Breeding of Elephantgrass (*Pennisetum purpureum* Schum.) for Improved Biomass/Biofuel Yield and Enhanced Biosafety

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INTRODUCTION

Elephantgrass, also known as napiergrass, is a promising feedstock for lignocellulosic biofuel production due to its high yield (Table 1) and biomass quality. However, the currently available cultivars and naturalized populations can produce wind dispersed seeds, which contribute to potential for invasiveness (Category I in the List of the Florida Exotic Pest Plant Council). Seed production is not required for establishment of new plantings, since stem cuttings are used for this purpose. Elephantgrass flowers under shortening day length, and seed formation or viability is often compromised in late flowering accessions due to low temperature. Therefore, sexual hybridization and selection of late flowering, high yielding accessions would increase the biofuel yield and enhance the biosafety of elephantgrass.

METHODS

Genetically distant, high-yielding, late-flowering accessions were selected as parents for sexual hybridization to enhance the biomass yield and biosafety of elephantgrass. A nursery of 1600 F1 hybrids (Pseudo F2) and 20 clones from each parent was established. The 50 highest yielding hybrids and 183 hybrids from the two most contrasting parents (P3 x P5) were vegetatively propagated in replicated row plots for evaluation of biomass yield and flowering date during three growing periods. Merkeron was included in this trial as a control, since it is a commonly used elephantgrass cultivar. In addition the number of tillers, stem diameter, plant height and leaf width were measured and correlated with plant biomass.

RESULTS

Generation of Elephantgrass Hybrids and Selection for High Biomass Yield

Table 1. Average annual biomass yield of elephantgrass (eg), energycane (ec), sugarcane (sc), at five locations in southeastern United States over three growing seasons (Prine et al. 1991, 1997).

	Oven dry biomass (Mg ha^{-1} yr^{-1})				
	Florida				Alabama
Crops	Ona	Gainesville	Quincy	Jay	Auburn
N-51 eg	46.7	39.7	33.8	32.1	24.0
PI 300086 eg	41.6	28.6	24.1	24.0	18.6
L79-1002 ec	23.3	32.2	30.1	33.9	24.2
CP72-1210 sc	19.4	10.4	19.2	8.2	6.0

(Prine and French 1999)

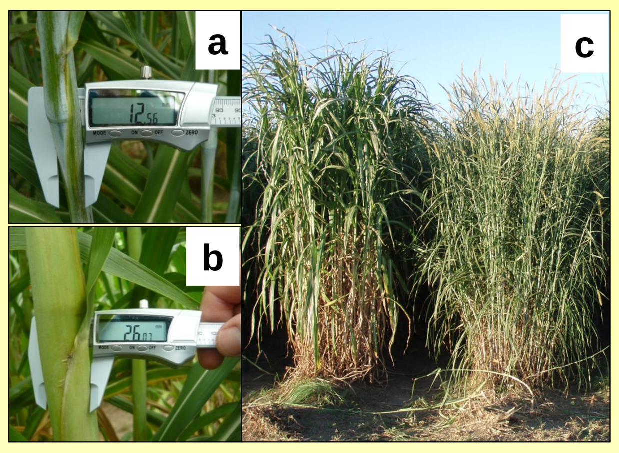

Fig. 1. Phenotype of the contrasting parents P4 and P6: (a) thin stems belonging to P4, (b) thick stems belonging to P6, (c) P4 is high tillering and flowers early, (d) P6 is low tillering and flowers late.

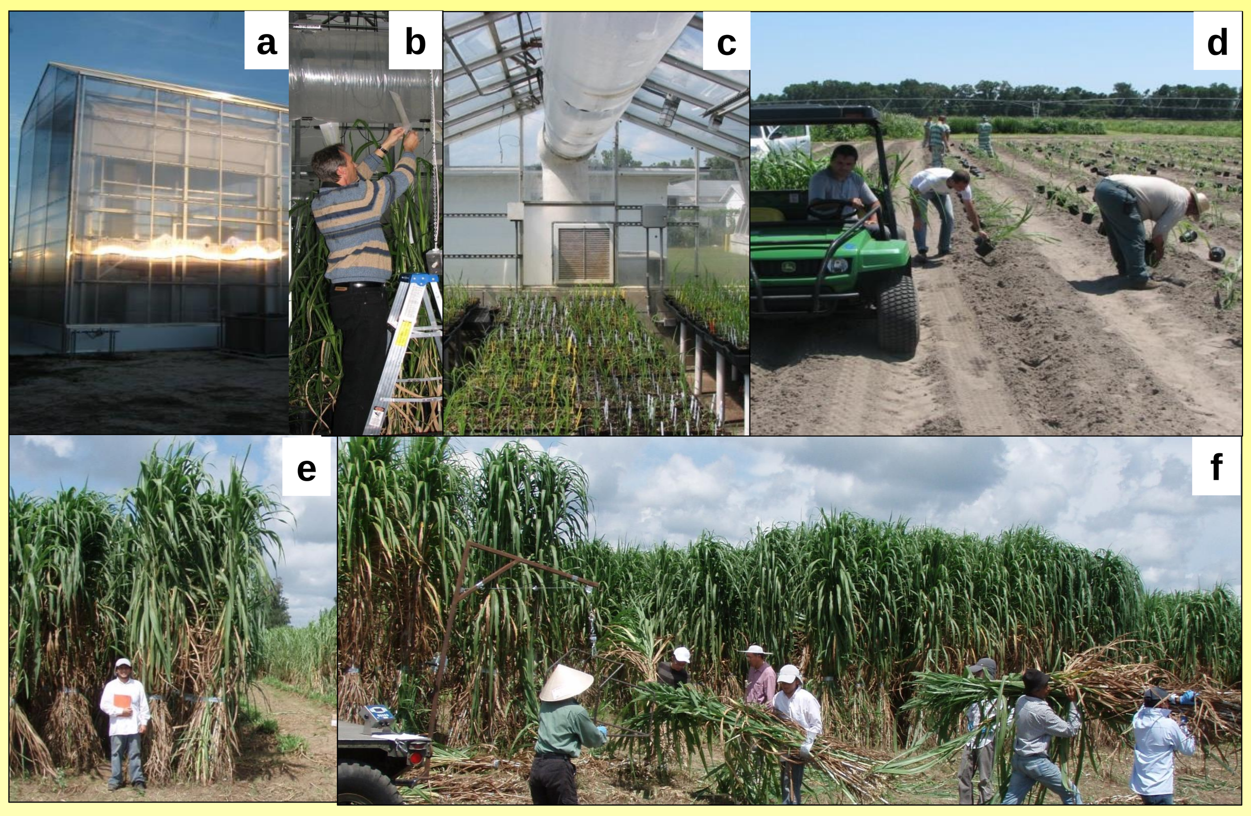

Fig. 2. Sexual hybridization and selection of the most promising hybrids: (a) greenhouse with photoperiod control system, (b) making crosses using glassine bags, (c) assessment of germination rate and seedling vigor, (d) seedlings transferred to the field (PSREU at Citra, Fl.), (e) plants at the end of the growing period, (f) harvest and biomass weight determination.

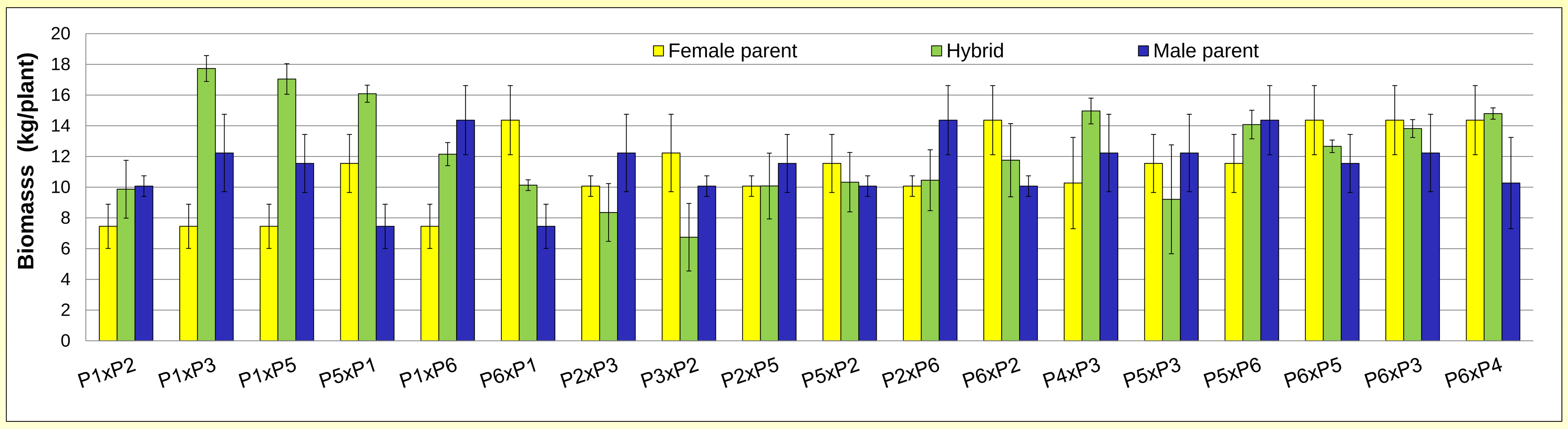

Fig. 3 Average fresh biomass weight determined in November, 2011. The green bars represent the average biomass of the F1 hybrids (Pseudo F2), while the blue and yellow bars represent the average biomass of the corresponding parents.

Evaluation of 183 F1 hybrids (Pseudo F2) from a cross of genetically diverse and contrasting parents (P6xP4)

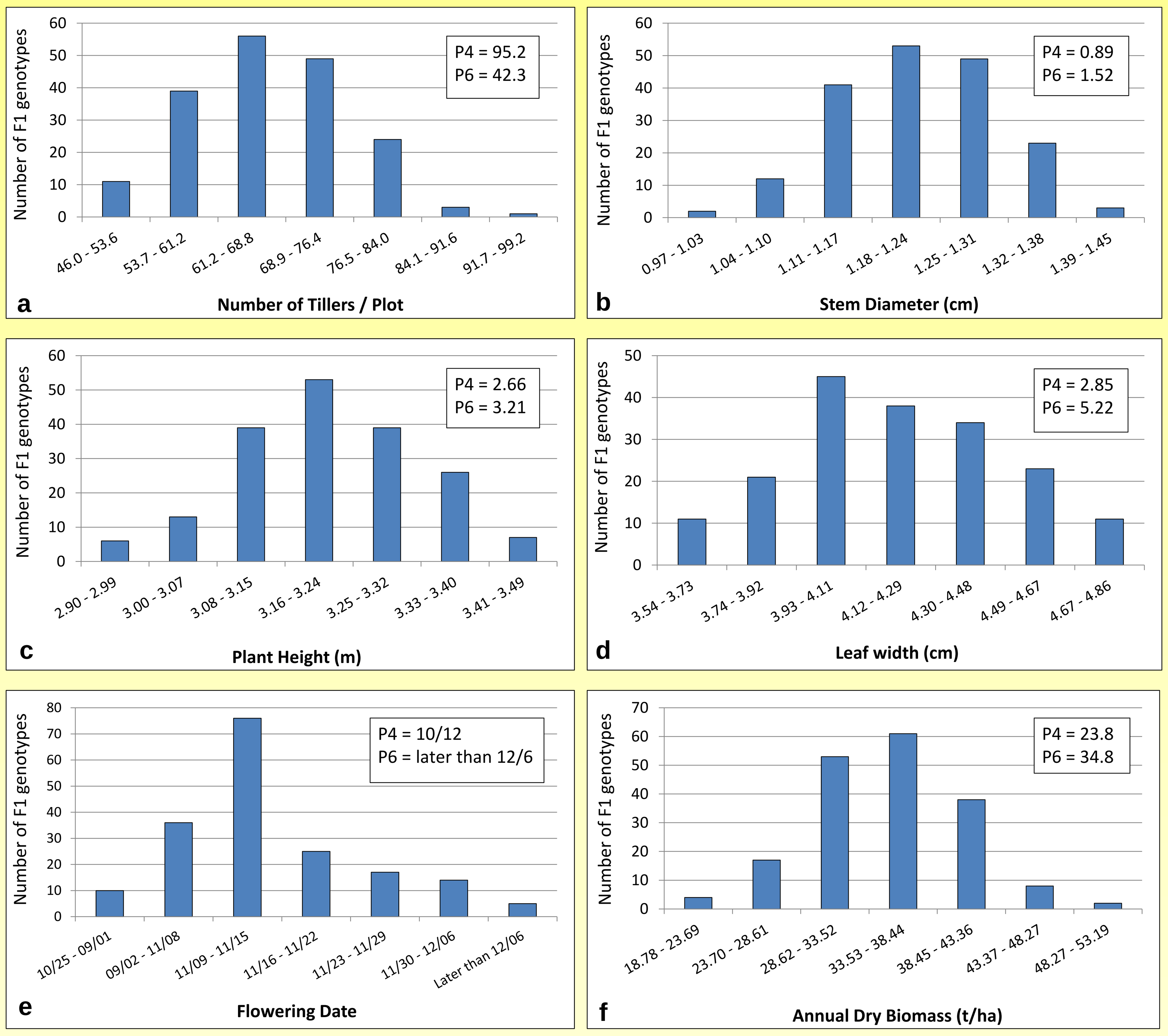

Fig. 4. Frequency distribution of biomass-related traits for 183 F1 hybrids of the cross P6xP4 in replicated conditions, at Citra, Fl. In 2012: (a) number of tillers, (b) stem diameter, (c) plant height, (d) leaf width, (e) flowering date, (f) annual dry biomass weight. The data is based on the average of 3 replications for each of the hybrids and 6 rep. for the parents P6 and P4. Each replication consisted in a 6ft long row plot, in a RCBD. The values of the parental acessions are also shown.

Evaluation of Selected Elephantgrass Hybrids following Crosses with Genetically Distant Parents

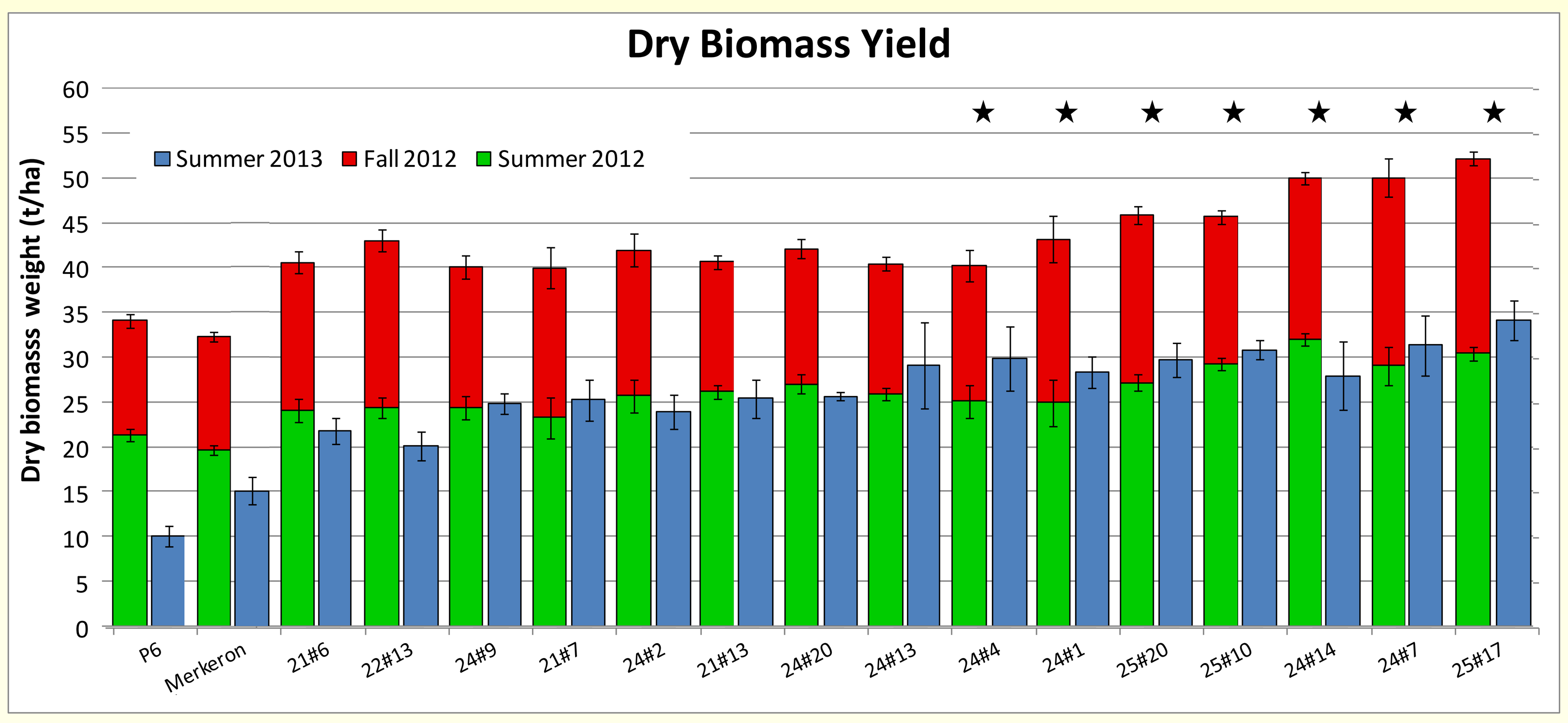

Fig. 5. Dry biomass yield of the 15 higher yielding genotypes, in comparison to the most productive of the parents (P6) and the commonly used elephantgrass cultivar "Merkeron". Plots were harvested in August and December 2012, and August 2013. The calculations were based on 3 replications per genotype, each in a 6-foot long row plot in a RCBD.

★ = Significantly higher than Merkeron (p<0.05) in the total biomass production.

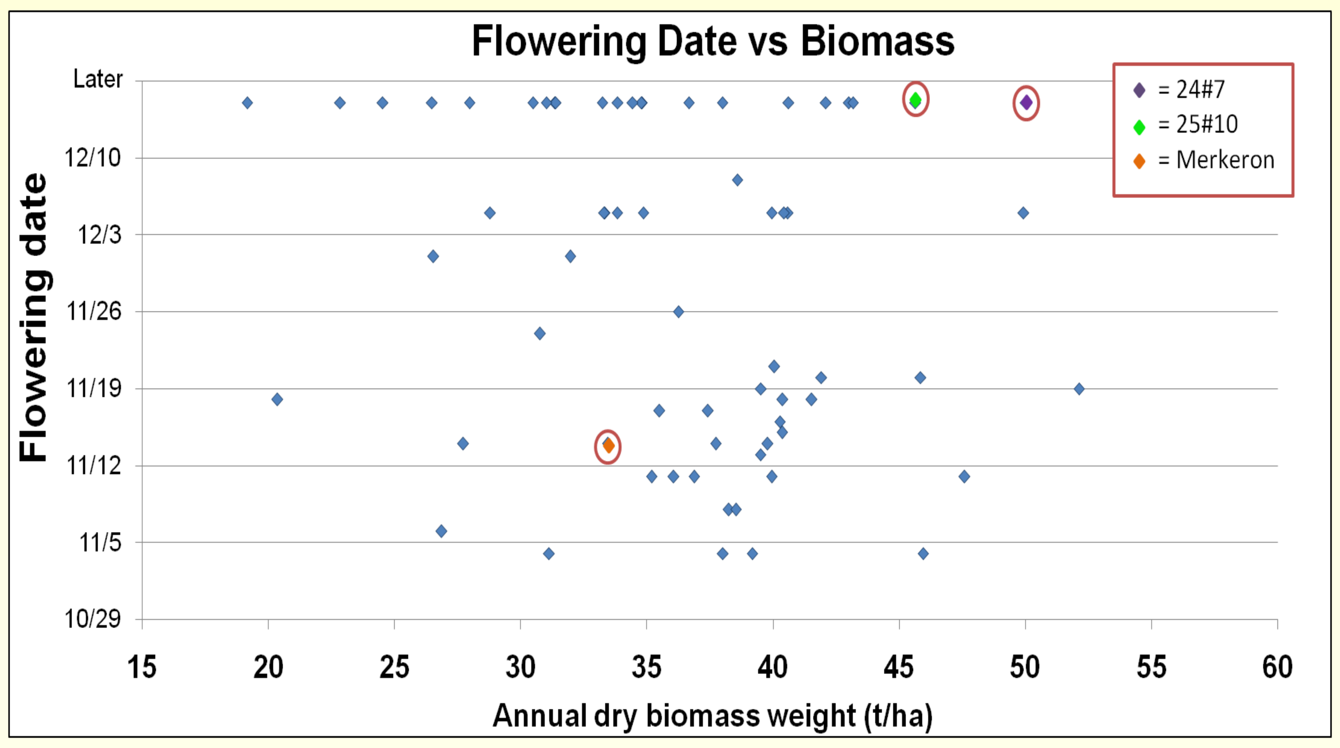

Fig. 6. Relationship between flowering date and annual dry biomass production in 2012. Plots were harvested (Dec. 10th), after the first frost. "Later" indicates genotypes that did not flower until harvest (Dec. 10th). The non-flowering, highest-yielding hybrids are highlighted, as well as cultivar Merkeron.

	Hybrids from the cross P6xP4		Selected Hybrids	
Trait	R	p	R	p
Plant height	0.236	<0.0001	0.414	<0.0001
Stem diameter	0.049	0.1232	0.034	0.3434
Number of tillers	0.538	<0.0001	0.618	<0.0001

Table 2. Correlation between biomass yield and biomass-related traits (all the harvests). Calculations were based on 6 replications of each genotype.

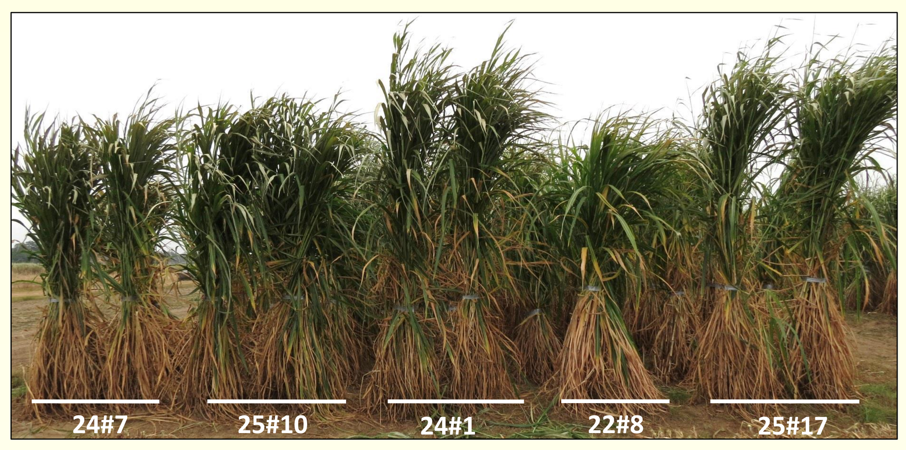

Fig. 7. Genotypes differing in biomass production and flowering time. The picture was taken before the harvest in December 2012.

CONCLUSIONS

- F1 hybrids from the crosses P1xP3 and P1xP5 produced on average 45% and 48% more biomass than their most productive parent.
- Non- or late-flowering genotypes with biomass yields significantly higher than Merkeron were identified.
- Number of tillers and plant height were the traits with the highest correlation with plant biomass.
- The phenotyping of the mapping population (P6xP4) will support the identification of molecular markers for these quantitative traits to accelerate future selection cycles.
- Elephantgrass accessions combining high yield and biosafety will be evaluated in other SE locations and are expected to support a sustainable biofuels industry.

Acknowledgements

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Reference

Prine, G. M., and E. C. French. 1999. New forage, grain and energy crops for humid lower south, US.