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Full Length Research Paper

Rhizome development in *Sorghum bicolor* × *Sorghum halepense* families in the tropical ecosystem of Uganda

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Many landraces and improved cultivars of sorghum (*Sorghum bicolor*) grown in Uganda have late maturity and are susceptible to several biotic and abiotic stresses. Introgression of the rhizomatous trait from perennial sorghum (*Sorghum halepense*) could improve stress tolerance. However, phenotypic characterization of exotic perennial sorghum germplasm under Ugandan environmental conditions is essential to select desirable genotypes. Rhizome-forming capacity of 192 *S. bicolor* × *S. halepense* backcross tetraploid families developed in a temperate North American environment was evaluated at two locations in Uganda over two consecutive growing seasons. Numbers of rhizomes and emerging shoots as well as mean distances from shoot to crown were evaluated. Forty-seven percent of families were moderately to strongly rhizomatous in the first season of growth and this value rose to 91% in the second season. Developing perennial grain sorghum for East Africa will require hybridization between exotic perennial and locally adapted germplasm. Screening for emerging rhizome-derived shoots in early generations is simple, rapid, and effective; however, more detailed selection based on both aboveground and belowground rhizome traits is recommended for later generations. Researchers and farmers should work together to find suitable ways in which perennial sorghum might fit into new types of crop and livestock systems.

Key words: Rhizome, perennial sorghum, rhizome buds, ramets.

INTRODUCTION

In Uganda, sorghum [*Sorghum bicolor* (L.) Moench] is the third most important cereal crop after maize (*Zea mays* L.) and finger millet [*Eleusine coracana* (L.) Gaertn], occupying 285,000 ha (TECA, 1995). It is grown primarily in drier areas of eastern, northern, and southwestern Uganda. The climate in these regions of the country is characterized by frequent droughts and other problems related to water stress. Although sorghum is more drought tolerant than maize, its productivity can be greatly reduced by water stress. As with other annual crop species, sorghum production requires frequent cultivation of the land, accelerating soil erosion, and degradation.

Introducing genes that confer rhizome development

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Table 1. Description of the scores used in assessing rhizome production potential of *S. bicolor* × *S. halepense* germplasm in Uganda.

Rhizome score	Rhizome number	Rhizome production potential
0	0	Not rhizomatous
1	1-2	Very weakly rhizomatous
2	3-4	Weakly rhizomatous
3	5-6	Moderately rhizomatous
4	7-10	Strongly rhizomatous
5	Above 10	Very strongly rhizomatous

from the weedy perennial species *Sorghum halepense* L. into locally adapted grain sorghum cultivars could improve the stress resilience and sustainability of grain production in Uganda. Perennial rhizomatous sorghum plants can maintain extensive living root systems in the soil through several grain harvests, preserving soil structure and capturing water from infrequent rainfall events. Furthermore, the vigorous postharvest vegetative growth often seen in perennial sorghum can be a valuable source of forage to support livestock grazing that is often severely limited in East Africa. Development of tropically adapted perennial sorghum could create many of such opportunities for researchers and farmers to explore new and more sustainable crop and livestock systems in the region.

A collection of perennial sorghum breeding lines was introduced from the United States in order to characterize rhizome development in Uganda's tropical ecosystems and approaches need to be identified that accurately evaluate the potential of *S. bicolor* × *S. halepense* plants and families to produce rhizomes consistently in tropical environments where growth is continuous throughout the year. Rhizomatous lines could then be selected on the basis of such data for use as perennial parents in crosses with locally adapted annual *S. bicolor* cultivars. Thus, the objectives of this study were to investigate phenotypic evaluation methods and identify the most effective selection criteria for future introduction of the rhizome trait from *S. bicolor* × *S. halepense* lines into East Africa-adapted populations under tropical conditions.

MATERIALS AND METHODS

The experiment was conducted at two locations in Uganda representing different agro-ecological zones (Supplementary Figure 1). The National Semi-Arid Resources Research Institute (NaSARRI) in the eastern Lake Kyoga basin, Serere district is located on a plateau (1,140 m.a.s.l), at 1°32'N, 33°27'E, with a minimum temperature of 17°C and maximum temperature of 33°C. The area is relatively dry, receiving bimodal rainfall ranging from 800 to 1,150 mm. The Makerere University Agricultural Research Institute, Kabanyolo (MUARIK) in the Lake Victoria crescent, Wakiso district is located in a lowland (1200 m.a.s.l), at 0°28'N; 32°27'E, with a mean minimum temperature of 17°C and mean maximum temperature of 27°C (Charles, 1998). The area receives a mean annual bimodal rainfall of 1,270 mm.

The 192 experimental entries were produced in Kansas, USA, between 2002 and 2014 as part of a program to develop perennial sorghum as a grain crop (Nabukalu and Cox, 2016) (Supplementary Table 1). Entries included 115 BC_1F_2 tetraploid sorghum families from the cross BTx623 (*S. bicolor*) × [BTx623 × Gypsum 9 (*S. halepense*)] and 77 tetraploid sorghum families derived from backcrossing *S. bicolor* inbred lines as recurrent parents with perennial plants that had been selected from a *S. bicolor* × *S. halepense* population developed by Piper and Kulakow (1994). Additionally, three induced tetraploid *S. bicolor* inbred lines, one U.S.-adapted diploid *S. bicolor* inbred line, and four Uganda-adapted diploid *S. bicolor* inbred lines were included as non-rhizomatous controls (Supplementary Table 1).

Experiments were planted at MUARIK and NaSARRI on April 22 through 25, 2015. Because of the large number of genotypes and the need to reduce experimental error, an alpha-lattice design was used. The experiment consisted of 2 replicates and 25 lattice blocks with 8 entries per block. Experimental plots measured 4.0 m^2 with 2 rows each 5 m long. Rows were spaced at 0.8 m apart and hills 0.5 m apart within the row. Two to three seeds were sown per hill with seedlings thinned to one plant per hill. Recommended agronomic practices were followed for sorghum at each location.

Experiments were conducted over two seasons. In Season 1 (April through August, 2015), the number of emerging rhizome-derived shoots per plant (referred to hereinafter as "Shoots") was recorded 130 days after planting at MUARIK and 140 days after planting at NaSARRI. New shoots were considered to have grown out of rhizomes when they emerged from the ground at least 5 cm from the crown. The distance from each emerging rhizome shoot to the crown from which the rhizome initiated (referred to hereinafter as "Spread") was also recorded. After grain harvest, three plants (20% of each family) were randomly selected from each plot and removed from the soil while ensuring that all rhizomes and rhizome-derived shoots remained intact. The total number of rhizomes, including very short ones growing out just below the crown, was recorded for each extracted plant as the trait "Rhizomes". The total number of rhizomes was used to categorize the different families into "rhizome production potential" (Table 1). Furthermore, the sum of Rhizomes and Shoots per plant was used as an index of rhizomatousness called "rhizomes plus shoots". Grain was also harvested and remaining aboveground biomass was removed and discarded on September 9, 2015 at MUARIK and September 17, 2015 at NaSARRI, marking the end of Season 1 and the beginning of season 2 (September through December, 2015). Plants were allowed to regrow and experiment management and data collection were carried out as described for Season 1. Shoots and spread data were collected 14 days after the completion of season 1 for the season 2 evaluation at MUARIK and 21 days at NaSARRI.

Data for the traits rhizomes, shoots, and spread were subjected to analysis of variance (ANOVA) to test for significance of entry effect, using the package JMP Version 11 (SAS Institute, Cary, NC, USA). Linear regression analysis was carried out to quantify

Table 2. Analyses of variance for number of rhizomes (Rhizomes), number of rhizome-derived shoots emerging (Shoots), and mean distance between emerging shoots and plant crown (Spread) in perennial sorghum experiments at two locations (MUARIK and NaSARRI) over two seasons (Season 1 and Season 2).

Source of variation	Degrees of freedom	Mean square		
		Rhizomes	Shoots	Spread
Season	1	2380.5**	1235.9**	2349.7**
Location	1	33.1*	526.9**	0.1
Season × Location	1	66.8**	26.7**	138.3**
Replicate (Season × Location)	4	272.4**	86.9**	50.7**
Replicate × Block (Season × Location)	192	13.4**	7.4**	7.1
Entry	1	19.3**	12.1**	11.7**
Season × Entry	197	7.5[a]	4.3[a]	6.3[a]
Location × Entry	197	7.3	3.8	6.9
Season × Location × Entry	196	6.7[a]	3.4[a]	5.8[a]
Error (Rhizomes)	567	6.4	-	-
Error (Shoots)	566	-	3.6	-
Error (Spread)	489	-	-	7.1

*Significant at the 0.05 level; **Significant at the 0.01 level; [a] Significance not tested.

Table 3. Mean numbers of rhizomes (Rhizomes), mean numbers of emerging shoots (Shoots) and mean distance from crown to shoots (Spread) over 194 sorghum families in two seasons at two locations in Uganda.

Trait	Location*	Season 1	Mean	Season 2
Rhizomes	NaSARRI	2.6		5.7
	MUARIK	2.8		5.0
Shoots	NaSARRI	3.0		5.1
	MUARIK	2.0		3.7
Spread	NaSARRI	8.0		10.1
	MUARIK	7.3		10.7

*****Experimental locations at National Semi-Arid Resources Research Institute (NaSARRI) and Makerere University Agricultural Research Institute, Kabanyolo (MUARIK).

relationships between traits. Statistical analysis of season × entry and season × location × entry interactions was not tested, because it was not possible to randomize families spatially between seasons 1 and 2; therefore, the effect of season on a given family was confounded with any microenvironmental effects that might exist because of the family position in the field. To avoid such confounding, simulated selection and evaluation of selected families were practiced at different locations in different seasons. That is, 20% of families with the greatest rhizome development in season 1 at NaSARRI were selected and their mean was compared to the overall mean in season 2 at MUARIK and vice-versa.

RESULTS

Rhizomes, shoots, and spread showed similar patterns with highly significant variation among families (Table 2). For rhizomes and shoots, differences between overall means at the two locations and in the two seasons were highly significant, whereas family × location interactions were non-significant. At both locations, means over all families (Table 3) showed that plants produced more rhizomes and emerging shoots and greater rhizome spread in season 2 (the regrowth season) than in season 1. Mean numbers of rhizomes per plant across locations were 2.7 in season 1 and 5.4 in season 2. Corresponding means for emerging shoots were 2.5 and 4.4, respectively.

Across-location means for rhizomes and shoots were strongly correlated in season 1 (r=0.81, P<0.0001) and season 2 (r=0.67, P<0.0001). These two variables are structurally related, because a plant producing a larger number of rhizomes is more likely to also produce a large number of emerging shoots. “Rhizomes plus shoots index”, was correlated with spread, strongly in season 1 (r=0.65, P<0.0001) but less so in season 2 (r=0.34, P<0.001).

Rhizome-related variables were normally distributed in

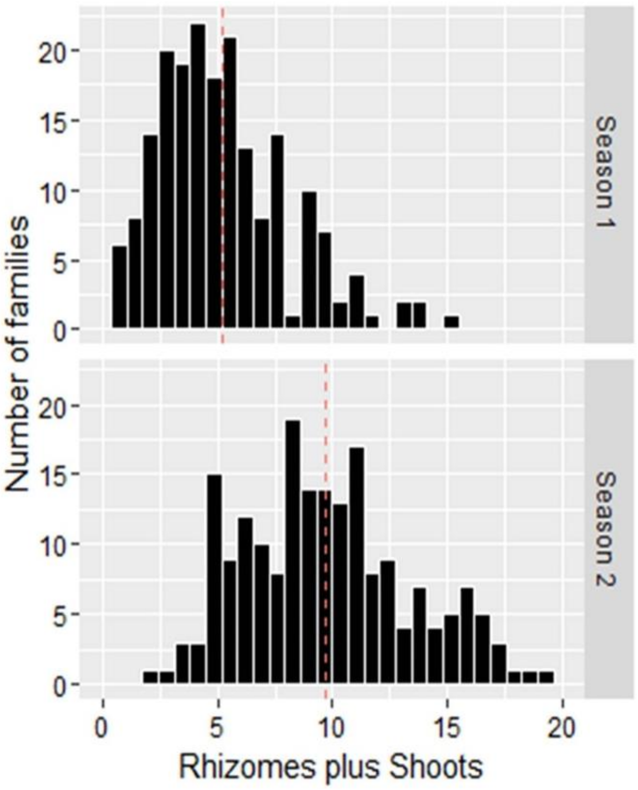

Figure 1. Frequency distributions for the index rhizomes plus shoots among 192 sorghum families in season 1 (top) and season 2 (bottom).

both seasons and across locations. The distribution of family means for the index rhizomes plus shoots (Figure 1) emphasizes the greater rhizome production that occurred in the regrowth season. In season 1, only 6% of families were very strongly rhizomatous with a mean index exceeding 10, whereas the index exceeded 10 for 43% of families in season 2. In contrast, 47% of families were strongly rhizomatous in season 1, and that share rose to 91% in season 2, because many of the weakly rhizomatous plants did not survive and contribute data in season 2 (some weakly rhizomatous plants and the non-rhizomatous checks showed some survival by ratooning after season 1 harvest; however, the ratoon shoots were much less vigorous than the shoots produced by strongly rhizomatous plants).

The results of simulated selection (Table 4) were not symmetrical across locations. The 20% of families with the highest means for the index rhizomes plus shoots in season 1 at NaSARRI had a mean in season 2 at MUARIK that exceeded the experiment mean by 28%. On the other hand, the 20% most strongly rhizomatous families at MUARIK, as evaluated in season 1, did not differ from the experiment mean when evaluated at NaSARRI in season 2.

The trait shoots is strongly correlated with rhizomes plus shoots (r=0.94, P<0.0001). Simulated selection for shoots at NaSARRI increased the mean index rhizomes plus shoots by 25% at MUARIK, while selection at MUARIK increased the mean index at NaSARRI by 9%. Selection also resulted in significant increases in the single trait shoots as well (Table 4). Selection for an alternative index, that is, the sum of the two nondestructive traits shoots and spread resulted in similar significant increases but did not improve on the results of selecting for shoots only.

Families ranking among the top few for rhizome development varied from season to season. In season 1 at MUARIK, the entry S1383-1-R193 produced 14 rhizomes per plant, exceeding all other families; it was followed by entries X117-697-R2 and S1465-2-R02 with 13 shoots per plant (Supplementary Table 1). At NaSARRI, S1383-1-0-R396D-R193D, having the same pedigree as the top family at MUARIK, produced a mean of 24 rhizomes per plant; it was followed by entries S1655-R75A-R146B, S1781-R79S-R214B, S1760-R40, and X117-697-R3 (same pedigree as X117-697-R2) with 20, 19, 17 and 16 rhizome shoots per plant, respectively (Supplementary Table 2). In season 2 at MUARIK, S1265-1-0-R519 and S1312-6-R203A produced 21 rhizomes per plant, while X337, H6-143-4, and S1383-2-2-R121 (which shares a pedigree with the Season 1 top families) produced 19, 18, and 17 rhizomes per plant, respectively. At NaSARRI, S1474-1-dw5-R136 produced 24 rhizome shoots per plant. S1781-R79S-R214B, S1755-dw76-R73A, S1479-6-R61-R76B, X80-968-R3, and X163-RF4 produced 24 rhizome shoots per plant each.

DISCUSSION

In temperate ecosystems, perennial sorghum can survive over multiple seasons due to the presence of rhizomes that are able to overwinter, because of their depth and/or cold tolerance. The ability of rhizomes to survive deep in the soil through extended periods of low air temperatures (Washburn et al., 2013) suggests that they might also ensure survival through dry seasons or droughts at other times of the year in tropical environments (Whitmire, 2013). Most families did in fact display such survival in this study.

In tropical ecosystems, sorghum shows continuous growth over multiple seasons either through ratooning of annual sorghum or by producing rhizomes. Grain yield in the ratoon season is almost always lower than in the first season of growth (Duncan and Moss, 1987), and their survival and productivity depend on an adequate supply of soil moisture during the ratoon growing season. Because of the bimodal rainfall pattern in Uganda, ratoon cropping is rarely practiced. In contrast, plants growing from rhizomes rapidly produce new root systems independent of the parent plant and grow faster and

Table 4. Difference between mean shoots plus rhizomes or mean shoots of the selected 20% of families and the location mean at each location in season 2 when selection was for high values of shoots plus rhizomes, shoots, or shoots plus spread at the other location in season 1.

Trait selected in season 1	Destructive	Selection location	(Mean of selected – location mean) in season 2			
			Shoots plus rhizomes		Shoots	
			MUARIK	NaSARRI	MUARIK	NaSARRI
Shoots plus Rhizomes	Yes	NaSARRI	2.4**	-	1.2**	-
		MUARIK	-	0	-	0
Shoots	No	NaSARRI	2.2**	-	1.1**	-
		MUARIK	-	1*	-	0.3*
Shoots plus distance	No	NaSARRI	2.1**	-	1.2**	-
		MUARIK	-	1.5**	-	0.5*
Grand mean in season 2		-	8.7	10.8	3.7	5.1

*Significantly different from zero (P<0.05); **Significantly different from zero (P<0.01).

larger than those that emerge from aboveground nodes in the second-year, and the second-season grain yields have been shown to be similar to the first-season yields in the temperate zone (Cox and Nabukalu, 2016). If the first crop matures at the beginning of a dry season, some rhizomes can remain in the soil without sprouting until the end of the dry season and then establish a new crop quickly when the next rains begin (Washburn, 2012).

Environments at the two locations in the present study did have differential effects on simulated selection. Families with higher season 2 rhizome production at MUARIK could be predicted in part on the basis of season 1 rhizome production at NaSARRI, but the converse was not true. That is, MUARIK data were not effective in identifying families that were most highly rhizomatous at NaSARRI. This asymmetry between MUARIK and NaSARRI could be attributed to climatic differences and soil types between the two locations. NaSARRI is located within the semi-arid regions and experiences higher temperatures. It also has coarse/sandy soils, while MUARIK in the Lake Victoria crescent which is rain fed, experiences lower temperatures, is humid, has heavy loam soils. Thus, initial screening for rhizome production should be conducted at NaSARRI with further screening of selected genotypes at multiple locations.

Paterson et al. (1995), working in the warm temperate climate of southern Texas, assessed rhizomatousness using both rhizome-derived shoots and underground buds while Washburn et al. (2013) used aboveground shoots alone. Paterson et al. (1995) showed that the rhizome-derived shoot count is a viable measure of the rhizome potential, although higher precision was obtained when underground rhizomes were also considered. A question in tropical environments is whether selecting on the basis of shoot numbers alone will underestimate the capacity of some plants to be rhizomatous, considering that in the tropical environment, rhizomes can continue to grow throughout the year.

In the present study, many families had more rhizomes than they did emerging shoots. All such underground structures have the potential to germinate and produce new plants. The two traits rhizomes and shoots were strongly correlated with each other, so their sum was used as an index of rhizomatousness. For selection in large populations, however, the excavation required to evaluate rhizomes would entail much more effort and expense per family than would evaluating only shoots, and this could reduce the number of families that can be evaluated. It is also destructive. Although it could be possible to re-bury plants after counting rhizomes, their subsequent growth and development would at that point be seriously affected, and screening large numbers would also become doubly laborious. Counting green shoots that have emerged from rhizomes, on the other hand, is simple, rapid, and nondestructive. Data from this study suggest that selection based only on shoots will be as effective as that based on the sum of rhizomes and shoots. Furthermore, including the trait spread in an index with shoots did not improve the effectiveness of selection. All of this implies that the number of rhizome derived shoots can still be a reliable indicator of the potential of rhizome formation of a sorghum hybrid line as suggested by Washburn et al. (2013). It was concluded that with the germplasm pool and environments used in this study, season 1 selection based on shoots alone would be most efficient for choosing more strongly rhizomatous families to carry ahead for more extensive testing or for use as parents. However, in later stages of selection when numbers of plants and families have been reduced, a complete assessment using both aboveground and below ground rhizome traits would be optimum.

The correlation between total number of rhizomes and the distance of the rhizome from the crown was positive and strong. However, not all rhizome-derived shoots emerged from the ground at or beyond 5 cm from the crown. Many very short rhizomes with terminal shoots that would have emerged very close to the crown were observed in the present study (Nakasagga, 2017). In Kansas, the 5 cm threshold was used because very short, shallow rhizomes, like tillers, have no chance of surviving the freezing temperatures of winter, but our observations suggest that this threshold may be too high for tropical environments. However, reducing the threshold could result in some rhizome derived shoots being misclassified as tillers or tillers misclassified rhizome-derived shoots if the 5 cm criterion is used when recording numbers of rhizome-derived shoots based on aboveground observation. On the other hand, some shoots closer to the crown may be misclassified as rhizome-derived when they are actually tillers, especially if soil has been pushed up around the base of the plant during cultivation for weed control. These findings further highlight the need for including both underground rhizomes and aboveground shoots when screening reduced numbers of advanced lines or conducting basic research under tropical conditions. Standard breeding methods can improve perennial sorghum’s adaptation and agronomic traits. If selection for those traits is practiced in the second (regrowth) season, the frequency of perennial plants in the population will be higher than in the first season, because the bulk of the regrowth will have come from perennial plants originating from rhizome shoots.

Consistent rhizomatousness and perenniality was expressed by many of the sorghum families in this study. Given this result, they appear to be no insurmountable obstacles to developing grain sorghum with a perennial growth habit in East Africa. However, as with any sorghum germplasm developed in high-latitude environments, it can be expected that introduced perennial sorghum germplasm will not be well adapted in other respects to the photoperiod, climatic conditions, soils, and plant diseases and insects of tropical Uganda.

Successful deployment of perennial sorghum in East Africa will require extensive breeding efforts supported by research in genetics, physiology, pathology, and entomology. There are two reasons for this: (1) perennial sorghum is still a crop in the making derived from hybrids between a cultivated and a wild species and (2) at this time, the entire gene pool of perennial sorghum consists of germplasm adapted to the temperate zone. Therefore, parental lines of perennial sorghum will need to be hybridized with germplasm that is well adapted to tropical conditions in general and East Africa’s local environments in particular, in order to produce diverse populations that can be selected for local adaptation to East African environments.

On-farm evaluation should be incorporated into research on perennial sorghum in East Africa from the beginning. By necessity, much of the breeding cycle will remain largely in the realm of the research station. But because adaptation traits, plant vigor, seed characteristics, and perenniality can be selected for visually with no reliance on costly infrastructure or technology, selection and progeny-testing of superior plants by people on their own farms must also be carried out.

In all the mentioned efforts, the vigorous postharvest vegetative growth of perennial sorghum can provide additional benefits in East African agriculture, where grazing potential after the end of the rainy season is often limited. Researchers and farmers should work together to find suitable ways in which perennial sorghum might fit into existing crop and livestock systems in the region and foster the development of new types of cropping systems.

Conclusion

Many sorghum families in this study had the capacity to form rhizomes as seen from the results; this therefore showed the potential of these breeding lines to express this trait in a tropical environment. However, selection of which traits to use in evaluation of the rhizomatousness of a family depends on the breeding objective. When screening large populations aboveground shoots is an appropriate measure, while after selections have been made both in aboveground and underground rhizomes should be considered.

Environments at the two locations in the present study did have differential effects on simulated selection. Families with higher season 2 rhizome production at MUARIK could be predicted in part on the basis of season 1 rhizome production at NaSARRI, but the converse was not true. Thus, initial screening for rhizome production should be conducted at NaSARRI with further screening of selected genotypes at multiple locations.

Given their ability to regenerate from vegetative structures, that is to say rhizomes, these materials are good for forage at this stage of the breeding cycle. However, development of grain sorghum will require rigorous selection to identify potential lines that are adaptable to a tropical environment and therefore viable for future use in rhizome introgression with the locally adapted cultivars at later stages of the breeding cycle.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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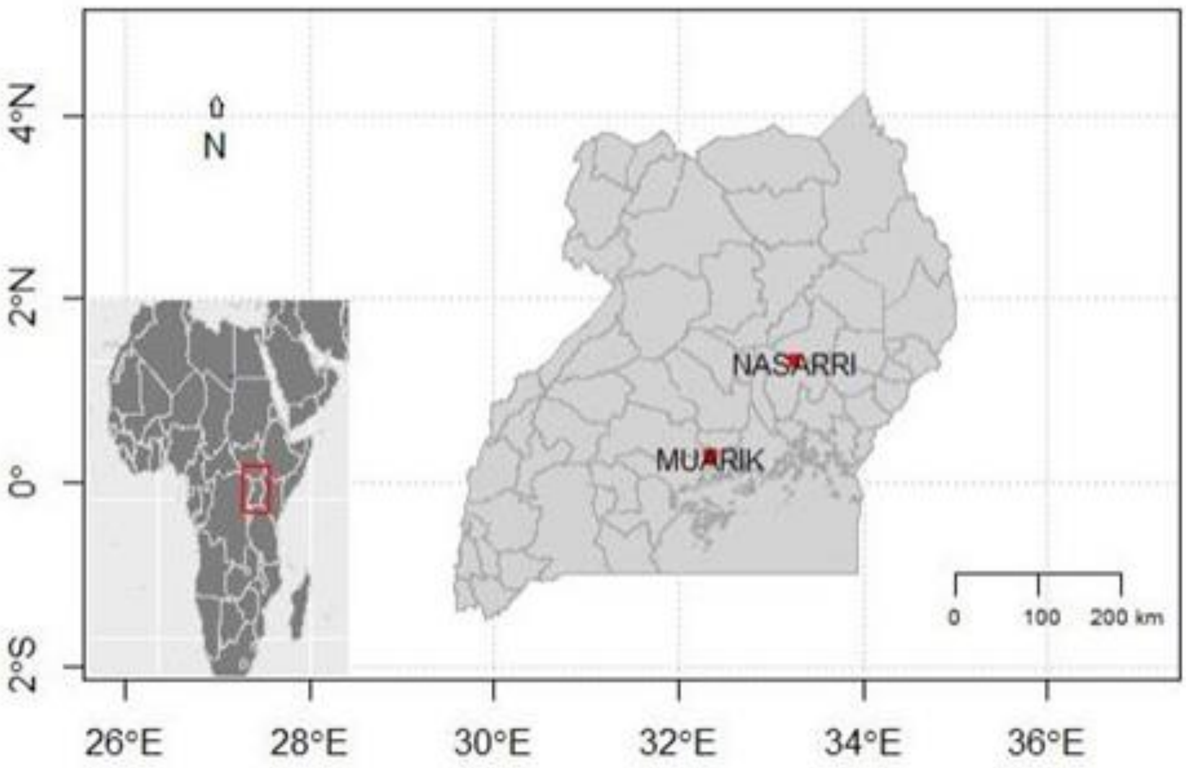

Supplementary Figure 1. Perennial sorghum experimental test sites based at National Semi-Arid Resources Research Institute (NaSARRI) and Makerere University Agricultural Research Institute, Kabanyolo (MUARIK) in Uganda.

Supplementary Table 1. Entry means for the rhizome production traits for *Sorghum bicolor* × *Sorghum halepense* families at MUARIK in two seasons in 2015.

Entry No.	Family	Season 1			Season 2		
		Rhizomes	Shoots	Spread	Rhizomes	Shoots	Spread
1	X423	3.9	0.6	4.6	4.6	3.1	6.9
2	X68	2	0.5	8	3.4	2.2	8.3
3	X615	5.9	1.8	8.4	8.4	3	11.6
4	X337	6.2	2	6	14	5.3	8.1
5	X105	1.9	0.5	9.1	2.5	1.5	6
6	X502	1	16	8.8	0.3	3.6	9.1
7	X606	1	0.2	6.9	1.5	1.4	11.2
8	X612	2.6	1.5	5.5	5.2	3.3	10.2
9	X108	2.2	2.9	6.2	3	2.8	9.9
10	X354	1.3	0.3	6.3	5.5	1.8	10.4
11	X114	3.7	3.4	6.9	6.4	5.3	14.2
12	X107	2	1.3	7.1	3.5	3	9.5
13	X503	1.5	0.2	5.2	5.9	2.6	8.2
14	X154	1.4	0.7	6.6	11.1	3.9	6.9
15	X47	4.7	1.3	6	11.1	3.9	9
16	X41	3.6	3	5.3	3	2.5	7.7
17	X24	3	1.2	6.1	7.7	2.7	9.5
18	X21	0.8	0.7	6	3.3	2.5	11.3
19	X209	2.6	2.1	7.3	7.7	4.7	11.6
20	X99	1.6	2.2	9	1.2	2.8	11.9

Supplementary Table 1. Contd

21	X410	3.8	0.7	6.7	1.8	0.8	7.2
22	TX623(2X)	-0.2	0.6	5.6	1.2	1	9.6
23	X38	2.2	0.8	4.1	5.3	4.7	12.4
24	X42	5.1	2.7	8.3	10.6	2.6	10.5
25	X76	3.4	1.9	8.7	3	3.3	8.3
26	X97	4.3	1.8	7	2.3	2.5	9.9
27	X104	1.8	1.9	5.7	3.7	1	7.7
28	X117	2.3	3.2	7	4.2	2.6	11.3
29	X406	4.1	2	10	6.9	3.3	10.2
30	X731	1.6	0.1	6.3	7.8	5.6	11.9
31	X756	1.2	1	6.3	8.5	2.8	7.4
32	X763	1.9	0.8	9.3	6.2	4.9	8.8
33	X770	2.1	2.2	10.2	3.6	2	9.7
34	X782	1	0.6	6.6	3.7	2.8	10.2
35	X803	1.6	2.8	6	3.9	3.6	13.1
36	X806	2.5	1.9	5.8	6.3	5.1	13.7
37	X1054	1.6	0.9	2.7	2.6	1.7	6.3
38	X1068	4.3	2	6.2	5.1	1.7	11.2
39	X1070	2.2	2.2	6.7	7.7	3.1	10.8
40	X312-290-R1	2.6	1.4	6.1	6.5	6.1	14.2
41	X202-RF4	2.2	0.9	4.7	6.5	8.8	13.6
42	X738-387-R3	3.2	2.4	6.6	4.9	4.4	8.9
43	X83 594 R4	0.7	0.5	11.5	5.4	3.7	10.4
44	X117-697-R2	6.6	6.1	7.5	9.9	5.3	15.9
45	X1076-18-R4	4.9	3	7.3	6.9	5.3	14.2
46	X803-1000-R3	0.4	0.3	5	2.3	2.3	10.1
47	X107-356-R3	1	1.4	6.2	1.8	1.8	11.1
48	X1090-195-R2	3.1	2.1	6.7	3.4	2.4	10.7
49	X1085-736-R4	6	3.3	7.3	4.9	3.4	10.6
50	S1465-2-R01	1.3	0.5	6.6	3.5	1.5	7.2
51	S1465-8-R16	2.6	1.8	6.7	0.9	1.2	17.3
52	S1475-1-R01	4.2	1.9	8	2.2	3.2	8.2
53	S1477-31-R52B	2.6	3.5	9	6.7	6.2	9.3
54	S1465-2-R02	9	3.9	12.7	9	8.2	12.7
55	S1467-1-R01	0.2	0.3	5.9	-1	-0.5	10
56	S1468-4-R17L	3.1	0.6	6.8	0.8	2.4	6.8
57	S1469-7-R21	4	3.1	7.9	5.5	6.7	11.1
58	S1474-2-R31A	2.7	4.4	7.1	6.9	5.8	12.6
59	S1479-1-R56A	3.5	2.3	6.5	3.9	3.6	11.8
60	S1479-3-R58B	1.4	1	7.5	5.7	3.7	11.5
61	S1646-R24A	1.1	0.9	6.1	1.4	0.2	6
62	S1653-3-R200	5.6	6.5	11.7	13.7	7	14.1
63	S1655-R75A	2.4	1.5	6.4	2.6	3.9	16.6
64	S1661-R32	3.2	3.8	7.3	8.6	4.7	12.1
65	S1662-R33A	4.3	2.9	9.5	7.5	6.7	10.8
66	S1686-R35A	4.4	2.6	7.3	4.2	6	12.3
67	S1708-1-R158	3.1	3.6	12.2	5.2	2.8	11.1
68	S1760-R40	4.6	3.8	9.5	10	3.9	13.4
69	S1761-R132A	1.9	0.8	7.2	1.1	0.1	10.7
70	X61-497-R4	1.2	1.1	7	1.9	2.8	8.9
71	X74-120-R3	2.4	4.4	7.2	3.1	3.3	9
72	X74-416-R4	3.3	3.8	5.9	8.7	3	8.9

Supplementary Table 1. Contd.

73	X127-412-R4	3.7	1.1	5.4	6.8	3.7	8.5
74	X129-588-R4	2.6	2.5	6.6	4.1	5.2	15
75	S1814-1-R220B	1.9	2.7	7	3.3	2.3	11.6
76	X151-511-R12	5.5	3.2	7.3	4.7	6.4	9.5
77	X151-511-R1	5	2.9	7.6	2.2	1.4	6.7
78	X151-511-R2	3.1	2	7.7	7.5	5.9	10
79	X151-511-R3	0.6	0.9	6.5	7.6	4.9	12.7
80	X151-511-R4	4.5	2.7	7.3	3.8	2.9	10.9
81	X174-453-R1	2.4	1.9	6.4	3.9	5.3	10.6
82	X413-077-1	3.5	2.8	8.8	3.4	10	13.7
83	X413-077-2	4.4	2	6	2.3	1.3	6.1
84	X413-077-3	2.8	1.2	9.2	6.2	3.5	11.7
85	S1836-1-R89A	1.8	3.4	6.5	2.8	2.5	10
86	X501-156-1	1.3	0.7	5.9	10.3	4.3	10.6
87	X501-156-3	0.9	0.8	5.7	2.9	1.3	13.9
88	S1931-2-R123C	5	3.2	6.7	11.2	4.1	12.5
89	S1939-2-R130	1.9	1.6	5.4	3.7	2.5	11.2
90	S1474>R84A	2.7	1.5	5.9	4.9	2.9	10.2
91	H6-70-8	5.7	1.5	5.5	1.5	2.1	9.8
92	H6-143-4	4.8	3.4	8	10.2	8.1	16.4
93	T321-157	2	1.7	6	5.9	0.4	7.7
94	S1265-1-0-R519	2.3	1.9	12.6	11.8	8.8	18.6
95	S1312-6-R203A	3	2.2	9.6	9.6	11.2	13.9
96	S1438-1-R193	4.5	3.8	9.6	5.9	8.3	14.7
97	TX403(4X)	2.4	1.4	7	1	1.5	8.8
98	D81-34	1.4	1.2	6.1	8.8	2.2	13.6
99	X756-299-R3	2.7	1.1	5.5	2.3	3	8.9
100	X42 987 R2	1.1	1	8.5	1.7	1.5	9.5
101	X148-300-R6	2.1	1.9	7.8	5.5	1.8	9.6
102	X782-560-R4	3.8	3.6	8.7	5	2.4	11.6
103	X107-559-R2	4.2	1.6	7	7.7	1.6	8.1
104	X1054-925-R5	0.6	0.3	5.6	3.8	3	10
105	X117-697-R3	3.3	2.9	6.5	6.9	5.6	10.2
106	X726-881-R4	1.5	1.8	6.7	6	1.3	11.9
107	X25 RF4	3.4	1.4	7.2	4.2	2.3	11.7
108	X163-RF4B	4.5	2.2	6	3.6	3.8	13.6
109	X782-560-R3	1.2	1.7	6.3	1.8	1.2	7.7
110	X731-230-R4	3.9	3.5	10.5	7.2	6.1	13.6
111	X1039-806-R4	3	1.8	6	3.8	3	12.3
112	X228-RF4	4.3	1	6.1	2.7	3.1	11.5
113	X770-829-R3	2.4	0.6	7.5	2.8	2.2	6.4
114	X3818 R4	1.8	1.5	4.7	3.6	5.1	13.1
115	X104-463-R5	1.7	0.9	4.8	4.8	2.2	8.6
116	X117-697-R4	2.6	1.1	6.4	0.9	1.5	8.1
117	X97 361 R3	3.3	2.3	8.7	4.3	3.5	8.3
118	X756-299-R4	0.7	1.5	6.8	-0.3	3	12.7
119	X999-RF4	0.7	0.5	6.3	6.9	3.9	10.7
120	X215-RF4A	4	2.4	5.7	8	6	11.2
121	X1070-470-R3	3.5	3.8	6.2	6.9	4.7	11.8
122	X148-300-R4	2.9	3.5	5.2	4.6	3.6	12.6
123	X797-953-R1	0.3	0.1	4.7	1.4	1.8	5.9
124	X104-463-R6	1.7	0.7	6.3	5.1	4	9

Supplementary Table 1. Contd.

125	X1052-220-R2	0.3	0.6	6.9	-1.1	1.3	8.1
126	X406-935-R4	3.5	3.7	7.1	4.8	2.9	11.8
127	X1222-755-R3	0.8	1.3	6.7	2.6	1.5	9.3
128	X215-RF4B	0.3	0	5.1	3.4	3.8	10.1
129	X166-RF4	4.2	3.3	5.6	7.9	3.7	13
130	X114-136-R1	1.3	1.4	6.6	3.1	2.7	8
131	X80 968 R3	1.5	0	8.1	6.4	4.6	8.4
132	X163-RF4C	0.5	0.2	7	8.1	4.1	8.1
133	X803-1000-R2	2	0.9	6.1	2.1	1	6
134	X780-850-R4	3.2	2.6	4.3	1.8	2	9.3
135	X1059-401-R2	1.8	5.5	7.1	3	1.3	6.7
136	X85 RF4	3.1	5.3	6.4	2	2.3	12.4
137	X1222-755-NR4	3.1	1	6.5	8.1	4.4	11.1
138	X438-RF4	2.1	1.9	6.8	3.9	1.5	8.9
139	X466-679-R3	3.1	0.5	8.7	3.5	2.6	8
140	X468-RF4	1.8	1.8	5.1	3.3	3.9	12.2
141	X148-300-R5	4.4	3.4	7.3	7.2	4.3	10.6
142	X763-132-R4	2.9	2.7	5.5	5.3	3.6	11.2
143	X321-458-R3	1.8	2.9	8	3.9	3.9	12.3
144	X756-299-R2	2.1	0.7	9	5.1	4.3	9.2
145	X121-327-R3	3.5	3.1	6.3	3.8	3.7	11.6
146	TX623(4X)	0	-0.3	*	3	2	10.9
147	T115>163A-1	1.5	2.2	5.8	3.4	2.1	8.8
148	S1219-15-354D	0.8	1.1	11.1	7.6	3.8	9.4
149	S1264-1-14-R304	1	0.8	7.9	4	3	18.2
150	S1312-6-R203A	1.7	0	6.4	1.5	2.1	8.7
151	S1374-18-R117	4.9	2.2	7.2	2.3	1.2	7.4
152	S1383-1-0-396D	1	1.2	4.8	3.2	2.8	10.8
153	S1383-1-R193	9.4	4.2	9.6	5.2	6.4	14.4
154	S1383-2-1-R121	3.3	2.6	7.7	10.4	6.2	12.5
155	S1477-30-R51	7.3	4.5	12.7	7.7	6	12.1
156	S1477-31-R52G	3.6	3.9	12.3	3	3.4	12.1
157	S1477-31-R52H	2.7	3.9	9.5	7.5	6.8	14.6
158	S1481-1-R69	4.5	2.8	8	4.2	3.3	8.1
159	S1482-1-R01	4.4	2.9	6.7	4.1	4.8	10.9
160	S1498-2-R106	5.4	2.5	9.4	6.1	5.1	10.2
161	S1662-R33C	4.3	6.7	12.3	5.1	4.6	10.7
162	S1662-R33F	2.7	2.6	7.8	8.6	4.2	12.3
163	S1836-1-R89	4.6	2.9	7.6	2.8	2.8	8.9
164	S1265-1-0-R519-R85	1.1	0.7	6.3	2.9	2.2	9.2
165	S1383-1-0-R396D-R193D	3.3	3.2	9.4	7	3.7	11.4
166	S1383-1-0-R396D-R193D	4.5	2.4	6.4	10.9	1.2	7.7
167	S1465-4-dw14B-R157A	0.4	0.4	7.8	6.6	2.7	9.6
168	S1465-4-dw14B-R157E	3.2	2.4	8.7	0.4	0.4	8.9
169	S1473E-2-R29C-R25D	2.8	2.1	6.6	3.2	2.3	10.4
170	S1474-1-dw5-R136	3.8	3.1	9.1	4.2	5.4	14.7
171	S1474-2-R31A-R235B	5.6	2.9	7.2	6.1	5.7	9.9
172	S1477-30-R51-R229A	0.1	0.4	6	2.7	2.2	12.3
173	S1477-30-R51-R229C	2.7	2.8	9.6	3.5	2.2	9.9
174	S1477-30-R51-R229D	0.1	0.2	5.7	2.1	2	8.7
175	S1477-43-dw54B-R181	1.1	1.7	9.1	7.8	4.4	12
176	S1477-43-dw54C-R89A	2.2	2.3	9.3	3.4	3.2	10.3

Supplementary Table 1. Contd.

177	S1477-43-dw54C-R424A	1.5	1	6.3	2	3.3	11.5
178	S1477-X-R55A-R122	3.3	2.7	7.2	3.7	2.3	10.8
179	S1479-6-R61-R78B	0.4	0.1	6	2.2	3.1	12.1
180	S1479-6-R61-R78C	2.5	4.2	10.4	5	3.5	9.7
181	S1479-1-R56B	3.7	4.5	12.3	5.6	5.5	15.1
182	S1481-1-R01-R213B	2.4	2.5	7.5	7.9	7.1	13.8
183	S1481-1-R01-R213D	3.7	3.6	8.2	4.2	5	12.8
184	S1481-1-R01-R213F	5	2.7	10.3	5.6	2	10.5
185	S1498-15-R182B-R184A	2.8	1.6	7.1	5.5	4.1	12.8
186	S1655-R75A-R146B	0.4	1.6	7.3	6.9	6.3	11.4
187	S1662-R33C-R177A	1.3	2	9.5	9.9	6.2	14.6
188	S1662-R33C-R177E	1.4	2.3	5.9	6.7	7	13.2
189	S1755-dw76-R73A	1.8	3.5	6.9	4.8	3.7	7.1
190	S1755-dw76-R73B	3.2	3	8.1	5.5	6.9	14.6
191	S1781-R79S-R214A	2.6	1.9	8.1	5.4	8.1	10.2
192	S1781-R79S-R214B	5	3.4	9.2	4.2	5.2	11
193	S1811-3-R17A	2	1.3	6.1	3.2	3.4	11
194	X61-497-R4-R204A	1	0.8	7.7	2.7	1.8	9.9
195	X61-497-R4-R204D	2.4	0.6	10.8	3.4	3.1	10
196	X74-120-R3-R19	5.1	3.1	7.5	8.2	6	12.8
197	SESO 1	0.1	0.2	*	1.1	0.9	*
198	SESO 3	0.1	0.1	*	-0.4	-1.1	*
199	EPURIPUR	0.2	0.1	*	-0.1	-0.5	*
200	SEKEDO	0.2	0	*	1.3	0.8	*
LSD	-	3.5	2.6	4.6	6.7	4.8	6

Supplementary Table 2. Entry means for the rhizome production traits for *Sorghum bicolor* × *Sorghum halepense* families at NaSARRI in two seasons in 2015.

Entry No.	Family	Season 1			Season 2		
		Rhizomes	Shoots	Spread	Rhizomes	Shoots	Spread
1	X423	1.1	1.5	6.8	4.4	5.8	9.7
2	X68	1.4	1.5	5.6	3.5	2.3	10.2
3	X615	1.8	2.1	5.4	4.1	2.9	8.5
4	X337	3.9	1.4	9.4	9.3	6.7	10.1
5	X105	1.7	1.8	7.8	9.2	5.1	12.2
6	X502	2	1.8	6.5	7.2	5.2	8.1
7	X606	-0.2	0.7	6.3	4.5	4.3	8.4
8	X612	0.6	0.7	5.9	6	4.2	7.3
9	X108	7	3.9	9.5	9.6	7.4	11.8
10	X354	3.4	4.6	6.7	6.6	5.8	8.4
11	X114	1.5	1.6	7.6	2.2	4	5.7
12	X107	1.2	1.3	5.9	7.3	4.9	9.4
13	X503	1.3	1.7	7.3	5.3	3.6	10
14	X154	1.4	1.4	8.4	6.4	8.6	10.7
15	X47	2.6	3.5	8	6.4	6.8	9.7
16	X41	1.3	1.2	6.1	2.7	3.5	7
17	X24	1.1	2.2	7.3	9	6.1	8
18	X21	2.5	3.7	7	4.6	4.7	8.7
19	X209	2	2.6	9.3	2.3	3.6	7

Supplementary Table 2. Contd.

20	X99	0.7	0.1	5	5.8	3.9	8.3
21	X410	0.6	0.3	11.8	5	5	10
22	TX623(2X)	-0.1	0.3	4.9	1.3	5.4	6.9
23	X38	2.3	1.3	6.9	3.6	5.3	7.1
24	X42	2	4.2	9.9	3.8	3.6	10.4
25	X76	3.1	2.8	6.3	5.2	7	14.9
26	X97	0.9	1.9	5.5	5.3	4.1	10
27	X104	0.2	0	0	4.3	4	8.2
28	X117	2.7	2.4	9	5.3	2.7	9.3
29	X406	1.5	2	6.8	5.7	5	10
30	X731	2.1	1.5	10.4	5.9	4.8	7.9
31	X756	2.5	2.8	9.2	8.6	6.7	10.9
32	X763	1.1	2.3	6.8	1.2	3.4	8.7
33	X770	1.8	1.3	7.2	13.8	4.9	13
34	X782	2.1	2.3	9.6	9	8.2	12
35	X803	1.3	1.5	5.4	3.9	2.8	8.6
36	X806	1.9	4.1	9.2	1.6	3.7	8.6
37	X1054	1.9	2.8	6.8	8.1	3.5	11
38	X1068	2.6	3.4	9.6	7.5	5.9	8.9
39	X1070	3.7	5	9.8	5.4	5.8	8.8
40	X312-290-R1	1.9	1.2	7.1	5.7	7.1	15.7
41	X202-RF4	2.3	2	6.2	2.1	3.4	8.1
42	X738-387-R3	1.8	1.8	7.9	5.6	4.1	7.4
43	X83 594 R4	3.4	2.7	8	6.1	5.6	11.3
44	X117-697-R2	1.9	4.3	8.4	10.1	7.1	13
45	X1076-18-R4	0	-0.1	7.4	2.9	2.6	7.9
46	X803-1000-R3	1.3	0.7	5.9	3.9	5	9.4
47	X107-356-R3	0.8	1.2	6.3	3.7	4.3	7.7
48	X1090-195-R2	2.9	6.2	7.4	7.3	5.4	13
49	X1085-736-R4	1.7	2.6	6.7	4.1	6.1	10.5
50	S1465-2-R01	1.5	0.9	5.3	3.6	3.6	8.8
51	S1465-8-R16	-0.1	0.5	5.6	3.7	3.7	9.2
52	S1475-1-R01	4	4.2	14	2.1	2.4	7.8
53	S1477-31-R52B	3.5	4.8	6.8	4.5	4.8	11.4
54	S1465-2-R02	3.1	4.1	9.9	3.7	2.8	15.2
55	S1467-1-R01	0.2	1.2	7.2	2.3	2.7	15.9
56	S1468-4-R17L	0.1	0.6	7.6	-0.9	1	9.5
57	S1469-7-R21	4.4	5.6	6.7	6.3	5.8	11.5
58	S1474-2-R31A	2.8	2.9	6.7	8.4	6.9	12
59	S1479-1-R56A	0.7	2.1	9.3	4.5	3.2	9.2
60	S1479-3-R58B	2.2	2	7.9	2.5	4	11.2
61	S1646-R24A	0.3	1	5.5	2.9	2.2	6.5
62	S1653-3-R200	5.3	8.6	8.8	6	5.4	9.3
63	S1655-R75A	3.1	5.2	9.4	4.3	4.4	11.3
64	S1661-R32	6.9	8.2	10.6	12.9	6.1	13.6
65	S1662-R33A	5.2	5.9	11.2	11.3	6.4	13.4
66	S1686-R35A	3.6	4.6	7.6	6.1	5.5	14.1
67	S1708-1-R158	0.9	1.7	8	5.9	7.2	8.8
68	S1760-R40	7	10.4	13.5	8.3	6.1	14.3
69	S1761-R132A	2.1	1.7	7.7	4	4.7	8.7
70	X61-497-R4	1.7	1.6	18.6	1.9	2.8	4.4
71	X74-120-R3	2	2.5	7.6	4.8	6.9	11.7

Supplementary Table 2. Contd.

72	X74-416-R4	2.3	2	6.8	6.6	7.9	14.6
73	X127-412-R4	3.2	2.2	6.1	8.2	5.3	13.4
74	X129-588-R4	0.4	1.4	5.7	6.6	3.2	9.6
75	S1814-1-R220B	4.9	2.7	7.4	3.1	2.8	5.5
76	X151-511-R12	8.6	6.4	8.9	7.1	7.6	14.8
77	X151-511-R1	1.3	0.7	8.5	3.2	3.1	6.2
78	X151-511-R2	2.8	3	7	3.4	5.5	8.8
79	X151-511-R3	1.3	3.1	7.8	3.4	3.9	7.3
80	X151-511-R4	1.7	2	6.4	6.5	5.6	11.7
81	X174-453-R1	0.9	2.5	6.9	1.7	6.5	8.1
82	X413-077-1	1.4	2.4	7.4	9.7	7.9	17.7
83	X413-077-2	0.5	2	5.8	5.9	5.7	11.9
84	X413-077-3	0.1	0.3	5.1	8.7	8.2	16.9
85	S1836-1-R89A	0.9	2.3	5.8	1.6	2.1	3.5
86	X501-156-1	1.7	2.3	6.6	5.3	6.1	11.6
87	X501-156-3	0.8	0.5	5.1	3.1	3	5.8
88	S1931-2-R123C	1.7	1.6	6.7	5.1	2.6	7.4
89	S1939-2-R130	3	2.4	8.6	7.7	5.2	13
90	S1474>R84A	4.9	8.2	7.6	6.8	7.9	14.7
91	H6-70-8	1.7	1.4	9.2	3.6	4.2	8
92	H6-143-4	6.5	6.3	13	6.8	5.4	12.2
93	T321-157	4.4	5.1	7.3	9.2	7.3	16.3
94	S1265-1-0-R519	3.1	1.7	7.2	6.1	6.3	12.4
95	S1312-6-R203A	5.4	8	11.4	4.6	5.5	9.7
96	S1438-1-R193	5.8	4.9	9	-0.2	6.7	6.5
97	TX403(4X)	2.2	1.5	7.2	2.6	4.7	7.1
98	D81-34	0.3	1.8	6.4	6.4	5.9	12.3
99	X756-299-R3	0.3	1.8	6.6	2.8	4.4	7.3
100	X42 987 R2	0.2	0.4	5.2	1.7	3.7	5.3
101	X148-300-R6	3.3	3.7	9.7	6.9	5.4	12.4
102	X782-560-R4	1.5	3.3	9.1	2.1	2.5	4.8
103	X107-559-R2	0.7	1	6.5	13.9	4.5	18.1
104	X1054-925-R5	2.1	2.2	6.8	2.8	3.2	5.8
105	X117-697-R3	9.3	6.6	9.4	3	4.7	7.3
106	X726-881-R4	1.7	0.9	5.9	4.2	3.6	7.7
107	X25 RF4	2.1	1.8	6.6	5.1	4.4	9.5
108	X163-RF4B	2	2.8	7.1	7.6	5.8	13.5
109	X782-560-R3	0.5	0.5	5.2	6.1	5.4	11.4
110	X731-230-R4	2.5	3.7	8.1	11.5	8	19.6
111	X1039-806-R4	3.4	3.2	8	7.5	4.3	12
112	X228-RF4	1.8	1.2	7.1	7.4	7.6	15
113	X770-829-R3	0.3	0	5.2	3.2	3.4	6.7
114	X3818 R4	2.7	2.8	6.5	2.7	3.2	5.9
115	X104-463-R5	0.5	0.8	5.6	4.9	2.3	7.4
116	X117-697-R4	1.8	1.8	7.2	5.1	3.8	8.9
117	X97 361 R3	1.4	1.2	8.8	9.7	5.7	15.6
118	X756-299-R4	3.4	3.7	6.8	6	4.2	10
119	X999-RF4	2.2	1.5	7.3	1.3	5.3	6.5
120	X215-RF4A	2.4	3	7.5	10.6	8.7	19.5
121	X1070-470-R3	5.4	5.7	9.5	4.9	4.2	9
122	X148-300-R4	3.7	2.3	8.1	10.7	4.9	15.6
123	X797-953-R1	1.5	1.1	6.6	5.8	5.4	11.1

Supplementary Table 2. Contd.

124	X104-463-R6	0.8	3.4	8.8	6.2	5.7	11.9
125	X1052-220-R2	0	0.1	5.3	-0.5	-2.6	-2.9
126	X406-935-R4	4.2	3.3	8.3	8.7	8.6	17.2
127	X1222-755-R3	0	0.4	8.6	5.9	5.1	10.9
128	X215-RF4B	2.5	2.6	8.1	5.7	5	11
129	X166-RF4	1.6	2	7	7.8	7.6	15.6
130	X114-136-R1	1.1	6	8.8	9.1	6.7	15.9
131	X80 968 R3	5.5	2.2	9.7	13.2	7.6	20.9
132	X163-RF4C	0.5	1	5.2	10.7	10.2	20.8
133	X803-1000-R2	1.2	2.1	6.4	1.6	4.9	6.5
134	X780-850-R4	0.6	1.3	6.7	2.8	3.1	5.7
135	X1059-401-R2	1.6	2.5	5.7	7.5	4.6	11.4
136	X85 RF4	2.1	1.6	6.1	5.8	5.4	9.3
137	X1222-755-NR4	2.5	1	7.1	5.6	4.7	7
138	X438-RF4	3.7	1.9	6.2	1.1	3.2	8.4
139	X466-679-R3	2.3	2.5	6.5	4.3	4.1	7.8
140	X468-RF4	1.3	2.4	6.7	6.7	6.6	8.8
141	X148-300-R5	1.6	2.3	9.5	3.4	2	11.9
142	X763-132-R4	1.2	1.4	12.4	3.5	5	10.8
143	X321-458-R3	4.5	6.1	8.6	9	6.1	11.3
144	X756-299-R2	1.1	0.8	6.5	4.7	7.4	6.5
145	X121-327-R3	0.6	2.4	5.7	7.2	4.1	6
146	TX623(4X)	0	0.9	6.6	4.5	2.5	5.7
147	T115>163A-1	1.3	3.2	8.9	2.6	5.2	9.5
148	S1219-15-354D	0.4	2.4	8	1.4	0.8	5.1
149	S1264-1-14-R304	2.6	2.7	7.4	5.5	5.4	10.2
150	S1312-6-R203A	0.8	1	7.2	5	3.7	11.5
151	S1374-18-R117	4.1	3.6	8.3	6.1	5.3	11.6
152	S1383-1-0-396D	2	2	8.5	4.4	6.1	10.9
153	S1383-1-R193	3.5	2.2	8.2	4.9	5.8	11.3
154	S1383-2-1-R121	3.2	4.8	8.5	8.6	6	11.5
155	S1477-30-R51	6.7	8.3	10.2	7.3	5	13.4
156	S1477-31-R52G	5.2	4	8	5	6.5	11.7
157	S1477-31-R52H	3.7	3.8	7.8	6.9	5.1	10.8
158	S1481-1-R69	6.1	6.2	9.5	8.9	6.5	10.9
159	S1482-1-R01	4.3	3.5	12.1	5	4.3	9.6
160	S1498-2-R106	4.3	3.5	6.7	8.5	6.8	10.6
161	S1662-R33C	4.7	6	11.6	8.7	5.3	10.8
162	S1662-R33F	3.4	3.2	8.2	4.7	3.5	10.5
163	S1836-1-R89	3.3	5.1	9.6	5.1	5.8	21.1
164	S1265-1-0-R519-R85	3.4	2.7	9.1	6.3	4.4	8.5
165	S1383-1-0-R396D-R193D	10.9	13.3	13.5	5.2	7.5	13.5
166	S1383-1-0-R396D-R193D	2.8	2.3	6.6	3.8	3.8	9.9
167	S1465-4-dw14B-R157A	1.7	1.8	6.8	6.8	6.4	7.7
168	S1465-4-dw14B-R157E	2.5	2.2	11.5	5	3.7	7.9
169	S1473E-2-R29C-R25D	2.8	5	8.8	4	5.6	8.2
170	S1474-1-dw5-R136	6.1	6	9.4	14.6	9.9	19
171	S1474-2-R31A-R235B	5.1	4.8	10.1	6	6.4	14.9
172	S1477-30-R51-R229A	1.3	1	6.6	3.4	2	9.7
173	S1477-30-R51-R229C	3.8	6.1	9.5	8.7	5.1	11.2
174	S1477-30-R51-R229D	0.3	0.9	6.4	1.3	3.8	6.5
175	S1477-43-dw54B-R181	2.7	2	6.6	4.8	4.3	7

Supplementary Table 2. Contd.

176	S1477-43-dw54C-R89A	2.5	4.7	7.8	3.2	5.6	9.6
177	S1477-43-dw54C-R424A	0.9	2	8.3	6.7	8.2	10.4
178	S1477-X-R55A-R122	2.4	2.9	8.2	3.6	4.6	8.5
179	S1479-6-R61-R78B	0.4	0.6	6.2	12.2	9.2	14.3
180	S1479-6-R61-R78C	4.5	6.2	11.3	7.1	3.6	7.2
181	S1479-1-R56B	5.1	1.8	8.7	7.6	5	12.1
182	S1481-1-R01-R213B	2.4	3.3	7.6	10.5	6.3	11.5
183	S1481-1-R01-R213D	5.7	4.7	9.3	4.7	6.1	12.7
184	S1481-1-R01-R213F	5.1	5.7	9.3	6.1	6.9	10
185	S1498-15-R182B-R184A	5.3	8	10.7	6	4.7	11.8
186	S1655-R75A-R146B	9.4	10.1	14.7	4.8	3.5	10.8
187	S1662-R33C-R177A	4.9	3.4	9.7	11.3	7.4	12.1
188	S1662-R33C-R177E	0.8	2.7	8.1	5.6	5.3	8
189	S1755-dw76-R73A	2.7	3	8.9	13.6	7.6	17.1
190	S1755-dw76-R73B	3.1	3.2	6.6	1.7	2.7	5.4
191	S1781-R79S-R214A	8	5	9.3	6.3	10.5	16.2
192	S1781-R79S-R214B	9.4	9.7	8.4	12.5	9	9.6
193	S1811-3-R17A	5.1	6.3	10.6	4.9	3.8	12
194	X61-497-R4-R204A	2	5.2	8.9	2.8	4	9.1
195	X61-497-R4-R204D	5	3.3	11.3	6.5	6.2	10.7
196	X74-120-R3-R19	5.5	4.3	9.3	5.7	5.9	13
197	SESO 1	0.1	0	*	-0.5	-0.9	*
198	SESO 3	0	0	*	-1.1	-1.2	*
199	EPURIPUR	0	0	*	0.2	-0.4	*
200	SEKEDO	0.1	0	*	-1.1	-2	*
LSD	-	3.5	3.5	4.7	6.9	4.3	6.6