Published online September 28, 2017
JOURNAL OF PLANT REGISTRATIONS

CULTIVAR

Registration of 'Kenhy' and 'Gibtuck' Limpograss Hybrids

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Abstract

'Kenhy' (Reg. No. CV-283, PI 682663) and 'Gibtuck' (Reg. No. CV-284, PI 682664) hybrid limpograss [*Hemarthria altissima* (Poir.) Stapf & C.E. Hubbard] cultivars were produced by the University of Florida Agronomy Department, a unit of the Florida Agricultural Experiment Station, and released in 2014. These two hybrids were selected from 51 hybrid seedlings produced by greenhouse hand crosses of 'Floralta' × 'Bigalta'. Floralta is estimated to constitute >95% of the limpograss grown in Florida, raising concerns about genetic vulnerability. Bigalta, although less persistent than Floralta, has been shown to have slightly greater in vitro organic matter digestion. Evaluations of these hybrids were conducted at the Range Cattle Research and Education Center, Ona, FL, at two locations near Gainesville, FL, and at the North Florida Research and Education Center, Marianna, FL. Evaluations included greenhouse pot studies, small plot clipping experiments, two different mob stocking grazing experiments, and an experiment to evaluate herbage accumulation and nutritive value under stockpiling management. Kenhy and Gibtuck were selected for superior herbage accumulation, persistence under grazing defoliation, improved nutritive value compared with Floralta, and utility as stockpiled forage. Vegetative planting material was first distributed in summer 2014 to a group of growers selected by the Florida Cattlemen's Research Committee, and further public distribution will be coordinated by this committee.

Journal of Plant Registrations
doi:10.3198/jpr2017.03.0012crc
Received 1 Mar. 2017.
Accepted 19 July 2017.
Registration by CSSA.
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'Kenhy' (Reg. No. CV-283, PI 682663) (entry 4F in this manuscript) and 'Gibtuck' (Reg. No. CV-284, PI 682664) (entry 10 in this manuscript) hybrid limpograss [*Hemarthria altissima* (Poir.) Stapf & C.E. Hubbard] cultivars were produced by the University of Florida Agronomy Department, a unit of the Florida Agricultural Experiment Station, and were released by the same in 2014. They were selected for superior yield, persistence under grazing defoliation, improved nutritive value, and utility as stockpiled forage.

Limpograss was first introduced into Florida in 1964, and evaluations were conducted in Gainesville, at the USDA-NRCS Plant Materials Center in Arcadia, at the University of Florida Range Cattle Research and Education Center at Ona, and later at other locations in Florida. There were four original accessions collected from southern Africa (see USDA Germplasm Resources Information Network [GRIN], https://npgsweb.ars-grin.gov/gringlobal/search.aspx, for specific origin of collection information), PI 299039, PI 299993, PI 299994, and PI 299995. The first accession was not useful agronomically, but the latter three were widely evaluated for pasture use. These clonal lines were ultimately released as the cultivars 'Redalta' (PI 299993), 'Greenalta' (PI 299994), and 'Bigalta' (PI 299995) (Quesenberry et al., 1978, 1979). Each cultivar had some production limitation, either related to low nutritive value (Redalta and Greenalta) or poor persistence under regular defoliation (Bigalta; Quesenberry et al., 2004). An additional group of 50 plant introductions were introduced to Florida between 1964 and 1971 and were entered into germplasm evaluation experiments. From preliminary clipping and grazing evaluations, eight superior plant introductions were selected for further evaluation and entered in grazing experiments to determine persistence under animal defoliation at two locations. PI 364888 was selected from these experiments and released as 'Floralta' in 1984 (Quesenberry et al., 1984, 1987).

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Abbreviations: CP, crude protein; DM, dry matter; IVDOM, in vitro digestible organic matter.

Floralta has received wide acceptance for use in southern Florida and is estimated to be planted on more than 200,000 ha in the state (Wallau et al., 2016). Reasons for the widespread adoption and use of Floralta limpograss on extensive beef cattle operations include superior winter forage production and greater digestibility, especially at mature growth stages, than bahiagrass (*Paspalum notatum* Flügge) and bermudagrass [*Cynodon dactylon* (L.) Pers.], and improved persistence under grazing relative to Bigalta. The successful adoption of this cultivar illustrates the value of the mob stocking technique (Quesenberry et al., 1977) to evaluate forage germplasm for persistence under grazing.

Stockpiling is a management technique that is widely used for limpograss (Quesenberry et al., 2004). Typically, the forage plants are either cut or grazed late in the warm season followed by fertilization and an extended period of regrowth before use during the cool season. Limpograss is particularly well suited for use as stockpiled forage because of its ability to continue growth into the cool season and its characteristic slow rate of decline in digestibility with increasing maturity. The extended winter grazing season of Floralta, particularly in years with limited freeze events, has allowed south Florida producers to reduce their reliance on conserved forages and costly supplements. Nevertheless, due to the widespread use of a clonal vegetatively propagated cultivar, there are concerns related to genetic vulnerability.

Identification of an improved limpograss incorporating some of the higher nutritive value of Bigalta and higher persistence under grazing of Floralta should have a significant positive impact in livestock production in Florida. Thus, the objective of this research was to produce hybrids of Bigalta crossed with Floralta and to identify new limpograss plants with enhanced nutritive value, persistence under grazing and potential for use as stockpiled forage primarily for beef cattle production in Florida.

Methods

Breeding History

In spring 2005, crosses were made by approach pollination (enclosing two flowering racemes in a glassine pollination bag and shaking daily during anthesis to promote cross pollination) in a greenhouse of the Agronomy Department, Florida Agricultural Experiment Station, University of Florida in Gainesville, between Floralta and Bigalta. From these crosses, 51 hybrid plants were generated (39 having Bigalta as the female parent and 12 having Floralta as the female parent). The hybrids were planted in pots in the greenhouse and were hand harvested to determine in vitro digestible organic matter concentration (IVDOM) at 4- and 8-wk regrowth intervals. The data from the greenhouse evaluation are not presented in full, but the IVDOM data were included in a selection index that will be described later.

Initial Clipping Evaluation at Hague, Ona, and Marianna

Each hybrid plant was subsequently planted in the field in spring 2006 at the Agronomy Forage Research Unit at Hague, FL (29°80′ N, 82°41′ W) (near Gainesville). The same experiment was planted at the Range Cattle Research and Education Center in Ona, FL (27°26′ N, 82°55′ W), in October 2006. The experiment was a randomized complete block of 53 entries (51 hybrids plus Floralta and Bigalta) with two replications. Plots were 1.5 by 1.5 m; after allowing a period for establishment, the plots at Hague and Ona were harvested regularly.

At Hague and Ona, a forage harvester was used to cut a strip through the center of each plot to approximately a 12-cm stubble height. At Hague, harvests occurred once in fall 2006, four times in 2007 (15 May, 27 June, 7 August, and 17 September), and five times in 2008 (20 May, 1 July, 11 August, 22 September, and 11 November). At Ona, plots were harvested six times in 2007 (7 May, 25 June, 7 August, 18 September, 30 October, and 10 December) and five times in 2008 (7 May, 18 June, 30 July, 22 October, and 10 December). Herbage was dried at 60°C for 48 h in a forced-air oven to constant weight, and the dry matter (DM) concentration used to calculate herbage accumulation. At Ona, limpograss ground cover was determined visually by two observers at the end of the experiment in 2008. A scoring system from 5 (fully covered with limpograss) to 0 (no limpograss plants present) was used to assess the persistence of the plots after 2 yr of harvesting.

In late March 2009, an index (Table 1) was created to integrate data from all three locations and to arrive at a ranking of the hybrids. Data included in the index were percentage cover at Hague from early March 2009, second harvest herbage accumulation at Hague from 2008 (representative of summer production 2 yr after plot establishment), IVDOM of 8-wk regrowth from the greenhouse study in Gainesville, a persistence rating (1 to 5, where 5 = most persistent) from Ona in Fall 2008, and a vigor rating and percentage cover data from Marianna in spring 2009. An example of the data used for this selection index is the herbage accumulation and ground cover data from Ona (Table 2). If a hybrid was ranked in the top third for a trait, it received a +2 value, if in the middle third a +1, and if in the bottom third a −1. Table 1 shows data for 18 hybrids to illustrate the ranking system.

Eight hybrids with a selection index of +5 or greater were selected for further evaluation. The hybrids selected were FXB1, FXB4, FXB9, FXB10, BXF4, BXF27, BXF32, and BXF34 (four with Floralta as the female parent and four with Bigalta as the female parent). For simplicity, these eight hybrids will be designated herein as 1, 4F (Kenhy), 9, 10 (Gibtuck), 4B, 27, 32, and 34, respectively.

Clipping and Grazing Studies at Marianna, Gainesville, and Ona

The eight selected hybrids plus Floralta and Bigalta were planted in small plots in a randomized block design of four replications at Marianna on 10 Sept. 2009. Plots were defoliated by clipping once or twice per year and observed for vigor, frost damage, leaf rust (caused by *Puccinia* spp.), and spring greenup for 4 yr. In July 2009, the eight hybrids plus Floralta were planted at the Forage Evaluation Support Laboratory, near Gainesville, FL, and five hybrids (1, 4F, 9, 10, and 27) plus Floralta were planted at Ona to evaluate production, persistence, and nutritive value under grazing. Plot size was 25 m^2, and each entry was grazed at two frequencies (2 and 4 wk) to a

Table 1. Subset of data from initial clipping experiments with 51 limpograss hybrids demonstrating the selection index used to identify superior hybrids.†

Hybrid (ID number)	Hague % cover‡	Ona vigor§	IVDOM¶	Hague yield#	Marianna % cover‡	Marianna vigor§	Selection index
	%	1–5	g kg^{-1}	kg ha^{-1}	%	1–5	
FXB1 (1)††	***85***	*3*	*618*	2840	*80*	*2.5*	**5‡‡**
FXB4 (4F)††	*80*	*2.5*	***630***	***6330***	***88***	***4***	**10**
FXB5	***85***	2	586	*4770*	*70*	*2.5*	3
FXB6	***93***	1.5	***644***	3880	*73*	2	2
FXB9 (9)††	*60*	***4***	598	***5560***	*70*	*2.5*	**6**
FXB10 (10)††	***85***	***4.5***	*603*	***6830***	***98***	***5***	**11**
BXF4 (4B)††	*70*	0.5	***628***	*4110*	***83***	***4***	**7**
BXF7	45	*3.5*	***651***	*4280*	53	2	1
BXF8	*75*	*4*	***628***	*5070*	45	2	3
BXF14	*75*	0	***645***	3630	53	*2.5*	1
BXF15	*75*	0.5	***621***	3840	*78*	*3.5*	3
BXF17	25	*3*	***636***	***5310***	18	1.5	2
BXF27 (27)††	*75*	*3*	***622***	*4700*	*68*	*2*	**7**
BXF32 (32)††	***80***	*2*	*611*	***5560***	*68*	*2.5*	**8**
BXF34 (34)††	***80***	0	*601*	*4040*	*70*	*3*	**5**
BXF37	65	*3.5*	598	*4470*	53	*2.5*	0
BXF38	65	*2.5*	588	***5470***	20	1.5	–1
BXF39	*75*	*2*	*608*	3700	38	2	0
Bigalta	***93***	*2.5*	578	***5790***	***85***	*3*	7
Floralta	***90***	*3.5*	*604*	*4240*	*80*	*3*	7

† Top third for a trait = selection value +2, shown in bold italic type; middle third = selection value of +1 shown in italic type; bottom third = selection value of –1, shown in roman (regular) type.

‡ Estimated percentage cover spring 2009 at Hague and Marianna, FL.

§ Visual vigor rating at Ona, FL, in fall 2008 and Marianna, FL, in spring 2009 (1 to 5 = most vigor)

¶ In vitro organic matter digestion determined on 8-wk regrowth of greenhouse grown plants

Dry matter yields from 1 July 2008 harvest of plots at Hague.

†† Hybrid selected for further evaluation.

‡‡ Entries with a selection index value of 5 or higher, noted in bold type, were selected for further evaluation.

Table 2. Herbage accumulation (mean of 2 yr) and ground cover at the termination of the experimental period (December 2008) for selected limpograss hybrid entries, Floralta, and Bigalta at the Range Cattle Research and Education Center, Ona, FL. Only entries with herbage accumulation above 8.5 Mg ha^{-1} are shown.

Entry	Herbage accumulation	Ground cover†
	Mg ha^{-1}	0–5
9	13.1	4
10 (Gibtuck)	13.0	4.5
Bigalta	12.8	1.5
7	12.4	0
32	12.0	2
8	11.8	0
Floralta	11.5	2.5
1	11.1	4
11	10.6	4
4F (Kenhy)	10.4	2.5
37	9..8	3.5
27	9.5	3
19	8.9	1
12	8.8	0
18	8.6	2.5
7	8.5	1.5
SE	1.51	0.5

† Ground cover scored on a scale of 0 to 5, where 0 = bare ground and 5 = fully covered.

20- (Gainesville) or 17-cm (Ona) stubble height. Grazing was done using the mob stocking method, which involves putting a relatively large number of animals (e.g., 6–10) per plot so that defoliation can be accomplished in a short time (Allen et al., 2011).

The eight breeding lines and Floralta were grazed for 2 yr at each location. The stubble height and grazing frequencies were chosen to impose significant defoliation stress to select for persistence under grazing. Plots were fertilized with 120 kg N ha^{-1} divided in three applications of 40 kg ha^{-1} in May, June, and August. Grazing occurred from May to October (Gainesville) or November (Ona) each year. From these two experiments and based primarily on DM harvested, limpograss cover, and weed frequency, three lines (27, 9, and 4B) were deemed to be inferior and were not carried over to subsequent evaluation. Lines 1, 4F, 10, 32, and 34 were advanced for more detailed evaluation in a larger grazing experiment in Gainesville (Vendramini et al., 2013; Wallau et al., 2012, 2013, 2016).

Advanced Line Grazing Experiment at Gainesville

Breeding lines 1, 4F, 10, 32, and 34 plus Floralta were further evaluated for productivity, nutritive value, and persistence under a larger range of grazing treatments. Plots of 8 by 8 m were established in July 2011. The plots were grazed using mob stocking during May through October of 2012 and 2013. Treatments

were the factorial combinations of two grazing frequencies (initiation of grazing at 80 and 95% pregrazing canopy light interception) and two postgrazing stubble heights (20 and 30 cm). Pastures were fertilized with 120 kg N ha^{-1} yr^{-1} in three applications of 40 kg N ha^{-1} (see Wallau et al. [2016] for additional experimental details).

Stockpiling Experiment

A stockpiling experiment was conducted in 2012 and 2013 to compare entries 1, 4F, 10, and Floralta. Plots of each entry were 1.5- by 1.5-m in area and were cut to a 20-cm height in early August of each year, fertilized with either 50 or 100 kg N ha^{-1}, and stockpiled for 8, 12, or 16 wk. A 0.25-m^2 quadrat was clipped from each plot at the end of the stockpiling period, and herbage harvested was measured. Samples were ground and analyzed to determine herbage crude protein (CP) and IVDOM (see Wallau et al. [2015] for additional experimental details).

Characteristics

Disease Incidence and Spring Greenup

Data are presented in Table 3 for incidence of leaf rust on 5 July 2012 and spring greenup on 1 Mar. 2013. Only Bigalta showed infection by *Puccinia* leaf rust (all hybrids and Floralta were symptom free). In spring 2013, hybrids 1, 4F, 10, 32, and 34 and Bigalta had superior spring greenup ratings compared with Floralta and hybrids 9, 4B, and 27.

Yield and Persistence (Two Locations, Mob Stocking)

At Gainesville, lines 4F and 10 had similar forage DM harvested as Floralta in 2010, but in 2011 they outyielded Floralta by 35 and 31%, respectively (Table 4). Although not different from Floralta, 10, 4F, and 1 were the only lines to maintain limpograss cover of ≥85% and weed frequency of ≤15% during 2 yr of grazing (Table 5). Lines 4F and 1 had greater IVDOM than Floralta, and 10 was similar to Floralta in IVDOM (Table 5). Both 4F and 10 had lower CP than Floralta, a response that often occurs for more productive entries, i.e., N is diluted through greater plant biomass. This is illustrated by the response of hybrid 1, which had relatively low forage DM harvested but relatively high CP.

At Ona, hybrid 10 had the greatest total annual herbage accumulation (6.6 Mg ha^{-1}), followed by Floralta and 1 (5.8 Mg ha^{-1}), which had greater herbage accumulation than 4F, 9, and 27 (4.7–5.2 Mg ha^{-1}) (Table 6). There was no difference in CP concentrations among entries (average of 100 g kg^{-1}); however, Floralta and 10 herbage had greater IVDOM concentration than 1, 4F, 9, and 27 (Vendramini et al., 2013). At Ona, there was no difference in limpograss ground cover among entries (79%) at the end of the experimental period.

Yield and Persistence (Advanced Lines, Gainesville)

Entries 4F and 10 had greater herbage accumulation than 1, 32, and 34 but were not different from Floralta in the first year (2012) of the experiment (Table 7). In the second year, 1, 4F, and 10 had greater herbage accumulation than 32, 34, and Floralta. In that year, 10 and 4F had 42 and 60% greater forage accumulation than Floralta, respectively. Limpograss cover after 2 yr of grazing was 49 and 36% greater for 10 and 4F than Floralta (data not shown), explaining in part the

Table 3. Leaf rust and spring greenup ratings at Marianna.

Entry	Rust†	Greenup‡
	5 July 2012	1 Mar. 2013
	1–10	0–9
10 (Gibtuck)	1§	4.8§
1	1	4.3
4F (Kenhy)	1	4.0
32	1	4.0
34	1	4.0
Bigalta	4.5	4.0
Floralta	1	3.0
9	1	2.8
4B	1	2.8
27	1	2.0

† Leaf rust rated on a scale of 1 to 10, where 1 = no rust, 10 = 100% leaf coverage.

‡ Spring greenup was rated on a scale of 0 to 9, where 0 = poor, 9 = vigorous.

§ LSD (0.05) = 1.76 for spring greenup and 1.0 for rust.

Table 4. Limpograss entry × year interaction for herbage harvested by grazing cattle during 2 yr of mob stocking at the Forage Evaluation Field Laboratory in Gainesville, FL.

Entry	Year		*P* value
	2010	2011	
	Mg ha^{-1} yr^{-1}		
1	7.3 cd†	6.7 bc	0.52
4B	6.7 d	5.5 bcd	0.25
4F (Kenhy)	9.8 ab	10.1 a	0.73
9	6.1 d	4.6 d	0.14
10 (Gibtuck)	10.1 a	9.8 a	0.79
27	6.8 d	5.4 cd	0.17
32	8.0 bcd	6.3 bcd	0.10
34	8.1 bcd	6.8 bc	0.21
Floralta	9.2 ab	7.5 b	0.09
SE	1.00		

† Means within a column not followed by the same letter are different ($P < 0.05$).

Table 5. Limpograss entry effects on limpograss cover, weed frequency, crude protein (CP), and in vitro digestible organic matter (IVDOM) during 2 yr of mob stocking at the Forage Evaluation Field Laboratory in Gainesville, FL.

Entry	Limpograss cover	Weed frequency	CP	IVDOM
	%		g kg^{-1}	
1	90 ab†	8 e	99 ab	573 abc
4B	66 de	37 bc	101 a	575 ab
4F (Kenhy)	85 abc	14 de	85 c	580 a
9	54 ef	49 bc	99 ab	561 cde
10 (Gibtuck)	92 ab	9 e	83 c	566 bcd
27	46 f	58 a	96 ab	576 ab
32	80 bc	22 de	95 ab	553 e
34	77 cd	25 cd	95 ab	568 abcd
Floralta	82 abc	18 de	93 b	559 de
SE	6.2	6.7	0.50	0.90

† Means within a column not followed by the same letter are different ($P < 0.05$).

Table 6. Average herbage accumulation and ground cover of limpograss entries grazed using the mob stocking technique at the Range Cattle Research and Education Center, Ona, FL. The values presented are means across 2 yr.

Entry	Herbage accumulation	Ground cover
	Mg ha^{-1}	%
1	5.8 b†	82
4F (Kenhy)	5.2 c	80
9	5.2 b	74
10 (Gibtuck)	6.6 a	82
27	4.7 c	75
Floralta	5.8 b	76
SE	0.2	4

† Means within a column not followed by the same letter are different ($P < 0.05$).

Table 7. Limpograss entry × year interaction for herbage accumulated during 2 yr of mob stocking at the Forage Evaluation Field Laboratory in Gainesville, FL.†

Entry	Year		*P* value
	2012	2013	
	Mg ha^{-1} yr^{-1}		
1	9.0 b‡	10.8 a	0.13
4F (Kenhy)	11.7 a	13.0 a	0.25
10 (Gibtuck)	12.8 a	11.5 a	0.26
32	9.2 b	7.8 b	0.21
34	9.2 b	5.7 b	0.01
Floralta	10.7 ab	8.1 b	0.05
SE	1.20		

† Abstracted from Table 2 in Wallau et al. (2016). Reprinted with permission.

‡ Means within a column not followed by the same letter are different ($P < 0.05$).

greater forage accumulation in Year 2 for those entries. Entry 34 had the poorest persistence of all hybrids, while 32 was not different from Floralta. The increase in weed frequency percentage during the second year of the experiment was least for entries 10 (−1), 4F (12), and 1 (15) and greatest for Floralta (42) and 34 (46). Herbage IVDOM was not different among entries 1, 4F, 10, and Floralta (data not shown). Additional experimental details and results can be found in Wallau et al. (2016).

Yield and Nutritive Value under Stockpiling Management

Entry 4F had superior herbage harvested compared with all other entries when averaged over 2 yr in the stockpiling study, while 10 was also greater than Floralta (Table 7). Herbage CP was less for 4F than the others, again likely associated with greater forage harvested for that entry (Table 8). Growth habit of 4F, 10, and Floralta was similar, and all three were taller growing than 1 (Table 8). There was an entry × stockpiling period interaction for herbage IVDOM, but for all three lengths of stockpiling period IVDOM of hybrid 4F was superior to Floralta. The IVDOM of 10 was at least similar to that of Floralta for all stockpiling periods. These data suggest that 4F may be particularly well suited for use in stockpiling because of its high DM harvested and digestibility (Wallau et al., 2013, 2015).

Table 8. Limpograss entry effect on herbage harvested, stem length, and herbage crude protein (CP) concentration of stockpiled limpograss forage. Data are means across 2 yr at Gainesville.†

Entry	Herbage harvested	Stem length	CP
	Mg ha^{-1}	cm	g kg^{-1}
1	6.1 bc‡	82 b	38 a
4F (Kenhy)	7.3 a	105 a	32 b
10 (Gibtuck)	6.2 b	101 a	39 a
Floralta	5.4 c	100 a	37 a
SE	1.0	3.0	16

† Abstracted from Tables 1 and 5 of Wallau et al. (2015). Reprinted with permission.

‡ Means within a column not followed by the same letter are different ($P < 0.05$).

Summary

Based on the combination of superior DM yields under small plot mechanical harvest, persistence under grazing defoliation with high defoliation pressure at multiple locations, and superior performance under stockpiling management, 4F and 10 were approved for release by the Florida Agricultural Experiment Station in 2014 and were named Kenhy and Gibtuck, respectively. As far as we are aware, these two limpograss hybrids represent the first release of genetically recombined germplasm in this species (all previous releases were plant introductions collected from native conditions in Africa).

Availability

Foundation planting material vegetative blocks of Kenhy and Gibtuck will be maintained by UF/IFAS at Hague and Ona, FL. Initial releases of limited quantities of planting material were made in summer 2014. The Research Committee of the Florida Cattlemen's Association coordinated release and distribution of initial certified planting stock to a group of selected cattlemen growers. These growers now have certified plant material available for sale to additional cattlemen growers. Members of the Florida Cattlemen's Association were given initial priority for purchase of planting material in 2015. Vegetative planting material has been supplied to the Plant Genetic Resources Conservation Unit, Griffin, GA and will be immediately available for distribution.

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