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REGISTRATION

Cultivar

‘FLLA09015-U1’: A broadly adapted dual-purpose oat cultivar for southern USA

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Abstract

‘FLLA09015-U1’ (Reg. no. CV-387, PI 699117) is a new facultative oat (*Avena sativa* L.) cultivar that was co-developed by the University of Florida and Louisiana State University Agricultural Center and was released in 2019. This line was derived from a single cross of FL0210-J1/MN06203. FLLA09015-U1 has considerable potential for grain and forage yield and for conservation tillage purposes in the southern United States. Exclusive marketing rights for FLLA09015-U1 has been granted to JoMar Seeds and is currently commercialized under the name of *Juggernaut*. FLLA09015-U1 was developed using selected bulk breeding method and was selected as an F_{5,6} head row. The line was evaluated in advanced, regional, and state grain and forage yield trials from 2015 to 2021. FLLA09015-U1 was observed to be uniform and stable across environments in the southern United States from 2015 to present. The line possesses a semi-prostrate growth habit and has large leaves that are dark green in color. It is a mid-maturing, medium to mid-tall height with excellent grain yield and good forage yield and test weight. It has excellent crown rust

BYDV, *Barley yellow dwarf virus*; CR, crown rust; LSUAC, Louisiana State University Agricultural Center; SR, stem rust; UWOYN, Uniform Winter Oat Yield Nursery.

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resistance and very good resistance to *Barley yellow dwarf virus* and stem rust and demonstrated moderate lodging resistance. It has performed very well in both grain and forage trials. FLLA09015-U1 has broad environmental adaptation and has performed well in Louisiana, Florida, Georgia, Texas, Alabama, and South Carolina. We consider FLLA09015-U1 to be a good dual-purpose type of oat because of its high grain yield potential and vigorous growth and high tillering capacity.

1 | INTRODUCTION

'FLLA09015-U1' (Reg. no. CV-387, PI 699117) is a new facultative dual-purpose oat (*Avena sativa* L.) cultivar co-developed by the University of Florida and Louisiana State University Agricultural Center (LSUAC) and approved for release in 2019 under the SUNGRAINS cooperative that includes small grain breeding programs from seven universities in the southern United States (University of Florida, Louisiana State University, Texas A&M University, North Carolina State University, University of Georgia, University of Arkansas, and Clemson University). Livestock production is one of the major agricultural incomes for southern and southeastern growers. Due to cold temperature during later fall to mid-spring (November to mid-April), the warm-season grasses cannot produce forage to support the livestock industry as they remain dormant. Different small grain crops including oat are used for annual cool-season pastures in these regions due to their cold tolerance and prolific forage production potentials. In the southern and southeastern United States, oat has been extensively used as a winter forage crop for silage, grazing, and hay for different classes of livestock including beef and dairy. Winter/facultative oat has established itself as an excellent choice for the growers for forage as well as grazing system due to its high-quality early fall–winter forage production, high tillering, and regrowth potential that allows flexibility for earlier grazing or increased stockpiling for later season use (Suttie & Reynolds, 2004). Despite its excellent forage and grazing potentials, the quality of winter/facultative oat declines during later growth stages (Eagles et al., 1979). Winter/facultative oat has also been grown in the southern and southeastern United States as wildlife forage for whitetail deer, turkey, quail, and other game animals and as cover crop in minimum tillage system. Additionally, oat grain is used for animal feed in these regions, particularly for horses. Different diseases, including crown rust (CR; caused by *Puccinia coronata* Corda), stem rust (SR; caused by *Puccinia graminis* f. sp. *avenae*), and *Barley yellow dwarf virus* (BYDV), and lodging are the major problems in growth and management of winter/facultative oat. In addition, oat could be prone to cold injury (particularly facultative) and produces poor-quality seed as it encounters high humidity during heading to maturity. The University of Florida oat breeding

program has adopted an aggressive approach to develop facultative oat cultivars with high early biomass and grazing potential, good grain yield, robust resistance to CR SR, and BYDV, and adequate winterhardiness for fall planting.

FLLA09015-U1 is a broadly adapted dual-purpose (grain and forage) facultative oat. FLLA09015-U1 demonstrated early season vigorous growth and a high tillering capacity due to its facultative growth habit. FLLA09015-U1 has also very competitive spring forage yield. It is medium-tall and has mid-maturity, excellent grain yield, good volume weight, yellow kernels, and excellent CR resistance. Although it was slightly less winter hardy than other popular winter cultivars such as 'LA99016' (PI 658152) or 'Gerard 224' (PI 665935), FLLA09015-U1 performed very well throughout the southern United States. FLLA09015-U1 has considerable potential for grain, forage, conservation tillage, and wildlife use in the southern United States. FLLA09015-U1 oat was released because of its broad adaptation, better grain yield potential and disease resistance, and competitive forage yield compared to LA99016, 'Horizon 720' (PI 678418) and 'Horizon 306' (PI 678581).

2 | METHODS

2.1 | Pedigree and breeding history

'FLLA09015-U1' was derived from a cross between a Florida advanced oat breeding line (FL0210-J1) and a University of Minnesota spring oat breeding line (MN06203). FL0210-J1 was derived from a cross between a Texas oat breeding line, TX97C1130 and an oat breeding line from New Zealand, AS93176,04. AS93276,04 has the pedigree of OT1/01. Texas oat line, TX97C1130, was derived from a three-way cross between two Texas advanced oat lines and an unknown pedigree, TAMO386ERB//TAMO386R/92SAT24-4. MN06203 was derived from a single cross between advanced oat breeding line from Minnesota (MN98133) and South Dakota (SDX11653). Overall, FLLA09015-U1 has a pedigree with diverse genetic background. The original cross number of FLLA09015-U1 was LA09015 made at LSUAC, Baton Rouge, LA greenhouse during the spring of 2009. F₁ seed from cross LA09015 was planted in the summer nursery at the

USDA Small Grains and Potato Germplasm Research Unit in Aberdeen, ID. LA09015 was grown at Baton Rouge in 2010 as an F₂ bulk. Then it was grown as an F₃ bulk in the summer nursery at Aberdeen. It was then entered as an F₄ bulk in the 2011 Quaker International Oat Nursery as entry no. 127. In 2011, LA09015 was grown in the summer nursery at Aberdeen as a F₄ bulk by the University of Florida (Idaho summer nursery row number was FL11Ab127) and population was named as FLLA09015. FLLA09015 was grown as a F₅ Bulk in Quincy, FL in an observation plot in 2012. Forty plants that showed good CR resistance and good agronomic type were selected, and a single panicle was harvested from each of those selected plants. In 2013, 40 F_{5:6} head rows of FLLA09015 were grown at Quincy (FL2013OHR13-41-80). FLLA09015-U1 was an individual row (U indicates the year 2013 and 1 indicates row no. 41) harvested that showed good CR resistance and good agronomic potential. Four panicles from FLLA09015-U1 were collected and planted in 2013 Idaho summer nursery and harvested as bulk to produce F_{5:7} pure seed.

2.2 | Line selection and evaluation

In 2014, FLLA09015-U1 (F₇ generation) was evaluated in an Oat Observation nursery as 14FLOO51 in Quincy, and Baton Rouge. FLLA09015-U1 showed high grain yield potential and good disease resistance. The line appeared to be extremely promising and was entered in the 2015 Sungrain unrepliated multilocation trial (Sunpre oat). Four panicles collected from the plot in Quincy were sent to Aberdeen summer nursery for generation advancement and to produce pure breeder seed in 2015. FLLA09015-U1 was entered in Sunpre oat trial in 2015 and was planted in three locations, Quincy, Baton Rouge, and Prosper, TX. FLLA09015-U1 showed medium maturity, moderately tall, very strong CR and SR resistance, and good forage and grain yield potential. A small seed increase of the line for pure seed was harvested in 2015. In 2016, FLLA09015-U1 was entered in the regional USDA Uniform Winter Oat Yield Nursery (UWOYN), a multi-environment replicated yield trial that tests several public university advanced oat breeding lines at 10 to 12 environments in Texas, Louisiana, Georgia, Arkansas, Alabama, Mississippi, Florida, North Carolina, and South Carolina. FLLA09015-U1 showed excellent performance and ranked no. 1 in the trial for grain yield. FLLA09015-U1 was again evaluated in the 2020 UWOYN to understand the consistency of the performance and reaction to different diseases over the time. The line also demonstrated excellent performance and ranked no. 1 in 2020 trial for grain yield. A summary data is presented in Table 1. The grain yield data in the table are the means of 18 environments (11 environments in 2016 are as follows: Citra and Quincy, FL, Prattville,

Core Ideas

- FLLA09015-U1 a facultative oat cultivar that was co-developed by the University of Florida and Louisiana State University.
- FLLA09015-U1 has broad adaptation and has performed well in Louisiana, Florida, Georgia, Texas, and Alabama.
- FLLA09015-U1 is a good dual-purpose type of oat and has high grain yield potential and vigorous growth and high tillage.
- FLLA09015-U1 has good crown and stem rust and *Barley yellow dwarf virus* resistance.
- FLLA09015-U1 has considerable potential for grain, forage, conservation tillage, and wildlife use in the southern USA.

AL, Plains, GA, Baton Rouge and Winnsboro, LA, Clayton, Raleigh, and Salisbury, NC, McGregor, TX, Brooksville, MS; 7 environments in 2020 are as follows: Prattville, AL, Brooksville, MS, Clayton, NC, Raleigh, NC, Salisbury, NC, Ardmore, OK, McGregor, TX). FLLA09015-U1 was evaluated for yield performance in Louisiana (2017 and 2018), Texas (2018 and 2019), Alabama (2018 and 2020), Georgia (2018 and 2021), and South Carolina (2021) state variety trials and summary data are presented in Tables 2, 3, 4, 5, and 6, respectively. FLLA09015-U1 was also entered in multi-state, multi-cut clipping variety trial for forage yield potential led by the University of Georgia and tested in Mariana, FL (2018 and 20121), Georgia (three environments from 2018 to 2021) and Alabama (two environments from 2020 to 2021). The summary data of forage yields are presented in Tables 7, 8, and 9. In the multi-cut clipping forage trials, the biomass was harvested two to four times over the growing season to estimate fall, winter, and early and late spring forage yield. Biomass was harvested from the middle four rows of the plot, and total fresh weight was measured. A sample of fresh biomass was dried at 50°C until dry, and total dry weight of biomass was calculated in kilograms per hectare. These trials provided regional testing and evaluation of the grazing potential of oat lines and cultivars under several environmental conditions.

Morphological data were collected from the yield trials conducted from 2016 and 2021 seasons in different UWOYN and state variety trials. Plant height was measured to the top of the panicle. Grain yield and volume weight and days to heading (50% of heads visible based on Julian date) were recorded in different environments. Lodging (0 = none, 9 = total lodging), CR and SR (0 = none, 9 = severe), and leafiness (0 = excellent leafiness or forage; 9 = very poor forage potential or few leaves) data were collected in the UWOYN and

TABLE 1 Grain yield and other traits of FLLA09015-U1 and other oat cultivars in Uniform Winter Oat Nursery at different environments in the southern and southeastern United States averaged across 2016 and 2020 (harvest years)

| Cultivar | Yield | Vol. wt. | Heading days | Height | Lodging ^a | BYDV ^b | BYDV ^c | Crown rust ^d | Stem rust ^d | Leafiness ^e |
|--------------|---------------------|--------------------|--------------|--------|----------------------|-------------------|-------------------|-------------------------|------------------------|------------------------|
| | kg ha ⁻¹ | kg m ⁻³ | Julian days | cm | 0–9 | 0–9 | 0–9 | 0–9 | 0–9 | 0–9 |
| Gerard 224 | 5067 | 408 | 97 | 104 | 3.0 | 4.2 | 6.0 | 4.1 | 4.8 | 5.0 |
| LA99016 | 5200 | 434 | 97 | 117 | 2.7 | 3.7 | 5.3 | 2.4 | 2.5 | 5.8 |
| TAMO 411 | 4667 | 417 | 97 | 99 | 3.0 | 3.2 | 7.0 | 4.9 | f | 4.6 |
| Horizon 201 | 4800 | 409 | 96 | 122 | 3.3 | 3.7 | 4.0 | 5.0 | 3.7 | 4.2 |
| FLLA09015-U1 | 6600 | 422 | 95 | 114 | 3.5 | 2.2 | 2.5 | 0.4 | 0.3 | 5.2 |
| Mean | 5333 | 427 | 94 | 109 | 2.8 | 3.2 | 5.0 | 2.7 | 2.5 | 5.0 |
| LSD (0.05) | 1033 | 28 | 2.1 | 6 | 2.5 | 1.5 | 1.3 | 1.5 | 2.9 | 1.4 |
| Environments | 18 | 11 | 13 | 12 | 9 | 3 | 2 | 7 | 3 | 6 |

^aLodging score: 0 = none, 9 = total lodging.

^b*Barley yellow dwarf virus*. Score: 0 = none, 9 = severe.

^c*Barley yellow dwarf virus* screening nursery at the University of Illinois. Score: 0 = none, 9 = severe.

^dCrown and stem rust scores: 0 = none, 9 = severe.

^eLeafiness score: 0 = very poor forage potential/few leaves, 9 = excellent leafiness/forage.

^fMissing data.

TABLE 2 Performance of FLLA09015-U1 oat cultivar in Louisiana state variety trial averaged across four environments in harvesting years 2017 (Winnsboro) and 2018 (Alexandria, Baton Rouge, and Winnsboro)

| Cultivar | Yield | Vol. wt. | Heading days | Plant height | Lodging ^a | Crown rust ^b | Stem rust ^b | BYDV ^c | Leafiness ^d |
|--------------|---------------------|--------------------|--------------|--------------|----------------------|-------------------------|------------------------|-------------------|------------------------|
| | kg ha ⁻¹ | kg m ⁻³ | Julian days | cm | 0–9 | 0–9 | 0–9 | 0–9 | 0–9 |
| Horizon 306 | 4967 | 347 | 95 | 124 | 0.8 | 3.4 | 1.0 | 2.0 | 5.6 |
| Horizon 270 | 5200 | 361 | 90 | 122 | 0.6 | 3.4 | 1.0 | 3.0 | 4.4 |
| Horizon 720 | 7600 | 436 | 92 | 132 | 1.2 | 1.0 | e | 2.0 | 7.0 |
| Horizon 201 | 5333 | 357 | 89 | 137 | 0.8 | 3.4 | 1.8 | 1.0 | 6.0 |
| LA99016 | 3600 | 336 | – | – | – | 4.5 | 1.8 | – | 6.0 |
| FLLA09015-U1 | 6967 | 381 | 87 | 122 | 0.6 | 0.2 | 0.8 | 1.0 | 5.4 |
| Mean | 5393 | 372 | 89 | 122 | 1.0 | 4.5 | 1.1 | 2.1 | 4.8 |
| LSD (0.05) | 1520 | 21 | 3 | 8 | 1.0 | 1.2 | NS | 1.0 | 1.1 |
| Environments | 4 | 4 | 2 | 3 | 1 | 3 | 1 | 2 | 3 |

^aLodging score: 0 = none, 9 = total lodging.

^bCrown and stem rust scores: 0 = none, 9 = severe.

^c*Barley yellow dwarf virus* screening nursery in University of Illinois. Score: 0 = none, 9 = severe.

^dLeafiness score: 0 = very poor forage potential/few leaves, 9 = excellent leafiness/forage.

^eMissing data.

TABLE 3 Performance of FLA09015-U1 oat cultivar in Texas state variety trial averaged across eight environments in harvesting years 2018 (College Station, McGregor, Castroville, Thrall) and 2019 (Brady, Castroville, College Station, Uvalde)

| | Yield | Vol. wt. | Heading days | Height | Lodging ^a | Crown rust ^b |
|--------------|---------------------|--------------------|----------------|--------|----------------------|-------------------------|
| | kg ha ⁻¹ | kg m ⁻³ | Julian | cm | | |
| TAMO 411 | 5403 | 380 | 98 | 86 | 1.5 | 8.3 |
| TAMO 412 | 5840 | 411 | – ^c | – | – | – |
| LA99016 | 6040 | 395 | 98 | 95 | 1.5 | 7.5 |
| Horizon 720 | 5470 | 369 | 103 | 105 | 2.5 | 2.3 |
| Horizon 201 | 6160 | 384 | 97 | 97 | 5.5 | 6.8 |
| FLA09015-U1 | 7513 | 382 | 98 | 94 | 1.5 | 2.0 |
| Mean | 5067 | 399 | 99 | 93 | 2.9 | 5.2 |
| LSD (0.05) | 1200 | 37.3 | 2.3 | 7.6 | 2.1 | 1.6 |
| Environments | 8 | 8 | 4 | 3 | 3 | 1 |

^aLodging score: 0 = none, 9 = total lodging.

^bCrown and stem rust scores: 0 = none, 9 = severe.

^cMissing data.

different state grain trials. Percentage lodging was rated in the UWOYN, Louisiana, Texas and Georgia state variety trials. Leafiness was also recorded in the UWOYN and Louisiana state variety trial. *Barley yellow dwarf virus* (0 = none, 9 = severe) data were collected from the BYDV screening nursery at the University of Illinois, Urbana–Champaign and UWOYN. Analysis of variance of within and across environments was performed using SAS version 9.4 (SAS Institute, 2013). The regional and state yield trials were subjected to analysis of variance across locations and years. PROC MIXED procedure was used to estimate genotypic adjusted mean within location and year × location combination. To identify significant differences among genotypes, a mean comparison of traits was performed using the protected least significant difference (LSD; $P = .05$) test where genotype × environment mean square was used to estimate the standard error of differences between genotype means across environments.

3 | CHARACTERISTICS

3.1 | Morphological description and agronomic adaptation

FLA09015-U1 is a facultative winter, awnless, white-glumed, midseason dual-purpose oat. It has a dark green and glabrous leaf with hairless sheaths, and twisted flag leaf at booting. It possessed a semi-prostrate growth habit with large leaves and five to seven leaves per stalk. At maturity, FLA09015-U1 plants were shorter (114 cm) than the check cultivars Horizon 201 (122 cm) and LA99016 (117 cm) but taller than two winter type checks, Gerard 224 (104 cm) and TAMO 411 (99 cm; Table 1), across 12 environments in UWOYN. In general, it showed shorter height (94–130 cm) than Horizon 201 (97–137 cm) and Horizon 720 (102 to 132 cm), but higher than TAMO 411 (86 cm), Gerard 224 (89–122 cm), and Horizon 306 (91–124 cm) in different state trials (Tables 2, 3, 5, and 6). The line is at a similar height to the widely cultivated forage oat cultivar, Horizon 270 (122 cm; Table 2). Across the southern U.S. region, FLA09015-U1 has mid-maturity (95 Julian heading days; Table 1). Heading of FLA09015-U1 is approximately 2 days earlier than Gerard 224, LA99016, and TAMO 411, and 1 day earlier than Horizon 201 across 13 environments (Table 1). In different state trials, the line had 6 days later heading (mean 99 and range 87–110 Julian days) than Horizon 201 (mean 93 and range 89–97 Julian days), but 3 days earlier than Horizon 720 (mean 102 and range 92–112 Julian days), 5 days earlier than Horizon 306 (mean 104 and range 95–113 Julian days), and 10 days earlier than Gerard 224 (mean 109 and range 106–111 Julian days; Tables 2, 3, 5, and 6). The line showed similar maturity of widely cultivated

TABLE 4 Performance of FLLA09015-U1 oat cultivar in Alabama state variety trial averaged across eight environments in harvesting years 2018 (Marion Junction, Prattville, Tallassee, Headland, Brewton, Fairhope) and 2020 (Brewton and Headland)

| Cultivar | Yield kg ha ⁻¹ | Volume weight kg m ⁻³ |
|--------------|------------------------------|-------------------------------------|
| Horizon 306 | 6003 | 420 |
| Horizon 720 | 5190 | 404 |
| FLLA09015-U1 | 6027 | 387 |
| Mean | 5733 | 354 |
| LSD (0.05) | 833 | 13 |
| Environments | 8 | 8 |

TABLE 5 Performance of FLLA09015-U1 oat cultivar in Georgia state variety trial averaged across nine environments in harvesting years 2018 (Tifton, Plains, Midville, Calhoun) and 2021 (Rome, Griffin, Midville, Plains and Tifton)

| Cultivar | Yield kg ha ⁻¹ | Vol. wt. kg m ⁻³ | Heading days Julian | Height cm | Lodging ^a 0–9 |
|--------------|------------------------------|--------------------------------|------------------------|--------------|-----------------------------|
| Gerard 224 | 7800 | 425 | 106 | 122 | 5.6 |
| Horizon 270 | 7333 | 425 | 107 | _b | _b |
| Horizon 306 | 7333 | 420 | 105 | 124 | 6.7 |
| Horizon 720 | 7133 | 407 | _b | _b | _b |
| FLLA09015-U1 | 8000 | 402 | 101 | 130 | 7.7 |
| Mean | 7133 | 398 | 104 | 128 | 6.2 |
| LSD (0.05) | 800 | 39 | 3 | 11 | 2.3 |
| Environments | 8 | 7 | 6 | 9 | 9 |

^aLodging score: 0 = none, 9 = total lodging.

^bMissing data.

TABLE 6 Performance of FLLA09015-U1 oat cultivar in South Carolina state variety trial averaged across three environments (Blacksville, Florence, and Pendleton) in 2021 harvesting year

| Cultivar | Yield kg ha ⁻¹ | Volume weight kg m ⁻³ | Heading days Julian | Plant height cm |
|--------------|------------------------------|-------------------------------------|------------------------|--------------------|
| Gerard 224 | 7940 | 429 | 112 | 89 |
| Horizon 306 | 6680 | 368 | 113 | 91 |
| Horizon 720 | 6367 | 367 | 112 | 102 |
| FLLA09015-U1 | 7867 | 403 | 110 | 99 |
| Mean | 7087 | 387 | 112 | 91 |
| LSD (0.05) | 473 | 24 | 3 | 10 |
| Environments | 3 | 3 | 2 | 3 |

forage oat cultivar LA99016 (98 Julian days), Horizon 201 (97 Julian days), and grain cultivar TAMO 411 (98 Julian days) in the Texas state variety trial (Table 3). It has demonstrated a plasticity in maturity. The line showed longer maturity duration in southeastern environments (Georgia and South Carolina) compared to southwestern environments (Louisiana and Texas). FLLA09015-U1 possessed similar or less lodging than checks in different trials (Tables 1, 2, and 3)

except the Georgia state cultivar trial where it had higher lodging than most of the checks (Table 5). Winterhardness is an important trait for the adaptation in southern U.S. oat, and although FLLA09015-U1 did show very limited data, but FLLA09015-U1 did show some leaf burning (data not presented). Though the performance of line was not affected by leaf burning, it does have spring oats in its pedigree and is likely to show some injury to hard freezing conditions.

TABLE 7 Dry matter yield of oat cultivars FLLA09015-U1 evaluated in Mariana, FL in a multiple-cut clipping oat variety trial in 2018 and 2021 harvesting years

| Cultivar | Forage Cut 1 | | Forage Cut 2 | | Forage Cut 3 | | Forage Cut 4 | | Season total | | Mean |
|--------------|---------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|--------------|------|------|
| | 9 Jan. 2018 | 14 Jan. 2021 | 14 Feb. 2018 | 17 Feb. 2021 | 14 Mar. 2018 | 16 Mar. 2021 | 18 Apr. 2018 | 14 Apr. 2021 | 2018 | 2021 | |
| | kg ha ⁻¹ | | | | | | | | | | |
| Horizon 306 | 2183 | 1042 | 1984 | 1796 | 2264 | 2741 | 2413 | 1196 | 8845 | 6775 | 7810 |
| LA99016 | 1916 | 759 | 1658 | 1900 | 2140 | 2966 | 3083 | 1167 | 8796 | 6793 | 7794 |
| Horizon 720 | 2412 | 1922 | 1627 | 2032 | 1472 | 1289 | 3408 | 1442 | 8917 | 6685 | 7801 |
| Legend 567 | 2871 | 1662 | 1413 | 1853 | 1042 | 915 | 3168 | 1099 | 8492 | 5528 | 7010 |
| FLLA09015-U1 | 2453 | 1470 | 1093 | 1733 | 1796 | 1178 | 3782 | 1786 | 9124 | 6164 | 7644 |
| Mean | 2220 | 1478 | 1612 | 1537 | 1527 | 1812 | 3159 | 1052 | 8519 | 5879 | 7199 |
| LSD (0.05) | 448 | 462 | 362 | 331 | 437 | 407 | 557 | 482 | 451 | 421 | 436 |

TABLE 8 Dry matter yield of oat cultivar FLLA09015-U1 evaluated in Georgia state multiple-cut clipping variety trial from 2018 to 2021

| Cultivar | 2018 ^a | 2020 ^b | 2021 ^c | Mean |
|--------------|---------------------|-------------------|-------------------|------|
| | kg ha ⁻¹ | | | |
| Horizon 306 | 7269 | 5413 | 6213 | 6298 |
| LA99016 | 6980 | 5331 | 6453 | 6255 |
| Horizon 720 | 6628 | 5088 | 6332 | 6016 |
| Legend 567 | 5792 | 5186 | 6049 | 5676 |
| FLLA09015-U1 | 6702 | 4921 | 5878 | 5834 |
| Mean | 6499 | 4806 | 5711 | 5671 |
| LSD (0.05) | 514 | 574 | 612 | 522 |
| Environments | 3 | 3 | 3 | 9 |

^aBiomass cuts were made three times in Tifton, four times in Athens, and two times in Plains in 2018.

^bBiomass cuts were made four times in Tifton, two times in Athens, and two times in Plains in 2020.

^cBiomass cuts were made four times in Tifton, three times in Griffin, and three times in Plains in 2021.

TABLE 9 Dry matter yield of oat cultivars FLLA09015-U1 evaluated in Alabama state multiple-cut clipping variety trial in 2020 and 2021

| Cultivar | 2020 ^a | 2021 ^b | Mean |
|--------------|---------------------|-------------------|------|
| | kg ha ⁻¹ | | |
| LA99016 | 2022 | 5582 | 3802 |
| Legend 567 | 2196 | 4716 | 3456 |
| FLLA09015-U1 | 2016 | 5648 | 3832 |
| Mean | 1986 | 5223 | 3605 |
| LSD (0.05) | 596 | 765 | 681 |
| Environments | 2 | 2 | 4 |

^aBiomass cuts were made three times in Headland and two times in Clanton in 2020.

^bBiomass cuts were made two times in Headland and four times in Clanton in 2021.

3.2 | Field performance

FLLA09015-U1 was tested for grain yield potential in the advanced yield trial of UWOYN and state variety trials of Louisiana, Georgia, Texas, Alabama, and South Carolina from 2016 to 2021 (49 environments). FLLA09015-U1 did

excellent and was ranked no. 1 (6600 kg ha⁻¹) for grain yield when data were averaged over 18 environments in UWOYN trial in 2016 and 2020 (Table 1). The check varieties Horizon 201, Gerard 224, LA99016, and TAMO 411 yielded 4800, 5067, 5200, and 4667 kg ha⁻¹, respectively. FLLA09015-U1 had an average volume weight of 422 kg m⁻³, which was

higher than Horizon 201 (409 kg m⁻³), Gerard 224 (408 kg m⁻³), and TAMO 411 (417 kg m⁻³) but lower than LA99016 (434 kg m⁻³) across 11 environments.

In state trials of the southwestern region (Louisiana and Texas) from 2017 to 2019 (Tables 2 and 3), FLLA09015-U1 showed excellent yield performance (6967–7513 kg ha⁻¹). FLLA09015-U1 (6967 kg ha⁻¹) yielded significantly higher than all checks except Horizon 720 (7600 kg ha⁻¹) in Louisiana state trial (Table 2), while in the Texas state trial (Table 3), FLLA09015-U1 (7513 kg ha⁻¹) outyielded all checks (5403–6160 kg ha⁻¹) significantly. The line also had good and consistent volume weight (381–382 kg m⁻³) in Texas and Louisiana state trials and was higher than four commercial checks (Horizon 306, Horizon 361, Horizon 201, and LA99016) in Louisiana across four environments (Table 2). Similarly in Texas state variety trials across eight environments, FLLA09015-U1 (382 kg m⁻³) had similar volume weight to TAMO 411 (380 kg m⁻³), Horizon 201 (384 kg m⁻³), but higher than Horizon 720 (369 kg m⁻³), and lower than TAMO 412 (411 kg m⁻³) and LA99016 (395 kg m⁻³; Table 3). In Southeastern oat state trials (Alabama, Georgia, and South Carolina), FLLA09015-U1 also demonstrated excellent performance (Tables 3, 4, and 5). The yield of the line ranged from 6017 to 8000 kg ha⁻¹ across 19 environments from 2018 to 2021. FLLA09015-U1 out yielded most of the checks (Horizon 306, Horizon 720, and Horizon 270; Tables 3, 4, and 5) and yielded similar to well-known grain cultivar Gerard 224 (7800–7940 kg ha⁻¹) in Georgia and South Carolina state variety trials (Tables 4 and 5). The volume weight of FLLA09015-U1 (387–403 kg m⁻³) was slightly lower than most of checks in Alabama, Georgia, and South Carolina state trials (367–425 kg m⁻³). Overall, FLLA09015-U1 demonstrated consistent and strong grain yield performance across all the state trials.

3.3 | Disease resistance

FLLA09015-U1 demonstrated strong resistance to CR, SR, and BYDV, which are major diseases of oat in the southern United States. Crown rust is a major limitation of oat production in the southern United States. FLLA09015-U1 has shown consistently high level of resistance to new virulence combinations of CR that have caused significant disease on commonly grown cultivars in the region. Based on data collected on 2015 Sunpre Oat trial at Quincy, FLLA09015-U1 showed very strong CR resistance, while all checks were moderately susceptible to susceptible (data not shown). Crown rust was rated at seven environments in UWOYN trial in 2016 and 2020. FLLA09015-U1 scored a 0.4 (0–9 scale) compared with Horizon 201 (5.0), LA99016 (2.4), Gerard 224 (4.1), and TAMO 411 (4.9). From these data, we could say that FLLA09015-U1 is highly resistant to CR, whereas Hori-

zon 201, Gerard 224, and TAMO 411 are susceptible, and LA99016 is moderately resistant (Table 1). FLLA09015-U1 also demonstrated better BYDV resistance when evaluated in the BYDV screening nursery conducted by Dr. Fred Kolb, University of Illinois, Urbana. FLLA09015-U1 (2.5) had greater BYDV resistance than LA99016 (5.3), TAMO 411 (7.0), Gerard 224 (6.0), and Horizon 201 (4.0) (Table 2). Stem rust data were collected in three environments and FLLA09015-U1 showed resistance against the races in the southern United States. The line was scored a 0.3 compared with Gerard 224 (4.8), Horizon 201 (3.7), and LA99016 (2.5).

FLLA09015-U1 showed excellent CR resistance, while all four commercial checks showed moderate susceptibility to the CR races available in the Louisiana state variety trial in 2017 and 2018, except Horizon 720, which showed strong resistance and is also a forage oat released by the University of Florida in 2014 (Table 2). For BYDV, it showed significantly better disease resistance than most of the checks (Horizon 306, Horizon 270, and Horizon 720). FLLA09015-U1 also possessed lower SR reaction than other checks (Table 2). Crown rust was a major problem in Castroville, south Texas, in 2018 Texas state trial, and FLLA09015-U1 showed strong resistance (2.0) and was significantly better than TAMO 411 (8.3), LA99016 (7.5), and Horizon 201 (6.8) but similar to Horizon 720 (2.3) (Table 3).

3.4 | Forage performance

Leafiness is a visual rating of forage production (tillering and leaf production) potential (based on a 0–9 scale) and was rated in the winter and early spring when oat is in their vegetative stage prior to flag leaf development. FLLA09015-U1 had good leafiness (5.2) rating in UWOYN trials across six environments in 2016 and 2020 (Table 1) and Louisiana state oat variety trials (5.4) in 2017 and 2018 (Table 2). The leafiness rating for FLLA09015-U1 was either similar or higher than checks with a few exceptions (Tables 1 and 2).

FLLA09015-U1 was evaluated for forage production in advanced forage clipping trials as part of the University of Georgia statewide variety testing (from 2018 to 2021) at several environments including Marianna, FL. Results of those trials are presented in Tables 7, 8, and 9. In Marianna, FL, FLLA09015-U1 performed well at the first, third, and fourth clipping and was above the test average in 2018 and season total dry biomass yield (9124 kg ha⁻¹) was slightly higher than all checks (8492–8917 kg ha⁻¹; Table 7). The line performed moderately in 2021 and produced lower dry biomass (6164 kg ha⁻¹) than checks (Horizon 306, LA99016, and Horizon 720) except early forage oat line Legend 567. When considering 2 years of performance, FLLA09015-U1 produced season total dry biomass that is highly competitive to different forage oat cultivars growing in the southern United

States (Table 7). The line produced higher forage yield than widely grown forage lines Horizon 306 and LA99016 in late fall and produced higher forage yield than all commercial checks in late spring cut. Forage yield of FLLA09015-U1 at the boot stage, which measures silage yield potential (fourth cut) was higher than all checks, which indicates that this line will be a good potential candidate for high silage producing cultivar.

FLLA09015-U1 was evaluated across four locations in Georgia (Tifton, Athens, Griffin, and Plains) in 2018, 2020, and 2021. The line produced similar forage yield like early oat cultivar Legend 567 (released by the University of Florida in 2013). It was very competitive in forage production with other three commercial checks in the trial (Horizon 306, LA99016, and Horizon 720). It was above the test average in all 3 years (Table 8). In two locations in Alabama, FLLA09015-U1 produced similar forage yield (3832 kg ha^{-1}) to Horizon 306 (3802 kg ha^{-1}) but slightly higher than early check Legend 567 (3456 kg ha^{-1} ; Table 9). The line showed good potential to produce forage yield over the growing season across many different locations.

4 | CONCLUSION

In summary, FLLA09015-U1 has excellent grain yield potential, good test weight, and good early and late season forage production capacity, which will give it a competitive advantage as a new oat cultivar for the southern United States. It has shown moderate maturity and excellent disease resistance, particularly resistance to a new race of CR that is currently attacking most of the currently available cultivars. It also demonstrated moderate lodging resistance. FLLA09015-U1 was observed to be uniform and stable from 2016 to present. This new oat cultivar will be excellent as forage, grain, or cover crop or for use in wildlife plantings.

5 | AVAILABILITY

An exclusive license for commercialization of FLLA09015-U1 has been granted to JoMar Seeds, Plymouth, IN. The Florida Agricultural Experiment Station will maintain breeder seed of FLLA09015-U1. U.S. Plant Variety Protection has been applied for FLLA09015-U1. All seed requests should be sent to the corresponding authors. Seed of FLLA09015-U1 has been deposited in the USDA National Plant Germplasm System where it will become available after the expiration of the PVP for research purposes, including the development and commercialization of new breeding lines or cultivars resulting from this germplasm.

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AUTHOR CONTRIBUTIONS

Md Ali Babar: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Resources, Supervision. Stephen A. Harrison: Conceptualization, Data curation, Funding acquisition, Writing – review & editing. Ann R. Blount: Data curation, Formal analysis, Funding acquisition, Resources, Writing – review & editing. Ronald D. Barnett: Conceptualization, Funding acquisition, Resources, Writing – review & editing. Jerry Johnson: Data curation, Resources. Mohamed Mergoum: Data curation, Resources. Daniel J Mailhot: Data curation, Resources. J. Paul Murphy: Data curation, Resources. Richard E. Mason: Data curation, Formal analysis, Resources. Amir Ibrahim: Data curation, Resources, Writing – review & editing. Russell Sutton: Data curation, Resources, Writing – review & editing. Bryan Simoneaux: Data curation, Formal analysis, Resources. Richard E Boyles: Data curation, Formal analysis, Resources. Brad Stancil: Data curation, Writing – review & editing. David Marshall: Data curation, Resources, Writing – review & editing. Myron Fountain: Data curation, Formal analysis, Resources. Kathy Esvelt Klos: Resources, Writing – review & editing. Naeem Khan: Data curation, Formal analysis, Writing – review & editing. Marcelo Wallau: Data curation, Resources. Henry G. Jordan: Data curation, Resources.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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