean no. application	22.4 a	20.1 b	

[z] Mean separation by Waller-Duncan with p=0.05.

ANOVA	Pr>F
No. application	0.0006
Rate	NS
No. application x rate	NS

Table 3-5. Anova table for flower number four weeks after initial treatment for *Gaillardia pulchella* 'Torch' treated with ethephon.

Rate ($mg \cdot L^{-1}$)	One ethephon application	Two ethephon applications
500	7.3 a[z]	0.00 b
1,000	0.7 b	0.00 b
Untreated	12.3[y]	

[z] Mean separation by Waller-Duncan with p=0.05.
[y] Mean significant difference for all treatments including control (untreated)=1.50

ANOVA	Pr>F
No. application	0.0001
Rate	0.0004
No. application x rate	0.0004

Table 3-6. Growth index, size change, dry weight, compactness rating, and flower number data of *Gaillardia pulchella* 'Torch' treated with uniconazole drench.

Rate (mg·L^{-1})	# of sprays	Growth index[z]	Size change[y]	Dry weight (g)	Compactness rating[x]	Flower no. at 3 weeks	Flower no. at 4 weeks
Control	-	31.8 a[w]	15.0 a	15.4 a	1.0 b	4.7 a	9.5 a
6	1	29.2 b	13.3 a	14.9 abc	1.3 b	3.0 a	11.0 a
6	2	26.7 c	11.1 b	12.9 bcd	1.4 b	3.2 a	5.0 a
12	1	25.8 c	9.8 c	12.4 cd	1.4 b	4.3 a	9.5 a
12	2	25.9 c	8.6 c	15.1 ab	2.2 a	2.7 a	3.5 a
24	1	21.9 d	6.6 d	10.7 d	2.7 a	3.2 a	5.5 a
24	2	22.5 d	4.9 d	12.4 d	2.4 a	2.3 a	5.0 a

[z] Growth index (GI) was calculated by the equation: (height+(width 1+width 2)/2)/2.
[y] Size change=final GI – initial GI.
[x] Compactness rating was a visual assessment based on a scale of 1-3, where 1=not compact, 2=somewhat compact, and 3=highly compact.
[w] Mean separation by Waller-Duncan with p=0.05.

Table 3-7. Anova table data for growth index at three weeks after initial treatment for *Gaillardia pulchella* 'Torch' treated with uniconazole. Size was calculated by the equation: (height+(width 1+width 2)/2)/2.

Rate (mg·L^{-1})	One uniconazole application	Two uniconazole applications	Mean rate
6	29.8 a[z]	26.7 c	27.9 a
12	25.7 c	25.9 c	25.8 b
24	21.9 d	22.5 d	22.2 c
Untreated	31.8 a		
Mean no. application	25.8 a	25.0 a	

[z] Mean separation by Waller-Duncan with p=0.05.

ANOVA	Pr>F
No. application	NS
Rate	<0.0001
No. application x rate	NS

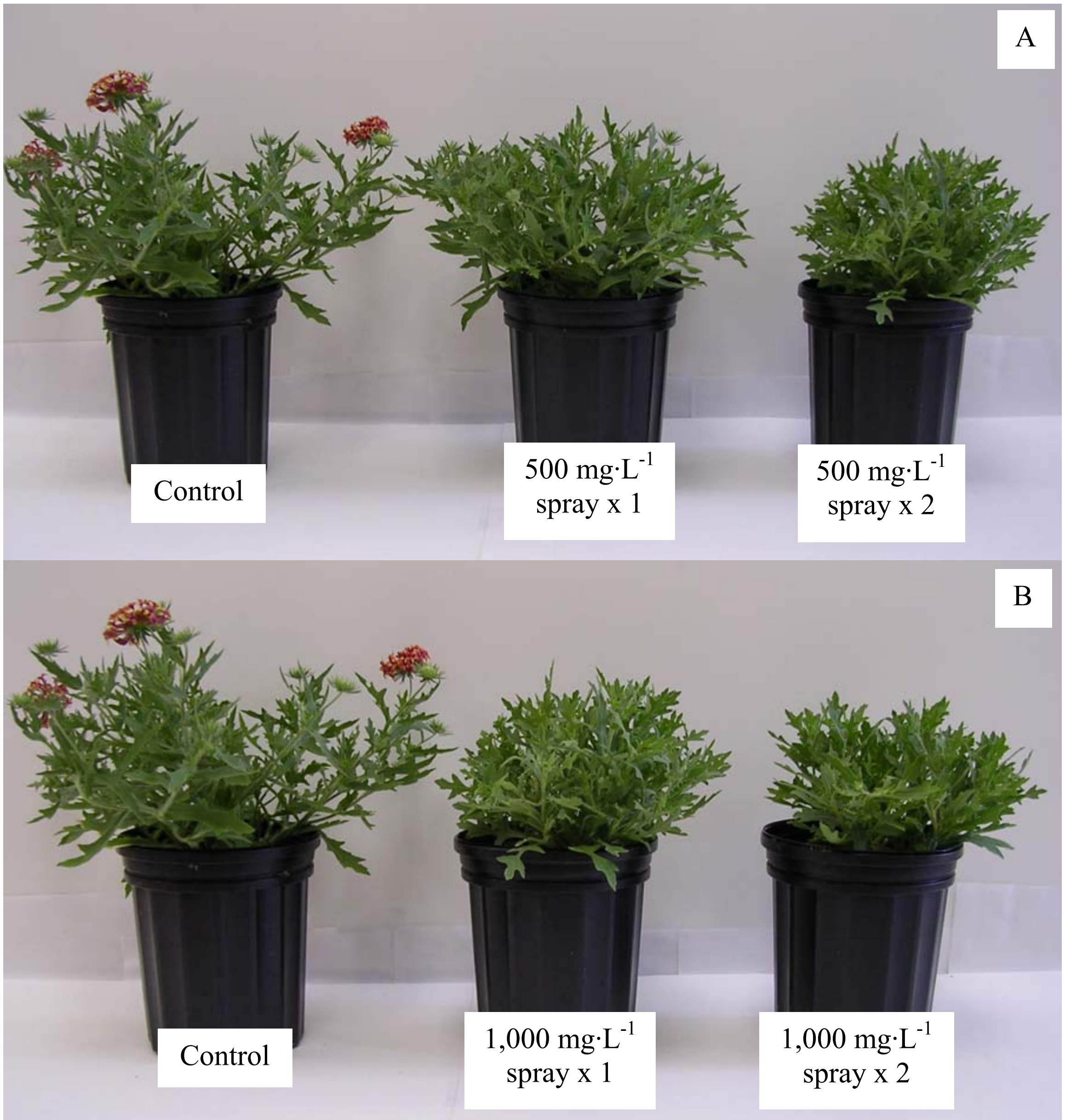

Figure 3-1. *Gaillardia pulchella* 'Torch' after treatment with ethephon. (A) Control, 500 $mg \cdot L^{-1}$ (ppm) ethephon sprayed once, 500 $mg \cdot L^{-1}$ ethephon sprayed twice, 1 week apart. (B) Control, 1,000 $mg \cdot L^{-1}$ ethephon sprayed once, 1,000 $mg \cdot L^{-1}$ ethephon sprayed twice, 1 week apart.

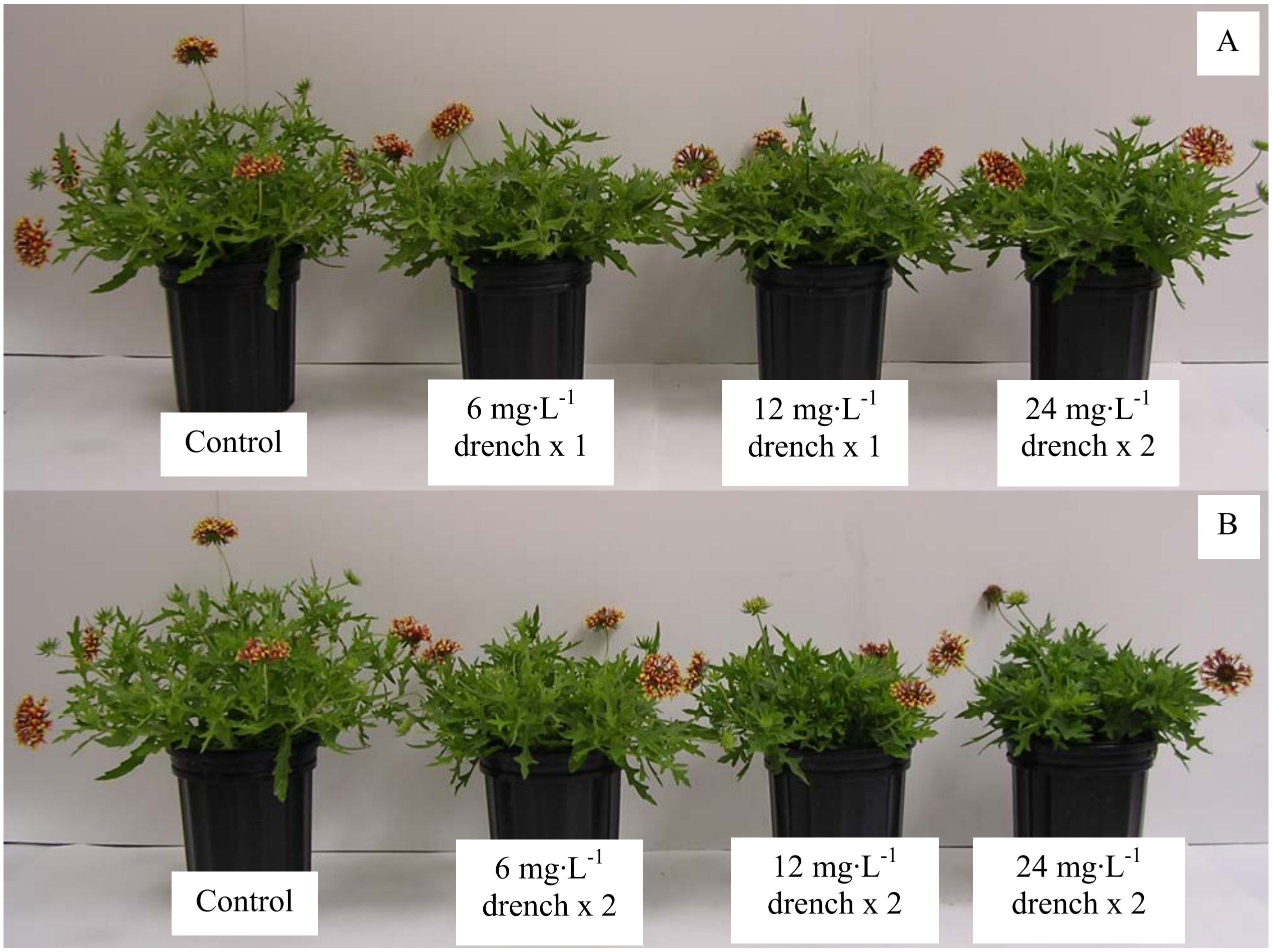

Figure 3-2. *Gaillardia pulchella* 'Torch' after uniconazole soil drench. (A) Control, 6 $mg \cdot L^{-1}$ (ppm) uniconazole drench once, 12 $mg \cdot L^{-1}$ uniconazole drench once, and 24 $mg \cdot L^{-1}$ uniconazole drench once. (B) Control, 16 $mg \cdot L^{-1}$ (ppm) uniconazole drench twice, 12 $mg \cdot L^{-1}$ uniconazole drench twice, and 24 $mg \cdot L^{-1}$ uniconazole drench twice, 1 week apart.

CHAPTER 4
EVALUATION OF *Gaillardia* CULTIVARS AND ECOTYPES FOR LANDSCAPE PERFORMANCE IN NORTH CENTRAL FLORIDA

Introduction

While many consumers may chose a plant based on catalog pictures, price, and availability, these factors tell little about the plant's ability to perform in a given climate. Facts about performance often come from plant trials. Many universities have bedding plant trials to compare how various cultivars perform in a landscape environment. Trial entries are generally rated on qualities such as flowering and disease susceptibility.

Plant trials can be important for introducing new crops. For example, Allan Armitage's trials at the University of Georgia (University of Georgia [UGA], 2005) and the trials at the University of Florida (University of Florida, 2005) allow both private and public sectors to view new and interesting crops and monitor their performance in a specific growing region. Growers may base their future crops on results of the trials, and consumers may modify their preferences and buying habits depending on what they see at these trials.

Many of the entries in these trials are newly discovered cultivars that have promise in the bedding plant market. Few native plants get this same kind of publicity, though there are some that do capture the public's attention. Species of *Gaillardia* (Foug.), many of which native to the US, have been crossed and cultivated, producing an array of cultivars. Several of these cultivars and species have been included in the trials at the University of Georgia for at least the last 3 years. The *Gaillardia* trialed there have received high ratings, most averaging above 4 on a scale of 1-5 (UGA, 2005). In the 2003 trial, two cultivars, ‘Torch Flame’ and ‘Torch Yellow’ were chosen to be among the “UGA Best of the Best” (UGA, 2005). *Gaillardia* cultivars have also been in trials at Colorado State University, North Carolina State University, Auburn University, Penn State University, and even in Canada at the University of Guelph, where ‘Arizona Sun’ was one of the 2004 Public’s Picks (University of Guelph, 2005). ‘Arizona Sun’ was also a winner of the 2005 All-America Selections, which conducts plant trials throughout North America (All-America, 2005).

At the 2003 University of Florida trials, *Gaillardia* plants, of both native and cultivated origins were trialed, and the native plants were among the best entries in the trial (Schoellhorn, 2004). Their impressive performance prompted interest in further evaluations of both native and cultivated varieties of *Gaillardia*. In the following study, several native and cultivated *Gaillardia* varieties were trialed in the 2004 Spring Trials at the University of Florida in Gainesville (USDA Hardiness Zone 8b). There are several reasons for conducting trials. One reason is to test plants in a certain climate or time of year. Different cultivars of the same species may bloom at different times of year and have longer or shorter seasons of flowering (Kelly and Harbaugh, 2002). It is important to know these differences, especially in marketing and production. Plants must be made available to consumers at the best time of year for planting, and this date will vary across climates. Performance of one cultivar can differ based on environmental elements such as soil, temperature, rainfall, day length and a number of other factors. Growers want to supply their customers with plants that will do well in their area, which is information they can obtain from local trial gardens (Schoellhorn, 2005).

Another reason for having plant trials is to showcase new products. Growers can view new plant performance at local trials and base future crops on what they like in the trials. They are then able to provide the newest and best of what is available to their customers (Schoellhorn, 2005). Trials also allow consumers to see plant performance in the landscape, giving a better idea of how they would look once planted at home.

Trials can instigate further research on cultivars. Investigations such as looking at why certain cultivars of the same species perform so differently or deciding which traits should be bred into a new cultivar may begin after seeing cultivars together in a trial. The outstanding showing of blanket flower in trials at the University of Florida prompted the studies presented in this thesis. It was apparent that certain cultivars or native species of blanket flower could be great garden performers, and further research of this plant could expand our knowledge base about it and increase its marketability.

Many *Gaillardia* cultivars have been bred from the parentage of *G. pulchella* and *G. aristata*. The resulting cross is named *G.* x *grandiflora* (Floridata, 2003). This hybrid has some cold-hardiness inherited from *G. aristata* and some heat and humidity tolerance inherited from *G. pulchella* (Schoellhorn, 2004). Other cultivars have been selected from various *Gaillardia* species, generally from *G. aristata* or *G. pulchella*.

As a result, at least 32 cultivars of *Gaillardia* can now be attained from a number of seed companies, propagators and growers. The cultivars differ in floral attributes, flowering time, and vegetative characteristics. They also differ in landscape performance.

Most of the cultivars available today are propagated from seed. There are benefits to both seed- and vegetative-propagated varieties of *Gaillardia*. As vegetative cuttings come from essentially one plant, genes are homologous, resulting in a uniform crop (Thomas, 2002). Plants grown from seed, on the other hand, generally lack uniform morphological characteristics due to genetic variation.

Abstract

Twenty-three *Gaillardia* spp. cultivars and ecotypes were evaluated for 12 weeks in a trial garden in north central Florida. Plants were evaluated bi-weekly based on vigor, uniformity, flowering and landscape impact. ‘Torch Red Ember’ received the highest ratings for uniformity. ‘Arizona Sun,’ ‘Double Lorenziana,’ and ‘Lollipop Gold’ received the highest ratings for flowering, and ‘Torch Red Ember’ and the St. Lucie County ecotype received the highest ratings for landscape impact.

Materials and Methods

Plant Material and Site Conditions

Four vegetatively propagated *Gaillardia* cultivars, 13 seed-produced *Gaillardia* cultivars, and 6 naturally-occurring *Gaillardia* accessions were obtained from various sources (Table 4-1). The seeds were sown atop 72-cell trays containing Fafard #2 media (Fafard Inc., Apopka, FL) and lightly covered (1-2 mm) with Fafard #2. Trays were kept under intermittent mist until germination occurred, at which time trays were transferred to a greenhouse where they were grown until time of transplant. After about 14 days, plugs were transplanted into prepared trial beds, along with the vegetatively propagated plants.

The beds were prepared by tilling the native soil, incorporating mushroom compost, and covering with 6.6 cm of organic mulch. Within a single row, nine of each

Gaillardia selection were evenly spaced in a plot 96 cm wide by 112 cm long. Drip tape delivered water and liquid fertilizer as needed throughout the duration of the trial.

Average daily temperature throughout the study was 25.9 C, with a minimum temperature of 18 C and a maximum of 36 C. Average weekly rainfall was 4.07 cm (1.6 inches) during the study. Average daily solar radiation was 222 watts/m^2.

Evaluations

Six evaluations were conducted bi-weekly from 9 June to 12 August, 2004. Vigor, uniformity, flowering and landscape impact ratings were based on the visual average of all nine plants in each plot.

Vigor ratings were based on a scale of 0 to 3, where 0=dead plants, 1=low vigor, 2=medium vigor, and 3=high vigor. Vigor is an indication of how well plants are growing. High vigor plants had new leaf emergence, branching, and were producing flowers. A plant with medium vigor was not producing a flush of new leaves, but was maintaining the current amount of vegetation. A plant with low vigor was not producing new leaves or increasing stem length. These plants ultimately died because of the lack of growth maintenance.

Uniformity was rated on a scale of 1 to 3, where 1=low uniformity, 2=medium uniformity, and 3=high uniformity. Uniformity ratings encompassed size, vigor, health, and flowering of plants. A one rating indicated greater than 40% deviation of one or more of these parameters, a two rating indicated 20-40% deviation, and a three rating indicated less than 40% deviation within a plot.

Flowering ratings were based on a scale of 0 to 2, where 0=no flowers, 1=less than 20% of the plant was covered by fully open flowers, and 2=20% or more of the plant was covered in flowers.

Landscape impact ratings were based on a scale of 1 to 3, where 1=not pleasing, 2=somewhat pleasing, and 3=very pleasing. A rating of one was assigned if plants were very small, not in flower, diseased, or dying. This rating indicated that plants lacked a positive impact on the aesthetics of the landscape. A rating of two was assigned to plants with a pleasing, but not outstanding appearance. These plants may have had some flowers, been of small or medium size, or had slight, if any, insect or disease problems. This rating indicated that plants had a slightly positive impact on the landscape. A rating of three was assigned to plants that were in full flower and had abundant healthy vegetation.

Results and Discussion

Uniformity

'Torch Red Ember' had the highest average uniformity rating (3.0) for all bi-weekly evaluations and 'Burgundy' had the lowest average uniformity rating (1.7) (Table 4-2). On average, uniformity ratings of seed-propagated *Gaillardia* were much lower than that of vegetatively propagated *Gaillardia*.

Flowering

'Arizona Sun,' 'Double Lorenziana,' and Lollipop Gold' had the highest average flowering (2.0). 'Torchlight,' 'Burgundy,' and 'Monarch' all received average flowering ratings less than one.

Landscape Impact

In the landscape impact category, 'Torch Red Ember' and plants from the St. Lucie County source both had a 2.8 average, which was the highest average for all *Gaillardia* types.

Weekly landscape impact ratings are shown in Figure 4-1, which allowed us to categorize trial entries by when peak occurred. Plants were separated into three groups based on the time of their peak performance (Table 4-3). Peak performance was the time when plants rated an average of above 2 in the landscape impact category over a period of time. Averages of landscape performance were calculated for weeks 5-9 and weeks 11-15 for each *Gaillardia* selection. Selections which received average ratings above 2.0 for weeks 5-9 were considered early performers (Table 4-3). Those which received average ratings above 2.0 for weeks 11-15 were considered late performers. If both averages were greater than 2.0, the selection was considered a long season performer. 'Torchlight' and 'Burgundy' did not receive average ratings above 2.0 for either period, so could not be designated as long, early or late season performers. These cultivars may not have had time to reach their peak within the time of the study, so a longer study may be required to determine their peak seasons.

Conclusions

Although vegetatively propagated *Gaillardia* were more uniform than seed propagated *Gaillardia*, there were no general trends among species with regards to overall performance. A longer study in varying climates would have revealed more conclusive data on plant performance. Cultivars of *G. aristata* and *G.* x *grandiflora*, for example, have greater cold tolerance than those of *G. pulchella* (Schoellhorn, 2004), and subsequently may have had higher ratings for a longer period if grown during cooler conditions.

The best choice of *Gaillardia* for a landscape ultimately depends on the desired outcome. If small, neat plants are needed, the best choice based on this study may be one of compact varieties such as 'Goblin,' 'Fanfare' or Bijou.' These may be more appropriate for formal gardens and front borders. The Florida native ecotypes and most of the cultivated varieties of *G. pulchella* have a spreading habit, becoming large and filling in space, which may be appropriate for wildflower meadow plantings. However, uniformity, flowering, and landscape impact ratings among *G. pulchella* cultivars and ecotypes varied widely. Due to the differences among the native blanket flower ecotypes, additional research is warranted to observe regional variation among ecotypes.

Table 4-1. List of cultivar or ecotype name, source, species name, propagation method, flower description and plant description of *Gaillardia* trialed in north central Florida.

Name	Source	Species	Propagation	Flower description	Habit
'Arizona Sun'	Benary Seed (Sycamore, IL)	*G. aristata*	Seed	Single, red with yellow tips	Compact
'Bijou'	Proven Winners (Sycamore, IL)	*G. aristata*	Vegetative	Single, red with yellow tips	Compact
'Goblin'	Thompson & Morgan (T&M) Seed (Jackson, NJ)	*G. aristata*	Seed	Single, red with yellow tips	Semi-compact
'Indian Yellow'	T&M Seed (Jackson, NJ)	*G. aristata*	Seed	Single, large yellow	Upright
Leon County, FL	Jeff Norcini (Quincy, FL)	*G. aristata*	Seed	Single, red with yellow tips	Spreading
'Sundance'	T&M Seed (Jackson, NJ)	*G. aristata*	Seed	Double, red with yellow tips	Spreading
'Torchlight'	Benary Seed (Sycamore, IL)	*G. aristata*	Seed	Single, red with yellow tips	Compact
Okaloosa Co., FL	Jeff Norcini (Quincy, FL)	*G. pulchella*	Seed	Single, red with yellow tips	Spreading
'Double Lorenziana'	Stokes Seed (Buffalo, NY)	*G. pulchella*	Seed	Double, many colors	Spreading
St. Lucie Co., FL	Sandy Wilson (Ft. Pierce, FL)	*G. pulchella*	Seed	Single, red with yellow tips	Spreading
'Lollipop Gold'	Sahin Seed (The Netherlands)	*G. pulchella*	Seed	Double, yellow	Spreading
'Red Plume'	T&M Seed (Jackson, NJ)	*G. pulchella*	Seed	Double, dark red	Spreading
TX (Farm-raised)	DR Bates (Loxahatchee, FL)	*G. pulchella*	Seed	Single, red with yellow tips	Spreading
TX (Wild-grown)	DR Bates (Loxahatchee, FL)	*G. pulchella*	Seed	Single, red with yellow tips	Spreading
'Torch Red Ember'	Ball FloraPlant (W Chicago, IL)	*G. pulchella*	Vegetative	Double, bright red	Spreading
Volusia Co., FL	The Natives, Inc. (Davenport, FL)	*G. pulchella*	Seed	Single, red with yellow, orange or white tips	Spreading
'Yellow Flame'	R.H. Shumway (Randolph, WI)	*G. pulchella*	Seed	Single, large yellow	Upright
'Burgundy'	T&M Seed (Jackson, NJ)	*G. x grandiflora*	Seed	Single, dark red	Semi-compact
'Dazzler'	Proven Winners (Sycamore, IL)	*G. x grandiflora*	Vegetative	Single, red with yellow tips	Semi-compact
'Fanfare'	PlantHaven, Inc. (Santa Barbara, CA)	*G. x grandiflora*	Vegetative	Single, red tubular ray florets with yellow tips	Compact
'Gold Goblin'	T&M Seed (Jackson, NJ)	*G. x grandiflora*	Seed	Single, large yellow	Upright
'Grandiflora Mix'	T&M Seed (Jackson, NJ)	*G. x grandiflora*	Seed	Single, all red or red with yellow tips	Spreading
'Monarch'	Stokes Seed (Buffalo, NY)	*G. x grandiflora*	Seed	Single, red with yellow tips	Semi-compact

Table 4-2. Frequency table of *Gaillardia* trial entries with the number of times each received a specific rating in the uniformity, flowering, and landscape impact categories for six bi-weekly evaluations. For uniformity, 1=low, 2=medium, and 3=high uniformity. For flowering, 0=no flowers present, 1=1-20% of the plants were covered in flowers, and 2=greater than 20% of plants were covered in flowers. For landscape impact, 1=negative aesthetic impact, 2=slightly positive aesthetic impact, and 3=highly positive aesthetic impact on the landscape. One rating for each category was given to each plot which contained nine replicate plants.

	Uniformity				Flowering				Landscape Impact			
Name	Overall^{z}	1	2	3	Overall	0	1	2	Overall	1	2	3
'Arizona Sun'	2.7	0	2	4	2.0	0	0	6	2.5	0	3	3
'Bijou'	2.7	0	2	4	1.2	2	1	3	2.3	1	2	3
'Goblin'	1.8	0	1	5	1.5	1	1	4	2.5	0	3	3
'Indian Yellow'	2.5	0	3	3	1.5	1	1	4	2.5	0	3	3
Leon County, FL	2.2	1	3	2	1.5	0	3	3	2.7	0	2	4
'Sundance'	2.8	0	1	5	1.8	0	1	5	2.2	2	1	3
'Torchlight'	1.8	1	5	0	0.0	6	0	0	1.3	4	2	0
Okaloosa Co., FL	2.7	0	2	4	1.5	0	3	3	2.5	0	3	3
'Double Lorenziana'	2.0	0	6	0	2.0	0	0	6	2.5	1	1	4
St. Lucie Co., FL	2.8	0	1	5	1.7	0	2	4	2.8	0	1	5
'Lollipop Gold'	2.7	0	2	4	2.0	0	0	6	1.8	3	1	2
'Red Plume'	2.3	0	4	2	1.8	0	1	5	2.2	2	1	3
TX (Farm-Raised)	2.5	0	3	3	1.0	2	2	2	2.3	1	2	3
Texas Wild-Grown	2.0	0	6	0	1.3	1	2	3	1.7	1	3	1
'Torch Red Ember'	3.0	0	0	3	1.8	0	1	5	2.8	0	1	5
Volusia Co., FL	1.8	2	3	1	1.5	0	3	3	2.0	1	4	1
'Yellow Flame'	2.2	1	3	2	1.5	1	1	4	2.0	0	2	4
'Burgundy'	1.7	2	4	0	0.2	5	1	0	1.3	4	2	0
'Dazzler'	2.5	1	1	4	1.7	0	2	4	2.7	0	2	4
'Fanfare'	2.7	0	2	4	1.8	0	1	5	2.7	0	2	4
'Gold Goblin'	2.3	1	2	3	1.5	1	1	4	2.5	1	1	4
'Grandiflora Mix'	2.5	0	3	3	1.0	2	2	2	2.2	1	3	2
'Monarch'	2.5	0	3	3	0.5	4	1	1	2.2	1	3	2

^{z} Overall figure is an average of all 6 bi-weekly evaluations in that category.

Table 4-3. *Gaillardia* cultivars and ecotypes based on landscape impact during periods of the landscape trial. “Early performers” received an average rating above 2.0 for the period from week 5 to week 9, “late performers” received an average rating above 2.0 for the period from week 11 to week 15, and “long season performers received an average rating above 2.0 both periods, where 2=slightly positive impact and 3=highly positive impact on landscape aesthetics. ‘Burgundy’ and ‘Torchlight’ received average landscape impact ratings of 2 or 1, so they could not be assigned to any of the aforementioned categories.

Early Performers	Late Performers	Long Season Performers
‘Arizona Sun’	‘Bijou’	‘Goblin’
‘Sundance’	TX (Farm-Raised)	‘Indian Yellow’
‘Double Lorenziana Mix’	‘Gold Goblin’	Leon County, FL
‘Lollipop Gold’	‘Grandiflora Mix’	Okaloosa County, FL
‘Red Plume’	‘Monarch’	St. Lucie County, FL
Texas Wild-Grown		‘Torch Red Ember’
Volusia County, FL		‘Yellow Flame’
		‘Dazzler’
		‘Fanfare’

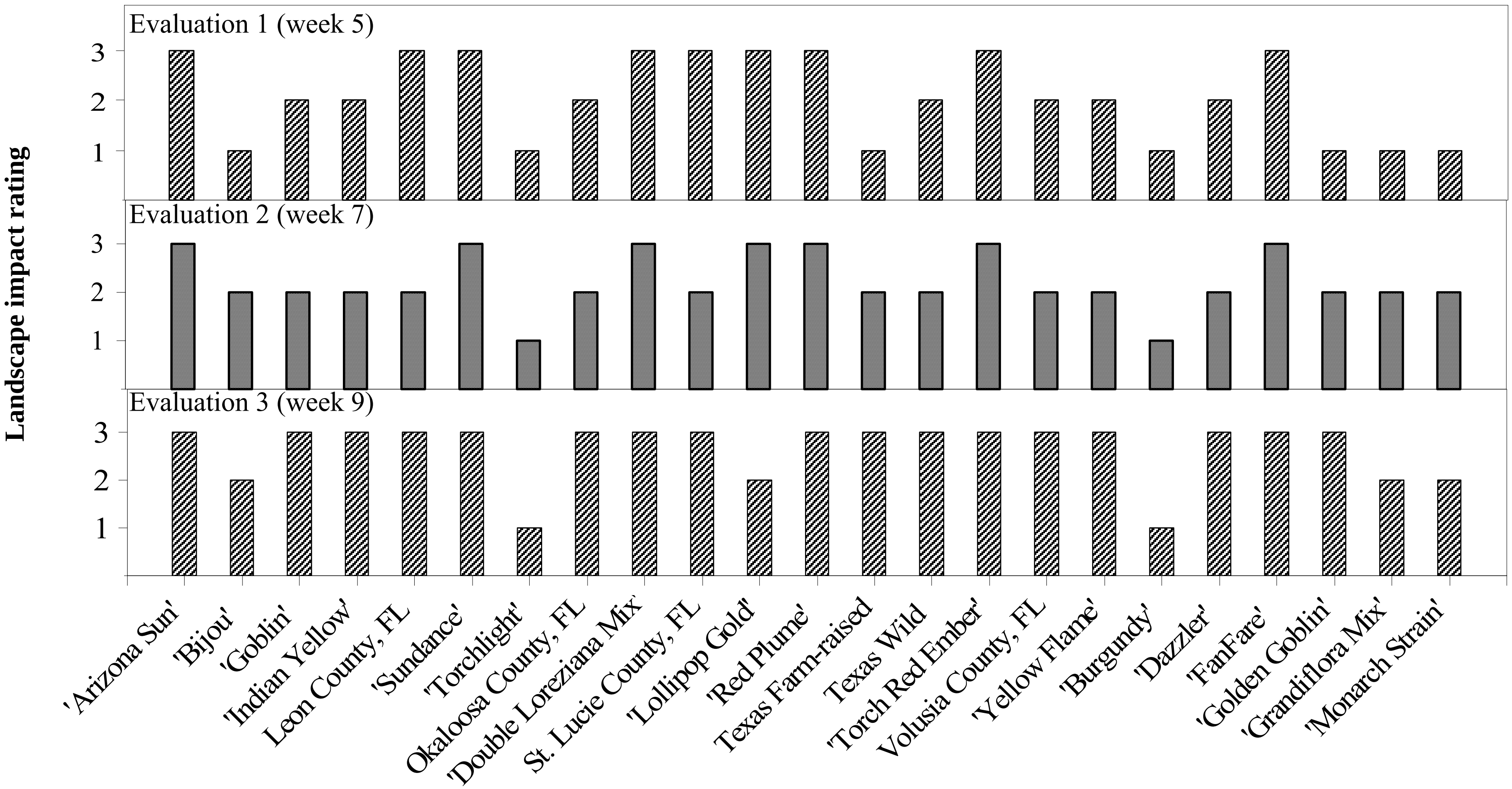

Figure 4-1. Landscape impact ratings of *Gaillardia* cultivars and ecotypes evaluated in the study. Ratings were based on a scale of 1-3, where 1=plants had a negative impact, 2=a slightly positive impact and 3=a highly positive impact on landscape aesthetics. Evaluations began 6 June 2004, 5 weeks after planting, and ended 18 Aug 2004.

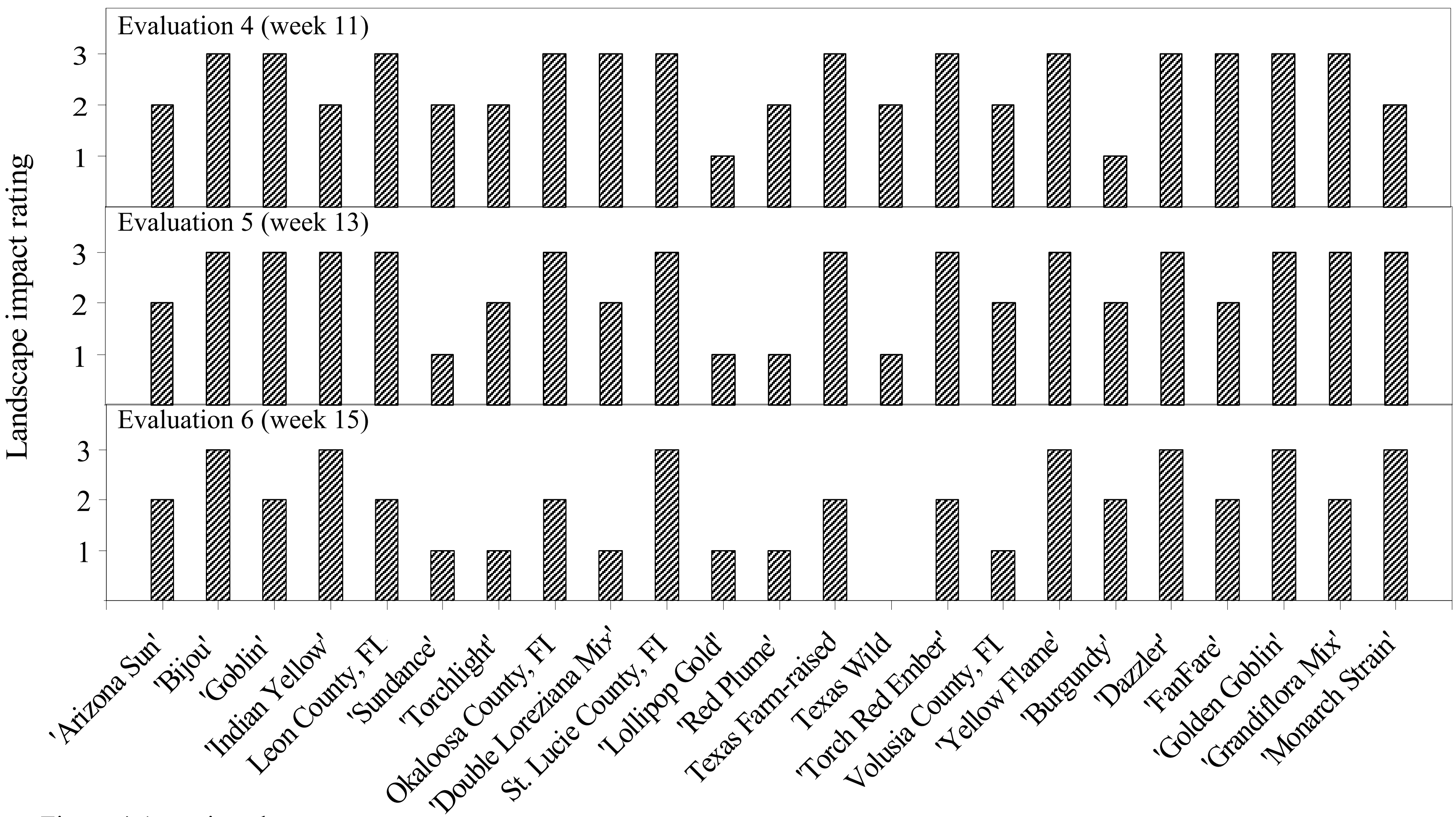

Figure 4-1 continued.

CHAPTER 5
GROWTH, FLOWERING, AND SURVIVAL OF BLANKET FLOWER (*Gaillardia pulchella* FOUG.) BASED ON SEED SOURCE AND GROWING LOCATION

Introduction

Over the past few years, there has been an emphasis towards using more native plants in landscapes. For some native species, the use of plants that are regionally adapted to the planting location can be of particular importance. The ecotype concept of environmentally-based genotypic differences within species was first introduced in 1922 by Turesson (Turesson, 1922). Since then, several terms and varied definitions have been used to describe distinct groups that have adapted to local conditions (Quinn, 1978).

What makes one ecotype distinct from others is a genetic difference resulting in a morphology and physiology adapted to a certain region (Daehler et al., 1999). Clary (1975) showed that adaptations resulted in varied timing of phonological development and growth rate among ecotypes. The environmental factors to which an ecotype has adapted may include the soil type, elevation, and climate within an area of about 321 km (200 ft) (McCully, 2000). Norcini et al. (2001) studied the effects of ecotype on black-eyed susan (*Rudbeckia hirta* L.), a wildflower native to the US, and found evidence of regional adaptation to conditions such as low fertility. Heywood (1986) reported that there are two ecotypes of blanket flower (*Gaillardia pulchella* Foug. [Asteraceae]), referred to as “races,” among populations in central Texas which were differentiated by the carbonate content of the soil in which they grew. If similar divisions exist among populations of blanket flower in Florida, physiological differences could result when plants are grown in soils unlike that to which they have adapted.

There were two objectives of this study: (1) to assess possible genetic variation characteristic of blanket flower seed sources through visual observation of phenotypic differences, and (2) to determine how blanket flower from various sources perform in varying growing locations in Florida.

Abstract

Blanket flower (*Gaillardia pulchella*) seeds were collected from wild populations in east Texas (ET) and northeast Florida (NEF), central west Florida (CWF), central east Florida (CEF), and southeast Florida (SEF). Seeds were germinated in plug trays, and finished in 3.8 L pots prior to planting in three locations in Florida (north, north central, and central south). Plant size, vigor, flowering, quality, and survival were evaluated bi-weekly for 22 weeks. In north Florida, total vigor and flowering were similar among ecotypes, but the quality of the NEF ecotype was significantly higher than the other ecotypes. In north central Florida, flowering was similar among ecotypes, but the vigor and quality of the CEF ecotype was generally lower than that of the other ecotypes. In central south Florida, vigor, flowering, and quality of NEF, SEF, and ET ecotypes were generally higher than that of the CEF ecotype. Plant survival varied widely by ecotype and planting location, thus emphasizing the value of ecotype selection and use.

Materials and Methods

Plant Material

Seeds of blanket flower were collected from five sites: northeast Florida (NEF) (29.8^{o}N 81.2^{o}W; AHS Heat Zone 9, USDA Hardiness Zones 9a), central west Florida (CWF) (28.6^{o}N 82.3^{o}W; AHS Heat Zone 10, USDA Hardiness Zones 9a), central east Florida (CEF) (28.8^{o}N 80.9^{o}W; AHS Heat Zone 9, USDA Hardiness Zones 9b), southeast Florida (SEF) (26.9^{o}N 80.1^{o}W; AHS Heat Zone 10, USDA Hardiness Zones 10a), and east Texas (ET) (29.8^{o}N 95.6^{o}W; AHS Heat Zone 9, USDA Hardiness Zones 9a) (Figure 5-1). The collection sites were natural areas where seeds had not been intentionally planted.

Seeds were sown on the surface of plug trays containing Fafard #2 medium (Fafard Inc., Apopka, FL), lightly covered (1-2mm) with Fafard #2, and placed under intermittent mist. Once a root system was established, plugs were potted up into 3.8 L (one-gallon) pots using Fafard #2 media. Plants were produced under greenhouse conditions and watered as needed via drip irrigation tubes delivering 150 $mg \cdot L^{-1}$ (ppm) 20-10-20 N-P-K liquid fertilizer (The Scotts Company, Marysville, OH) until they were transplanted the first week of April 2005.

Site Conditions

The three sites chosen for this study were north, north central, and central south Florida (Figure 5-1). The northern site was Quincy (30.5^{o}N, 84.6^{o}W; AHS Heat Zone 9, USDA Hardiness Zone 8b) in Gadsden County. The soil was Ruston series, having fine-loamy, siliceous, and semiactive properties (NRCS, 1999). The north central site was Gainesville (29.6^{o}N, 82.4^{o}W; AHS Heat Zone 10, USDA Hardiness Zone 8b) in Alachua County. The soil was Millhopper series, which is loamy, siliceous, and semiactive

(NRCS, 1999). The central south site was Fort Pierce (27.4°N, 80.4°W; AHS Heat Zone 10, USDA Hardiness Zones 9b) in St. Lucie County. The soil was Ankona series, which is sandy, siliceous, and hyperthermic (NRCS, 1999).

Soil samples were taken from a composite of soil from several planting holes at each of the three planting sites, and were sent to A&L Southern Agricultural Laboratories Inc. (Pompano Beach, FL) for elemental analysis. Sites were prepared by tilling the native soil and covering rows with black landscape fabric (Synthetic Industries Inc., Alto, GA). Daily rainfall, minimum and maximum temperatures, and solar radiation were recorded at each site by Florida Automated Weather Network (FAWN) monitoring stations.

Nine replicate plants of each ecotype were chosen at random from the median 80% of the produced population, and planted at each site and watered by drip (north and north central Florida) or canal irrigation (central south Florida) until established (about two weeks). No irrigation was administered after establishment, and no fertilizers or pesticides were applied at anytime after transplant.

Growth index for each plant was recorded at four intervals throughout the study. Height was measured from the soil level to the highest vegetative point. One width measurement was taken at the widest vegetative point of the plant passing through the center; the second width was measured perpendicular to the first. The growth index value was made using the equation $((W1+W2)/2+H)/2$, where W1=width one, W2=perpendicular width, and H=plant height. Initial measurements were taken when plants were transplanted at each site during the first week in April (week 0). Measurements were also taken 10 and 17 weeks after transplanting, when most plants were at a first and second peak in quality and flowering. Final measurements were taken on the last evaluation day (during week 22).

At the time when most plants at all sites were at or near their first peak (week 10), one plant was harvested from each treatment in every block. The stem was severed at the soil level and the aboveground plant material was dried at 70C for one week.

Visual evaluations based on the vigor, flowering, and quality of each plant were recorded bi-weekly for the duration of the study (22 weeks). Vigor ratings for this study referred to the growth rate in plants and were based on a scale from one to three, where 1= low vigor, 2= medium vigor, and 3= high vigor. Plants with high vigor (3) were characterized by active growth of new leaves and branches. Plants with medium vigor (2) were characterized by maintenance growth where new leaves are produced, but only at the rate that older leaves are dying. Plants with low vigor were not growing, with leaves dying faster than new ones were being produced. The flower rating was based on the amount of live flowers on each plant. To be counted as a flower, the flowering body had to have fully extended ray florets. Ratings ranged from zero to three, where 0= no flowers present, 1= one to three fully open flowers, 2= more than three flowers, but no more than one-third of the plant was covered in flowers, and 3= greater than one-third of the plant was covered in open flowers. The quality rating described the overall look, attractiveness, and health of the plant. This included the fullness of vegetation and flower coverage, and was based on a scale of 1 to 3, where 1=low quality, 2=medium quality, and 3=high quality. Once a plant died, it was no longer included in evaluations. A high rating (3) described a plant that had flowers, a healthy amount of vegetation, and was at or near its peak. If the plant had fewer flowers, did not look full, or had disease or pest problems, the plant received a medium rating (2). A low rating (1) was assigned to plants that may have been small or unattractive, and had few or no flowers. These plants would be unacceptable when in a cultivated landscape.

Experimental Design

The experimental design was a split plot. The three planting sites were the blocks, and each of these contained three main plots. Subplots of the five treatments (ecotypes) were randomized within each main plot.

A proc GLM SAS (version 8.02 Cary, NC) program using Waller-Duncan Mean Separator was applied to data for individual sites. This allowed for missing data when plants were absent due to sub-sampling harvest or death. For identifying interactions among sites, a repeated measures analysis mixed procedure was run in SAS. For all other mean separation, Tukey-Kramer was applied. For identifying interactions among sites, a repeated measures analysis mixed procedure was run in SAS. Survival data was arc-sine transformed to identify differences within sites and among ecotypes.

Results and Discussion

Site Conditions

Initial soil analysis of each location indicated that north Florida had higher K, Mg, Ca, and pH than north central or central south locations (Table 5-1). Heywood (1986) found ecotypic differences due to soil contents among Texas ecotypes of blanket flower. The ecotypes used in this study could also have experienced varying reactions to the soil, which may have contributed to the varied performance of ecotypes among planting sites. Gordon and Rice (1998) also concluded that local soil conditions were a major factor when choosing an ecotype for plantings. North Florida had high Mg, Ca, and pH relative to the other planting sites, which may indicate the presence of dolomitic lime

($CaMg(CO_3)_2$) (J.G. Norcini, personal communication). Ecotypes in north Florida generally had greater survival rates and growth indexes than in the other sites, which could correlate with the difference in soil if the ecotypes had a proclivity for better growth under such conditions.

North, north central, and central south Florida received 230, 214, and 219 w/m^2 (watts per square meter) average daily solar radiation during the experiment, respectively (Figure 5-2A). While the mean monthly maximum temperatures were similar among sites, the mean monthly minimum temperatures were substantially greater in central south Florida than in the other locations (Figure 5-2B). Average rainfall was substantially greater in central south Florida throughout the first twelve weeks of the study (April-June) compared to the other sites (Figure 5-2C). Rainfall in north Florida was significantly greater than the other sites from week 13 through the end of the study.

Growth

In north Florida, ecotype CEF was the smallest and had the lowest dry weight at the first peak (week 10) (Table 5-2), but at the second peak (week 17) and at the end of the study (week 22), ecotypes were similar in size (Table 5-3). In north central Florida, there were no differences among ecotypes in size or dry weight at first peak. At the second peak, the NEF ecotype was larger than the other ecotypes, but similar in size to ET. By the end of the study, the growth index was similar among NEF, SEF, and ET ecotypes. In central south Florida at first peak, the ET ecotype was larger in size than the CWF, CEF, and SEF ecotypes, though dry weight were not significantly different among ecotypes. At the second measurement, ecotypes from CEF and ET were significantly larger than the CWF ecotype; by the end of the study, growth index was similar among surviving ecotypes. The NEF, CWF, and SEF ecotypes had significantly lower dry weight at first peak in central south Florida as compared to north Florida (Table 5-2).

Vigor

In north Florida, there were no significant differences among the ecotypes for vigor in any single week, nor when data from each evaluation were compiled (Figure 5-3, Table 5-4). For north central Florida, the CEF ecotype had significantly less vigor than the other ecotypes when data were compiled. During weeks 18-22, a noticeable decline in vigor was observed for ecotypes ET, CEF, and SEF in the north and north central Florida. In central south Florida, all ecotypes experiences a decline in vigor between weeks 12 and 14, with the exception of the WCF ecotype, all of which died by week 18. When all data were compiled among weeks, the CWF ecotype had the highest average vigor, though all CWF plants died before the end of the study, thus the average vigor included only evaluations for which plants were alive. This could have caused artificially high average vigor for CWF. There was a significant interaction among site, treatment, and time (Pr>F=0.0003) for vigor.

Flowering

The ET ecotype had the highest flowering ratings during the first and second evaluations for central south Florida, as well as for the second and third evaluations in north and north central Florida (Figure 5-4). This indicates that plants from the ET seed source are earlier flowerers than the others. Flower ratings among ecotypes in north Florida were similar for the remainder of the study. Subsequently, total flowering was not significantly different among ecotypes (Table 5-4). In central south Florida, the CWF and CEF ecotypes had the lowest overall flowering compared to all ecotypes over the course of the study. There was a significant interaction among site, treatment, and time (Pr>F=0.0002) for flowering.

Quality

The NEF ecotype had the highest and the CEF ecotype had the lowest overall quality rating in north Florida (Figure 5-5). In north central and central south Florida, CEF had the lowest overall quality while the other ecotypes were not significantly different in quality ratings (Table 5-4). There was not a significant interaction among site, treatment, and time for quality.

Survival

In north Florida, all plants survived the study except for those of the CEF ecotype, having 83% survival (Table 5-5). The CEF ecotype also had the lowest survival rate in north central Florida (66.7%), though there was no significant difference among survival for ecotypes in north central Florida (Table 5-5). The CEF ecotype had the second lowest in central south Florida (33.3%), with CWF having the lowest survival (0%). Only the SEF ecotype had 100% survival in central south Florida. It is possible that the high survival rate of this ecotype when grown in central south Florida is due to its genetic adaptation to the climate and soils of the area. This is consistent with results of Marois and Norcini (2003), who found that north Florida black-eyed susan ecotypes had a greater survival rate when planted in north Florida than ecotypes from central Florida and Texas.

It is interesting to note that the CEF ecotype had the lowest (north and north central Florida) or second lowest (central south Florida) survival rate for all three planting sites. This could suggest that there is a genetic difference in the life cycle of plants from this seed source as compared to those from other areas. A varied life cycle could mean that more energy went into production of seed rather than maintenance of growth. This occurs in ecotypes of annual bluegrass (*Poa annua* L.), in which the annual ecotype produced more seed than the other ecotypes evaluated and was less vigorous vegetatively (Frank, 2000). Further investigation into seed number and quality could help to confirm or deny that this occurs in blanket flower ecotypes.

The only significant difference in survival within an ecotype was for the CWF ecotype (Table 5-5). The other ecotypes performed similarly regardless of planting site. These results indicate that planting site does not affect survival for most ecotypes.

Conclusions

As there were minimal differences in temperature and solar radiation among the sites during the time of this study, and less than a 70m difference in altitude, soil and rainfall may have been what determined ecotype performance among sites. In central south Florida, the ground was flooded several days from mid-June through July. This coincides with the sudden decrease in vigor, flower, and quality ratings. Most ecotypes (the exception being the CWF ecotype) recovered well after this time and were back to previous flowering and quality performance by the end of the study, although, these ratings were mostly in the unacceptable range of below two. Ecotypes of paspalum grass (*Paspalum* L. sp.) have shown variance in ability to tolerate stress from such occurrences as drought and flood (Duncan, 2001). Similar abilities to tolerate environmental stresses may occur in blanket flower ecotypes other than the CWF ecotype.

North Florida received more rain in August than the other sites, but unlike the plants in central south Florida, after experiencing high rainfall, plants continued to do well with consistent ratings. This could be due to a lower water table in north Florida and/or soil with better drainage. As indicated by these findings, blanket flower plants grow best in well-drained soils regardless of ecotype.

Since there were significant interactions among site and treatment for vigor and flowering, it is important to choose the best ecotype for the planting location. For restoration plantings, however, it may be appropriate to use local sources or a mix of local and non-local, depending on the desire for genetic variability. Lesica and Allendorf (1999) recommend using local ecotypes for slightly disturbed sights, and a mix of local and non-local sources for very disturbed sites to introduce more genetic variability for speedier establishment and adaptability.

This study used transplants of blanket flower, thus results apply only to the use of plants produces outside of the final planting site. Results may vary due to possible differences in germination and establishment if ecotypes were to have been directly seeded at the planting sites.

Table 5-1. Analysis of soil from the three planting locations in Florida used in this study.

Planting site	Organic matter (%)	Est. N release (kg/ha)	P ($mg \cdot L^{-1}$)	K ($mg \cdot L^{-1}$)	Mg($mg \cdot L^{-1}$)	Ca ($mg \cdot L^{-1}$)	pH
North	3.9	137	81	102	131	1040	6.1
North central	4.0	139	119	60	98	610	5.5
Central south	3.7	132	9	18	42	330	5.4

Table 5-2. Dry weight (in grams) of five blanket flower (*Gaillardia pulchella*) ecotypes planted in north, north central, and central south Florida.

Ecotype	North	North central	Central south
NEF[z]	346.8[y] A[x]a[wv]	190.3 Aab	121.2 Ab
CWF	343.5 Aa	237.3 Aab	122.5 Ab
CEF	122.3 Ba	238.4 Aa	98.4 Aa
SEF	339.4 Aa	273.2 Aab	97.8 Ab
ET	306.1 Aa	233.6 Aa	134.3 Aa
p values	Ecotype	0.0022	
	Site	0.0188	
	Ecotype * site	0.0006	

[z] NEF=northeast Florida, CWF=central west Florida, CEF=central east Florida, SEF=southeast Florida, and ET=east Texas.
[y] Values taken from averages of replications within each block.
[x] Uppercase letters signify difference within columns (main effect of site).
[w] Lowercase letters signify difference within rows (sub effect of ecotype).
[v] Mean separation by Tukey-Kramer (p=0.05).

Table 5-3. Growth index of five blanket flower (*Gaillardia pulchella*) ecotypes planted in north, north central, and central south Florida.

		GI Ti[z]	GI T1	GI T2	GI T3
Ecotype	NEF[y]	24.9 abc[x]	62.7 a	79.3 a	80.4 a
	CWF	25.5 ab	60.3 a	63.0 b	dead
	CEF	21.7 c	53.2 b	66.9 ab	68.3 b
	SEF	23.2 bc	58.3 ab	64.6 b	68.3 b
	ET	27.1 a	62.8 a	79.3 a	79.7 a
Site	North	22.4 b	67.5 a	91.7 a	84.3 a
	North central	23.8 b	65.0 a	73.4 b	81.0 a
	Central south	27.3 a	45.9 b	70.2 b	non-estimable
p values	Ecotype	0.0021	<0.0001	0.0008	0.0044
	Site	0.0122	0.0008	<0.0001	<0.0001
	Ecotype * site	NS	NS	NS	NS

[z] GI=Growth index, calculated as: (height+(width 1+width 2)/2)/2; Ti=date of planting at site, T1=date of average first peak flowering for all plants, T2=GI on date of second average peak flowering, and T3=GI at date of final evaluation.
[y] NEF=northeast Florida, CWF=central west Florida, CEF=central east Florida, SEF=southeast Florida, and ET=east Texas.
[x] Mean separation by Tukey-Kramer (p=0.05).

Table 5-4. Total vigor, flowering, and quality ratings compiled from bi-weekly evaluations of five blanket flower (*Gaillardia pulchella*) ecotypes grown in the north, north central, and central south Florida.

Planting site	Ecotype[z]	Vigor[y]	Flowering[x]	Quality[w]
North	NEF	2.75 a[v]	1.90 a	2.22 a
	CWF	2.72 a	1.83 a	2.00 bc
	CEF	2.59 a	1.76 a	1.92 c
	SEF	2.83 a	2.10 a	2.06 b
	ET	2.70 a	2.06 a	2.09 b
p values	Ecotype	0.1211	0.3634	0.0003
North central	NEF	2.80 a	1.86 a	2.38 a
	CWF	2.68 a	1.89 a	2.21 ab
	CEF	2.45 b	1.60 a	2.06 b
	SEF	2.64 a	1.92 a	2.27 a
	ET	2.66 a	1.85 a	2.24 ab
p values	Ecotype	0.0032	0.3142	0.0140
Central south	NEF	1.90 b	1.69 ab	2.04 ab
	CWF	2.17 a	1.32 c	2.09 a
	CEF	1.85 b	1.48 bc	1.94 b
	SEF	1.91 b	1.80 ab	2.08 a
	ET	1.81 b	1.92 a	1.96 ab
p values	Ecotype	0.0007	<0.0001	<0.0001

[z] NEF=northeast Florida, CWF=central west Florida, CEF=central east Florida, SEF=southeast Florida, and ET=east Texas.

[y] Vigor was based on a scale from 1 to 3 where 1=low vigor, 2=medium vigor, and 3=high vigor.

[x] Flowering was based on a scale from 0 to 3 where 0=no fully open flowers present, 1=one to three fully open flowers present, 2=more than three flowers but less than one-third of the plant was covered in fully open flowers, and 3=one-third or more of the plant was covered in fully open flowers.

[w] Quality was based on a scale from 1 to 3 where 1=low quality, 2=medium quality, and 3=high quality.

[v] Means within each site with different letters are significantly different according to Waller-Duncan mean separation (p=0.05).

Table 5-5. Percent survival of survival of five blanket flower (*Gaillardia pulchella*) ecotypes grown in the north, north central, and central south Florida.

Ecotype	North	North central	Central south
NEF[z]	100% A[y]a[xw]	100% Aa	83% ABa
CWF	100% Aa	100% Aa	0% Cb
CEF	83% Ba	67% Aa	33% BCa
SEF	100% Aa	83% Aa	100% Aa
ET	100% Aa	83% Aa	83% ABa
p values	Ecotype	0.0044	
	Site	NS	
	Ecotype * site	0.0043	

[z] NEF=northeast Florida, CWF=central west Florida, CEF=central east Florida, SEF=southeast Florida, and ET=east Texas.
[y] Uppercase letters signify difference within columns (main effect of site).
[x] Lowercase letters signify difference within rows (sub effect of ecotype).
[w] Means within each site with different letters are significantly different according to Tukey-Kramer mean separation (p=0.05). Mean separation was done on arc-sine transformed data. Values shown are original percent survival.

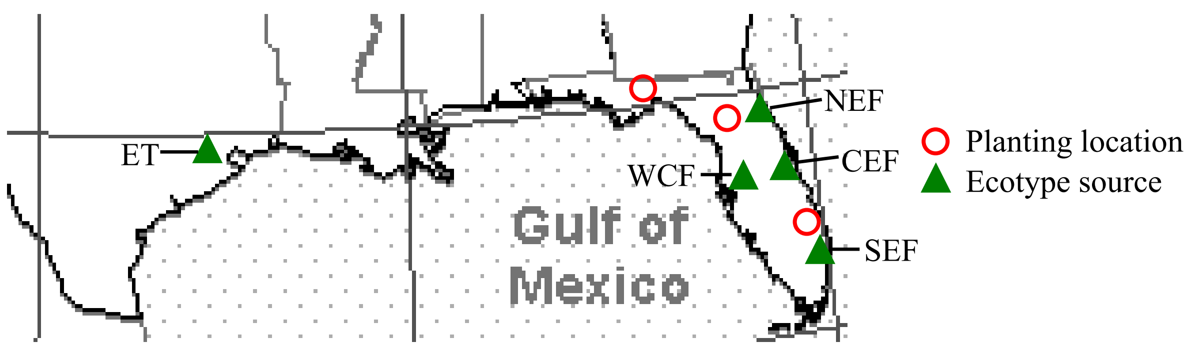

Figure 5-1. Map of blanket flower (*Gaillardia pulchella*) ecotype planting locations and seed sources in Florida and Texas (Col, 2005).

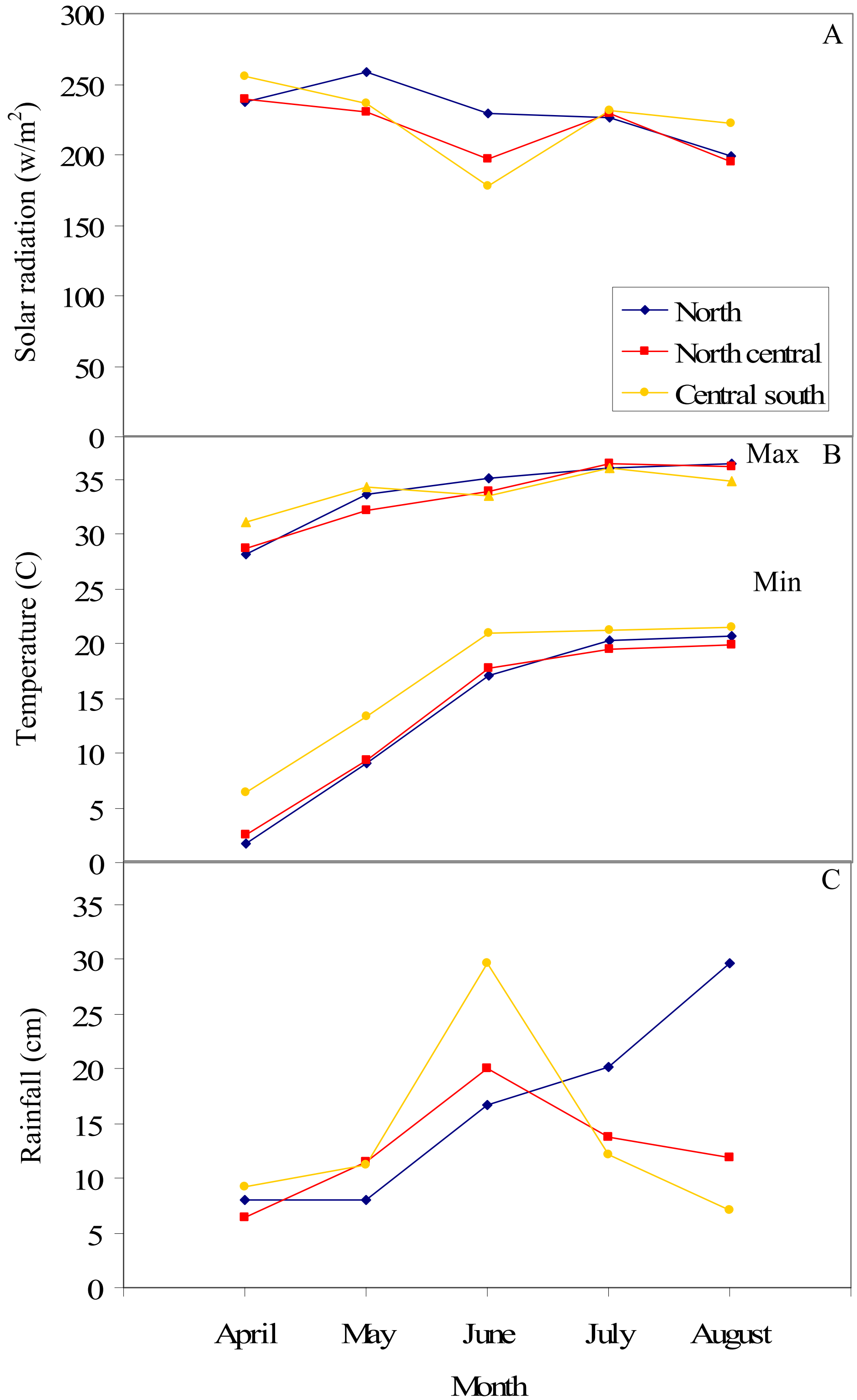

Figure 5-2. Monthly average total daily solar radiation (A), average maximum and minimum daily temperatures (B), and total of rainfall (C) from first planting date (5 Apr. 2005) to last evaluation date (9 Sept. 2005) at three planting sites (north, north central, and central south Florida) used in this study.

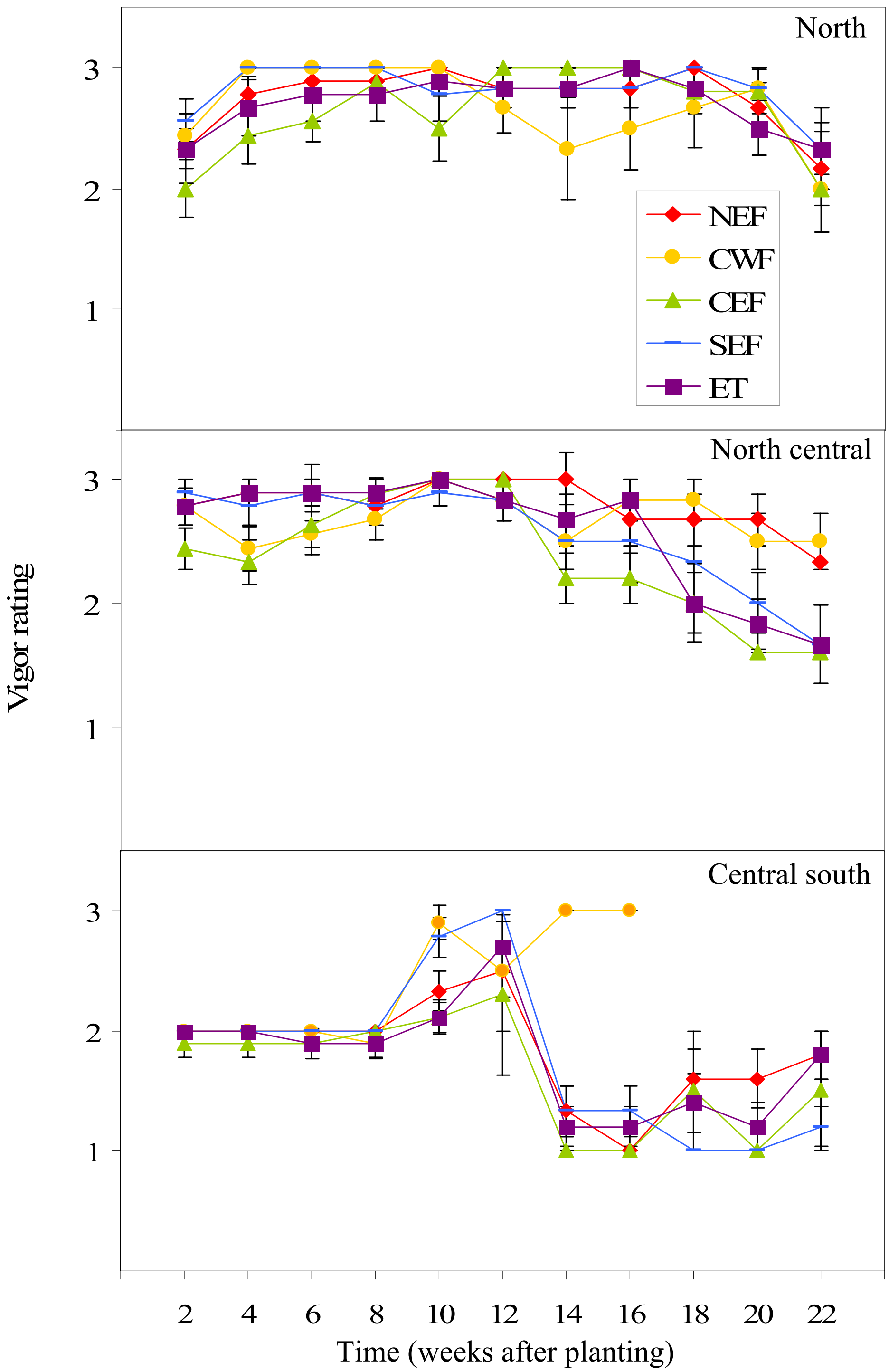

Figure 5-3. Weekly vigor ratings of five blanket flower (*Gaillardia pulchella*) ecotypes (NEF=northeast Florida, CWF=central west Florida, CEF=central east Florida, SEF=southeast Florida, ET=east Texas) planted in three locations in Florida [north, north central, and central south]. Ratings were based on a scale of 1 to 3 where 1=low vigor, 2=medium vigor, and 3=high vigor. Vertical bars represent standard error.

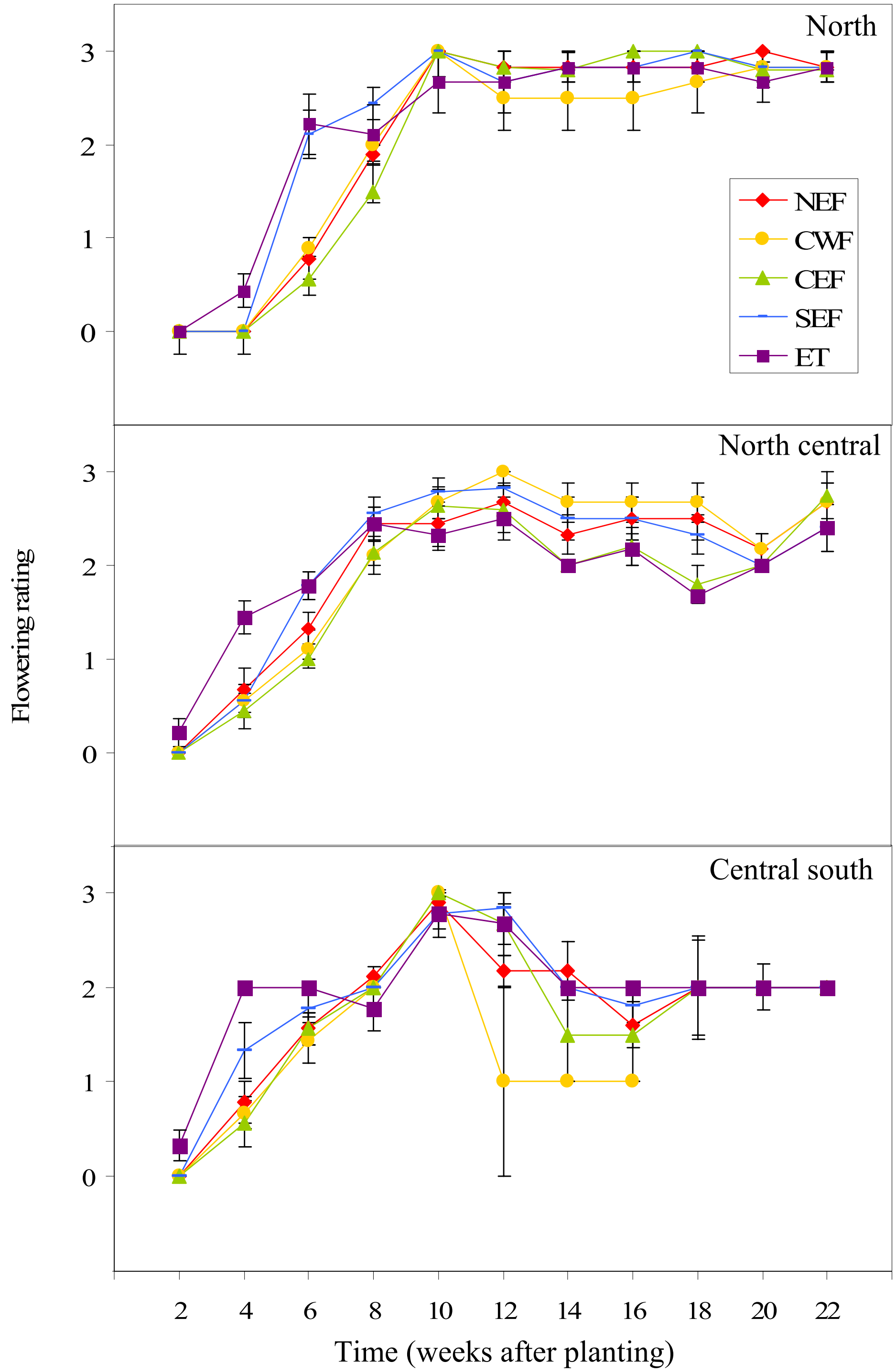

Figure 5-4. Weekly flower ratings of five blanket flower (*Gaillardia pulchella*) ecotypes (NEF=northeast Florida, CWF=central west Florida, CEF=central east Florida, SEF=southeast Florida, ET=east Texas) planted in three locations in Florida [north, north central, and central south]. Ratings were based on a scale of 1 to 3 where 0=no flowers present, 1=one to three flowers present, 2=more than three flowers but less than one-third of the plant covered in flowers, and 3=one-third or more of the plant covered in flowers. Vertical bars represent standard error.

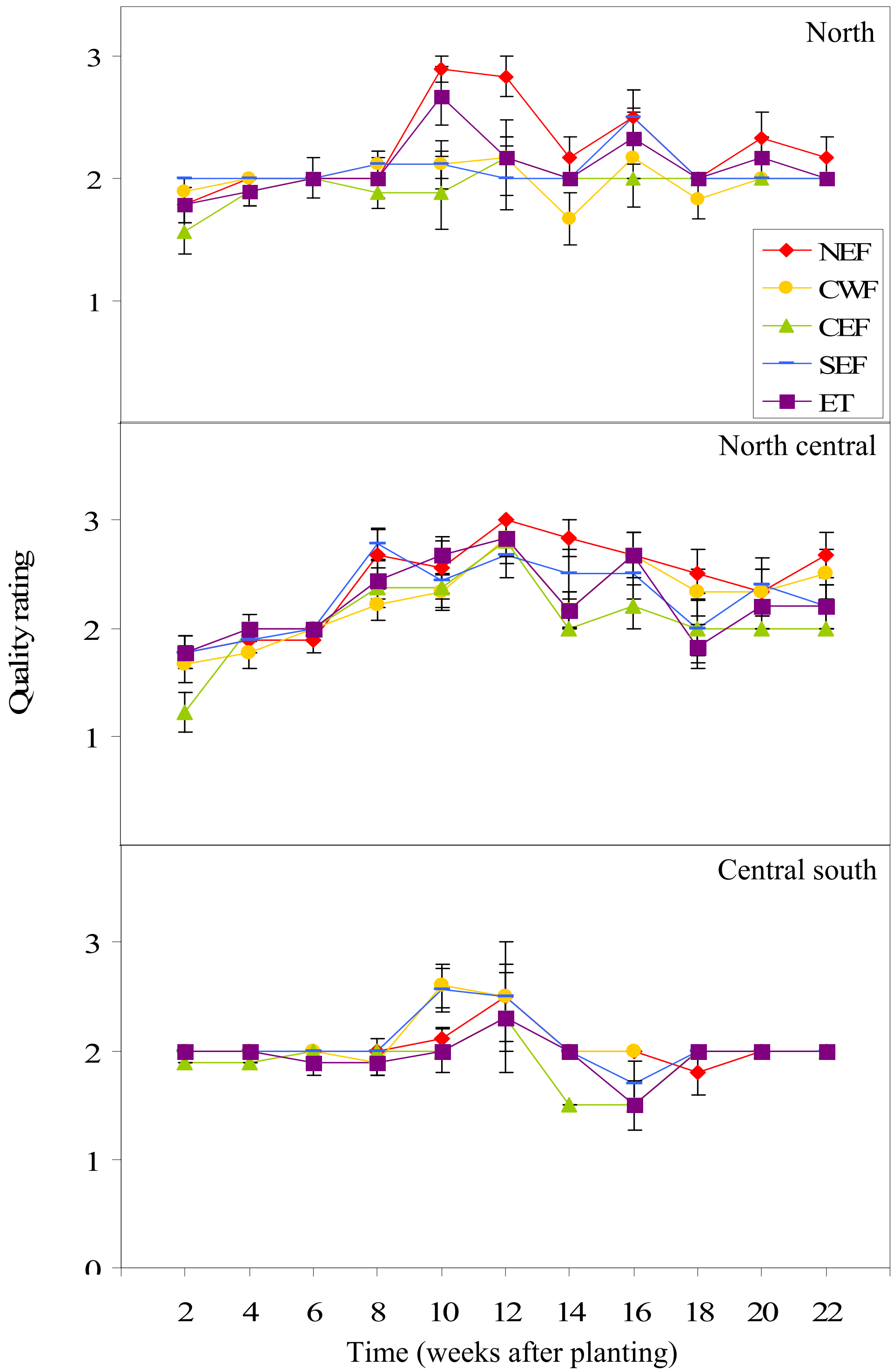

Figure 5-5. Weekly quality ratings of five blanket flower (*Gaillardia pulchella*) ecotypes (NEF=northeast Florida, CWF=central west Florida, CEF=central east Florida, SEF=southeast Florida, ET=east Texas) planted in three locations in Florida [north, north central, and central south]. Ratings were based on a scale of 1 to 3 where 1=low quality, 2=medium quality, and 3=high quality. Vertical bars represent standard error.

CHAPTER 6
CONCLUSIONS

Environmental and economical implications of peat usage have led to the development of new substrate substitutes worldwide, many of which contain waste byproducts. Horticultural grade composts of sufficient quantity and quality are now being produced by private enterprises and public municipalities and marketed at economical values. Our study evaluated blanket flower (*Gaillardia pulchella* Foug.) grown in peat or compost-based media, and found compost to be a viable alternative to peat use in containerized nursery media, while maintaining sufficient plant growth, development, and ultimately, plant quality.

Rapid growth of blanket flower in containers can result in a leggy appearance and become problematic for handling and shipping. Our study evaluated the effect of two plant growth regulators (Florel and Sumagic) on the growth and development of *Gaillardia pulchella* 'Torch' and a native north Florida ecotype. While neither growth regulator affected plant size of the north Florida ecotype, application of Florel or Sumagic (drench only) significantly reduced plant size of 'Torch'. Thus, use of Florel or Sumagic may help extend the production times of 'Torch' and facilitate shipping.

Plant trials are an important part of nursery trade, as they allow both private and public sectors to view new and interesting crops and monitor their performance in a specific growing region. Our study evaluated twenty-three *Gaillardia* spp. cultivars and ecotypes for 12 weeks in a trial garden in north central Florida. Uniformity, flowering, and landscape impact ratings varied widely among *G. pulchella* cultivars and ecotypes.

‘Torch Red Ember’ received the highest ratings for uniformity. ‘Arizona Sun,’ ‘Double Lorenziana,’ and ‘Lollipop Gold’ received the highest ratings for flowering, and ‘Torch Red Ember’ and the St. Lucie County ecotype received the highest ratings for landscape impact.

For some native species, the use of plants that are regionally adapted to their planting location can be of particular importance. Our study evaluated five geographically distinct ecotypes planted in north, north central, and central south Florida for 22 weeks. In north Florida, total vigor and flowering were similar among ecotypes, but the quality of the northeast ecotype was significantly higher than the other ecotypes. In north central Florida, flowering was similar among ecotypes, but the vigor and quality of the east central ecotype was generally lower than that of the other ecotypes. In central south Florida, vigor, flowering, and quality of northeast, southeast and east Texas ecotypes were generally higher than that of central west and central east ecotypes. Plant survival varied widely by ecotype and planting location, thus emphasizing the value of ecotype selection and use.

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