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# LINKAGE GROUP ASSEMBLY AND ORDERING AS A SOURCE OF SPURIOUS QTL ESTIMATES IN MANGO

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#### **ABSTRACT**

**Objective:** This study aimed to align genetic linkage groups (LGs) with the mango physical map by comparing single nucleotide polymorphism (SNP) sequences in the 'Alphonso' mango genome.

**Theoretical Framework:** Few studies have evaluated the impact of linkage group (LG) formation and marker ordering on quantitative trait loci (QTL) estimates for marker-assisted selection (MAS).

**Method:** SNPs from the mango linkage groups (n=20) were aligned on the chromosomes of the genome sequence of the 'Alphonso' mango (n=20), evaluating the correspondence between the genetic linkage map and the physical map

**Results and Discussion:** Four major aberrations were identified: (a) chromosome 1 was divided into LGs 9 and 14; (b) chromosome 4 was split between LGs 1 and 3; (c) LG 8 was formed by combining SNPs from chromosomes 9 and 17 of 'Alphonso'; and (d) chromosome 18 was not represented in any of the 20 LGs. All remaining LGs, except LGs 11, 14 and 20, contained at least one SNP from non-corresponding reference chromosomes. Significant discrepancies in SNP ordering were observed across the 20 LGs, particularly in 12 LGs.

**Research Implications:** For species with available genome sequences, physical maps, created through SNP sequence Blast alignment, yield better results for quantitative trait mapping aimed at marker-assisted selection.

**Originality/Value:** QTLs utilization in MAS remains limited. Insufficient attention has been given to limitations in linkage group formation and marker ordering compared to physical mapping as sources of spurious QTL estimates.

**Keywords:** *Mangifera Indica*, QTL, SNPs.

## FORMAÇÃO E ORDENAÇÃO DO GRUPO DE LIGAÇÃO COMO FONTE DE ESTIMATIVAS ESPÚRIAS DE QTL EM MANGA

#### **RESUMO**

**Objetivo:** Este estudo teve como objetivo alinhar grupos de ligação genética (LGs) com mapa físico da manga comparando sequências de polimorfismos de nucleotídeo único (SNP) no genoma da manga 'Alphonso'.

**Referencial Teórico:** Poucos estudos avaliaram o impacto da formação do grupo de ligação (LG) e ordenação dos marcadores nas estimativas de 'loci' de características quantitativas (QTL) para seleção assistida por marcadores (MAS).

**Método:** SNPs dos grupos de ligação da manga (n=20) foram alinhados nos cromossomos do sequenciamento genomico da manga 'Alphonso' (n=20), avaliando a correspondência entre mapa de ligação genética e mapa físico.

**Resultados e Discussão:** Quatro aberrações foram identificadas: (a) cromossomo 1 foi dividido nos LGs 9 e 14; (b) cromossomo 4 foi dividido entre os LGs 1 e 3; (c) LG 8 foi formado pela combinação de SNPs dos

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cromossomos 9 e 17 de "Alphonso"; e (d) cromossomo 18 não estava representado em nenhum dos 20 LGs. Todos os LGs restantes, exceto os LGs 11, 14 e 20, continham pelo menos um SNP de cromossomos de referência não correspondentes. Discrepâncias significativas na ordenação dos SNPs foram observadas nos 20 LGs, particularmente em 12 LGs.

**Implicações da Pesquisa:** Para espécies com sequências genômicas disponíveis, mapas físicos, criados por meio do alinhamento de sequência de SNP, produzem melhores resultados para mapeamento de QTLs.

**Originalidade/Valor:** A utilização de QTLs em MAS permanece limitada. Esse trabalho enfatiza as limitações de LG e ordenação de marcadores, em comparação ao mapeamento físico, como fontes de estimativas espúrias de QTLs.

Palavras-chave: Mangifera Indica, QTL, SNPs.

## ENSAMBLAJE Y ORDENAMIENTO DE GRUPOS DE ENLACE COMO FUENTE DE ESTIMACIONES DE QTL ESPURIAS EN MANGO

#### **RESUMEN**

**Objetivo:** Este estudio buscó alinear los grupos de ligamiento genético (GL) con el mapa físico del mango mediante la comparación de secuencias de polimorfismos de un solo nucleótido (SNP) en el genoma del mango 'Alphonso'.

**Marco teórico:** Pocos estudios han evaluado el impacto de la formación de grupos de ligamiento (GL) y el ordenamiento de marcadores en las estimaciones de loci de caracteres cuantitativos (QTL) para la selección asistida por marcadores (SAM).

**Método:** Los SNP de los grupos de ligamiento del mango (n=20) se alinearon en los cromosomas de la secuencia genómica del mango 'Alphonso' (n=20), evaluando la correspondencia entre el mapa de ligamiento genético y el mapa físico.

**Resultados y discusión:** Se identificaron cuatro aberraciones principales: (a) el cromosoma 1 se dividió en los GL 9 y 14; (b) el cromosoma 4 se dividió entre los GL 1 y 3; (c) el GL 8 se formó mediante la combinación de SNP de los cromosomas 9 y 17 de 'Alphonso'. y (d) el cromosoma 18 no estaba representado en ninguno de los 20 LG. Todos los LG restantes, excepto los LG 11, 14 y 20, contenían al menos un SNP de cromosomas de referencia no correspondientes. Se observaron discrepancias significativas en el ordenamiento de los SNP en los 20 LG, particularmente en 12 LG.

**Implicaciones de la investigación:** Para las especies con secuencias genómicas disponibles, los mapas físicos, creados mediante el alineamiento Blast de secuencias de SNP, producen mejores resultados para el mapeo cuantitativo de rasgos dirigido a la selección asistida por marcadores.

**Originalidad/Valor:** El uso de QTL en la selección asistida por marcadores (MAS) sigue siendo limitado. Se ha prestado poca atención a las limitaciones en la formación de grupos de ligamiento y el ordenamiento de marcadores en comparación con el mapeo físico como fuentes de estimaciones falsas de QTL.

Palabras clave: Mangifera Indica, QTL, SNP.

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#### 1 INTRODUCTION

Most economically important traits in crops, livestock, and humans are quantitative (i.e., polygenic), including height, weight, disease resistance, and yield (Kaur et al. 2023). Such traits pose significant challenges for marker-assisted selection (MAS) implementation due to their genetic complexity. In contrast, traits governed by single genes or simple inheritance patterns (e.g., the male sterility 'S' locus in onion) allow more straightforward and reliable MAS applications.

According to Kaur et al. (2023), although numerous quantitative trait loci (QTL) associated with key agronomic traits have been mapped across various crops, their direct utilization in MAS remains limited. According to Xu and Crouch (2008), the annual number of publications containing the term "marker-assisted selection" has consistently been threefold lower than those referencing "quantitative trait locus/loci," with the disparity continuing to widen.

The limitations in applying QTLs to MAS stem from small population sample sizes, genotyping and phenotyping errors, and insufficient marker coverage (resulting in linkage maps with large gaps) (Miles and Wayne 2008, Xu and Crouch 2008, Kaur et al. 2023). Insufficient attention has been given to proper marker assembly and ordering in pseudo-chromosomes or linkage maps, which are crucial for robust QTL estimation. Medeiros et al. (2022) identified linkage groups containing segments from multiple chromosomes when comparing genetic and physical maps of the guava genome, demonstrating how improper linkage group assembly and marker ordering can lead to spurious QTL estimates.

Kuhn et al. (2017) noted that genetic and genomic resources for mango (*Mangifera indica*) remain limited and have not significantly advanced global mango breeding efforts. Luo et al. (2016) reviewed the four mango genetic maps available by 2016: 1) the first map constructed using 197 RFLP and 650 AFLP markers; 2) the second using 34 AFLP markers; 3) the third using 81 AFLP markers; and 4) a partial linkage map using 9 microsatellite and 67 RFLP markers. Subsequently, Luo et al. (2016) developed a high-density genetic map using 6,594 SLAF-seq markers, while Kuhn et al. (2017) published a linkage map with 888 SNPs across seven mapping populations, describing it as "a tool for mango breeding".

From this perspective, the present study aimed to evaluate the reliability of the Kuhn linkage map for QTL estimation by comparing SNPs from the mango linkage groups (n=20) developed by Kuhn et al. (2017) with the same SNP set aligned against the chromosome-scale assembly of mango 'Alphonso' (n=20) published by Wang et al. (2020). This comparison was



performed using BLAST analysis to assess the correspondence between genetic and physical maps.

#### 2 THEORETICAL FRAMEWORK

Quantitative trait locus (QTL) analysis is a statistical method that integrates phenotypic data (trait measurements) with genotypic data (typically molecular markers) to elucidate the genetic basis of variation in complex traits (Miles and Wayne 2008). QTL analysis is expected to facilitate: (1) precise map-based cloning of alleles/genes, (2) comparative studies of trait evolution across species, and (3) marker-assisted selection (MAS) (Semagn et al. 2006), the latter being the primary focus of this study. The QTL mapping process involves developing a segregating mapping population for the target trait, constructing a linkage map, and performing QTL analysis - often using interval mapping methods - to identify genomic regions associated with the trait of interest (Semagn et al. 2006).

Two most important mapping programs have been applied for linkage groups building, adopting different strategies and algorithms:

- 1. OneMap ((Margarido et al. 2007) implements a maximum likelihood-based algorithm that simultaneously estimates linkage and linkage phases for diverse marker types, including fully informative markers (segregating 1:1:1:1) and partially informative markers (segregating 1:2:1, 3:1, and 1:1) in full-sib families from outbred parent plants (Wu et al. 2002). Wu et al. (2002) identified 18 possible cross combinations based on parental genotypes,
- 2. JoinMap4 (Van Ooijen 2006) implements a Monte Carlo multipoint maximum likelihood algorithm (Van Ooijen, 2011) capable of simultaneously estimating recombination frequencies and determining marker order based on five segregation types. This methodology was implemented in JoinMap4.1, utilizing a simulated annealing ordering algorithm that optimizes marker arrangement by minimizing the sum of recombination frequencies between adjacent segments.



#### 3 METHODOLOGY

#### 3.1 MANGO LINKAGE MAPS AND SNPS SEQUENCES

The linkage groups developed by Kuhn et al. (2017) served as the primary analytical framework. According to their methodology, the assembly and alignment of the mango genome were performed using two mapping programs - JoinMap4 (Van Ooijen 2006) and OneMap (Margarido et al. 2007) - applied to each of the seven mapping populations. The authors employed these complementary programs as follows:

- 1) OneMap was used to establish 20 linkage groups through recursive analysis, progressively increasing the LOD threshold (in increments of 0.1) until achieving 20 linkage groups (LGs) with a minimum of 10 markers per LG. This process was conducted separately for all seven mapping populations (Kuhn et al. 2017);
- 2) The resulting OneMap LGs provided the initial marker groupings for JoinMap4 analysis. JoinMap4 calculations employed default parameters for population grouping and Maximum Likelihood (ML) mapping. The program's Strongest Cross Link (SCL) function incorporated ungrouped markers with SCL values ≥ 5.0 into appropriate groups. The most informative map, derived from the TA × KP population, served as the template for other population maps in JoinMap4, which were subsequently merged using the software's integration functions to generate the consensus map (Kuhn et al. 2017).

The SNP markers analyzed by Kuhn et al. (2017) originated from three institutions: the Department of Agriculture and Fisheries, Queensland (DAFQ, Australia); the Subtropical Horticulture Research Station (SHRS, USA); and the Agriculture Research Organization (ARO, Israel). Kuhn et al. (2017) provided sequences for 1,409 SNPs in their supplementary materials (Table 2). Among these, 1,054 SNP assays were processed using Fluidigm technology (South San Francisco, CA, USA) and analyzed on a Fluidigm EP-1 platform across all mapping populations.

BLAST analysis of SNP sequences against the 'Alphonso' reference genome

Basic Local Alignment Search Tool (BLAST) analysis was performed by aligning the mango SNPs (query sequences from Kuhn et al. 2017) against the 'Alphonso' reference genome (subject sequence from Wang et al. 2020), available through the National Center for Biotechnology Information (NCBI) under accession number GCA\_011075055.1\_CATAS\_Mindica\_2.1\_genomic. The analysis procedure was as follows:



1) Blast software was downloaded and installed in a personal computer, 2) the Mangifera indica genome was downloaded from NCBI site (https://www.ncbi.nlm.nih.gov/genome/?term=mangifera&utm\_source=gquery&utm\_mediu m=search), 3) a 'mango genome' folder was created to unzip the downloaded 'Alphonso' genome, 4) a multifasta file .fna with the SNPs was added to the folder, 5) commands in the DOS prompt: > cd desktop, >cd "genoma mangifera", >blastn -query ARQUIVO.fna -subject GCA\_011075055.1\_CATAS\_Mindica\_2.1\_genomic.fna -out resultado.txt -outfmt 7.

Each mango SNP sequence had a length of approximately 231 nucleotides. The BLAST output provided for each SNP included: percentage identity, alignment length, genomic start/end positions, E-value, and bit score. SNP-to-chromosome assignments were determined by selecting alignments with the lowest E-values and highest bit scores, even when SNPs showed multiple genomic hits. SNPs were subsequently ordered according to their positions in the 'Alphonso' chromosome assembly. Comparative alignment between the linkage groups (Kuhn et al. 2017) and reference chromosomes (Wang et al. 2020) was visualized using Microsoft Excel and PowerPoint, with corresponding SNPs connected by manually drawn lines.

#### **4 RESULTS AND DISCUSSIONS**

The implemented BLAST protocol for aligning SNP sequences against the 'Alphonso' genome successfully identified Kuhn et al. (2017) SNPs with e-values < 1e-21 and bit-scores >191 (data not shown), which mapped to the 20 linkage groups originally published by Kuhn et al. (2017). The total number of blasted SNPs (1,201) exceeded the number of genotyped SNPs (1,054; Table 1 and Kuhn et al. 2017 supplementary data), due to repetitive SNPs showing similar e-values and bit scores that mapped to multiple positions across the 'Alphonso' chromosomes.



**Table 1**Number of mango SNPs (#SNPs)/'Alphonso' chromosome and linkage groups (LG) (Kuhn et al., 2017) 'blasted' against each one of the 20 chromosomes (Chr) of the Mangifera indica 'Alphonso' reference genome CATAS\_Mindica\_2.1 (GCA\_011075055.1) (Wang et al. 2020)

Chr	#SNPs/Chr	LG	#SNPs/LG	Chr	#SNPs/Chr	LG	#SNPs/LG
1	91	9	34	11	56	13	1
1		14	26	11		12	35
2	56	4	34	11		5	2
2		8	1	12	73	15	45
3	95	17	52	12		2	1
3		19	1	12		19	1
3		2	1	13	68	13	41
4	89	3	25	13		17	1
4		1	28	13		4	1
5	93	16	67	14	64	15	1
5		10	1	14		20	18
6	62	19	31	15	41	6	25
7	57	11	25	16	48	7	29
7		2	1	16		9	1
7		17	1	17	31	8*(Chr9)	19
8	61	10	35	17		16	1
8		16	2	18	34	missing	missing
9	61	17	1	19	38	5	30
9		8*(Chr17)	23	19		12	1
9		6	2	19		17	1
10	49	2	28	20	34	18	21
	Total SNPs				1201		694

The 91 SNPs from chromosome 1 (Chr) (Wang et al. 2020) were divided into linkage groups (LGs) 9 and 14 from Kuhn et al.'s (2017) mapping, with 34 and 26 SNPs, respectively. This division was also observed for the 89 SNPs from chromosome 4 (Chr), which were split between LGs 1 and 3 with 25 and 28 SNPs respectively (Table 1). LG 8 from Kuhn et al. (2017) was composed of 23 and 19 SNPs from chromosomes 9 and 17, respectively, of the 'Alphonso' mango reference genome (Table 1), indicating significant limitations for mapping and molecular marker-assisted selection applications.

The remaining LGs, except LGs 11, 14 and 20, contained at least one SNP from non-corresponding reference chromosomes: LG 2 contained one SNP each from chromosomes 3, 7 and 12; LG 4 contained one SNP from chromosome 13; LG 5 contained two SNPs from chromosome 11; LG 6 contained two SNPs from chromosome 9; LG 8 contained one SNP from chromosome 2; LG 9 contained one SNP from chromosome 16; LG 10 contained one SNP from chromosome 5; LG 12 contained one SNP from chromosome 19; LG 13 contained one SNP from chromosome 11; LG 15 contained one SNP from chromosome 14; LG 16 contained two SNPs from chromosome 8 and one from chromosome 17; LG 17 contained one SNP each from chromosomes 7, 13 and 19; and LG 19 contained one SNP each from chromosomes 3 and 12



(Table 1). Chromosome 18 of the 'Alphonso' mango reference genome (Wang et al. 2020) was not represented in any of the 20 linkage groups (Table 1), indicating another major limitation of the linkage map presented by Kuhn et al. (2017).

In the formation of genetic linkage groups (Kuhn et al. 2017), four major aberrations were observed when compared to the 'Alphonso' reference genome: a) chromosome 1 was divided into linkage groups 9 and 14; b) chromosome 4 was divided into linkage groups 1 and 3; c) LG 8 was formed by combining SNPs from chromosomes 9 and 17 of 'Alphonso'; and d) chromosome 18 was not represented in any of the 20 linkage groups. The remaining LGs, except LGs 11, 14 and 20, contained at least one SNP from non-corresponding reference chromosomes, indicating limitations in the mango linkage map (Kuhn et al. 2017). Similarly, Medeiros et al. (2022) also reported DNA segments from different chromosomes when comparing genetic linkage maps with the physical map of guava (Psidium guajava).

Santos et al. (2023) reported the formation of 23 linkage groups in the Haden  $\times$  Tommy Atkins cross, one of the seven populations in Kuhn et al.'s (2017) study, indicating that the 20 linkage groups reported by Kuhn et al. (2017) are inconsistent and were somehow, statistically or otherwise, forced to match the n = 20 of the mango genome.

The alignment of LG 9 showed discrepant SNP order relative to chromosome 1, particularly in the first 10 cM and between 76-81 cM, while LG 14 showed minor discrepancies in SNP order relative to chromosome 1 (Figure 1-A), noting that this chromosome was divided into two LGs (Kuhn et al. 2017) (Table 1). LG 4 showed non-conformity in SNP order, particularly between 30-53 cM, while LG 17 showed major discrepancies in SNP order relative to chromosome 3, covering nearly 100 cM (Figure 1-A). Minor SNP order discrepancies were observed in LG 1 when compared to chromosome 4, while LG 3 showed discrepancies between 39-41 cM, 63-65 cM and 65-67 cM when compared to chromosome 4 (Figure 1-A), noting that this chromosome was divided into LGs 3 and 1 by Kuhn et al. (2017).

The alignment of SNPs from LG 16 (Kuhn et al. 2017) showed major non-conformity with the SNP order of chromosome 5 from the 'Alphonso' reference genome, particularly between 181-228 cM (Figure 1-B). LGs 19, 11, 10, 8 and 2 showed minor discrepancies in SNP order when blasted against chromosomes 6, 7, 8, 9 and 10 respectively of the 'Alphonso' reference genome (Figure 1-B).

Minor discrepancies in SNP order were observed in LGs 12, 6 and 7 (Kuhn et al. 2017) when blasted against chromosomes 11, 15 and 16 (Figure 1-C), respectively, of the 'Alphonso' reference genome (Wang et al. 2020). Significant inconsistencies were observed when blasting



LGs 15, 13 and 20 against chromosomes 12, 13 and 14, respectively, of the 'Alphonso' reference genome (Figure 1-C).

Minor discrepancies in SNP order were observed in LGs 8 and 5 (Kuhn et al. 2017) when blasted against chromosomes 17 and 19 (Figure 1-D), respectively, of the 'Alphonso' reference genome (Wang et al. 2020). Significant inconsistencies were observed when blasting LG18 against chromosome 20 of the 'Alphonso' reference genome (Figure 1-D).

Major discrepancies were observed in the SNP ordering within the 20 linkage groups of Kuhn et al. (2017), particularly in LGs 9, 4, 17, 3, 16, 19, 10, 12, 15, 20, 5 and 18 (Figure 1). Simulations of some software for genetic linkage map construction indicated that JoinMap4.1, the software used by Kuhn et al. (2017), showed ordering that was far from the predefined order of 20 markers (Zhang et al. 2015). In this scenario, QTL mapping becomes extremely limited and compromised, resulting in false linkages between markers and regions controlling agronomically important traits.

**Figure 1**A. Alignment of the mango linkage groups (Kuhn et al. 2017) (left) and mango physical chromosomes (right) based on the same SNPs and mapped to the 1, 2, 3 and 4 chromosomes of the Mangifera indica 'Alphonso' reference genome CATAS Mindica 2.1 (GCA 011075055.1)

SNP - LG 9	cM T	o Chr	SNP - Chr 1	To LG	bp	SNP - LG 14	cM To	Chr	SNP-Chr1	To LG bp
mango_rep_c4696	0	1	/SSKP008C1_A700T	9	41176	Contig1373	0	1	Contig1373	14 20511298
Mi_0466	0.548	1	/Mi_0561	9	385815	SSKP047C1_C678T	9.508	1_	Contig2887	14 21295021
Mi_0563	1.047	1	Mango_rep_c4696	9	593357	Contig2887	13.297	1	SSKP047C1_C678T	14 21811563
mango_rep_c3663	3.305	1	Mi 0466	9	784244	Mi_0030	25.776	1	Mango_rep_c11313	14 22755102
Mi_0554	4.824	1	Mango rep c3663	9	903234	SSKP006C1_G845T	31.325	1	SSKP006C1_G845T	14 22841672
SSKP008C1 A700T	8.698	1/	Mi 0563	9	936920	mango_rep_c11313	32.415	1	Mi_0030	14 22890486
Mi 0561	14.196	1/	Mi 0554	9	1145722	mango_rep_c2650	34.257	1	Mango_rep_c2650	14 23081724
Contig942	18.067	1	Contig942	13	1618793	Mi_0025	36.869	1	Mi_0025	14 23347132
mango_rep_c9029	43,776	1	_Mi 0350		2478660	Mi_0253	44.133	1	Mi_0253	14 23533600 14 24446611
Mi_0350	44,378	1	-Mi 0110		2534890	SSKP046C2_A827G mango_rep_c1316	53305 57.35	1	SSKP046C2_A827G  Mango_rep_c1316	14 24446611
Mi_0110	45.592	1	Mi 0268		2696402	Mi_0138	59.468	1	Mi_0138	14 24818479
110000000000000000000000000000000000000	48.946	1				mango_rep_c4311	60.99	1	Mango_rep_c3432	14 24853057
Mi_0268		1-	Mango_rep_c9029		2897344	mango_rep_c3432	60.4	1>	Mi 0158	14 24853157
mango_rep_c1190		1	Mango_rep_c11906		3531176	Mi_0158	60.42	1	Mango_rep_c4311	14 24932013
mango_rep_c758	66.98	1	Mango_rep_c758		4082294	Contig1365	68.215	1	Contig1365	14 25458299
Contig5786	67.754	1	Contig5786		4188937	mango_rep_c12371	72.084	1	Mango_rep_c12371	14 25513357
Mi_0340	76.257	1	/Mi_0074		4403075	Mi 0451	75.587	1	Mango_rep_c6097	14 26005290
Mi_0114	76.612	1	/SSKP136C1_A519G	9	4742800	mango_rep_c6097	76.191	1	Mi 0526	14 26371352
Mi_0494	77.148	1	Mi_0491		4835273	Mi_0526	77.125	1	Mi_0451	14 26389664
Contig756	77.818	16	Mi_0494	9	4896922	SSKP141C2_C347T	83.093	1_	Mango_rep_c2016	14 26879986
Mi_0491	77.99	1//	Mi_0114	9	4969855	mango_rep_c2016	83528	1	SSKP141C2_C347T	14 27044842
SSKP136C1_A519G	79.445	1//	Mi_0340	9	5130965	mango_rep_c16226	85.25	1	SSKP141C2_C347T	14 27045041
Mi_0074	80.626	1/	Mi_0148	9	5618618	mango_rep_c2828	85.895	1	Mango_rep_c2828	14 27127265
Mi_0148	88.849	1	SSKP041C1_A653T	9	5785581	SSKP058C2_A431G	108.488	1_	Mango_rep_c16226	14 27372769
Mi_0318	94.321	1	Mi_0318	9	6011854	Mi_0202	114.59	1_	SSKP058C2_A431G	14 29093394
SSKP041C1_A653T	97.305	1	Contig1087	9	6542986				Mi_0202	14 29297975
Contig1087	102.962	1	Mi_0035	9	6745914					
Mi_0035	106.725	1	Mi_0417	9	6952016					
Mi_0417	109.215	1-	Mi 0402	9	7911973					
Mi 0402	122,355	1	Mango_rep_c9549	9	8449500					
mango_rep_c9549	124.504	1	Mi_0497	9	9364446					
Mi_0142	128.837	1	Mi_0142	9	9700652					
Mi 0497	129.648	1	Mi 0008		15157352					
Mi 0008	142.072	1	_Mi 0133		15613230					
Mi 0133	143.132									



SNP LG-4	cM To	chr SNP-Chr2	To LG bp	SNP LG-17	cM	To Chr SNP - Chr3	To LG	bp
SSKP021C1_C1039T		2——SSKP021C1_C1039T	4 2769441	Mi_0281	156.703	3	17	212508
SSKP109C1_C764T	220,276	2 SSKP109C1_C764T	4 3296127	mango_rep_	c9129 148.908	3Contig4872	17	261959
Contig398	198,474	2——Contig398	4 4428543	Contig4872	146.49	3 Mango_rep_c	9129 17	629462
SSKP116C1_A524G	156,84	2—————————————————————————————————————	4 12845786	Mi_0167	145.906	3 Mi_0167	700	751317
Mi_0024	149,379	2 SSKP050C1_C518T	4 13468796	Mi_0328	141.794	3		1122891
SSKP050C1 C518T	148,744	2 Mi_0024	4 13581644	mango_rep_		3		1238093
Mi_0300	146,369	2-Mi_0300	4 13716950	Contig3337	129.61	3Contig3337		1553774
Mi_0467	146,033	2 Mi_0467	4 13731944	Contig4330	127.052	3 Contig4330		1681799
				Mi_0550	116.059	3 Mi_0129		2354488
Mi_0290	125,903		8 13924205	Mi_0129	115.184	3 Mi_0550		2407777
Mi_0150	122,375		4 15123776	mango_rep_		3Mango_rep_c		2861171 2873581
mango_rep_c5750	109,471	2 Mi_0150	4 15253317	mango_rep_	104.689	3 Mango_rep_c:		
Contig6253	107,126	2 Contig6253	4 16544620	Mi_0368		3 Mi_0368		2927603
Mi_0426	105,574	2 Mango_rep_c5750	4 16797477	Mi_0166	99.444	3——Mi_0166		3552969 3611964
Mi_0334	104,965	2 Mi_0426	4 16851936	mango_rep_ Mi_0063	97.241	3Mango_rep_c 3Mi_0063		3751767
Mi_0548	100,469	2 Mi_0334	4 16887589					3779559
Mi_0302	100,203	2 Mi_0548	4 17170226	mango_rep_	92.919	3 Mango_rep_c: 3 Mi_0071		4259587
Contig929	98,816	2 Mi_0302	4 17196131	Mi_0071	90.765	3Mi_0132		4601960
Mi_0284	86,434	2Contig929	4 17351125	Contig1878 Mi_0132	89.408	3 Mi_0382		4746609
Mi_0239	83,224	2 Mi_0284	4 18225412					
Mi_0230	56,822	2 Mi_0239	4 18380580	Contig1073 Mi 0382	88.592 88.287	Mango_rep_c		5026408 5038666
mango_rep_c9407	53,502	2 Mi_0230	4 19900168	Mi_0382 Mi_0321	86.684	3 Mango_rep_cl		5045899
	53,266	_	4 20151263		79.132	13 Contig1914		5208121
Contig2241		V		Contig2524 mango_rep_		mango_rep_cl		5354551
Mi_0045	41,097	2 Mango_rep_c9407	4 20496307		78.464	Mi_0121		5354551 5413355
Mi_0066	40,346	2 SSKP055C3_A517G	4 21042590	Contig3004		1 11		5413355 6419737
Mi_0124	40,062	2 Mi_0088	4 21167636	mango_rep_ Mi_0121	77.307	Mango_rep_c:		6736090
mango_rep_c8049	38,933	2 Mi_0066	4 21215818	Mi_0121 Contig1914	75.712	3 // Mango_rep_c:		6974904
Mi_0088	38,293	2 Mi_0045	4 21220927			3 // Mi_0492 Mi_0116		6994633
SSKP055C3_A517G	38,22	2/ Mi_0124	4 21419936	mango_rep_ Mi_0002	72.674	3 // Mi_0116 Mi_0235		7082271
Mi_0335	34,772	2 Mango_rep_c8049	4 21554003	Mi_0002 Mi_0397	70.859	3 MI_UZ35 Mango_rep_ci		7295708
Mi_0487	33,893	2 Mi_0487	4 22087839					7295708 7295969
mango_rep_c9478	30,377	2 Mi_0335	4 22111413	mango_rep_ mango_rep_		3 Mango_rep_c: 3 Mi_0473		7295969 7523819
Mi_0443	22,413	2 Mi 0443	4 22782169			V( A / / / / -		7550141
Mi_0221	21,15	2 Mi_0221	4 22848116	mango_rep_ Mi_0168	53.566	3 Mango_rep_ct		7701810
	17,974	2 Mi_0221 2 Mi_0549	4 22925039	Contig2668	52.648	9 Mi_0505		7793828
Mi_0549				Mi_0116	50.895	Mango_rep_c		8682235
mango_rep_c8614	0	2——Mango_rep_c8614	4 24017087	Mi_0492	50.687	Mango_rep_cl		8880513
				mango_rep_		3 Mango_rep_o		8932779
				Mi_0235	48.084	Mango_1ep_0		0526519
				WII_0233		3 W//M W/ MI_0133		
				MI OFRE		a //N/MW /subpoper A	C27T 47 40	
				Mi_0535	47.558	3 SMP009C1_A		
				mango_rep_	c34886 45.337	3 M_0535	17 14	4919699
				mango_rep_ mango_rep_	c34886 45.337 c2961 45.149	3 Nango_rep_c	17 14 3766 17 15	4919699 5966441
				mango_rep_ mango_rep_ Mi_0473	c34886 45.337 c2961 45.149 44.519	3 Mango_rep_ci 3 Mi_0168	17 14 3766 17 15 17 18	4919699 5966441 8214363
				mango_rep_ mango_rep_ Mi_0473 mango_rep_	c34886 45.337 c2961 45.149 44.519 c9532 41.829	3 Mango_rep_ci 3 Mi_0168 3 Qontig2715	17 14 3766 17 15 17 18 2 18	4919699 5966441 8214363 8245541
				mango_rep_ mango_rep_ Mi_0473 mango_rep_ mango_rep_	c34886 45.337 c2961 45.149 44.519 c9532 41.829 c8252 37.626	3 Mango_rep_ci 3 Mi_0168 3 Aprilg2715 3 Mi_0397	17 14 3766 17 15 17 18 2 18 17 20	4919699 5966441 8214363 8245541 0422455
				mango_rep_ mango_rep_ Mi_0473 mango_rep_ mango_rep_ Mi_0505	c34886 45.337 c2961 45.149 44.519 c9532 41.829 c8252 37.626 36.553	3 MAngo_rep_ci 3 Mi_0168 3 Mpntig2715 9 Mp_0397 3 Mango_rep_ci	17 14 3766 17 15 17 18 2 18 17 20 10593 17 20	4919699 5966441 8214363 8245541 0422455 0976026
				mango_rep_ mango_rep_ Mi_0473 mango_rep_ mango_rep_ Mi_0505 Contig2556	c34886 45.337 c2961 45.149 44.519 c9532 41.829 c8252 37.626 36.553 30.53	9 Mango_rep_ci 3 Mango_rep_ci 4 Mi_0168 9 Aprilig2715 9 Mi_0397 3 Mango_rep_ci 19 Mi_0002	17 14 3766 17 15 17 18 2 18 17 20 10593 17 20	4919699 5966441 8214363 8245541 0422455 0976026 1172833
				mango_rep_ mango_rep_ Mi_0473 mango_rep_ mango_rep_ Mi_0505 Contig2556 mango_rep_	c34886 45,337 c2961 45,149 44,519 c9532 41,829 c8252 37,626 36,553 30,53 c5787 28,211	My_0535 My_mang_rep_ci My_0168 My_0197 My_0397 My_mang_rep_ci My_0397 Contig1052	17 14 3766 17 15 17 18 2 18 17 20 10593 17 20 17 21 19 21	4919699 5966441 8214363 8245541 0422455 0976026 1172833 1632739
				mango_rep_ mango_rep_ Mi_Q473 mango_rep_ Mi_Q573 mango_rep_ Mi_0505 Contig2556 mango_rep_ mango_rep_	c34886 45,337 c2961 45,149 44,519 c9532 41,829 c8252 37,626 36,553 30,53 c5787 28,211 c8171 26,9	Min 0535 Mango_rep_ci Mi_0168 Contig2715 Mi_0397 Mingo_rep_ci Mi_0002 Contig1052 Contig1071*	17 14 17 18 17 18 2 18 17 20 10593 17 20 17 21 19 21 17 21	4919699 5966441 8214363 8245541 0422455 0976026 1172833 1632739 1632739
				mango_rep_ mango_rep_ Mi_0473 mango_rep_ mango_rep_ Mi_0505 Contig2556 mango_rep_ mango_rep_ mango_rep_ mango_rep_ mango_rep_	c34886 45.337 c2961 45.149 44.519 c9532 41.829 c8252 37.626 36.553 30.53 c5787 28.211 c8171 26.9 c417 26.828	MARQ_rep_ce_c.  MARQ_rep_ce_c.  MI_0168  Contig2715  M_0397  MR_00397  MR_0002  Contig1052  Contig1052  Contig1071*  M_0321	17 14 17 18 17 18 17 18 17 18 17 18 17 18 17 18 17 18 17 18 17 18 17 18 17 18 17 18 18 18 18 18 18 18 18 18 18 18 18 18	4919699 5966441 8214363 8245541 0422455 0976026 1172833 1632739 1632739 2098449
				mango_rep_ mango_rep_ Mi_0473 mango_rep_ Mi_0505 Contig2556 mango_rep_ mango_rep_ mango_rep_ mango_rep_ mango_rep_ SSKP00021.	c34886 45.337 c2961 45.149 44.519 c9532 41.829 68252 37.626 36.553 30.53 c5787 28.211 26.828 46271 0.14	Joy, 0335 Joy, 0335 Joy, 1, 0368 Joy, 1, 037 Joy, 1, 0	17 14 17 15 17 16 17 17 18 17 18 18 17 20 18 17 20 19 21 17 21 17 22 17 21 17 22	4919699 5966441 8214363 8245541 0422455 0976026 1172833 1632739 2098449 2774816
				mango_rep_ mango_rep_ Mi_0473 mango_rep_ mango_rep_ Mi_0505 Contlig2556 mango_rep_ mango_rep_ mango_rep_ Mi_0505 Mi_05	c34886 45.337 c2961 45.149 44.519 c9532 41.829 s8252 37.626 36.553 30.53 c5787 28.211 26.828 A627T 0.14	July 0,535 July 0,535	17 14 17 15 17 18 18 18 18 18 18 18 18 18 18 18 18 18	4919699 5966441 8214363 8245541 00422455 0976026 1172833 1632739 1632739 2098449 2774816 2876520
SNP-LG 1	cM T		TolG bp	mango_rep_ mango_rep_ Mi_Q473 mango_rep_ mango_rep_ Mi_g505 Contig2556 mango_rep_ mango_rep_ mango_rep_ mango_rep_ Mi_g505 SKP009C1_ Mi_0135 SNP-LG3	c34886 45.337 c2961 45.149 44.519 c9532 41.829 c8252 37.626 36.553 30.53 c5787 28.211 c8171 26.9 c417 26.828 A6227 0.14	Johnson 1	17 14 3766 17 15 17 18 2 18 17 21 10593 17 20 17 21 17 22 17 22 17 22 17 22 To LG	4919699 5966441 8214363 8245541 0422455 0976026 1172833 1632739 1032739 2098449 2774816 2876520 bp
SNP - LG 1 MI_0520	111.24	o Chr SNP - Chr 4 4 Contig871	1 13993390	mango_rep_ mango_rep_ Mi_0473 mango_rep_ Mi_0505 Contig2556 mango_rep_ mango_rep_ mango_rep_ mango_rep_ Mi_0305 SKP0041, Mi_0135 SNP-L63 mango_c154	c34886 45.337 c2961 45.149 44.519 c9532 41.829 c8252 37.626 36.553 30.53 30.53 c5787 28.211 c8171 26.92 c417 26.828 A627T 0.14 c69 cM T	Johnson St. Contig1878	17 14 17 18 17 18 17 18 17 18 17 18 17 18 17 18 17 18 17 18 17 18 17 18 17 18 17 18 17 18 18 18 18 18 18 18 18 18 18 18 18 18	4919699 5966441 8214363 8245541 0422455 0976026 1172833 1632739 2098449 2774816 2876520 bp 42004
				mango_rep_ mango_rep_ Mi_0473 mango_rep_ mango_rep_ Mi_0505 Contig2556 mango_rep_ mango_rep_ mango_rep_ SKR00905 SKR00905 Mi_0135 SAP - LG3 mango_t63 SKRP-LG3 mango_t63 SKRP-LG3	234886 45.337 422961 45.149 44.519 44.529 68252 37.626 36.553 30.53 5787 28.211 26.82 417 26.82 4017 0.14 0 CM T. 108 0 0 0 0 0 0 0 0 0 0 0 0 0 0	John Sass J. Mango_rep_ci Mango_rep_ci Mango_rep_ci Mango_rep_ci Mango_rep_ci Mi_0002 Jontig1071* John Sass John Sas	17 14 17 15 17 18 17 18 17 18 17 18 17 18 17 18 17 18 17 18 17 18 17 18 17 18 17 18 17 18 17 18 18 18 18 18 18 18 18 18 18 18 18 18	4919699 5966441 8214363 8245541 0422455 0976026 1172833 1632739 2098449 2774816 2876520 bp 42004 61552
Mi_0520	111.24	4 Contig871	1 13993390	mango_rep_ mango_rep_ mango_rep_ Mi_0473 mango_rep_ mango_rep_ Mi_0505 Contlig2556 mango_rep_ mango_rep_ mango_rep_ Mi_0135 SNP - LG3 mango_t546 SSKP131C1_ mango_rep_ mango_rep_	234886 45.337 45.149 45.149 45.159 45.169 45.169 45.169 45.169 45.169 45.169 45.169 45.169 45.169 46.179 46	John Sass Samman	17 14 17 18 17 18 17 18 17 18 17 18 17 18 17 18 17 18 17 18 17 18 18 18 18 18 18 18 18 18 18 18 18 18	4919699 5966441 8214363 8245541 0422455 0976026 1172833 1632739 2098449 2774816 2876520 bp 42004
Mi_0520 Contig871 mango_rep_c24937	111.24 105.849	4 Contig871 4 Mango_rep_c24937 Mi_0520	1 13993390 1 13993415	mango_rep_ mango_rep_ Mi_0473 mango_rep_ Mi_0505 Contig2556 mango_rep_ mango_rep_ mango_rep_ mango_rep_ SSKP0021_ Mi_0135 SNP-LG3 mango_cts4 SSKP131C1_ mango_rep_ Mi_0115	234886 45.337 22961 45.149 44.519 29532 41.829 82522 37.626 36.553 30.53 28.211 26.99 2417 26.828 A6271 0.14 0 0 0 0 0 0 0 88 0 88376 6.743 28.765	John St.	17 14 17 18 17 18 17 18 18 19 19 19 19 21 17 22 17 22 17 22 17 22 17 22 17 22 17 22 27 22 28 3 3 14 3 3 41 3 41	4919699 5966441 8214363 8245541 0422455 0976026 1172833 1632739 1632739 2098449 2774816 2876520 bp 42004 61552 12434 80909
Mi_0520 Contig871	111.24 105.849 105.604 95.072	4 Contig871 4 Mango_rep_c24937 Mi_0520 4 Mi_0186	1 13993390 1 13993415 1 14298008 1 14886799	mango_rep_ mango_rep_ Mi_Q473 mango_rep_ mango_rep_ Mi_D505 Contig2556 mango_rep_ mango_rep_ mango_rep_ SKR00091 Mi_0105 SAP - LG3 mango_rep_ SKR001 Mi_0115 SKP131C1 mango_rep_ Mi_0115 Mi_01556	234886 45.337 22961 45.149 45.149 45.149 26825 37.626 36.553 30.53 30.53 25787 28.211 26.92 41.72 26.828 A6627T 0.14 0 0 0M T 008 0 0M T 008 0 0M837G 6.743 25.654 17.139 28.765 30.119	John Sass Samman	17 14 17 15 17 18 17 18 17 18 17 18 17 21 17 21 17 21 17 21 17 22 17 22 17 22 17 22 17 23 17 24 17 24 17 24 17 25 17 25 17 26 3 144 3 31 3 441	4919699 5966441 8214363 8245541 422455 9976026 117283 1682739 1682739 1082739 1082739 1082739 1082739 1082739 1082739 1082739 10827416 1082739 10827416 1082739 10827416 1082739 10827416 1082739 10827416 1082739 10827416 1082739 10827416 1082739 10827416 1082739 10827416 1082746 10827
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Mi_0520 Contig871 mango_rep_c24937 Mi_0186 Mi_0242 Mi_0204	111.24 105.849 105.604 95.072 91.707 89.59	Contig871  Mango_rep_c24937  Mi_0520  Mi_0186  Mi_0242  Mi_0204	1 13993390 1 13993415 1 14298008 1 14886799 1 15127120 1 15208153	mango_rep_ mango_rep_ Mi_0473 mango_rep_ Mi_0505 Contig2556 mango_rep_ mango_rep_ mango_rep_ mango_rep_ SSKP009C1_ Mi_0135 SMP - LG3 mango_c154 SSKP131C1_ mango_rep_ Mi_0115 Mi_0556 Mi_0550 Mi_0540 Mi_0215	cc4886 45.337 45.49 45.4	John Share S	17 14 3766 17 19 17 18 2 18 17 2 18 17 22 18 27 27 17 22 17 22 17 22 17 22 17 22 17 22 17 22 17 22 18 3 14 3 3 3 3 50 3 3 51	9919699 9366441 8214363 8245541 9422455 9976026 1172833 1632739 163273
Mi_0520 Contig871 mango_rep_c24937 Mi_0186 Mi_0242 Mi_0204 Contig2867	111.24 105.849 105.604 95.072 91.707 89.59 83.745	Contig871  Mango_rep_c24937  Mi_0520  Mi_0186  Mi_0242  Mi_0204  Contig2867	1 13993390 1 13993415 1 14298008 1 14886799 1 15127120 1 15208153 1 15515955	mango_rep_ mango_rep_ mango_rep_ Mi_0473 mango_rep_ Mi_0505 Contig2556 mango_rep_ mango_rep_ mango_rep_ SKP009C1_ Mi_0335 SNP - LG3 mango_ct54 SSKP131C1_ mango_rep_ Mi_0556 Mi_0556 Mi_0556 Mi_0556 Mi_0556 Mi_0550 Mi_0152	C4886 45.337 45.391 45.392 45.392 45.392 45.392 45.392 45.392 45.292 45.292 45.292 45.292 46.	John Sass Samman	17 14 5766 17 12 17 12 17 12 17 12 17 20 17 21 17 21 17 21 17 22 17 22 17 22 17 22 17 22 17 22 17 22 17 3 3 14 3 41 3 50 3 50 3 50 3 50 3 86	1919699 19566441 2214363 2245541 2042455 1976026 1172833 1632739 16327
Mi_0520 Contig871 mango_rep_c24937 Mi_0186 Mi_0242 Mi_0204 Contig2867 Mi_0445	111.24 105.849 105.604 95.072 91.707 89.59 83.745 82.659	4 Contig871 4 Mango_rep_c24937 4 Mi_0520 4 Mi_0186 4 Mi_0242 4 Mi_0204 4 Contig2867 4 Mi_0445	1 13993390 1 13993415 1 14298008 1 14886799 1 15127120 1 15208153 1 15515955 1 15905673	mango_rep_ mango_rep_ Mi_0473 mango_rep_ Mi_0505 Contig2556 mango_rep_ mango_rep_ mango_rep_ mango_rep_ SSKP009C1_ Mi_0135 SMP - LG3 mango_c154 SSKP131C1_ mango_rep_ Mi_0115 Mi_0556 Mi_0550 Mi_0540 Mi_0215	C:4886 45.337 45.391 45.392 46.393	John St.	17 14 5766 17 12 17 12 17 12 17 12 17 20 17 21 17 21 17 21 17 22 17 22 17 22 17 22 17 22 17 22 17 22 17 3 3 14 3 41 3 50 3 50 3 50 3 50 3 86	9919699 9366441 8214363 8245541 9422455 9976026 1172833 1632739 163273
Mi_0520 Contig871 mango_rep_c24937 Mi_0186 Mi_0242 Mi_0204 Contig2867 Mi_0445 Mi_0400	111.24 105.849 105.604 95.072 91.707 89.59 83.745 82.659 78.35	4 Contig871 4 Mango_rep_c24937 4 Mi_0520 4 Mi_0186 4 Mi_0242 4 Mi_0204 4 Contig2867 4 Mi_0445 4 Mi_0486	1 13993390 1 13993415 1 14298008 1 14886799 1 15127120 1 15208153 1 15515955 1 15905673 1 16417706	mango_rep_ mango_rep_ mango_rep_ Mi_0473 mango_rep_ Mi_0505 Contig2556 mango_rep_ mango_rep_ mango_rep_ SKP009C1_ Mi_0335 SNP - LG3 mango_ct54 SSKP131C1_ mango_rep_ Mi_0556 Mi_0556 Mi_0556 Mi_0556 Mi_0556 Mi_0550 Mi_0152	C4886 45.337 45.391 45.392 45.392 45.392 45.392 45.392 45.392 45.292 45.292 45.292 45.292 46.	John Sass Sass Sass Sass Sass Sass Sass Sas	17 14 3766 17 11 3766 17 12 3 14 3 17 12 3 14 3 17 22 3 17 22 3 17 22 3 17 22 3 17 22 3 17 22 3 3 14 3 43 3 50 3 51 3 51 3 86 3 91	1919699 19566441 2214363 2245541 2042455 1976026 1172833 1632739 16327
Mi_0520 Contig871 mango_rep_c24937 Mi_0186 Mi_0242 Mi_0204 Contig2867 Mi_0445	111.24 105.849 105.604 95.072 91.707 89.59 83.745 82.659	4 Contig871 4 Mango_rep_c24937 4 Mi_0520 4 Mi_0186 4 Mi_0242 4 Mi_0204 4 Contig2867 4 Mi_0445	1 13993390 1 13993415 1 14298008 1 14886799 1 15127120 1 15208153 1 15515955 1 15905673	mango_rep_ mango_rep_ mango_rep_ Mi_0473 mango_rep_ Mi_0505 Contig2556 mango_rep_ mango_rep_ mango_rep_ mango_rep_ Mi_0505 SNP-LG3 mango_c154 SSKP131C1 mango_rep_ Mi_0155 Mi_0540 Mi_0540 Mi_0540 Mi_0215 Mi_0152 Mi_0133	C:4886 45.337 45.391 45.392 46.393	John St.	17 14 3766 17 11 17 14 2 11 17 12 110593 17 26 17 21 19 21 17 22 17 22 17 22 17 22 17 22 18 3 14 3 3 41 3 43 3 50 3 51 3 86 3 91	9919699  9966441  8214363  8245541  9422455  9976026  1172833  1632739  2098449  27774816  82876520  ———————————————————————————————————
Mi_0520 Contig871 mango_rep_c24937 Mi_0186 Mi_0242 Mi_0204 Contig2867 Mi_0445 Mi_0400	111.24 105.849 105.604 95.072 91.707 89.59 83.745 82.659 78.35	4 Contig871 4 Mango_rep_c24937 4 Mi_0520 4 Mi_0186 4 Mi_0242 4 Mi_0204 4 Contig2867 4 Mi_0445 4 Mi_0486	1 13993390 1 13993415 1 14298008 1 14886799 1 15127120 1 15208153 1 15515955 1 15905673 1 16417706	mango_rep_ mango_rep_ Mi_0473 mango_rep_ Mi_0505 Contig2556 mango_rep_ mango_rep_ mango_rep_ mango_rep_ SSKP0901_ Mi_0135 SMP - LG3 mango_ct54 SSKP131C1_ mango_rep_ Mi_0115 Mi_0556 Mi_0540 Mi_0540 Mi_0525 Mi_0333 Mi_0254	cc4886 45.337 45.191 45.192 45.192 45.192 45.192 45.192 45.192 45.192 45.192 45.192 46	John Sass Sass Sass Sass Sass Sass Sass Sas	17 14 3766 17 15 17 18 17 18 17 18 17 18 17 18 17 18 17 18 17 18 17 18 17 18 1	9919699 9966441 8214363 8245541 9042455 9976026 1172833 1632739 163273
Mi_0520 Contig871 mango_rep_c24937 Mi_0186 Mi_0242 Mi_0204 Contig2867 Mi_0445 Mi_0400 Mi_0486	111.24 105.849 105.604 95.072 91.707 89.59 83.745 82.659 78.35 77.819	4 Contig871 4 Mango_rep_c24937 Mi_0520 4 Mi_0186 4 Mi_0242 4 Mi_0204 4 Contig2867 4 Mi_0445 Mi_0486 4 Mi_0400	1 13993390 1 13993415 1 14298008 1 14886799 1 15127120 1 15208153 1 15515955 1 15905673 1 16417706	mango_rep_ mango_rep_ mango_rep_ Mi_0473 mango_rep_ Mi_0537 mango_rep_ Mi_0505 Contlig2556 mango_rep_ mango_rep_ mango_rep_ SSKP00961_ Mi_0135 SNP - LG3 mango_c154 SSKP13161_ mango_rep_ Mi_0115 Mi_0556 Mi_0540 Mi_0215 Mi_0552 Mi_0152 Mi_0333 Mi_02544 Mi_0339	cc4886 45.337 45.397 45	John State S	17 14 3766 17 11 17 12 18 17 12 19 17 12 19 17 17 19 17 17 17 17 17 17 17 17 17 17 17 17 18 18 18 18 18 18 18 18 18 18 18 18 18 1	9919699 9966441 8214363 8245541 9422455 9976026 1172833 1632739 163273
Mi_0520 Contig871 mango_rep_c24937 Mi_0186 Mi_0242 Mi_0204 Contig2867 Mi_0445 Mi_0400 Mi_0486 Mi_0018	111.24 105.849 105.604 95.072 91.707 89.59 83.745 82.659 78.35 77.819 72.999	4 Contig871 4 Mango_rep_c24937 4 Mi_0520 4 Mi_0186 4 Mi_0242 4 Mi_0204 4 Contig2867 4 Mi_0445 4 Mi_0486 4 Mi_0400 Mango_rep_c10257 4 Mi_0018	1 13993390 1 13993415 1 14298008 1 14886799 1 15127120 1 15208153 1 15515955 1 15905673 1 16417706 1 164976660 1 16868436	mango_rep_ mango_rep_ mango_rep_ Mi_0473 mango_rep_ Mi_0505 Contig2556 mango_rep_ mango_rep_ mango_rep_ mango_rep_ Mi_0505 SNPO051 SNPO051 Mi_0135 SNP - LG3 mango_rep_ Mi_0115 Mi_0540 Mi_0540 Mi_0540 Mi_0540 Mi_0540 Mi_0540 Mi_0333 Mi_0544 Mi_0339 Mi_0399 Mi_0388	cc4886 45.337 45.397 45	John Sass J. Mango_rep_c. Mango_rep_c. Mango_rep_c. Mangos J. Mango_rep_c. Mangos J. M	17 14 3766 17 11 17 12 18 17 12 19 17 12 19 17 17 19 17 17 17 17 17 17 17 17 17 17 17 17 18 18 18 18 18 18 18 18 18 18 18 18 18 1	9919699 5966441 214363 8245541 9422455 9976026 11772833 1632739 1632739 1632739 208849 27774816 2876520 287652
Mi_0520 Contig871 mango_rep_c24937 Mi_0186 Mi_0242 Mi_0204 Contig2867 Mi_0445 Mi_0400 Mi_0486 Mi_0018 mango_rep_c10257 mango_rep_c3169	111.24 105.849 105.604 95.072 91.707 89.59 83.745 82.659 78.35 77.819 72.999	4 Contig871 4 Mango_rep_c24937 Mi_0520 4 Mi_0186 4 Mi_0242 4 Mi_0204 5 Contig2867 4 Mi_0445 4 Mi_0486 6 Mi_0400 4 Mango_rep_c10257 6 Mi_0318 6 Mango_rep_c110257	1 13993390 1 13993415 1 14298008 1 14886799 1 15127120 1 15208153 1 15515955 1 15905673 1 16417706 1 16496660 1 16868436 1 16966816	mango_rep_ mango_rep_ mango_rep_ Mi_0473 mango_rep_ Mi_0505 Contig2556 mango_rep_ mango_rep_ mango_rep_ siskP009c1_ Mi_0335 SNP - 1.63 mango_t54 SSKP131(1 mango_rep_ Mi_0315 Mi_0556 Mi_0556 Mi_0556 Mi_0550 Mi_05152 Mi_05152 Mi_0333 Mi_0234 Mi_0338 mango_rep_ Mi_0348 mango_rep_	C4886 45.337  45.319  45.319  45.319  45.319  45.319  45.319  55.523  30.33  30.33  55.578  28.211  26.94  00  00  00  00  00  00  00  00  00	John Sass Sass Sass Sass Sass Sass Sass Sas	17 14 17 15 17 15 17 15 17 18 17 18 17 18 17 18 17 18 17 18 18 17 18 18 18 18 18 18 18 18 18 18 18 18 18	9919699 5966441 214363 8245541 9422455 9976026 11772833 1632739 1632739 1632739 208849 27774816 2876520 287652
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Mi_0520 Contig871 mango_rep_c24937 Mi_0186 Mi_0242 Mi_0204 Contig2867 Mi_0445 Mi_0400 Mi_0486 Mi_0018 mango_rep_c10257 mango_rep_c3169 Mi_0405 mango_c33092	111.24 105.849 105.604 95.072 91.072 89.59 83.745 82.659 78.35 77.819 72.999 72.515 70.451 69.331 68.302 53.673	4 Contig871 4 Mango_rep_c24937 Mi_0520 4 Mi_0186 4 Mi_0242 4 Mi_0204 4 Contig2867 4 Mi_0445 4 Mi_0440 4 Mango_rep_c10257 Mi_048 4 Mi_018 4 Mango_rep_c3169 4 Mi_040 4 Mango_rep_c33092	1 13993390 1 13993415 1 14298008 1 14886799 1 15127120 1 15208153 1 15515955 1 15905673 1 16417706 1 16868436 1 1799368 1 17199551 1 17245187 1 18064217	mango_rep_ mango_rep_ mango_rep_ Mi_0473 mango_rep_ Mi_0505 Contig2556 mango_rep_ Mi_0505 Contig2556 mango_rep_ mango_rep_ mango_rep_ mango_rep_ Mi_0135 SNP - LG3 mango_c154 SSKP131C1 mango_rep_ Mi_0156 Mi_0540 Mi_0540 Mi_0540 Mi_0540 Mi_0215 Mi_0333 Mi_0540 Mi_0333 Mi_0540 Mi_0399 Mi_0388 mango_rep_ Mi_0388 mango_rep_ Mi_0444 SSKP080C1_ SSKP081C1_ SSKP081C1_ SSKP081C1_	C4886 45.337 45.397 45.397 45.397 45.397 45.397 45.397 45.397 45.397 45.397 45.397 45.397 45.397 45.397 45.397 45.397 46.	John Sass January Company Comp	17 14 17 15 17 15 17 18 17 18 17 18 17 18 17 18 17 18 18 18 18 18 18 18 18 18 18 18 18 18	9919699 9966441 2214363 8245541 9422455 9976026 1172833 1632739 2098449 27774816 61552 9p 42004 61552 12434 80909 63733 43205 00849 95871 212842 21130 68088 68062 663936 603428
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Mi_0520 Contig871 mango_rep_c24937 Mi_0186 Mi_0242 Mi_0204 Contig2867 Mi_0445 Mi_0460 Mi_0486 Mi_0018 mango_rep_c10257 mango_rep_c3169 Mi_0140 Mi_0405 mango_c3092 Contig4503 Mi_0323 mango_c41026 Mi_0313	111.24 105.849 105.604 95.072 91.707 89.59 83.745 82.659 78.35 77.819 72.999 72.515 70.451 68.302 53.673 46.313 44.466 36.315 34.127 32.737	4 Contig871 4 Mango_rep_c24937 4 Mi_0520 4 Mi_0186 4 Mi_0242 4 Mi_0245 4 Mi_0445 4 Mi_04645 4 Mi_0400 4 Mango_rep_c10257 4 Mi_0410 4 Mi_0406 4 Mi_0436 4 Mi_0436 4 Mi_0436 4 Mi_0323 4 Mi_0323 4 Mi_0323	1 13993390 1 13993415 1 14298008 1 14886799 1 15127120 1 15208153 1 15515955 1 15905673 1 16417706 1 16496660 1 16868436 1 16966816 1 17199368 1 177245187 1 18064217 1 18341926 1 18351526 1 19081726 1 192855616	mango_rep_ mango_rep_ mango_rep_ Mi_0473 mango_rep_ Mi_0533 mango_rep_ Mi_0505 Contig2556 mango_rep_ mango_rep_ mango_rep_ siskP009c1_ Mi_0535 SNP - LG3 mango_rep_ siskP009c1_ Mi_0536 Mi_0545 SKP13161_ mango_rep_ Mi_0556 Mi_0556 Mi_0556 Mi_0552 Mi_0552 Mi_0552 Mi_0552 Mi_0333 Mi_0245 Mi_0338 mango_rep_ Mi_0044 SKRP0161_ SKRP1161_ SKRP080C1_ SKRP1161_ SKRP08C23_ Mi_0248 SKRP1161_ Mi_0544 Mi_0359 Mi_0388 Mi_0556 Mi_0544 Mi_0556 Mi_0556 Mi_0556 Mi_0557 Mi_0558 Mi_0558 Mi_0558 Mi_0558 Mi_0558 Mi_0558 Mi_0558 Mi_0559 Mi_0388 Mi_0569 Mi_0388 Mi_0569 Mi_0388 Mi_0569 Mi_0388 Mi_0569 Mi_0388 Mi_0569 Mi_0571	24886 45.337 2451 45.349 2451 2592 41.829 2592 41.829 2625 37.626 2625 30.536 2652 30.536 2652 41.726 2642 41.739 2652 41.739	John State    John State   John State    John State   John State    John State	17 14 17 16 17 17 17 18 17 18 1	9919699 59566441 8214363 8245541 9422455 9976026 11772833 1632739 1632
Mi_0520 Contig871 mango_rep_c24937 Mi_0186 Mi_0242 Mi_0204 Contig2867 Mi_0445 Mi_0400 Mi_0486 Mi_0018 mango_rep_c10257 mango_rep_c3169 Mi_0140 Mi_0405 mango_c33092 Contig4503 Mi_0456 Mi_0323 mango_c41026 Mi_0405	111.24 105.849 105.604 95.072 91.707 83.745 82.659 78.35 77.819 72.515 70.451 69.331 68.302 53.673 46.313 34.126 36.315 34.127 29.575	4 Contig871 4 Mango_rep_c24937 Mi_0520 4 Mi_0186 4 Mi_0242 4 Mi_0245 4 Mi_0445 4 Mi_0446 4 Mi_0480 4 Mango_rep_c10257 Mi_0140 4 Mango_rep_c10257 4 Mi_0140 4 Mi_05303 4 Mi_0405	1 13993390 1 13993415 1 1498008 1 14886799 1 15127120 1 15208153 1 15515955 1 15905673 1 16417706 1 164868436 1 1719968 1 1719968 1 1719968 1 18341926 1 18341926 1 18341926 1 193556316 1 193568 1 19964982	mango_rep_ mango_rep_ mango_rep_ mango_rep_ Mi_0473 mango_rep_ mango_rep_ Mi_0505 Contlig2556 mango_rep_ mango_rep_ mango_rep_ mango_rep_ mango_rep_ sSKP009C1_ Mi_0135 SNP - LG3 mango_rep_ Mi_0155 Mi_0556 Mi_0540 Mi_0215 Mi_0556 Mi_0540 Mi_0556 Mi_0540 Mi_0556 Mi_0540 Mi_0556 Mi_0540 Mi_0556 Mi_0584 Mi_0383 Mi_0244 SSKP080C1_ SSKP0	24846 45.337 45.337 45.337 45.338 45.	John Sass January Control of the Con	17 14 3766 17 11 37 12 31 17 12 31 17 12 31 17 12 31 17 12 31 17 12 31 17 12 31 17 12 31 14 31 1	9919699  \$5966441  \$214363  \$214363  \$2245541  \$422455  9976026  \$1172833  \$245541  \$422455  9976026  \$1172833  \$1632739  \$2098449  \$2774816  \$277
Mi_0520 Contig871 mango_rep_c24937 Mi_0186 Mi_0242 Mi_0204 Contig2867 Mi_0445 Mi_0400 Mi_0486 Mi_0018 mango_rep_c10257 mango_rep_c3169 Mi_0140 Mi_0456 mango_c33092 Contig4503 Mi_0456 Mi_0323 mango_c41026 Mi_0016 Mi_0016	111.24 105.849 105.604 95.072 91.707 89.59 83.745 82.659 77.819 72.999 72.515 68.302 53.673 46.313 44.466 36.315 34.127 32.737 29.575 23.612	4 Contig871 4 Mango_rep_c24937 Mi_0520 4 Mi_0520 4 Mi_0242 4 Mi_0204 5 Mi_045 6 Mi_046 6 Mi_0406 4 Mi_046 6 Mi_0400 4 Mango_rep_c10257 6 Mi_041 6 Mi_0406 6 Mi_0426 6 Mi_0323 6 Mi_0426 6 Mi_0323 6 Mi_0426 6 Mi_0323 6 Mi_0423 6 Mi_0423 6 Mi_0423	1 13993390 1 13993415 1 14298008 1 14886799 1 15127120 1 15208153 1 15515955 1 15905673 1 16417706 1 16966816 1 16966816 1 17199958 1 177245187 1 1804217 1 18341926 1 19349568 1 19349568 1 19349568 1 19349568 1 19496982	mango_rep_ mango_rep_ mango_rep_ mango_rep_ Mi_0473 mango_rep_ Mi_0505 Contig2556 mango_rep_ Mi_0135 SNP - LG3 mango_rep_ Mi_0155 Mi_0540 Mi_0540 Mi_0540 Mi_0540 Mi_0540 Mi_0333 Mi_0540 Mi_0333 Mi_0540 Mi_0399 Mi_0388 mango_rep_ Mi_0044 SSKF080C1_ SSKF080C1_ SSKF08C2C3_ Mi_0488 SSKP111C1_ mango_rep_ Mi_0711 Mi_0393 Mi_0399 Mi_0399 Mi_0388 Mi_0441 Mi_04711 Mi_	C:4886 45.337  C:4586 45.337  C:4586 45.337  C:4586 45.337  C:4586 45.338  C:4586	John State    John State   John State    John State   John State    John State	17 14 17 16 17 17 17 18 17 18 1	9919699 199269691 1982614163 18244461 182446163 18245541 19422455 19976026 11772833 1652739 16
Mi_0520 Contig871 mango_rep_c24937 Mi_0186 Mi_0242 Mi_0204 Contig2867 Mi_0445 Mi_0446 Mi_0018 mango_rep_c10257 mango_rep_c3169 Mi_0140 Mi_0405 mango_c3092 Contig4503 Mi_0456 Mi_0323 mango_c41026 Mi_00423 Mi_0423 Mi_0276 mango_rep_c9316	111.24 105.849 105.604 95.072 91.707 89.59 83.745 82.659 77.819 72.515 70.451 68.302 53.673 44.466 36.315 34.127 29.575 23.612 23.612	4 Contig871 4 Mango_rep_c24937 4 Mi_0520 4 Mi_0186 4 Mi_0242 4 Mi_0245 4 Mi_0445 4 Mi_0446 4 Mi_0466 4 Mi_0400 4 Mango_rep_c10257 6 Mi_01018 4 Mango_rep_c3169 4 Mi_0406 4 Mi_0436	1 13993390 1 13993415 1 1429808 1 14886799 1 15127120 1 15208153 1 15515955 1 15905673 1 16417706 1 16496660 1 16868436 1 17199368 1 77199651 1 17245187 1 18064217 1 18341926 1 19381526 1 19981726 1 19981726 1 19949982 1 19961442 1 19961442	mango_rep_ mango_rep_ mango_rep_ mango_rep_ Mi_0473 mango_rep_ mango_rep_ Mi_0505 Contlig2556 mango_rep_ mango_rep_ mango_rep_ mango_rep_ mango_rep_ sSKP009C1_ Mi_0135 SNP - LG3 mango_rep_ Mi_0155 Mi_0556 Mi_0540 Mi_0215 Mi_0556 Mi_0540 Mi_0556 Mi_0540 Mi_0556 Mi_0540 Mi_0556 Mi_0540 Mi_0556 Mi_0584 Mi_0383 Mi_0244 SSKP080C1_ SSKP0	24846 45.337 45.337 45.337 45.338 45.	John Sass January Control of the Con	17 14 3766 17 11 37 12 31 17 12 31 17 12 31 17 12 31 17 12 31 17 12 31 17 12 31 17 12 31 14 31 1	9919699  \$5966441  \$214363  \$214363  \$2245541  \$422455  9976026  \$1172833  \$245541  \$422455  9976026  \$1172833  \$1632739  \$2098449  \$2774816  \$277
Mi_0520 Contig871 mango_rep_c24937 Mi_0186 Mi_0242 Mi_0204 Contig2867 Mi_0445 Mi_0400 Mi_0486 Mi_0018 mango_rep_c10257 mango_rep_c3169 Mi_0140 Mi_0456 mango_c33092 Contig4503 Mi_0456 Mi_0323 mango_c41026 Mi_0016 Mi_0016	111.24 105.849 105.604 95.072 91.707 89.59 83.745 82.659 77.819 72.999 72.515 68.302 53.673 46.313 44.466 36.315 34.127 32.737 29.575 23.612	4 Contig871 4 Mango_rep_c24937 Mi_0520 4 Mi_0520 4 Mi_0242 4 Mi_0204 5 Mi_045 6 Mi_046 6 Mi_0406 4 Mi_046 6 Mi_0400 4 Mango_rep_c10257 6 Mi_041 6 Mi_0406 6 Mi_0426 6 Mi_0323 6 Mi_0426 6 Mi_0323 6 Mi_0426 6 Mi_0323 6 Mi_0423 6 Mi_0423 6 Mi_0423	1 13993390 1 13993415 1 14298008 1 14886799 1 15127120 1 15208153 1 15515955 1 15905673 1 16417706 1 16966816 1 16966816 1 17199958 1 177245187 1 1804217 1 18341926 1 19349568 1 19349568 1 19349568 1 19349568 1 19496982	mango_rep_ mango_rep_ mango_rep_ mango_rep_ Mi_0473 mango_rep_ Mi_0505 Contig2556 mango_rep_ Mi_0135 SNP - LG3 mango_rep_ Mi_0155 Mi_0540 Mi_0540 Mi_0540 Mi_0540 Mi_0540 Mi_0333 Mi_0540 Mi_0333 Mi_0540 Mi_0399 Mi_0388 mango_rep_ Mi_0044 SSKF080C1_ SSKF080C1_ SSKF08C2C3_ Mi_0488 SSKP111C1_ mango_rep_ Mi_0711 Mi_0393 Mi_0399 Mi_0399 Mi_0388 Mi_0441 Mi_04711 Mi_	C:4886 45.337  C:4586 45.337  C:4586 45.337  C:4586 45.337  C:4586 45.338  C:4586	John Sass January Control of the Con	17 14 3766 17 11 37 12 31 17 12 31 17 12 31 17 12 31 17 12 31 17 12 31 17 12 31 17 12 31 14 31 1	9919699  \$5966441  \$214363  \$214363  \$2245541  \$422455  9976026  \$1172833  \$245541  \$422455  9976026  \$1172833  \$1632739  \$2098449  \$2774816  \$277
Mi_0520 Contig871 mango_rep_c24937 Mi_0186 Mi_0242 Mi_0204 Contig2867 Mi_0445 Mi_0446 Mi_0018 mango_rep_c10257 mango_rep_c3169 Mi_0140 Mi_0405 mango_c3092 Contig4503 Mi_0456 Mi_0323 mango_c41026 Mi_00423 Mi_0423 Mi_0276 mango_rep_c9316	111.24 105.849 105.604 95.072 91.707 89.59 83.745 82.659 77.819 72.515 70.451 68.302 53.673 44.466 36.315 34.127 29.575 23.612 23.612	4 Contig871 4 Mango_rep_c24937 4 Mi_0520 4 Mi_0186 4 Mi_0242 4 Mi_0245 4 Mi_0445 4 Mi_0446 4 Mi_0466 4 Mi_0400 4 Mango_rep_c10257 6 Mi_01018 4 Mango_rep_c3169 4 Mi_0406 4 Mi_0436	1 13993390 1 13993415 1 1429808 1 14886799 1 15127120 1 15208153 1 15515955 1 15905673 1 16417706 1 16496660 1 16868436 1 17199368 1 77199651 1 17245187 1 18064217 1 18341926 1 19381526 1 19981726 1 19981726 1 19949982 1 19961442 1 19961442	mango_rep_ mango_rep_ mango_rep_ mango_rep_ Mi_0473 mango_rep_ Mi_0505 Contig2556 mango_rep_ Mi_0135 SNP - LG3 mango_rep_ Mi_0155 Mi_0540 Mi_0540 Mi_0540 Mi_0540 Mi_0540 Mi_0333 Mi_0540 Mi_0333 Mi_0540 Mi_0399 Mi_0388 mango_rep_ Mi_0044 SSKF080C1_ SSKF080C1_ SSKF08C2C3_ Mi_0488 SSKP111C1_ mango_rep_ Mi_0711 Mi_0393 Mi_0399 Mi_0399 Mi_0388 Mi_0441 Mi_04711 Mi_	C:4886 45.337  C:4586 45.337  C:4586 45.337  C:4586 45.337  C:4586 45.338  C:4586	John Sass January Control of the Con	17 14 3766 17 11 37 12 31 17 12 31 17 12 31 17 12 31 17 12 31 17 12 31 17 12 31 17 12 31 14 31 1	9919699  \$5966441  \$214363  \$214363  \$2245541  \$422455  9976026  \$1172833  \$245541  \$422455  9976026  \$1172833  \$1632739  \$2098449  \$2774816  \$277
Mi_0520 Contig871 mango_rep_c24937 Mi_0186 Mi_0242 Mi_0204 Contig2867 Mi_0445 Mi_0400 Mi_0486 Mi_0018 mango_rep_c10257 mango_rep_c3169 Mi_0140 Mi_0405 mango_c33092 Contig4503 Mi_0456 Mi_0323 mango_c41026 Mi_0403 Mi_0423 Mi_0276 mango_rep_c4916 Mi_0276	111.24 105.849 105.604 95.072 91.707 89.59 83.745 82.659 78.35 77.819 72.5915 70.451 69.331 68.302 53.673 46.313 34.127 32.737 29.575 23.612 18.261	Contig871  Mango_rep_c24937  Mi_0520  Mi_0520  Mi_0186  Mi_0242  Mi_0245  Mi_0445  Mi_0445  Mi_0446  Mi_0480  Mango_rep_c10257  Mi_0140  Mango_rep_c13169  Mi_0140  Mi_0405  M	1 13993390 1 13993415 1 1498008 1 14886799 1 15127120 1 15208153 1 15515955 1 15905673 1 16417706 1 16496600 1 16868436 1 17199368 1 17199451 1 18341926 1 18341926 1 1935576 1 19355616 1 19349982 1 19961442 1 20413731 1 20155570	mango_rep_ mango_rep_ mango_rep_ mango_rep_ Mi_0473 mango_rep_ Mi_0505 Contig2556 mango_rep_ Mi_0135 SNP - LG3 mango_rep_ Mi_0155 Mi_0540 Mi_0540 Mi_0540 Mi_0540 Mi_0540 Mi_0333 Mi_0540 Mi_0333 Mi_0540 Mi_0399 Mi_0388 mango_rep_ Mi_0044 SSKF080C1_ SSKF080C1_ SSKF08C2C3_ Mi_0488 SSKP111C1_ mango_rep_ Mi_0711 Mi_0393 Mi_0399 Mi_0399 Mi_0388 Mi_0441 Mi_04711 Mi_	C:4886 45.337  C:4586 45.337  C:4586 45.337  C:4586 45.337  C:4586 45.338  C:4586	John Sass January Control of the Con	17 14 3766 17 11 37 12 31 17 12 31 17 12 31 17 12 31 17 12 31 17 12 31 17 12 31 17 12 31 14 31 1	9919699  \$5966441  \$214363  \$214363  \$2245541  \$422455  9976026  \$1172833  \$245541  \$422455  9976026  \$1172833  \$1632739  \$2098449  \$2774816  \$277



### Figure 1

**B.** Alignment of the mango linkage groups (Kuhn et al., 2017) (left) and mango physical chromosomes (right) based on the same SNPs and mapped to the 5, 6, 7, 8, 9 and 10 chromosomes of the Mangifera indica 'Alphonso' reference genome CATAS\_Mindica\_2.1 (GCA\_011075055.1)

IP-LG16	cM To	Chr SNP - Chr5	To LG bp	SNP - LG19	cM To C	hr SNP - Chr 6	To LG
	0	5Mi_0483	16 160311	Contig560	0	6 Mi_0422	To LG 19 6032
go_rep_c8308	4.251	5 Mango_rep_c8308	16 766185	Mi_0422	1.86	6 Contig560	19 6564
_0299	8.636	5-Mi_0299	16 945276	Mi_0082	20.042	6Mi_0082	19 10561
ango_rep_c5581	10.559	5Mango_rep_c5581	16 1145640	mango_rep_c8996	25.018	6 Mango_rep_c8996	19 14523
mango_rep_c19882	12.995	5Mango_rep_c19882	16 1567896				
Mi_0151	29.192	5Mi_0151	16 7915397	SSKP049C1_C234T	25.144	6 Contig2850	19 15756
Contig1082	37.989	5, Contig2761	16 8833199	Contig2850	25.506	6 SSKP049C1_C234T	19 16791
mango_rep_c4440	55.843	5 Contig1082	16 9591660	SSKP004C1_A448G	26.592	6 SSKP004C1_A448G	19 17682
Mi_0126	57.2	5Mango_rep_c4440	16 10175147	Mi_0236	26.846	6 Mi_0236	19 18822
Mi_0506	63.027	5 Mi_0126	16 10219684	SSKP015C5_A260G	28.294	6SSKP015C5_A260G	19 20198
Mi_0119	68.179	5 Mi_0506	16 10552847	Contig1052	28.913	3 Contig2005	19 271934
Contig813	72.837	5Mi_0119	16 11132215	Contig_3049_A145G	38.296	6\ Contig445	19 280455
Mi_0411	81.464	5 Contig813	16 11246454	Contig2005	39.028	6 Mango_rep_c51872	19 29007
Mi_0464	82.742	5 Mi_0411	16 11704125			/	
Contig3904	97.495	5 Mi_0464	16 11851723	Contig445	39.75	V /-	19 316645
Contig1327	100.399	5 Contig3904	16 12450165	mango_rep_c51872	40.919	6 Mango_c19283	19 338761
Mi_0488	103.022	5 Contig1327	16 12587495	mango_c19283	42.272	6 Mango_rep_c3802	19 340829
Mi_0017	103.319	5 Mi_0017	16 12694789	mango_rep_c3802	42.272	6 Mi_0512	19 343310
Mi_0249	109.39	5 Mi_0488	16 12708118	Mi_0512	44.988	6 Contig2898	19 482040
Mi_0396	118.476	5 Mi_0249	16 12972004	Mi_0365	45.432	6/ Mi_0232	19 487687
Contig_1634_C97T	119.432	5 Mi_0396	16 13693534	Mi_0232	65.904	6 Mi 0131	19 581113
Mi_0298	120.973	5 Contig_1634_C97T	16 13801799	Contig2898	74.586	6 Contig5308	19 636441
Mi_0052	121.23	5 Mi_0298	16 14018961	Mi_0131	85.663	6 Contig1309	19 636818
Mi_0217	125.78	5 Mi_0052	16 14044340	(60)		V/	
Mi_0501	131.355	5 Mi_0217	16 14337349	mango_c14671	92.501	6 Contig1732	19 648387
Contig2761	140.777	5 Mi_0501	16 14902368	Mi_0374	93.1	6 Mango_c14671	19 652589
mango_c32234	145.703	5 Mango_c32234	16 15597967	Contig1732	94.289	6 Contig_3049_A1456	
Mi_0240	163.181	5 Contig430	10 15772575	Contig1309	96.505	6// Mi_0374	19 667701
Mi_0474	165.392	5 Mi_0240	16 16361789	Contig5308	97.573	6/ Mango_rep_c4366	19 682047
Mi_0418	169.138	5 Mi_0474	16 16545463	mango_rep_c4366	101.912	6 Mango_rep_c39598	19 738526
Mi_0363	170.846	5Mi_0418	16 17015838		108.562	6 Mi_0440	19 799628
Contig2251	171.717	17 Mi_0363	16 17117434		113.604	6 Mango_rep_c17905	19 834801
mango_rep_c4378	173.972	8 Mi_0529	16 17297698		121.896	6 Mi_0189	19 894492
Mi_0521	175.167	5Mi_0521	16 17306073	W01=0000			
Mi_0529	175.446	5 Mango_rep_c48374			122.994		19 957088
mango_rep_c48374	178.703	5 Mango_rep_c8037	16 17672747	Contig135	126.69	6	
mango_rep_c8037	181.885	5 Mi_0320	16 18133966				
Contig_2012_C154T	183,521	8 Mi_0272	16 18140613				
Contig4078	188.329	5 Contig4078	16 18154573				
Mi_0320	189.228	5 MI_0026	16 18210752				
Mi_0272	189.228	5 MI_0551	16 18245199				
Mi_0026	192.014	5 M_0128	16 18430957				
Mi_0551	192.066	5 Mango_rep_c6225	16 18516299				
Mi_0128	194.877	5 Mi_0053	16 18567192				
mango_rep_c6225	195.011	5 Mi_0270	16 18578885				
Mi_0053	196.679	5 Mi_0179	16 18598734				
Mi_0485	196.861	5 Mi_0118	16 18644101				
Mi_0270	197.467	5 Mi_0485	16 18718416				
Mi_0179	197.844	5 Mi_0050	16 19188941				
Wi_0118	198.257	5 Mango_rep_c6636	16 19189840				
Mi_0050	206.363	5 MI_0408	16 19597360				
mango_rep_c6636	206.676	5 Mi_0317	16 19641916				
Mi_0317	211.345	5 Mi_0237	16 19743886				
vi_0408	211.548	5/ SSKP134C3_A487G	16 19769976				
MI_0545	212.636	5 Mi_0234	16 19792179				
Mi_0234	213.14	5 Mi_0545	16 19810505				
Wi_0237	213.551	5/ Mango_c19388	16 19990925				
SSKP134C3_A487G	214.07	5/ Mi_0057	16 20089298				
mango_c19388	214.656	5 Contig352	16 20150371				
Mi_0057	217.182	5 Mi_0175	16 20163961				
Mi_0011	218.179	5 Mi_0011	16 20204687				
Contig352	218.289	5/ Mi_0038	16 20310172				
Mi_0175	218.559	5 Mi_0262	16 20437708				
Mi_0038	219.437	5 MI_0006	16 20550329				
MI_0262	220.162	5 Mi_0261	16 20574920				
Mi_0261	221.743	5 / Mi_0216	16 20823207				
Mi_0006	222.185	5/ Mi_0061	16 20875169				
Mi_0325	225.864	5Mi_0325	16 20926548				
Mi_0061	226.079	5/					
Mi 0216	228.013						



	cM T	o Chr SNP - Chr7	To LG	bp	SNP - L	LG10	cM To C	hr s	NP - Chr8	To LG	bp	
SSKP054C1_A861G	0	7 Mi_0181	2	3623247	Mi_025		0		Mi_0258	10	673543	
mango_rep_c50209	6.714	7 SSKP054C1_A861G	11	15081654	Mi_047		0.713		Mi_0477	10	693546	
mango_rep_c28055	8.041	7 Mango_rep_c6932	11	15419796	Mi_046		0.714		Wi_0532	10	730643	
mango_rep_c6932	8.642	7 Mango_rep_c50209	11	15510606	Mi_053		0.733		Mi_0468	10	764067	
mango_rep_c14171	12.777	7 Mango_rep_c28055	11	15530801	Contigé		5.625		Contig662	10	995410	
SSKP027C2_C495T	14.13	7 Mi_0159	11	15907254		o_rep_c4658	11.35		Mango_rep_c4658	10	1398097	
Mi_0159	14.132	7 Mango_rep_c14171	11	15997661	Mi_031		40.166		Contig_2012_C154T		2536758	
SSKP026C1_A1002T	14.817	7SSKP026C1_A1002T	11	16296361	Mi_039		44.794		Mi_0311		2697000	
Contig1567	15.615	7 SSKP027C2_C495T	11	16299029	Contig4	THE STATE OF THE PARTY OF THE P	67.439		Mango_rep_c4378	1 200	2700124	
mango_c48384	17.685	7 Contig1567	11	16317010			72.669	1	Wi_0390		2947119	
mango_rep_c52196	17.758	7Mango_c48384	11	16473751	Mi_047		74.803	1	Contig430		4292080	
Mi_0100	18.373	7 Mango_rep_c52196	11	16497955		o_rep_c53253	75.738	1	SKP107C1_A1014G	10	4681912	
Mi_0229	28.535	7 Mi 0100		16852025	Contigs		78.918		Mi_0478		4961363	
Mi_0048	30.817	7Mi_0229		17331773	Mi_015		91.619		Mango_rep_c53253	10	5045608	
Mi_0386	34.545	7 Mi 0048		17609700	Mi_009		92.11	11	Contig889		5090438	
Mi_0448	35.024	7 Mi 0386		17806765		o_rep_c14290	92.375		Mango_rep_c10854		6176131	
Contig343	37,477	7 Mi 0448		17825307		o_rep_c10854	92.432		Mango_rep_c14290		6188988	
SSKP025C1_A784G	42.873	7 Contig343		18059257		o_rep_c7681	94.229	1	Wi_0097		6212490	
SSKP025C1_A784G Mi 0307					Contig <sup>4</sup>		94.5	1	Wi_0153	10	6241408	
	43.05	11		18097698		o_rep_c4763	98.897		Mango_rep_c7681	10	6433075	
SSKP045C3_C621T	57.464	7 SSKP025C1_A784G		18277010		o_rep_c2106	99.57	1	Contig4240	10	6435901	
mango_rep_c8480	62,363	7 Mi_0307		18357541	Mi_010		101.44		Mango_rep_c4763	10	6669722	
mango_rep_c4422	64.899	7 S5KP045C3_C621T		18756840	Contig3	T-0000000	103.006		Mango_rep_c2106	10	6708326	
Mi_0136	68.44	7 Mango_rep_c8480		19032564	Mi_034		104.187	1	Mi_0105	10	6788959	
Mi_0051	75.261	7 Mango_rep_c4422		19371963	Mi_017		104.692	1 1	Contig3651	10	6951371	
Mi_0005	77.238	7 Mi_0136	11	19618856	Mi_047		109.715		Wi_0476	10	7118871	
		Mi_0051	11	20101471	Contig1		112.813	1	Mi_0345	10	7180827	
		Mi_0005	11	20393512	Mi_010		113.089	1	Mi_0177	10	7196284	
							118.233		Contig1199	10	7587219	
					Mi_023		118.387		Wi_0103	10	7711452	
					Mi_037		120.042		Mango_rep_c10386	10	7974419	
							120.517		SKP122C1_C873T	10	8008462	
					Mi_043		131.666	1	Mi_0231	10	8065502	
					Mi_027		136.577	1	Wi_0373	10	8263035	
					Contig1		137.977	-	Mi_0438	10	9057728	
					Contigs	g866	142.09	8.	Contig1344	10	9173333	
								1				
					Mi_044		145.071		Mi_0278	10	9349041	
					Mi_044 Mi_051	518	162.389	8	Mi_0278 Contig866	10 10	9349041 9576784	
					Mi_044 Mi_051 mango	518 o_rep_c9158	162.389 171.735	8	Mi_0278 Contig866 Mi_0442	10 10 10	9349041 9576784 9682631	
					Mi_044 Mi_051 mango Contig!	518 o_rep_c9158 g1686	162.389 171.735 174.79	8	Mi_0278 Contig866 Ni_0442 Mi_0518	10 10 10	9349041 9576784 9682631 10857894	
					Mi_044 Mi_051 mango	518 o_rep_c9158 g1686	162.389 171.735	8	Mi_0278 Contig866 Mi_0442 Mi_0518 Mango_rep_c9158	10 10 10 10 10	9349041 9576784 9682631 10857894 11355056	
					Mi_044 Mi_051 mango Contig!	518 o_rep_c9158 g1686	162.389 171.735 174.79	8 8 8 8	Mi_0278 Contig866 Mi_0442 Mi_0518 Wango_rep_c9158 Contig1686	10 10 10 10 10 10	9349041 9576784 9682631 10857894 11355056 11785404	
					Mi_044 Mi_053 mango Contigt Mi_032	518 to_rep_c9158 tg1686 329	162.389 171.735 174.79 186.529	8 8 8 8	Mi_0278 Contig866 Mi_0442 Mi_0518 Mango_rep_c9158 Contig1686 Mi_0329	10 10 10 10 10 10 10	9349041 9576784 9682631 10857894 11355056 11785404 12676773	
Name of the last o	-	To Chr SNP-Chr9	То	-	Mi_044 Mi_0532 mango_ Contig: Mi_032	518 to_rep_c9158 g1686 329	162.389 171.735 174.79 186.529	8 8 8 8 8 8 7	Mi_0278 Contig866 Mi_0442 Mi_0518 Mango_rep_c9158 Contig1686 Mi_0329 SNP-Chr10	10 10 10 10 10 10 10 To LG	9349041 9576784 9682631 10857894 11355056 11785404 12676773	
Mi_0493	247.848	9 Contig2668		17 260149	Mi_044 Mi_053 mango, Contigt Mi_032 SNP - Mi_054	518 50_rep_c9158 10_g1686 329 - LG 2 543 1	162.389 171.735 174.79 186.529 cM To (35.589	8 8 8 8 8 8 10 Chr	Mi_0278 Contig866 Mi_0442 Mi_0518 Mongo_rep_c9158 Contig1686 Mi_0329  SNP - Chr10  "Contig3006	10 10 10 10 10 10 10 10 To LG	9349041 9576784 9682631 10857894 11355056 11785404 12676773 bp	9
Mi_0493 Mi_0349	247.848 246.721			17 260149 8 1214497	Mi_044 Mi_053 mango Contigt Mi_032  SNP - Mi_054	518 50_rep_c9158 10_g1686 329 - LG 2 543 10_g3006	162.389 171.735 174.79 186.529 CM To (35.589 133.16	8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	Mi_0278 Contig866 Mi_0442 Mi_0518 Mango_rep_c9158 Contig1686 Mi_0329 SNP - Chr10 Contig3006 ™i_0543	10 10 10 10 10 10 10 10 10 10 10 10 10 1	9349041 9576784 9682631 10857894 11355056 11785404 12676773 bp 262169 457830	)
Ai_0493 Ai_0349 Ai_0460	247.848 246.721 244.508	9 Contig2668 9 Mi_0493 9 Mi_0349		17 260149 8 1214497 8 1265734	Mi_044 Mi_053 mango_ Contigt Mi_032 SNP - Mi_054 Contigt Contigt	518 : : : : : : : : : : : : : : : : : : :	162,389 171,735 174,79 186,529 CM To ( 35,589 133,16 10,064	8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	Mi_0278 Contig866 Mi_0442 Mi_0518 Mango_rep_c9158 Contig1686 Mi_0329 SNP - Chr10 "Contig3006 "Mi_0543 Contig1627	10 10 10 10 10 10 10 10 To LG	9349041 9576784 9682631 10857894 11355056 11785404 12676773 bp 262169 457830 2166335	) ) 5
VII_0493 VII_0349 VII_0460	247.848 246.721	9 Contig2668 9 Mi_0493		17 260149 8 1214497	Mi_044 Mi_053 mango Contigt Mi_032 SNP - Mi_054 Contigt Mi_04 Contigt Mi_04	518 :	162,389 171,735 174,79 186,529 OM To 0 35,589 133,16 10,064 00,517	8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	Mi_0278 Mi_0278 Contig866 Mi_0442 Mi_0518 Mango_rep_c9158 Contig1686 Mi_0329 SNP - Chr10 "Contig3006 "Mi_0543 Contig1627 _Contig3071	10 10 10 10 10 10 10 10 To LG 2 2 2	9349041 9576784 9682631 10857894 11355056 11785404 12676773 bp 262169 457830 2166335 2846875	5
Mi_0493 Mi_0349 Mi_0460 Mi_0542	247.848 246.721 244.508	9 Contig2668 9 Mi_0493 9 Mi_0349		17 260149 8 1214497 8 1265734	Mi_044 Mi_053 mango Contigt Mi_032  SNP - Mi_054 Contigt Contigt Mi_037	518 to rep_c9158 gt686 s29 - LG 2 s43 sg3006 gg1627 1 s12 1 gg3071 1 1	162.389 171.735 174.79 186.529 CM To C 35.589 133.16 10.064 00.517 00.156	2hr 10 10 10 10	Mi_0278 Contig866 Ail_0442 Mi_0518 Mango_rep_c9158 Contig1686 Mi_0329 SNP - Chr10 "Contig3006 "Mi_0543 Contig1627 _Contig3071 "Mi_0312	10 10 10 10 10 10 10 10 10 2 2 2 2 2 2	9349041 9576784 9682631 10857894 11355056 11785404 12676773 bp 262169 457830 2166335 2846875 2919807	5
Mi_0493 Mi_0349 Mi_0460 Mi_0542 Contig_6532_A130T	247.848 246.721 244.508 242.811	9 Contig2668 9 Mi_0493 9 Mi_0349 9 Mi_0460		17 260149 8 1214497 8 1265734 8 1422430	Mi_044 Mi_053 mango Contigt Mi_032  SNP - Mi_054 Contigt Mi_032 Contigt Mi_033	518 g1686 g1686 g1686 g29 LG 2 LG 2 g2006 g1627 1 g2071 1 g20771 1 g207	162.389 171.735 174.79 186.529 OM To 0 35.589 133.16 10.064 00.517 00.156 99.824	2hr 10 10 10 10 10 10 10 10 10 10 10 10 10	Mi_0278 Contig866 Ai_0442 Mi_0518 Mango_rep_c9158 Contig1686 Mi_0329 SNP - Chr10 Contig3006 Mi_0543 Contig1627 _Contig3071 Mi_0313 Thingorep_c21634	10 10 10 10 10 10 10 2 2 2 2 2 2	9349041 9576784 9682631 10857894 11355056 11785404 12676773 bp 262169 457830 2166335 2846875 2919807 2985745	5 5 7
Ai_0493 Ai_0349 Ai_0460 Ai_0542 Contig_6532_A130T SKP115C1_A7176	247.848 246.721 244.508 242.811 209.899	9 Contig2668 9 Mi_0493 9 Mi_0349 9 Mi_0460 9 Mi_0542	эт	17 260149 8 1214497 8 1265734 8 1422430 8 1529158	Mi_044 Mi_053 mango Contigt Mi_032  SNP - Mi_054 Contigt Mi_032 Contigt Mi_034 mango mango	518 to rep_c9158 g1686 g1686 g1686 g1686 g1627 1 312 1 g3001 g3071 to rep_c21634 to rep_c5764	CM TO C 35.589 133.16 10.064 00.517 00.156 99.824 91.83	2hr 10 10 10 10 10 10 10 10 10 10 10 10 10	Ni _0.278 Contig866 Ni _0.442 Ni _0.518 Ni _0.518 Ni _0.518 Ni _0.518 Ni _0.518 Ni _0.518 Ni _0.519 Ni _0.543 Contig.1054 Contig.1057 Time _0.543 Time _0.5443 Time	10 10 10 10 10 10 10 10 10 10 10 10 10 1	9349041 9576784 9682631 10857894 11355056 11785404 12676773 bp 262169 457830 2166335 2846875 2919807 2985745 3144816	7 7 5
Ai_0493 Ai_0349 Ai_0460 Ai_0542 Ontig_6532_A130T SKP115C1_A717G Contig2997	247.848 246.721 244.508 242.811 209.899 198.315	9 Contig2668 9 Mi_0493 9 Mi_0349 9 Mi_0460 9 Mi_0542 9 Contig_6532_A130	эт	17 260149 8 1214497 8 1265734 8 1422430 8 1529158 8 2986773	Mi_044 Mi_055 mango_ Contigit Mi_032  SNP - Mi_054 Contigit Contigit Contigit Mi_033	518 to rep_c9158 to rep_c91634 to re	CM To C 35.589  171.735  174.79  186.529  CM To C 35.589  133.16  10.064  00.517  00.156  99.824  91.83  89.951	8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	Mi_0278 contig866 Mi_0442 Mi_0518 Mango_rep_c9158 contig1686 Mi_0329 SNP - Chr10 "Contig3006 Mi_0329 Contig1627 _Contig3071 Mi_0312 Mango_rep_c21634 "Mi_0312 "Mango_rep_c21634 "Mi_0246	10 10 10 10 10 10 10 10 10 10 10 10 10 1	9349041 9576784 9682631 10857894 11355056 11785404 12676773 bp 262169 457830 2166335 2846875 2919807 2985745 3144816 3290207	7
M_0493 M_0499 M_0460 M_0542 Contig_6532_A130T SKP115C1_A717G Contig2997 M_0187	247.848 246.721 244.508 242.811 209.899 198.315 198.314	9 Contig2668 9 Mij 0.493 9 Mij 0.493 9 Mij 0.949 9 Mij 0.942 9 Contig_6532_A136 9 SSKP155C1_A7176	эт	17 260149 8 1214497 8 1265734 8 1422430 8 1529158 8 2986773 8 6256081	Mi_044 Mi_055 mango, Contigi Mi_032  SNP - Mi_054 Contigi Contigi Mi_031 Contigi mango, mango Mi_024 Mi_024	518 to rep_c9158 to rep_c9158 to rep_c9158 to rep_c9158 to rep_c9168 to rep_c5764 t	162.389 171.735 174.79 186.529 OM To (0 355.589 133.16 10.064 00.517 00.156 99.824 91.83 89.951 85.667	8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	Mi_0.278 ini_0.278	10 10 10 10 10 10 10 10 10 10 10 10 10 1	9349041 9576784 9682631 10857894 11355056 11785404 12676773 bp 262169 457830 2166335 2846875 2919807 2985745 3144816 3290207 3488245	5 5 5 7 5 5 7
Mi_0493 Mi_0349 Mi_0460 Mi_0542 Contig_6532_A130T SSKP115C1_A717G Contig2997 Mi_0187 mango_rep_c5137	247.848 246.721 244.508 242.811 209.899 198.315 198.314 195.856	9 Contig2668 9 Mi 0493 9 Mi 0449 9 Mi 0460 9 Mi 0542 9 Contig 6532_A133 9 SKRP15C1_A7276 9 Contig2997	эт	17 260149 8 1214497 8 1265734 8 1422430 8 1529158 8 2986773 8 6256081 8 6502356	Mi_044 Mi_052 mango, Contigit Mi_032  SNP Mi_054 Contigit Contigit Contigit mi_033 Contigit mango, mango Mi_024 Mi_026 Mi_026 Mi_026	518 co.rep_c9158 :gt1686 :gt1686 :gt29 : - LG 2	162.389 171.735 174.79 186.529  OM To C 35.589 133.16 10.064 00.517 00.156 99.824 91.83 89.951 89.954 85.435	8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	Mi_0278 Contig866 Mi_0442 Mi_0518 Mi_0518 Mi_0518 Mi_0518 Mi_0518 Mi_0329 SNP_Chr10 "Contig1086 Mi_0329 Contig107 TONIG107 Mi_0543 Contig107 TMi_0543 TMi_027 Mi_027 Mi_027 Mi_027 Mi_027 Mi_027 Mi_0266 TMi_0276	10 10 10 10 10 10 10 10 10 10 10 10 10 1	9349041 9576784 9682631 10857894 11355056 11785404 12676773 bp 262169 457830 2166335 2846875 2919807 2985745 3144816 3290207 3488245 3510272	5 5 7 5 5 7
ME_0493 ME_0460 ME_0542 Contig_6532_A130T SSKP115C1_A717G Contig2997 ME_0187 mango_rep_c5137 ME_0279	247.848 246.721 244.508 242.811 209.899 198.315 198.314 195.856 195.33	9 Contig2668 9 Mil 0943 9 Mil 0949 9 Mil 0940 9 Mil 0960 9 Mil 0952 9 Contig 2532_A130 9 SKP115C1_A7176 Contig2997 9 Mil 0187	эт	17 260149 8 1214497 8 1265734 8 1422430 8 1529158 8 1529158 8 2986773 8 6256081 8 6502356 8 8122507	Mi_044 Mi_055 mango Contigt Mi_032  SNP - Mi_054 Contigt Mi_033 Contigt mango Mi_024 Mi_027 Mi_027 Mi_028 Mi_027 Mi_028 Mi_027 Mi_028 Mi_038	518 to rep_c9158 : g1686 s29	162.389 171.735 174.79 186.529  CM To (  35.589 133.16 10.064 00.517 00.156 99.824 91.83 89.951 85.667 85.435 84.19	8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	Mi_0.278 contig862 di_0.042 di_0.042 di_0.0518 di_0.0518 contig1686 di_0.0329 fi_0.0540 Contig1006 Mi_0.0543 Contig3006 Mi_0.0543 Contig3071 Mi_0.0543 Mi_0.0543 Mi_0.0543 Mi_0.0543 Mi_0.0543 Mi_0.0543 Mi_0.0543 Mi_0.0543 Mi_0.0543 Mi_0.0561 Mi_0.0565 Mi_0.	10 10 10 10 10 10 10 10 10 10 10 10 10 1	9349041 9576784 9682631 10857894 11355056 11785404 12676773 bp 262169 457830 2166335 2846875 2919807 2985745 3144816 3290207 3488245 3510272 4207417	5 5 5 7 7 5 5 5 7
Mi_0493 Mi_0449 Mi_04460 Mi_0542 Contig_6532_A130T SSKP115C1_A7176 Contig2997 Mi_0187 mango_rep_c5137 Mi_0279 SSKP038C1_A444G	247.848 246.721 244.508 242.811 209.899 198.315 198.314 195.856 195.33 194.885	9 Contig2668 9 Mi 0493 9 Mi 0499 9 Mi 0549 9 Mi 0542 9 Contig 6532_A130 9 SKP115C1_A7370 0 Contig2697 9 Mi 05187 9 SKP308C1_A4440	or 3	17 260149 8 1214497 8 1265734 8 1422430 8 1529158 8 2986773 8 6256081 8 6502356 8 8122507 8 8368945	Mi_044 Mi_055 mango_ Contigt Mi_032  SSTP Mi_054 Contigt Mi_032  Contigt Mi_034 Mi_04 Mi_018 Mi_04 Mi_018 Contigt Mi_018	518	CM TO C C C C C C C C C C C C C C C C C C	8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	Mi_0.78 contig86 contig86 ii_0.442 ii_0.518 Mango_rep_c9158 contig1686 ii_0.329 SNP- Chr10 "Contig3006 "Mi_0.543 Contig1627 _Contig3071 "Mi_0.312 "Mango_rep_c21634 "Mango_rep_c21634 "Mango_rep_c5764 "Mi_0.266 "Mi_0.172 -Contig1205" Contig1205" Contig1205 Contig1205 Contig1205 Contig1205	10 10 10 10 10 10 10 10 10 10 10 10 10 1	9349041 9576784 9682631 10857894 11355056 11785404 12676773 bp 262169 457830 2166335 2846875 2919807 2985745 3144816 3290207 3488245 3510272 4207417 4207816	7 7 5 5 5 7 7 5 5 5 5 7 7 5 5 5 5 7 7 5 5 5 5 5 7 7 5 5 5 5 5 7 7 7 5 5 5 5 5 7 7 7 5 5 6 7 7 7 5 5 6 7 7 7 5 5 6 7 7 7 5 6 7 7 7 5 7 7 7 7
AL_0493 AL_0460 AL_0460 AL_0542 DONIE_6532_A130T SKP115C1_A7176 Centig2997 AL_0187 PEP_G5137 AL_0187 SKP038C1_A4446 AL_0314	247.848 246.721 244.508 242.811 209.899 198.315 198.314 195.856 195.33 194.885	9 Contig2668 9 Mi 0493 9 Mi 0499 9 Mi 0460 9 Mi 0542 9 Contig_6532_A130 9 SKP115C1_A7270 0 Contig_079 Mi 0387 9 SKP38C1_A4440 Mi 0279 9 Mi 0287	or 3	17 260149 8 1214497 8 1265734 8 1422430 8 1529158 8 2986773 8 6256081 8 6502356 8 8122507 8 8368945 8 8448777	Mi_044 Mi_055 mango_ Contigit Mi_032  SNP - Mi_054 Contigit Contigit Mi_033 Contigit Mi_034 Mi_024 Mi_026 Mi_01 Mi_018 Contigit Mi_031 Contigit	518 0, rep. 43158 : gi686   - LG 2   543	162.389 171.735 174.79 186.529  OM To C 35.589 133.16 10.064 00.156 99.824 91.83 91.83 89.951 85.667 85.435 84.19 66.315	8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	Mi_0278 contig869 ili_0442 ili_0442 ili_0548 ili_0548 contig1686 ili_0329 ili_0548 contig1686 ili_0329 ili_0548 contig16906 Twin_0543 contig1627contig3071 Twin_0543 contig1627contig1627contig2071 Twin_0312 Mango_rep_c21634 Twin_0312contig1205*contig1205*contig1205*contig1205*contig1205*contig1205*contig1205*contig1205*contig1205*	10 10 10 10 10 10 10 10 10 10 10 10 10 1	9349041 9576784 9682631 10857894 11355056 11785404 12676773 bp 262169 457830 2166335 2846875 2919807 2985745 3144816 3290207 3488245 3510272 4207417 4207816 4511311	5 5 5 7 7 5 5 5 7 7 5 5 5 5 7 7 5 5 5 5
AL_0493 AL_0349 AL_0349 AL_0542 SONTE, 5532_A130T SKP115C1_A717G SKP115C1_A717G AL_0279 AL_0279 SKP038C1_A444G AL_0314 SKP085C1_C285G	247.848 246.721 244.508 242.811 209.899 198.315 198.314 195.856 195.33 194.885 194.846 192.55	9 Contig2668 9 Mi 0943 9 Mi 0949 9 Mi 0460 9 Mi 0562 9 Contig 5932_A130 9 SKP115C1_A7176 Contig2997 9 Mi 0187 9 SKP038C1_A4446 Mi 0279 Mango_reg_C5137	or 3	17 260149 8 1214497 8 1265734 8 1422430 8 1529158 8 2986773 8 6256081 6 8502356 8 8122507 8 8368945 8 8448777 8 8992256	Mi_044 Mi_055 mango Contigi Mi_032  SNP Mi_054 Contigi Mi_033 Contigi Mi_031 Contigi Mi_031 Contigi Mi_031 Contigi Contigi Mi_016 Contigi Mi_026 Mi_017 Mi_018 Contigi Mi_018 Contigi Mi_018 Mi_018 Mi_018 Mi_018 Mi_018	518   10 prep_c9158   12 prep_c9158   12 prep_c9158   12 prep_c9168   12 prep_	CM TO C 35.589  CM TO C 35.589  133.16  10.064  00.517  00.156  99.824  99.83  89.951  85.667  70.337  88.419  70.337  70.335	8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	Mi_0.78 contig86 contig86 di_0.042 di_0.042 di_0.018 di_0.019 di_0.018 di_0.029 SNP - Chrl 10 Contig1006 - Mi_0.043 Contig2007 - Mi_0.043 Contig2071 - Mi_0.026 - Mi_0.046 - Mi_0.046 - Mi_0.046 - Mi_0.026 - Mi_0.026 - Mi_0.026 - Mi_0.028 - Mi_	10 10 10 10 10 10 10 10 10 10 10 10 10 1	9349041 9576784 9682631 10857894 11355056 11785404 12676773 bp 262169 457830 2166335 2846875 2919807 2985745 3144816 3290207 3488245 3510272 4207417 4207417 4207816 4511311 5104070	5 5 5 7 7 5 5 2 7 7 5 5 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
M_0493 M_0349 M_0549 M_0560 M_0542 Contig_6532_A130T SSKP115C1_A7176 Contig_997 M_0187 Fe_05137 M_0187 SSKP038C1_A4446 M_0314 M_0314 Fe_058KP038C1_A4446 M_0314 Fe_058KP038C1_A9446 M_038KP038C1_A9446 M_038KP038C1_A946 M_038KP038C1_A946 M_038KP038C1_A946 M_038KP038C1_A946 M_038KP038C1_A946 M_038KP0	247,848 246,721 244,508 242,811 209,899 198,315 198,314 195,856 195,33 194,885 194,846 192,55	9 Contig2668 9 Mi 0493 9 Mi 0493 9 Mi 0460 9 Mi 0542 Contig.0532_A136 9 SSKP115C1_A7176 Contig2997 Mi 0187 9 Mi 0187 9 Mi 0279 Mi 0279 Mi 0374 Mi 0374 Mi 0374 Mi 0374	or 3	17 260149 8 1214497 8 1265734 8 1422430 8 14529158 8 2986773 8 6256081 8 6502356 8 8122507 8 8368945 8 8448777 8 8992256 8 9360817	Mi_044 Mi_055 mango, Contigit mango, Contigit Mi_032  SNP - Mi_054 Contigit Contigit Contigit mango, mango, Mi_024 Mi_026 Mi_026 Mi_026 Mi_026 Mi_0106 Contigit Contigit Contigit Mi_031 Mi_018 SNF01 SNF01 SNF01 SNF01 SNF01	518 o, rep. c9158 : g1686 s229 - LG 2	cM To ( 174.79 186.529  cM To ( 25.589 133.16 10.064 00.517 00.156 99.824 91.83 89.951 85.667 85.435 84.19 70.337 66.315 63.782	8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	Mi_0278 Ontig869 Ontig869 Mi_0518 Mi_0518 Mi_0518 Mi_0518 SNP - Chr10 Contig1686 Mi_0329 SNP - Chr10 Contig16971 Mi_0543 Contig1627 Contig1627 Contig1627 Mi_0312 Mango_rep_c21634 Mi_0246 - Mi_0246 - Mi_0246 - Mi_0246 SSKP011C2_A4156 - Mi_0188 - SSKP011C2_A4156 - Mi_0128	10 10 10 10 10 10 10 10 10 10 10 10 10 1	9349041 9576784 9682631 10857894 11355056 11785404 12676773 bp 262169 457830 2166335 2846875 2919807 2985745 3144816 3290207 3488245 3290207 3488245 3490207 4207417 4207417 4207416 4511311 5104070 6173949	7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7
E_0493 E_0349 E_0542 ontig_6532_A130T KKP115C1_A7170 ontig2997 E_0187 E_0279 KKP038C1_A4446 E_0279 KKP038C1_A4446 E_0314 KKP038C1_C2850 KKP038C1_C2850	247,848 246,721 244,508 242,811 209,899 198,315 198,314 195,856 195,856 194,885 194,885 194,8743	9 Contig2668 9 Mi 0943 9 Mi 0949 9 Mi 0940 9 Mi 0940 9 Contig 5932_A130 9 SKP915C1_A717C Contig2997 9 Mi 0187 9 Mi 0279 Mi 0187 9 Mi 0314 9 SKP085C1_C2850	or 3	17 260149 8 1214497 8 1265734 8 1422430 8 1529158 8 2986773 8 6256081 8 6502356 8 8122507 8 8368945 8 848277 8 848275 8 9360817 8 9629880	Mi_054 Mi_055 mango Contigt Mi_032  SNP Mi_054 Contigt Mi_033 Contigt mango mango Mi_024 Mi_026 Mi_071 Mi_018 Contigt Contigt Mi_071 Mi_018 Contigt Mi_071 M	518   18   18   18   18   18   18   18	CM To C To	8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	Mi_0.78 Ontig866 Ontig867 Mi_0.042 Mi_0.042 Mi_0.042 Mi_0.042 Mi_0.042 Mi_0.042 SNP-Chr10 "Contig1006 Mi_0.042 Tontig1006 Mi_0.042 Mi_0.043 Mi_0.043 Mi_0.043 Mi_0.046 Mi_0.047 Mi_0.182 Mi_0.047 Mi_0.184 Mi_0.046 Mi_0.047 Mi_0.048 Mi_0.04	10 10 10 10 10 10 10 10 10 10 10 10 10 1	9349041 9576784 9682631 10857894 11355056 11785404 12676773 bp 262169 457830 2166335 2919807 2985745 3144816 3510272 407411 4207816 4511311 5104070 6173949 6190890	5 5 5 7 7 5 5 5 5 1 5 5 5 5 5 5 5 5 5 5
8_0493 8_0349 8_0542 ontig_6532_A130T \$\$\$\$715C1_A717G ontig2997 8_0187 8_0187 8_0279 \$\$\$\$\$738C1_A444G 8_0314 \$\$\$\$\$4446 8_0314 \$\$\$\$\$\$6736C1_C285G nango_rep_c3996 \$\$\$\$\$\$\$\$87037C2_A644G 8_0533	247,848 246,721 244,508 242,811 209,899 198,315 198,314 195,856 194,846 192,55 190,122 187,743 182,744	9 Contig2668 9 Mi 0493 Mi 0499 9 Mi 0460 Mi 0549 9 Contig_6532_A130 9 SKP115C1_A717C 0 Contig_797 Mi 0187 9 SKP018C1_A4440 Mi 0279 Mi 0314 9 SKP03RC1_A4640 9 Mi 0314 9 SKP03RC1_CA660 9 Mi 0314 9 SKP03RC1_CA660 9 Mi 0314	or i	17 260149 8 1214497 8 1265734 8 1422430 8 1529158 8 2986773 8 6256081 8 6502356 8 8122507 8 8368945 8 8448777 8 8992256 9 960817 9 960817 8 9629880 8 10368022	Mi_044 Mi_055 mango, Contiging Mi_032  SSIP Mi_054 Contiging Mi_031 Contiging Mi_031 Contiging Mi_031 Contiging Mi_024 Mi_024 Mi_024 Mi_025 Mi_013 Mi_014 Source Contiging Mi_017 Mi_018 SSKPO1	518   10 _ rep_c9158   1	162.389 171.735 171.7479 186.529  cM To C 35.589 133.16 10.064 00.517 00.156 99.824 91.83 99.824 91.83 85.667 85.435 84.19 70.337 66.315 66.315 66.3782 51.27 34.815	8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	Mi_0.278 Mi_0.18 Mi_0.	10 10 10 10 10 10 10 10 10 10 10 10 10 1	9349041 9576784 9682631 10857894 11355056 11785404 12676773 2166335 2846875 2919807 2919807 2985745 3144816 3290207 3488245 3510272 4207417	5 5 5 7 7 5 5 5 2 7 7 7 5 5 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
AL_0493 AL_0493 AL_0490 AL_0490 AL_0542 AL_0542 AL_0542 AL_0542 AL_0542 AL_0542 AL_0542 AL_0542 AL_0542 AL_0543	247,848 246,721 244,508 242,811 209,899 198,315 198,314 195,856 195,33 194,885 194,846 192,25 190,122 187,743 182,744 171,349	9 Contig2668 9 Mi 0943 9 Mi 0949 9 Mi 0940 9 Mi 0940 9 Contig 5932_A130 9 SKP915C1_A717C Contig2997 9 Mi 0187 9 Mi 0279 Mi 0187 9 Mi 0314 9 SKP085C1_C2850	or i	17 260149 8 1214497 8 1265734 8 1422430 8 1529158 8 2986773 8 6502356 8 8122507 8 8368945 8 848777 8 8992256 8 9360817 8 9609880 8 10368022 8 10444144	Mi_044 Mi_055 mango, Contiging Mi_032  SSIP Mi_054 Contiging Mi_031 Contiging Mi_031 Contiging Mi_031 Contiging Mi_024 Mi_024 Mi_024 Mi_025 Mi_013 Mi_014 Source Contiging Mi_017 Mi_018 SSKPO1	518	162.889 171.735 1714.79 186.529  OM To C 35.589 133.16 10.064 00.517 00.156 99.824 99.824 99.8389.951 85.667 85.435 84.19 70.337 66.315 63.782 63.782 33.95	8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	Mi_0.78 Ontig866 Ontig867 Mi_0.042 Mi_0.042 Mi_0.042 Mi_0.042 Mi_0.042 Mi_0.042 SNP-Chr10 "Contig1006 Mi_0.042 Tontig1006 Mi_0.042 Mi_0.043 Mi_0.043 Mi_0.043 Mi_0.046 Mi_0.047 Mi_0.182 Mi_0.047 Mi_0.184 Mi_0.046 Mi_0.047 Mi_0.048 Mi_0.04	10 10 10 10 10 10 10 10 10 10 10 10 10 1	9349041 9576784 9682631 10857894 11355056 11355056 11355056 262166 457830 2166335 2846875 2919807 2985745 3144816 3510272 4207417 4207816 4511311 5104070 6173949 6190890 6374875 6456471	5 5 5 7 7 5 5 5 7 7 5 5 7 7 7 5 5 7
ME_0493 ME_0499 ME_0542 ME_0542 ME_0542 ME_0542 ME_0542 ME_0542 ME_0542 ME_0542 ME_0543 ME_054	247.848 246.721 244.508 242.811 299.899 198.315 195.856 195.33 194.886 192.55 190.122 187.743 182.744 171.349 169.277 168.57	9 Contig2668 9 Mi 0943 Mi 0949 9 Mi 0940 9 Mi 0940 9 Mi 0952 9 Contig 5932_A136 9 SSKP115C1_A7176 Contig2997 Mi 0187 9 Mi 0187 9 Mi 0187 9 Mi 0187 9 SSKP03SC1_A4446 9 Mi 0344 9 SSKP03SC1_C2856 9 SSKP03SC1_C2856 2 Mango_rep_c3198 9 Mango_rep_c3198	or i	17 260149 8 1214497 8 1214497 8 1422434 8 1422434 8 1529158 8 2986773 8 6256081 8 6502356 8 8122507 8 8448777 8 8992256 8 9360817 8 962988 8 10368022 8 1044144 8 11518552 8 11512351	Mi_044 Mi_055 mango_ Contigit Mi_032  SNP Mi_056 Contigit Contigit Contigit Mi_033 Contigit Contigit Contigit Contigit Contigit Mi_034 Mi_026 Mi_027 Mi_018 Contigit Contigit Contigit Contigit Contigit Mi_018 SSKPO Mi_019 mango_ ma	518	162.389 171.735 171.7479 186.529  cM To C 35.589 133.16 10.064 00.517 00.156 99.824 91.83 99.824 91.83 85.667 85.435 84.19 70.337 66.315 66.315 66.3782 51.27 34.815	8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	Mi_0.278 Mi_0.18 Mi_0.	10 10 10 10 10 10 10 10 10 10 10 10 10 1	9349041 9576784 9682631 10857894 11355056 11785404 12676773 2166335 2846875 2919807 2919807 2985745 3144816 3290207 3488245 3510272 4207417	5 5 5 7 7 5 5 5 7 7 5 5 7 7 7 5 5 7
#[_0493 #[_0349 #[_0549 #[_0542 contig_6532_A130T \$80P115C1_A7176 contig_997 #[_0279 #[_0279 #[_0279 #[_0279 #[_0279 #[_0279 #[_0279 #[_0279 #[_0279 #[_0279 #[_0279 #[_0279 #[_0279 #[_0533 #[_0068 #[_0533 #[_0068	247,848 246,721 244,508 242,811 209,899 198,315 198,314 195,856 195,33 194,885 194,885 192,55 190,122 187,743 182,744 171,349 169,277 168,57	9 Contig2668 9 Mi 0943 Mi 0949 9 Mi 0949 9 Mi 0949 9 Mi 0942 9 Contig 6532_A130 9 SKP115C1_A717C 0 Contig2697 9 Mi 0187 9 SKP038C1_A4446 9 Mi 0279 9 Mang_rep_c5137 9 Mi 0314 9 SKP08SC1_C2850 9 SKP08SC1_C2850 9 Mi 0314 1 Mi 0316 1 Mi 0068 9 Mi 0068	or i	17 260149 8 1214497 8 142497 8 1422430 8 1422430 8 1529158 8 5296673 8 6256081 8 650256 8 842257 8 8448777 8 899225 8 992080 8 992080 8 1056002 8 10544144 8 11518552 8 115211279	Mi_044 Mi_055 mango_ Contigit Mi_032  SNP Mi_056 Contigit Contigit Contigit Mi_033 Contigit Contigit Contigit Contigit Contigit Mi_034 Mi_026 Mi_027 Mi_018 Contigit Contigit Contigit Contigit Contigit Mi_018 SSKPO Mi_019 mango_ ma	518   10 prep_c9158   12 prep_c9158   12 prep_c9158   12 prep_c9158   12 prep_c9168   12 prep_	162.889 171.735 1714.79 186.529  OM To C 35.589 133.16 10.064 00.517 00.156 99.824 99.824 99.8389.951 85.667 85.435 84.19 70.337 66.315 63.782 63.782 33.95	8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	Mi_0.278 contig866 ili_0.042 ili_0.043 ili_0.046 ili_0.0	10 10 10 10 10 10 10 10 10 10 10 10 10 1	9349041 9576784 9682631 10857894 11355056 11355056 11355056 262166 457830 2166335 2846875 2919807 2985745 3144816 3510272 4207417 4207816 4511311 5104070 6173949 6190890 6374875 6456471	5 5 5 7 7 5 5 5 1 1 1 1 1 1 1 1 1 1 1 1
ME_0493 ME_0493 ME_04949 ME_04642 ME_0542 Contig_6532_A130T SSEP115C1_A737G Contig_1997 ME_0187 ME_02197 ME_02197 ME_0314 ME_0314 ME_0314 ME_0314 ME_0314 ME_0314 ME_0314 ME_0314 ME_0318 ME_0314 ME_0318 ME_0314 ME_0318 ME_0	247.848 246.721 244.508 242.811 198.315 198.314 195.856 194.885 194.846 192.55 190.122 187.743 182.744 171.349 169.277 168.52 163.122 154.529	9 Contig2668 9 Mi 0943 9 Mi 0949 9 Mi 0949 9 Mi 0542 9 Contig 6532_A136 9 SKP115C1_A7176 Contig2997 Mi_0217 9 SKP003C1_A4444 Mi_0279 Mango_rep_c5137 9 Mi_0314 9 SKP003C1_C2856 9 SKP003C1_C2856 9 Mango_rep_c100 Mi_0088 9 Mi_0117 9 Mi_0319	or i	17 260149 8 1214497 8 1224497 8 1422430 8 1422430 8 1529158 8 6256081 8 6502356 8 812507 8 812507 8 8992256 8 9468777 8 9962980 8 1036802 8 10444144 8 1151855 8 1151855 8 11521551 8 11221559 8 112357509	Mi_044 Mi_052 mango_ Contigit Mi_032  SNP Mi_054 Contigit Mi_024 Mi_026 SSROW Mi_027 mango_ mango_ mango_ mango_ contigit Cont	518	162.889 177.735 174.79 186.529  OM To C 35.589 133.16 10.064 00.517 00.156 00.157 85.435 91.83 89.951 85.667 85.435 66.315 66.315 66.315 63.782 51.27 34.815 33.92 32.955	8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	Mi_0.278  ontig866 Mi_0.422 Mi_0.518 Mi	10 10 10 10 10 10 10 10 10 10 10 10 10 1	9349041 9576784 9682631 10857894 11355056 2616635 216633 21663 216633 21663 216633 216633 216633 216633 216633 216633 216633 216633 216633 216633 216633 216633 216633 216633 216633 216633 216633 216633 21	5 5 5 7 7 5 5 5 7 7 7 5 5 5 5 5 5 5 5 5
ME_0493 ME_0499 ME_0494 ME_0460 ME_0542 Contig_6532_A130T SSRP115C1_A7176 Contig_6997 ME_0279 ME_02797 ME_02797 ME_02797 ME_02797 ME_02797 ME_02797 ME_03333 ME_0048 ME_03333 ME_0048 ME_03339 ME_03339 ME_03339	247,848 246,721 244,508 242,811 209,899 198,315 195,856 195,33 194,885 194,885 194,743 182,744 171,349 169,277 168,57 163,122 154,529 154,529 154,529	9 Contig2668 9 Md 0493 9 Md 0493 9 Md 0460 9 Md 0542 9 Contig_6532_A130 9 SKP115C1_A717C 0 Contig_979 Md 0187 9 SKP038C1_A4846 9 Md 0279 9 Mango_rep_c5137 9 Md 0314 9 SKP038C1_C2664 2 Mango_rep_c396 9 Margo_rep_1308 9 Md 0014	or i	17 260149 8 124497 8 124497 8 1422430 8 1529158 8 5296673 8 6256081 8 6902356 8 8448777 8 869825 8 8982256 8 9902080 8 10368022 8 10444144 8 11518552 8 11521151 8 11521155 8 12211279 8 12357509	Mi_044 Mi_052 mango_ Contigit Mi_032  SNP Mi_054 Contigit Mi_024 Mi_026 SSROW Mi_027 mango_ mango_ mango_ mango_ contigit Cont	518	162.889 171.735 1714.79 186.529  CM To (  CM To	8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	Mi_0.278 Ontig869 Ontig869 Mi_0.942 Mi_0.9518 Mi_0.9518 Mi_0.9518 Ontig1686 Mi_0.329 SNP - Chr10 Contig16906 Mi_0.329 Mi_0.9518 Contig1627 Contig1627 Contig3071 Mi_0.312 Mango_rep_c21634 Mi_0.246 Mi_0.246 Mi_0.246 Mi_0.246 Mi_0.248 SSKP011C2_A4150 Mi_0.188 SSKP011C2_A4150 Mi_0.188 Mi_0.274 Mi_0.188 Mi_0.274 Mi_0.188 Mi_0.274 Mi_0.189 Mi_0.274 Mi_0.189 Mi_0.274 Mi_0.189 Mi_0.274 Mi_0.189 Mi_0.274 Mi_0.197 Mi_0.197 Mi_0.197 Mi_0.197 Mi_0.197 Mi_0.197 Mi_0.197 Mi_0.197 Mi_0.197 Mi_0.274 Mi_0.197	10 10 10 10 10 10 10 10 10 10 10 10 10 1	9349041 9576784 9682631 10857894 11355056 411785404 112676773 11785404 12676773 12663635 12919800 12663635 12919800 13900704 14907417 1490741	5 5 5 7 7 5 5 5 7 7 7 5 5 1 1 1 1 1 1 1
SSEP - LOB ML_0403 ML_0460 ML_0542 ML_0542 ML_0542 SSEP115C1_A7176 Contig_532_A130T SSEP115C1_A7176 Contig_5397 ML_0518 ML_051	247.848 246.721 244.508 242.811 209.899 198.315 198.314 195.856 195.856 194.846 192.55 190.122 187.743 182.744 171.349 169.277 168.57 163.122 154.529 145.674	9 Contig2668 9 Mi 0493 Mi 0493 9 Mi 0499 Mi 0460 9 Mi 0542 9 Contig 6532_A136 9 SKP115C1_A717C 0 Contig2699 9 Mi 0187 9 Mi 0187 9 Mi 0187 9 Mi 0219 9 Mingo_rep_c5137 9 Mi 0219 9 Mingo_rep_c5137 9 Mi 0314 9 Mingo_rep_c5137 9 Mi 0314 9 Mingo_rep_c5137 9 Mingo_rep_c5137 9 Mi 0314 9 Mingo_rep_c1308 9 Mingo_rep_c1308 9 Mingo_rep_c1308 9 Mingo_rep_c1308	or i	17 260149 8 121497 8 1265798 8 1422430 8 1529158 8 2986773 8 625081 8 6502356 8 8122507 8 8368945 8 844877 8 8992256 8 936887 8 962988 1 10444144 8 11518552 8 11521551 8 11521551 8 12211279 8 12357509 8 12712330	Mi_044 Mi_055 mango Contigit Mi_032  SNP Mi_054 Contigit Mi_033 Contigit mango mango Mi_024 Mi_026 Mi_010 Mi_021 Mi_031 Contigit mango contigit mango contigit	518   100_rep_c9158   12686   12697   1279	162.889 177.735 1774.79 186.529  CM To C 355.889 133.16 10.064 00.517 00.156 00.517 85.667 85.435 87.70,337 66.315 63.782 51.27 33.92 33.92 33.92 33.92 31.195	8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	Mi_0.78 ontig866 ini_0.422 ini_0.518 ini_0.422 ini_0.518 ini_0.428 ini_0.518 contig1686 ini_0.329 SNP- Chr10 "Contig1006 "Mi_0.548 SNP- Chr10 "Contig3006 "Mi_0.548 "Mi_0.748 "M	10 10 10 10 10 10 10 10 10 10 10 10 10 1	9349041 9576784 9576784 11355056 9682631 11355056 11785404 12676773  hp 261168373 221663373 2219690373 3144816 33900270 4207417 44207417 44207417 44207417 461908906 6106786 65600778 65575606 6600778	5 5 5 7 7 5 5 5 7 7 5 5 5 7 7 5 5 5 7 7 5 5 5 7 7 7 5 5 5 7 7 7 5 5 5 5 7 7 7 5 5 5 5 7 7 7 5 5 5 5 5 7 7 7 5 5 5 5 5 7
ME_0493 ME_0499 ME_0490 ME_0542 ME_0542 ME_0542 ME_0542 ME_0542 ME_0543 ME_054	247,848 246,721 244,508 242,811 209,899 198,315 195,856 195,33 194,885 194,885 194,743 182,744 171,349 169,277 168,57 163,122 154,529 154,529 154,529	9 Contig2668 9 Mi 0943 9 Mi 0949 9 Mi 0940 9 Mi 0940 9 Mi 0952 9 Contig 6592_A130 9 SKP115C1_A7176 9 Contig 2997 Mi 0147 9 Mi 0147 9 Mi 027 9 Min 0314 9 SKP085C1_C285C 2 Mango_rep_1308 9 Mi 0088 9 Mi 017 9 Min 0339 9 Min 0329 9 Min 0329 9 Min 0421	3 i i i i i i i i i i i i i i i i i i i	17 260149 8 121497 8 1265734 8 1422430 8 1529158 8 1529158 8 2986773 8 6256081 8 8092256 8 8488777 8 8992256 8 950817 8 10368022 8 1044144 8 11518552 8 11521531 8 12211279 8 1221279 8 1233579 8 12712330 8 12712330 8 12712330	Mi_044 Mi_055 mango_ Contigit Mi_032  SNP Mi_056 Contigit Contigit Mi_033 Contigit Contigit Mi_033 Contigit Contigit Mi_031 Contigit Contigit Mi_026 Mi_0	518	162.889 1717.735 1714.79 186.529  CM To C 35.589 133.16 10.064 10.064 91.83 99.951 99.824 91.83 99.951 85.667 85.435 84.419 70.337 66.315 66.315 65.782 51.27 34.815 33.92 32.955 31.248 31.195 31.009	8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	Mi_0.278  ontig866  iii, 0.442  iii, 0.518  iii, 0.442  iii, 0.518  iii, 0.518  iii, 0.518  iii, 0.518  iii, 0.518  iii, 0.518  iii, 0.529  SNP - Chr1.01  Contig1686  iii, 0.329  SNP - Chr1.01  Contig1607  Tontig1006  Tili, 0.53  Tili, 0.53  Tili, 0.543  Tili, 0.543  Tili, 0.72  Mango_rep_c3764  Mi_0.274  Mi_0.274  Mi_0.274  Mi_0.188  SSKP0.11C2_A415G  Mi_0.274  Mango_rep_c4965  -Mango_rep_c4965  -Mango_rep_c4965  -Mango_rep_c4965  -Mango_rep_c4965  -Mango_rep_c4965  -Mango_rep_c361463  -Contig1500  Tili, 0.0264  Mi_0.024	10 10 10 10 10 10 10 10 10 10 10 10 10 1	9349041 9576784 9682631 10857894 111785404 12676773 221863353 2846873 221980 221980 3144816 329020 348245 45783 3144816 45783 3144816 45783 4578	5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
ME_0493 ME_0499 ME_0499 ME_0542 Contig_6532_A130T SSPP135C1_A7176 Contig2997 ME_0187 ME_02197 ME_02197 ME_02197 ME_02197 ME_03197 ME_03197 ME_0319	247.848 246.721 244.508 242.811 209.899 198.315 198.314 195.856 195.856 194.846 192.55 190.122 187.743 182.744 171.349 169.277 168.57 163.122 154.529 145.674	9 Contig2668 9 Mi 0493 Mi 0499 9 Mi 0460 9 Mi 0542 9 Contig 6532_A130 9 SKP115C1_A717C 0 Contig_5939 Mi 0187 9 SKP038C1_A4446 9 Mi 0219 9 Mang_rep_c5137 9 Mi 0319 9 Mi 0329 9 Mi 0481 9 Mi 0481 9 Mi 0481 9 Mi 0481	) 1	17 260149 8 1214974 8 1224978 8 1422490 8 1422490 8 1422490 8 2986773 8 620256 8 8122507 8 8368847 8 8960817 8 960981 8 10588022 8 1058802 8 11518552 8 1152132 8 12211279 8 12327509 8 1232772	Mi_044 Mi_055 mango_ Contigit Mi_032  SNP Mi_056 Contigit Contigit Mi_033 Contigit Contigit Mi_033 Contigit Contigit Mi_031 Contigit Contigit Mi_026 Mi_0	518   10, rep. c) 518   12   13   13   13   13   13   13   13	162.889 171.735 174.79 186.529  CM To (  35.589 133.16 10.064 00.517 00.156 99.824 99.183 89.951 85.435 84.19 70.337 66.315 63.782 63.782 32.955 31.248 31.195 31.099 30.563	8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	Mi_0.78 contig866 contig867 di_0.042 di_0.0518	10 10 10 10 10 10 10 10 10 10 10 10 10 1	9349041 9576784 9576784 9682631 10857894 111785404 112676773 262166335 2846873 2249807 3144816 3290207 3488245 3510272407 4207816 457830 6600778 7127512	
ME_0493 ME_0499 ME_0499 ME_0542 Contig_6532_A130T SSPP135C1_A7176 Contig2997 ME_0187 ME_02197 ME_02197 ME_02197 ME_02197 ME_03197 ME_03197 ME_0319	247.848 246.721 244.508 242.811 209.899 198.315 198.314 195.856 195.856 194.846 192.55 190.122 187.743 182.744 171.349 169.277 168.57 163.122 154.529 145.674	9 Contig2668 9 Mi 0943 Mi 0949 9 Mi 0949 9 Mi 0949 9 Mi 0949 9 Contig 6532_A136 9 SKP115C1_A717C 0 Contig 299 Mi 0187 9 Mi 018	) 1	17 260149 8 121497 8 126579 8 126579 8 1422430 8 1529158 8 2986773 8 6256081 8 8122507 8 8368945 8 892256 8 946877 8 8992256 8 946887 8 946888 9 942988 8 1036802 8 1044814 8 1151855 8 11521515 8 1152151 8 12211279 8 12357509 8 1271230 8 1271230 8 1291302 8 1291302 8 1362772 8 1506918 8 1506918	Mi_044 Mi_055 manage Contligit Mi_032  SNP - Mi_056 Contligit Contligit Contligit Mi_033 Contligit manage manage Mi_024 Mi_026 Mi_026 Mi_010 Mi_021 Contligit Contligit Contligit Contligit manage manage Mi_026 Mi_010 Mi_027 manage manage contligit manage	518   10, rep. c) 518   12   13   13   13   13   13   13   13	162.889 177.735 174.79 186.529  OM To C 35.589 133.16 10.064 00.517 00.156 00.517 85.467 85.437 87.467 85.437 85.437 85.437 84.19 70.337 66.315 63.782 51.27 33.92 32.955 31.195 31.1059 30.563 24.366	8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	Mi_0.278  ontig866 ili_0.042 ili_0.0412 ili_0.0418 ili_0.0419 ili_0.0418 ili_0.0419 ili_0.0418 ili_0.0419 ili_0.0418 ili_	10 10 10 10 10 10 10 10 10 10 10 10 10 1	9349041 9376784 9376784 938263 11785404 11785404 11785404 127867273 12862166 457830 2886373 2886373 3148416 3104070 61739896 6174873 6457920 6537660778 7724098	5 5 5 7 7 5 5 2 7 7 5 5 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
ME_0493 ME_0499 ME_0499 ME_0542 Contig_6532_A130T SSPP135C1_A7176 Contig2997 ME_0187 ME_02197 ME_02197 ME_02197 ME_02197 ME_03197 ME_03197 ME_0319	247.848 246.721 244.508 242.811 209.899 198.315 198.314 195.856 195.856 194.846 192.55 190.122 187.743 182.744 171.349 169.277 168.57 163.122 154.529 145.674	9 Contig2668 9 Mi 0493 Mi 0499 9 Mi 0460 9 Mi 0542 9 Contig 6532_A130 9 SKP115C1_A717C 0 Contig_5939 Mi 0187 9 SKP038C1_A4446 9 Mi 0219 9 Mang_rep_c5137 9 Mi 0319 9 Mi 0329 9 Mi 0481 9 Mi 0481 9 Mi 0481 9 Mi 0481	) 1	17 260149 8 1214974 8 1224978 8 1422490 8 1422490 8 1422490 8 2986773 8 620256 8 8122507 8 8368847 8 8960817 8 960981 8 10588022 8 1058802 8 11518552 8 1152132 8 12211279 8 12327509 8 1232772	Mi_044 Mi_055 mango_ Contigit Mi_032  SNP Mi_054 Contigit Mi_033 Contigit mango_ mango_ Mi_024 Mi_026 Mi_010 Mi_018 Contigit Contigit Contigit mango_ mango_ mango_ mango_ mango_ Mi_024 Mi_026 SSPOS Mi_020 Mi_020 Mi_030 Mi_030 SSROS Mi_030 Mi_03	518   10 prep. 4158   12 prep.	162.889 171.735 171.735 171.735 174.79 186.529  28 To (335.889 133.16 10.064 00.517 00.156 99.824 91.83 89.951 85.667 85.435 84.19 70.337 66.315 63.782 51.27 34.815 34.92 32.955 31.109 31.009 30.563 31.195 31.009 30.563 31.4322 43.866 14.322 24.366	8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	Mi_0.278 contig866 contig866 di_0.042 di_0.0412 di_0.041	10 10 10 10 10 10 10 10 10 10 10 10 10 1	9349041 9576784 9576784 9682631 10857894 9682631 11785404 12676773 9 262166 4578302 2846875 2219807 3488274 3510272 3488274 42074124 42074124 42074124 42074126 65374875 6456472 66507787 7744098 9425930	
ME_0493 ME_0499 ME_0499 ME_0542 Contig_6532_A130T SSPP135C1_A7176 Contig2997 ME_0187 ME_02197 ME_02197 ME_02197 ME_02197 ME_03197 ME_03197 ME_0319	247.848 246.721 244.508 242.811 209.899 198.315 198.314 195.856 195.856 194.846 192.55 190.122 187.743 182.744 171.349 169.277 168.57 163.122 154.529 145.674	9 Contig2668 9 Mi 0943 Mi 0949 9 Mi 0949 9 Mi 0949 9 Mi 0949 9 Contig 6532_A136 9 SKP115C1_A717C 0 Contig 299 Mi 0187 9 Mi 018	) 1	17 260149 8 121497 8 126579 8 126579 8 1422430 8 1529158 8 2986773 8 6256081 8 8122507 8 8368945 8 892256 8 946877 8 8992256 8 946887 8 1044814 8 11518552 8 11521351 8 11211279 8 12357509 8 1271230 8 1271230 8 1291302 8 1366772 8 1526773 8 1536773 8 1536773 8 15367772 8 15367772	Mi_044 Mi_055 mango_ Contigit Mi_032  SNP Mi_054 Contigit Mi_033 Contigit mango_ mango_ Mi_024 Mi_026 Mi_010 Mi_018 Contigit Contigit Contigit mango_ mango_ mango_ mango_ mango_ Mi_024 Mi_026 SSPOS Mi_020 Mi_020 Mi_030 Mi_030 SSROS Mi_030 Mi_03	518   10 prep. 4158   12 prep.	162.889 177.735 1774.79 186.529  CM To C 35.589 133.16 10.064 00.517 00.156 00.517 85.667 85.435 87.70	8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	Mi_0.278  mi_0.01866 ini_0.042 ini_0.043 ini_0	10 10 10 10 11 10 11 10 11 10 11 10 11 10 11 11	9.349041. 1135.056. 1178-540. 1178-5	5 5 5 7 7 5 5 5 7 7 5 5 5 7 7 5 5 5 1 0 0 0 0 5 5 1 1 0 0 0 0 0 0 0 0



### Figure 1

C. Alignment of the mango linkage groups (Kuhn et al. 2017) (left) and mango physical chromosomes (right) based on the same SNPs and mapped to the 11, 12, 13, 14, 15 and 16 chromosomes of the Mangifera indica 'Alphonso' reference genome CATAS\_Mindica\_2.1 (GCA\_011075055.1)

SNP - LG12	cM T	o Chr	SNP - Chr11	To LG	bp	SNP - LG15	cM 1		SNP - Chr12	ToLG	bp
Mi_0244	0	11_	Contig2232	13	205180	SSKP039C1_C414T	166.222	12	Mango_rep_c25371	15	46445
/i_0294	0.345	11	Mango_rep_c2497	12	689197	Mi_0379	160.318	12	€ Mi_0289	15	4951117
mango_rep_c2497	1.225	11	Mi_0244	12	869763	Mi_0289	153.197	12	Mi_0379	15	5995215
SKP104C1_A463G	3.245	11	Mi_0294	12	896127	mango_rep_c25371	146.138	12	\$\$KP039C1_C414T	15	6460781
SKP105C1 A936G	3.469	11	SSKP105C1 A936G	12	1070562	Contig6170	133.211	12	Mango_rep_c7997	15	7344495
Mi_0391	4.144	11_	SSKP104C1_A463G	12	1072845	Contig878	132.942	12	Contig6170	15	7742165
SKP013C1_A574G	12.868	11_	Mi 0391	12	1175242	mango_rep_c7997 Contig2622	130.169	12/	Contig878 Mango_rep_c9915	15	7742165 8720027
Contig 3454 A139G	14.483	11	SSKP013C1 A574G	12	1598153	mango_rep_c9915	111.156	12	Mi_0562	15	9148757
	18.993		_	12	1696302	Mi_0562	100.215	12	Mi 0028	15	9194860
SSKP029C1_C509T		11	Contig_3454_A139G			Mi_0028	98.91	12	Mi_0233	15	9287203
SSKP031C1_A370G	18.993	11	Mi_0503	5	1802828	Mi_0233	97.352	12	Mi_0195	15	9407851
Mi_0504	19.019	11	SSKP031C1_A370G	12	1987029	Mi 0195	94.284	12-	-Mi 0251	15	9584464
Contig2019	19.499	11	SSKP029C1_C509T	12	1987793	Mi_0251	89.985	12	Contig1205*	2	9730687
Mi_0109	20.238	11	Mi_0504	12	1989806	Mi 0441	89.142	12	Mango rep c39	15	9790005
Mi_0433	21.65	11	Contig2019	12	2008411	Contig2048	89.142	12	Contig2048	15	9790151
Mi_0156	22.456	11	Mi_0109	12	2050617	mango_rep_c39	89.142	12/	Mi_0441	15	9790451
Mi_0313	27.541	11	Mi_0433	12	2102539	Mi_0377	85.504	12	— мі_0377	15	10000575
Mi_0193	34.295	11	Mi_0156	12	2128916	SSKP023C1_G385T	80.948	12	SSKP010C1_C421T	15	10010433
SKP030C1 G486T	35.899	11,	Mi 0313	12	2375509	SSKP010C1_C421T	80.772	12	SSKP023C1_G385T	15	10108927
Mi 0530	53,364	11	Mi 0444*	5	2582411	Contig_1650_A91G	80.456	12	Contig_1650_A91G	15	10260868
Mi_0352	53.607	11	Mi_0193	12	2634978	Mi_0096	70.884	12	Mi_0096	15	10604128
Mi_0378	59.218	11,	SSKP030C1_G486T	12	2808983	Mi_0059	69.379	12	Mi_0059		10685936
VII_0378 VII 0212	59.507	11)	Mi 0530	12	3482962	mango_rep_c1665	68.166	12	Mango_rep_c1665		10803258
		11	_			SSKP007C1_C621T	64.13	12	——SSKP007C1_C621T		11051704
mango_rep_c16724	59.618	11	Mi_0352	12	3494051	Mi_0211	62.374	12	Mi_0211		11408669
Contig640	60.323	11-	Mango_rep_c16724	12	3744072	Mi_0256	62.051	12	SSKP034C1_A537G		11450004
mango_rep_c7501	67.721	11	Contig640	12	3905310	Mi_0296	60.898	12	Mi_0296		11548896
Mi_0472	69.746	11	Mi_0212	12	3906004	mango_rep_c24145	60.435 58.138	12	Mango_rep_c24145 Mi_0256		11631385
Contig_1658_A98G	72.772	11	Mi_0378	12	3921867	SSKP034C1_A537G SSKP098C2_A234G	45.534	12-	SSKP098C2 A234G		11675623 12900445
mango_rep_c21404	76.486	11	Mango_rep_c7501	12	4497177	Mi_0252	32.62	12	SSKP098C2_A234G		13515783
Mi_0208	80.915	11	Mi_0472	12	4785187	MI_0252 MI_0205	28.661	12	Mi_0037		13519205
SKP129C1_C847T	96.309	11	Contig_1658_A98G	12	5024780	Mi 0243	22.531	12	Mi 0205		13627810
Mi_0054	96.948	11	Mango_rep_c21404	12	5411114	Mi 0037	20.036	12	Mi_0243		13870577
/i 0326	96.956	11	Mi 0208	12	5575463	mango_rep_c7620	15.545	12_	Mi_0499		14162900
SKP077C2_A650G	123.026	111	Mi 0054	12	6270434	Mi_0499	14.836	12	\$\$KP015C5_A260G*		14226379
mango_rep_c6972	139,219	11	SKP129C1 C847T	12	6343755	Mi_0287	12.13	12	Mango_rep_c7620		14293252
	100000 mm		-	12	6359161	SSKP138C2_C598G	7.297	12	Mi_0287		14543232
SSKP065C1_C260G	148.84	11	Mi_0326			Mi_0070	6.069	12	SSKP138C2_C598G	15	14879928
			SSKP077C2_A650G	12	7808670	SSKP014C1_A851G	5.299	12	SSKP014C1_A851G	15	15119181
			Mango_rep_c6972	12	9842366	mango_rep_c58273	4.604	12	Mi_0070	15	15285720
			SSKP065C1_C260G	12	11703474	Mi_0043	1.445	12	Mi_0043	15	15685136
						Mi_0409	0	12-	Mi_0409	15	15805674
									Mango_rep_c58273	15	15823469



NP - LG13	cM f	To Chr	SNP - Chr13	To LG	bp	3	SNP - LG20	cM To	Chr	SNP - Chr14	To LG	bp
Mi_0546	154.948	13-	Mi_0546	13		1	Mi_0214	156.067	14	Mi_0214	20	390403
Contig763	110.173	13	Contig763	13	5251164		Mi_0218	155.214	14	-Mi_0218	20	449978
Mi_0065	100.182	13	Mi_0065	13	6453565		Mi_0213	153.201	14	Mi_0517	20	678335
mango_rep_c3242	99.776	13	Mango_rep_c3242	13	6671576		Mi_0403	152.078	14	_Mi_0213	20	688814
Mi_0013	99.259	13	Mi_0013	13	6671676		Mi_0517	151.993	14	Mi_0403	20	811205
Mi_0394	97.721	13	Mi_0449	13		9	Mi_0250	131.869	14	_Mi_0297	20	1466064
Mi_0449	96.781	13	Mi_0500	13	7727701		Mi_0297	131.107	14	Mi_0250	20	1513292
Mi_0500	96.469	13	Mi_0394	13	7768251		Mi_0360	121.434	14	—мі_0360	20	2136242
mango_rep_c7670	94.257	13	Mango_rep_c7670	13	8271093		Mi_0042	116.996	14-	Mi_0042	20	2547564
Contig2080	91.496	13	Contig_6876_G118T	13	8943986		Contig255	115.822	13	Mango_rep_c4540	20	2549886
Contig_6876_G118T	90.816	13	Contig2080	13	8987070		Mi_0209	114.142	14	Contig117	20	2670863
Contig2232	76.441	11	Contig2524	17	9385227	1	mango_rep_c4540	113.765	14	✓Mi_0209	20	2841922
mango_rep_c4227	74.057	13	Contig2241	4	9722046	1	Mi_0453	113.267	14		20	2902036
Contig_2032_A105C	67.926	13	Mango_rep_c4227	13	9869740	9	mango_c16893	112.809	14	Mango_c16893	20	3034667
SSKP120C1_A561C	58.339	13	Contig_2032_A105C	13	10368690		Contig117	108.923	14	_Mi_0315	20	3980736
SSKP119C1_C705T	57.533	13	SSKP120C1_A561C	13	10788444		Mi_0315	97.411	14	_Mi_0086	20	4123782
SSKP117C1_A422C	57.131	13	SSKP117C1_A422C	13	10789100	1	Mi_0086	96.316	14-	-Mi_0062	20	4565757
SSKP118C1_C423G	57.13	13-	SSKP118C1_C423G	13	10790615	1	Mi_0062	89.366	14	_Contig735	20	4727666
Contig3148	55.223	13	SSKP119C1_C705T		10795683		Contig735	86.225	14	-Mango_rep_c4496	20	4843746
mango_rep_c6017	55.134	13	Mango_rep_c6017		10822810	1.5	mango_rep_c4496	80.525	14	Contig2622	15	5275826
Contig1447	54.683	13	Contig1447		10894868		Contig2601	74.009	3	Mi_0330	20	5388878
mango_rep_c5036	54.414	13	Mango_rep_c5036		10899209	1	Mi_0046	73.076	14	←Mi_0046	20	5429185
mango_rep_c8159	33.206	13	Contig3148		10950351		Mi_0330	72.411	14	_Mi_0357	20	5456184
Mi_0498	33.131	13	Mi_0498		12096109		Mi_0357	71.12	14	Mi_0343	20	5472557
mango_rep_c8423	31.473	13	Mango_rep_c8159		12132783	3	mango_rep_c8905	70.406	14	Mango_rep_c8905	20	5533725
Mi_0009	28.383	13	Mango_rep_c8423		12216908	8	mango_rep_c15051	69.614	14	_Mi_0277	20	5577893
Mi_0194	28.056	13.	Mi_0009		12441619	100	Mi_0277	68.592	14	Mango_rep_c15051	20	5608632
Mi 0084	27.711	13	Mi_0194		12504138		Mi_0343	67.468	14	-55KP003C1_C682T	20	6024683
Mi_0207	26.271	13_	Mi_0084		12570705		SSKP003C1_C682T	57.583	14	_Mi_0341	20	6430078
Mi_0566	21.002	13_	Mi_0207		12646978	- 3	Mi_0341	45.595	14	/Mi_0145	20	7271359
Mi_0547	18.767	13	Mi_0566		13101212	9.0	mango_rep_c4542	33.939	14		20	7448438
Mi_0012	16.737	13	Mi_0547		13354718		Mi_0145	30.756	14	_Mi 0450	20	8211230
Contig6127	16.661	13	Contig6127		13416403	- 3	Mi_0450	19.22	14	Mi_0160	20	8769515
Mi_0310	16.006	13	Mi 0012		13479624		Mi_0160	13.255	14	-Mi_0519		11826283
	11.407	13	Mi_0310		13618550		Mi_0519	10.2	14	Mango_rep_c12866		13138054
Contig1989	9.754	13	Contig1989		13924226		mango_rep_c12866	5.659	14			13559075
mango_rep_c10207	6.673		Mango_rep_c10207		13931822		SSKP062C1_C365T	3.944	14	SSKP062C1_C365T		13602717
Mi_0081		13					SSKP064C1_C176G	3.469	14	_ SSKP064C1_C176G		13640161
Mi_0029	5.61	13	Mi_0081		14129331			1.76	14-			13951692
Mi_0139	4.473	13	Mi_0139		14161077		Mi_0265	0.891	14	<ul><li>Mi_0265</li><li>Contig548</li></ul>		14349110
mango_rep_c4635	0.791	13	Mi_0029		14226689		Contig548	0.389	14_			14360021
Contig1142	0.383	13	Contig1142		14666630		Mi_0260		14	≤Mi_0076		
mango_rep_c2313	6 0	13	Mango_rep_c23136		14687019		SSKP018C1_G427T	0.023		_Mi_0260		14517734
			Mango_rep_c4635		15278428	-	Mi_0076	0	14	SSKP018C1_G427T		14701152
SNP - LG6	cM To	Chr	SNP - Chr15 To	LG	bp		SNP - LG7	cM To		SNP - Chr16	TolG	bp
Contig3281	0	15	Contig3281	6 4	1530356	9	Mi_0381	151.12	16	-SSKP075C1_A358G	7	74185
mango_rep_c53352	3.955	15-	Mango_rep_c53352	6 4	1969658		SSKP075C1_A358G	145.614	16	Mi_0381	7	164024
Mi_0536	7.294	15	Mi_0536	6 5	452862		mango_rep_c5276	135.496	16	Mango_rep_c5276	7	889563
Mi_0336	9.01	15	─Mi_0336	6 5	5852040		Mi_0137	134.773	16-	-Mi_0137	7	901382
Mi_0170	9.446	15	Mi_0170	6 6	5539793	3	Mi_0271	133.1	16-	Mi_0271	7	1031430
Mi_0380	9.692	15	Mi_0380		5588456	1	Mi_0157	131.194	16	Mi_0157	7	1403888
SSKP087C1_A198G	10.57	9	_Mi_0078		3389756	1	Mi_0465	127.738	16-	-Mi_0465	7	1591565
Mi_0078	12.409	15	_Mi_0245		0034398		SSKP145C1_C347T	124.003	16	SSKP145C1_C347T	7	1836791
	14.423	15	Mi_0243 Mi_0437		0452858	1	Mi_0149	109.914	16	Mi_0149	7	2296849
Mi_0245		15				1	Mi_0164	102.782	16	SSKP103C1_C430T	7	2677522
Mi_0437	18.657	_	Contig_3450_A115T		1021009	9	Mi_0083	99.198	16	Mi_0164	7	2699731
Contig_3450_A115T		15	_Mi_0004		1221279	1	SSKP103C1_C430T	98.894	16	Mi_0083	7	2732715
Mi_0004	25.765	15	€ontig2937		2104987	1	Mi_0123	92.823	16-	-Mi_0123	7	3281313
Contig2937	43.205	15	SSKP132C1_C377T	6 12	2524481	1	Mi_0238	91.517	16	Contig756	9	3294001
SSKP132C1_C377T	49.648	15	_Mi_0288	6 12	2618529	1	Mi_0092	66.52	16	Mi_0238	7	3326896
Mi_0288	51.157	15	Contig388	6 12	2682065		Mi_0169	66.12	16	-Mi_0092	7	4787365
SSKP001C2_C1509G	56.87	15	SSKP001C2_C1509G	6 12	2811702		Mi_0080	57.598	16	Mi_0169	7	4816176
Contig388	57.677	15	_Mi_0019	6 13	3190345		mango_rep_c5591	50.741	16	Mi_0092	7	4837842
Mi_0019	60.47	19	-Mi_0174		3288552		Contig952	50.606	16	Mi_0080	7	7998374
Mi_0174	61.327	15	Mi_0090		3313485	9	mango_rep_c11550		16	Mango_rep_c5591	7	8818242
Mi_0090	61.904	15	Mi_0455		3354135		Mi_0147	44.887	16	Contig952	7	8986177
							Mi_0033	41.989	16	Mango_rep_c11550		9335065
Mi_0455	62.562	15	Mi_0206		1110919		Mi_0415	41.446	16	Mi_0147		9545143
Mi_0206	76.218	15	Mi_0482		1575347		Mi_0375	30.212	16	Mi_0033		9820254
Mi_0482	79.711	9	Mango_rep_c13398	6 14	1698801				1	Mi_0033		9877854
mango_rep_c13398	80.435	15					Mi_0199	14.183	16			
							mango_rep_c3252	0.449	16	Mi_0375		10534563
							Mi_0369	0.002	16	Mi_0199		11417562
						3	mango_c11445	0	16	Mi_0369		13664484
										Mango_c11445		13664584
										Mango_rep_c3252	-	13754659



Figure 1

**D**. Alignment of the mango linkage groups (Kuhn et al. 2017) (left) and mango physical chromosomes (right) based on the same SNPs and mapped to the 17, 19 and 20 chromosomes of the Mangifera indica 'Alphonso' reference genome CATAS\_Mindica\_2.1 (GCA\_011075055.1)

SNP - LG8	cM T	o Chr	SNP - Chr17	To LG	bp	SNP -LG5	cM T	o Chr	SNP - Chr19	To LG	bp
Mi_0410	123.052	17-	Mi_0410	8	698767	mango_rep_c15007	0	19	SSKP065C1_C260G	12	2006944
Mi_0322	120.932	17	Mi_0322	8	824056	SSKP079C1_C660T	19.45	19	SSKP078C1_A520C	5	5529949
SSKP020C1_G377T	120.41	17	SSKP020C1_G377T	8	894723	SSKP078C1_A520C	26.761	19	SSKP079C1_C660T	5	554041
Contig_3554_A93C	119.722	17	Contig_3554_A93C	8	1039802	mango_rep_c5380	34.521	19	Mi_0161	5	652024
Mi_0219	118.983	17	Mi_0219	8	1157926	Mi_0161	37.422	19	Mango_rep_c5380	5	666995
Mi_0552	118.415	17	Mi_0376	8	1504426	mango_rep_c4512	44.591	19	Mango_rep_c4512	5	698239
Mi_0376	116.405	17	Mi_0552	8	1637352	mango_rep_c9267	56.983	19	Contig2556	17	719252
mango_rep_c8984	115.955	9	Mi_0306	8	1782218	mango_rep_c20786	57.227	19	Mango_rep_c20786	5	796141
mango_rep_c3908	111.508	17	Mango_rep_c3908	8	1865775	Mi_0073	59.925	19	Mango_rep_c9267	5	801393
Mi_0306	109.08	17	Mango_rep_c3160	8	2265858	Mi_0346	61.485	19	Mi_0073	5	839298
mango_rep_c3160	105.109	17	Mi_0102	8	2945989	Mi_0524	62.612	19	Mi_0346	5	851116
Mi 0102	85.347	17	Mango_rep_c886	8	3242070	SSKP056C2_A606G	63.466	19	\$\$KP056C2_A606G	5	856184
mango_rep_c886	80.205	17	Contig1936	8	3412856	Mi_0359	66.224	19	Mi_0524	5	867559
Contig1936	78.339	17-	Mango_rep_c6716	8	3668926	Contig670	67.439	19	Mi_0359	5	873118
mango_rep_c6716	74.814	17	Mi_0173	8	4821440	Mi_0021	68.383	19	Mango_rep_c3180	5	8771340
Mi_0173	46.139	17	_Mi_0192	8	6408189	Contig1987	75.832	19	Contig670	5	8801853
Mi 0192	29.62	17-	Contig2251		10236865	mango_rep_c3180	77.269	19	Mi_0021	5	889557
Mi_0528	12.854	17	Mi_0528		11419441	Mi_0095	80.715	19	Contig1987	5	899243
Mi_0210	0	17	Mi_0210		12070428	mango_rep_c5053	90.607	19	Mi_0095	5	942523
0220					12070120	mango_rep_c1598	93.107	19	Mango_rep_c5053	5	1005829
						Mi_0358	101.291	19	Mango_rep_c1598	5	1010391
						Contig825	104.867	19	Mi_0358	5	1070091
						Mi_0324	116.768	19	Contig825	5	1107029
						Mi_0342	118.015	19_	Mi_0324	5	1139408
						Mi_0447	118.2	19	Mi_0444*	5	1140117
						Mi_0503	122.263	11	Mi_0342	5	1171086
						Mi_0201	123.73	19	Mi_0447	5	1176355
						Contig_6698_C90T	125.994	19	Mi_0503	5	1229054
						Mi_0514	126.276	19	Mi_0201	5	1239139
									Contig_6698_C90T	5	1259904
									Mi_0514	5	1263605
									Mango_rep_c15007	5	1308178
SNP - LG18	cM T	o Chr	SNP - Chr20	To LG	bp						
mango_rep_c3409	76.515	20 \	Gontig_658_A124C	18	500378						
Mi_0263	74.017	20	Mango_rep_c4938	18	783717						
	69.833	20 \	Mi_0162	18	995921						
mango_rep_c26383	69.833 68.452	20	Mi_0162 Mi_0197	18 18	995921 1135121						
mango_rep_c26383 mango_rep_c2287		11	\ / / -								
mango_rep_c26383 mango_rep_c2287 mango_rep_c2314	68.452	20	Mi_0197	18	1135121						
mango_rep_c26383 mango_rep_c2287 mango_rep_c2314 Mi_0308	68.452 68.45	20	Mi_0197 Mango_rep_c3409	18 18	1135121 3758881						
mango_rep_c26383 mango_rep_c2287 mango_rep_c2314 Mi_0308 Contig42	68.452 68.45 46.885 46.805	20 20 20 20 20	Mi_0197 Mango_rep_c3409 Mi_0263	18 18 18	1135121 3758881 6225446 6800471 7325521						
mango_rep_c26383 mango_rep_c2287 mango_rep_c2314 Mi_0308 Contig42 mango_rep_c36028 Mi_0125	68.452 68.45 46.885 46.805 45.588 43.451	20 20 20 20 20 20 20	Mi_0197 Mango_rep_c3409 Mi_0263 Mango_rep_c2287 Mango_rep_c26383 Mango_rep_c2314	18 18 18 18 18	1135121 3758881 6225446 6800471 7325521 7497345						
mango_rep_c26383 mango_rep_c2287 mango_rep_c2314 Mi_0308 Contig42 mango_rep_c36028 Mi_0125 Mi_0395	68.452 68.45 46.885 46.805 45.588 43.451 42.562	20 20 20 20 20 20 20 20 20	Mi_0197 Mango_rep_c3409 Mi_0263 Mango_rep_c2287 Mango_rep_c26383 Mango_rep_c2314 Mi_0308	18 18 18 18 18 18	1135121 3758881 6225446 6800471 7325521 7497345 8896277						
mango_rep_c26383 mango_rep_c2287 mango_rep_c2314 Mi_0308 Contig42 mango_rep_c36028 Mi_0125 Mi_0395 Mi_0014	68.452 68.45 46.885 46.805 45.588 43.451 42.562 38.933	20 20 20 20 20 20 20 20 20	Mi_0197 Mango_rep_c3409 Mi_0263 Mango_rep_c2287 Mango_rep_c26383 Mango_rep_c2314 Mi_0308 Contig42	18 18 18 18 18 18 18	1135121 3758881 6225446 6800471 7325521 7497345 8896277 9010276						
mango_rep_c26383 mango_rep_c2287 mango_rep_c2314 Mi_0308 Contig42 mango_rep_c36028 Mi_0125 Mi_0395 Mi_0014 Mi_0431	68.452 68.45 46.885 46.805 45.588 43.451 42.562 38.933 29.351	20 20 20 20 20 20 20 20 20 20 20	Mi_0197 Mango_rep_c3409 Mi_0263 Mango_rep_c2287 Mango_rep_c26383 Mango_rep_c2314 Mi_0308 Contig42 Mango_rep_c36028	18 18 18 18 18 18 18 18	1135121 3758881 6225446 6800471 7325521 7497345 8896277 9010276 9012502						
mango_rep_c26383 mango_rep_c2287 mango_rep_c2314 Mi_0308 Contig42 mango_rep_c36028 Mi_0125 Mi_0395 Mi_0014 Mi_0431 mango_rep_c4938	68.452 68.45 46.885 46.805 45.588 43.451 42.562 38.933 29.351 18.319	20 20 20 20 20 20 20 20 20 20 20 20	Mi_0197 Mango_rep_c3409 Mi_0263 Mango_rep_c2287 Mango_rep_c26383 Mango_rep_c2314 Mi_0308 Contig42 Mango_rep_c36028 Mi_0125	18 18 18 18 18 18 18 18 18	1135121 3758881 6225446 6800471 7325521 7497345 8896277 9010276 9012502 9294884						
mango_rep_c26383 mango_rep_c2287 mango_rep_c2314 Mi_0308 Contig42 mango_rep_c36028 Mi_0125 Mi_0395 Mi_0014 Mi_0431 mango_rep_c4938 Mi_0197	68.452 68.45 46.885 46.805 45.588 43.451 42.562 38.933 29.351 18.319 16.683	20 20 20 20 20 20 20 20 20 20 20 20 20 2	MI_0197 Mango_rep_c3409 Mi_0263 Mango_rep_c2287 Mango_rep_c26383 Mango_rep_c2314 Mi_0308 Contig42 Mango_rep_c36028 Mi_0125 Mi_0395	18 18 18 18 18 18 18 18 18	1135121 3758881 6225446 6800471 7325521 7497345 8896277 9010276 9012502 9294884 9489747						
mango_rep_c26383 mango_rep_c2287 mango_rep_c2314 Mi_0308 Contig42 mango_rep_c36028 Mi_0125 Mi_0395 Mi_0014 Mi_0431 mango_rep_c4938 Mi_0197 Mi_0162	68.452 68.45 46.885 46.805 45.588 43.451 42.562 38.933 29.351 18.319 16.683 13.56	20 20 20 20 20 20 20 20 20 20 20 20 20 2	Mi_0197 Mango_rep_e3409 Mi_0263 Mango_rep_e2287 Mango_rep_e26383 Mango_rep_e26314 Mi_0308 Contig42 Mango_rep_e36028 Mi_0125 Mi_0395 Mi_0014	18 18 18 18 18 18 18 18 18 18	1135121 3758881 6225446 6800471 7325521 7497345 8896277 9010276 9012502 9294884 9489747 9693031						
mango_rep_c26383 mango_rep_c2287 mango_rep_c2314 Mi_0308 Contig42 mango_rep_c36028 Mi_0125 Mi_0395 Mi_0014 Mi_0431 mango_rep_c4938 Mi_0197 Mi_0162 Mi_0227	68.452 68.45 46.885 46.805 45.588 43.451 42.562 38.933 29.351 18.319 16.683 13.56 9.798	20 20 20 20 20 20 20 20 20 20 20 20 20 2	Mi_0197 Mango_rep_c3409 Mi_0263 Mango_rep_c2287 Mango_rep_c26383 Mango_rep_c2314 Mi_0308 Contig42 Mango_rep_c36028 Mi_0125 Mi_0395 Mi_0014 Mi_0431	18 18 18 18 18 18 18 18 18 18 18	1135121 3758881 6225446 6800471 7325521 7497345 8896277 9010276 9012502 9294884 9489747 9693031						
mango_rep_c26383 mango_rep_c2287 mango_rep_c2314 Mi_0308 Contig42 mango_rep_c36028 Mi_0125 Mi_0395 Mi_0014 Mi_0431 mango_rep_c4938 Mi_0197 Mi_0162 Mi_0227 Mi_0427	68.452 68.45 46.885 46.805 45.588 43.451 42.562 38.933 29.351 18.319 16.683 13.56 9.798 2.14	20 20 20 20 20 20 20 20 20 20 20 20 20 2	Mi_0197 Mango_rep_c3409 Mi_0263 Mango_rep_c2287 Mango_rep_c2314 Mi_0308 Contig42 Mango_rep_c36028 Mi_0125 Mi_0395 Mi_0014 Mi_0431 Mi_0227	18 18 18 18 18 18 18 18 18 18 18	1135121 3758881 6225446 6800471 7325521 7497345 8896277 9010276 9012502 9294884 9489747 9693031 10025771 11188541						
mango_rep_c26383 mango_rep_c2287 mango_rep_c2314 Mi_0308 Contig42 mango_rep_c36028 Mi_0125 Mi_0395 Mi_0014 Mi_0431 mango_rep_c4938 Mi_0197 Mi_0162 Mi_0227 Mi_0427 mango_rep_c4777	68.452 68.45 46.885 46.805 45.582 43.451 42.562 38.933 29.351 18.319 16.683 13.56 9.798 2.14	20 20 20 20 20 20 20 20 20 20 20 20 20 2	Mi_0197 Mango_rep_c3409 Mi_0263 Mango_rep_c2287 Mango_rep_c26383 Mango_rep_c2314 Mi_0308 Contig42 Mango_rep_c36028 Mi_0125 Mi_0395 Mi_0014 Mi_0431 Mi_0227 Mi_0459	18 18 18 18 18 18 18 18 18 18 18 18	1135121 3758881 6225446 6800471 7325521 7497345 8896277 9010276 9012502 9294884 9489747 9693031 10025771 11188541 11924447						
mango_rep_c26383 mango_rep_c2287 mango_rep_c2314 Mi_0308 Contig42 mango_rep_c36028 Mi_0125 Mi_0395 Mi_0014 Mi_0014 mi_0431 mango_rep_c4938 Mi_0197 Mi_0162 Mi_0227 Mi_0227 mi_0227 mango_rep_c4777 Mi_0513	68.452 68.45 46.885 45.588 43.451 42.562 38.933 29.351 16.683 13.56 9.798 2.14 1.487	20 20 20 20 20 20 20 20 20 20 20 20 20 2	MI_0197 Mango_rep_c3409 Mi_0263 Mango_rep_c2287 Mango_rep_c26383 Mango_rep_c2314 Mi_0308 Contig42 Mango_rep_c36028 Mi_0125 Mi_0395 Mi_0014 Mi_0459 Mi_0227 Mi_0459 Mi_0513	18 18 18 18 18 18 18 18 18 18 18 18 18	1135121 3758881 6225446 6800471 7325521 7497345 8896277 9010276 9012502 9294884 9489747 9693031 10025771 11188541 11924447 11999853						
mango_rep_c26383 mango_rep_c2287 mango_rep_c2314 Mi_0308 Contig42 mango_rep_c36028 Mi_0125 Mi_0395 Mi_0014 Mi_0431 mango_rep_c4938 Mi_0197 Mi_0162 Mi_0227 Mi_0427	68.452 68.45 46.885 46.805 45.582 43.451 42.562 38.933 29.351 18.319 16.683 13.56 9.798 2.14	20 20 20 20 20 20 20 20 20 20 20 20 20 2	Mi_0197 Mango_rep_c3409 Mi_0263 Mango_rep_c2287 Mango_rep_c26383 Mango_rep_c2314 Mi_0308 Contig42 Mango_rep_c36028 Mi_0125 Mi_0395 Mi_0014 Mi_0431 Mi_0227 Mi_0459	18 18 18 18 18 18 18 18 18 18 18 18 18 1	1135121 3758881 6225446 6800471 7325521 7497345 8896277 9010276 9012502 9294884 9489747 9693031 10025771 11188541 11924447						

To overcome the limitations of the mango genetic linkage map, Santos et al. (2023) employed BLAST alignment of SNPs from the Haden × Tommy Atkins population against the 20 chromosomes of the 'Alphonso' mango (physical map) for genome-wide association studies (GWAS) of resistance to dieback diseases caused by Lasiodiplodia theobromae and



Neofusicoccum parvum fungi. An identical GWAS procedure, but using different SNPs (133,590), was adopted by Ali et al. (2025) to identify polyembryony loci in mango.

The strategy of BLAST-aligning mango SNPs against the 'Alphonso' reference genome (Wang et al. 2020) recovered 166 SNPs that had been excluded from previous analyses for various reasons, such as aberrant segregation patterns or being unmappable (Kuhn et al. 2017). The physical map approach incorporated all genotyped SNPs, enabling better genome coverage.

The first genetic linkage map, proposed by A. Sturtevant (1913), pioneered gene mapping on chromosomes. Sturtevant used crossover frequency to identify recombinant individuals in Drosophila, establishing gene positions, order, and distances (in cM) on chromosomes. A genetic linkage group is defined as a set of markers where each marker is linked (in cM) to at least one other in the same set, while a physical map represents the nucleotide distance (bp) between markers on a sequenced chromosome.

Marker-assisted selection (MAS) uses molecular markers linked to agronomically important traits to accelerate cultivar development: marker presence indicates the trait of interest. Despite this appealing concept, MAS has contributed minimally to releasing improved cultivars with greater abiotic stress tolerance, with few exceptions mainly for quality traits (Henkrar and Udupa 2020).

According to Evans et al. (2021), practical outcomes of QTL mapping for MAS remain limited due to multiple factors including small population sizes, linkage group gaps, and unsaturated maps. Insufficient attention has been given to limitations in linkage group formation and marker ordering compared to physical mapping as sources of spurious QTL estimates. For species with available genome sequences, physical maps created through SNP sequence BLAST alignment yield better results for quantitative trait mapping aimed at MAS applications

## **5 CONCLUSION**

Four major aberrations were identified: (a) chromosome 1 was divided into LGs 9 and 14; (b) chromosome 4 was split between LGs 1 and 3; (c) LG 8 was formed by combining SNPs from chromosomes 9 and 17 of 'Alphonso'; and (d) chromosome 18 was not represented in any of the 20 LGs. All remaining LGs, except LGs 11, 14 and 20, contained at least one SNP from non-corresponding reference chromosomes. Significant discrepancies in SNP ordering were observed across the 20 LGs, particularly in 12 LGs.



Grouping and ordering of linkage genetic maps must been taken into account as a source of spurious QTLs estimates. For species with available genome sequences, physical maps yield better results for quantitative trait mapping aimed at marker-assisted selection.

#### **REFERENCES**

- Ali, G.S., Eltaher, S., Li, J., Freeman, B. & Singh, S. (2025). GWAS identifies a polyembryony locus in mango: development of KASP and PACE markers for marker-assisted breeding. *Frontiers in Plant Science* 16: 1508027.
- Evans, K.S., van Wijk, M.H., McGrath, P.T., Andersen, E.C. & Sterken, M.G. (2021). From QTL to gene: C. elegans facilitates discoveries of the genetic mechanisms underlying natural variation. *Trends in Genetics* 37, 933-947.
- Henkrar, F. & Udupa, S.M. (2020). Marker assisted selection in plant breeding. *Moroccan Journal of Agricultural Sciences* 1, 237-247.
- Kaur, S., Das. A., Sheoran. S. & Rakshit, S. (2023) QTL Meta-Analysis: An Approach to Detect Robust and Precise QTL. *Tropical Plant Biology* 16, 225-243.
- Kuhn, D.N., Bally, I.S.E., Dillon, N.L., Innes, D., Groh, A.M., Rahaman, J., Ophir, R., Cohen, Y. & Sherman, A. (2017). Genetic map of mango: A tool for mango breeding. Frontiers in Plant Science 8, 233922.
- Luo, C., Shu, B., Yao, Q., Wu, H., Xu, W. & Wang, S. (2016). Construction of a high-density genetic map based on large-scale marker development in mango using specific-locus amplified fragment sequencing (SLAF-seq). *Frontiers in Plant Science* 7, 209016.
- Margarido, G.R.A., Souza, A.P. & Garcia, A.A.F. (2007). OneMap: Software for genetic mapping in outcrossing species. *Hereditas* 144, 78-79.
- Medeiros, F.L.B., Santos, C.A.F., Costa & A.E.S. (2022). Comparing SNP-based genetic linkage and physical maps in guava (Psidium guajava). *Genetics and Molecular Research* 21, 1-12.
- Miles, C. & Wayne, M. (2008). Quantitative Trait Locus (QTL) Analysis. *Nature Education 1*, 208.
- Santos, C.A.F., Aquino, D.A.L., Batista, D.C. & Alves, E.O.S. (2023). Genome-wide association studies of resistance to dieback diseases in a pseudo-F2 mango population. *Genetics and Molecular Research* 22, GMR19158.
- Semagn, K., Bjørnstad, Å. & Ndjiondjop, M.N. (2006). Principles, requirements and prospects of genetic mapping in plants. *African Journal of Biotechnology* 5, 2569-2587.
- Sturtevant, A. (1913). The linear arrangement of six sex-linked factors in Drosophila, as shown by their mode of association. *Journal of Experimental Zoology 14*, 43-59.
- Van Ooijen, J.W. (2006). *JoinMap® 4: Software for the calculation of genetic linkage maps in experimental populations*. Wageningen: Kyazma BV.



- Van Ooijen, J.W. (2011). Multipoint maximum likelihood mapping in a full-sib family of an outbreeding species. *Genetics Research* 93, 343-349.
- Wang, P., Luo, Y., Huang, J., Gao, S., Zhu, G., Dang, Z., Gai, J., Yang, M., Zhu, M., Zhang, H., Ye, X., Gao, A., Tan, X., Wang, S., Wu, S., Cahoon, E.B., Bai, B., Zhao, Z., Li, Q., Wei, J., Chen, H., Luo, R., Gong, D., Tang, K., Zhang, B., Ni, Z., Huang, G., Hu, S. & Chen, Y. (2020). The genome evolution and domestication of tropical fruit mango. *Genome Biology* 21, 1-17.
- Wu, R., Ma, C.X., Painter, I. & Zeng, Z.B. (2002). Simultaneous Maximum Likelihood Estimation of Linkage and Linkage Phases in Outcrossing Species. *Theoretical Population Biology* 61, 349-363.
- Xu, Y. & Crouch, J.H. (2008). Marker-assisted selection in plant breeding: From publications to practice. *Crop Science* 48, 391-407.
- Zhang, L., Li, H. & Wang, J. (2015). Linkage analysis and map construction in genetic populations of clonal F1 and double cross. *G3: Genes, Genomes, Genetics* 5, 427-439.