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Genome-wide association study of terpenoids in resin reveals candidate genes for resin yield in *Pinus massoniana*



Supplementary Material

Fig. S1. Genome-wide association study of four compounds in masson pine resin

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Table S1. Sample geographical distributions and content (%) of five chemical components with high heritability

Location	Sample ID	Pimaric acid	Neoabietic acid	Camphene	Dipentene	Carvophyllene
DQ	GW13	9.60	16.40	2.05	1.05	3.40
	GW130	8.90	15.40	1.70	2.90	0.70
	GW143	9.70	15.40	2.00	1.60	0.70
	GW16	9.50	17.10	2.05	1.10	0.90
	GW19	10.50	18.30	2.35	2.20	2.55
	GW3	9.70	19.80	2.40	1.10	0.00
	GW39	9.80	15.00	2.20	1 40	0.00
	GW42	11 30	17.70	3.05	1.10	0.80
	GW54	8 40	22.25	2.50	1.50	0.30
DY	GW129	9.50	14.80	2.30	1.90	1 91
DI	GW123	9.50	16.05	2.00	1.50	4 90
	GW135	7.80	22 40	2.60	2 30	4 10
	GW5	9.40	16.90	2.00	1.30	1.10
G7	GW132	5.20	18.60	2.20	3 55	2 10
0L	GW152 GW17	9.40	18.00	1 70	1 90	2.10
	GW17	9.40	18.00	2.00	1.90	2.50
	GW24 CW20	0.55	10.45	2.00	1.00	2.75
	GW29	11.40	16.20	1.40	1.70	2.70
	GW 30	10.10	10.12	1.90	1.90	2.00
	GW31	0.47	19.13	2.47	2.30	4.23
	GW34	7.50	20.00	1.50	1.90	2.00
	GW35	10.10	17.70	1.80	1.50	1.20
	GW45	8.80	16.40	2.10	2.20	1.80
	GW47	4.70	16.50	1.80	2.10	2.20
	GW51	9.00	19.30	1.20	2.20	2.20
	GW53	7.20	19.00	2.10	1.50	0.70
	GW55	9.90	14.30	1.40	3.40	2.90
LZ	GW131	10.40	16.30	1.80	1.40	1.91
	GW135	7.90	18.30	1.80	0.80	0.90
XY	GW10	8.30	17.10	1.80	1.20	0.60
	GWII	9.90	17.25	1.70	1.60	1.50
	GW122	9.40	14.90	1.90	2.40	1.10
	GW2	8.70	16.50	1.70	1.80	1.70
	GW20	10.00	21.70	1.30	1.60	1.10
	GW21	8.30	16.70	1.30	1.70	1.50
	GW22	9.10	16.40	1.50	3.10	2.20
	GW23	8.60	19.10	1.40	2.00	2.80
	GW26	9.20	18.30	1.60	1.90	1.20
	GW27	9.00	18.30	1.60	2.00	2.00
	GW28	9.30	16.30	1.40	2.00	1.50
	GW32	9.90	13.20	1.50	2.20	1.30
	GW33	9.70	16.70	3.60	2.50	2.50
	GW36	8.00	17.50	2.00	1.60	0.50
	GW38	8.00	18.60	1.80	1.90	1.70
	GW4	6.70	18.50	1.20	1.60	1.10
	GW40	8.80	16.40	1.60	2.20	1.00
	GW41	9.30	15.80	1.60	1.40	1.00
	GW43	10.30	19.50	1.60	1.95	3.25
	GW44	7.60	17.05	2.60	1.50	1.00
	GW48	8.40	20.30	2.50	2.00	2.70
	GW50	8.80	15.70	1.90	2.90	1.90
	GW56	8.20	17.40	0.90	1.60	2.00
	GW6	8.40	16.30	1.10	1.60	2.40
	GW7	9.10	17.10	1.30	2.20	2.00

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Location	Sample ID	Pimaric acid	Neoabietic acid	Camphene	Dipentene	Caryophyllene
YN	GW1	7.40	18.80	2.30	0.90	1.91
	GW121	9.20	21.20	1.80	1.60	0.80
	GW123	9.55	20.20	2.00	2.20	1.70
	GW125	7.60	18.50	1.30	1.30	1.91
	GW128	3.30	20.20	2.00	1.30	1.91
	GW14	10.00	14.70	2.20	1.30	1.91
	GW140	9.25	19.55	2.10	2.20	2.45
	GW144	7.90	19.80	2.00	1.30	3.70
	GW145	8.50	17.40	1.60	2.00	2.80
	GW148	10.00	17.40	2.00	1.30	1.91
	GW15	10.80	15.90	1.50	1.80	1.90
	GW18	9.70	19.20	2.30	2.45	2.20
	GW25	5.15	20.25	3.90	2.65	1.70
	GW37	9.20	16.80	1.90	1.80	2.20
	GW46	9.50	17.60	1.70	1.60	1.91
	GW52	9.75	18.80	2.30	1.45	1.40

Table S2. Primer info	ormation used for qRT-	-PCR validations		
Classification	Name	Forward primer	Reverse primer	Length
Reference gene	Actin	TGGCCCATCAATTGTTCACA	TCCTACGTAATTGCCAAACCA	246
	Cluster-40412.12602	CTGTCCCCAGCTAGTCTCTG	CAACTGTCCACTGCCATTCC	151
F-DOX (qK1-PCK)	Cluster-40412.56520	GTGGAGGATGTCGTGGTGAA	GTGAAACCTCGGCAAGAACT	184
7 1 (/ / / /	Cluster-40412.12602	ATGAGCATTCTTTTCTGTTTGGTCTGTTGTTG	TTATTCTAAGGATTCATTGGGCCACAACTG	1.086
r-dox (gene clone)	Cluster-40412.56520	ATGTATTTGGAGTTCGGCTGCAAGC	CTAGAAAGAATTCATTTCCAAAAGGTAAGTCCTCTTCTTC	1.086
	Cluster-40412.77475	AACCCTCGCAAAACCAGAAC	TCATAGGAGCCGAGCCAAAT	154
AFZ	Cluster-40412.66676	GGATTTCATTCCCGGCCAACA	TATCCCTCGTCGAAGCTGTC	141
0110	Cluster-40412.104061	GCAACAAGAAAGGCCCTGAT	GTATGCGAATCTGACCTGCC	91
Cytochronne P430	Cluster-40412.142585	TTCGTTGTGGAAGAATCGCG	TCCACGTTTTCAGGATTCGC	135
	Cluster-40412.80841	TCTTCCTGGTGTGAGTGGTC	TACAATTCGGCCTGTGTCCA	178
ADC traitsporter	Cluster-40412.69095	AGGGTITCAGATTATTGCGAGC	ACCTGCTTGCTCTTGGTATCT	122
ultimet accurate of 1:1 of 10	Cluster-40412.80881	GGAGTGGTGATCTTGGAGCT	TCCTCCTTGAAGCAACCCAT	158
FNC_IIKE SUPER LAILIN	Cluster-40412.80688	CGAGTCCGGTGTATGCAAAG	GCCACCACCATTTATCCTGC	126

validations
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Primer info
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Trait name	Method	Marker name	QTN effect	LOD score	-lg(P)	r ² (%)
Camphene	FASTmrEMMA	Marker377614	-0.6973	3.3397	4.0558	12.9835
-		Marker448909	0.4151	3.8301	4.5731	9.0712
		Marker629224	0.3407	3.2545	3.9655	5.3629
	ISIS EM-BLASSO	Marker193813	-0.2167	8.6348	9.5426	11.7254
		Marker309579	-0.229	4.2245	4.9869	7.3019
		Marker354580	-0.2556	7.4384	8.3154	13.0742
		Marker413867	0.2296	9.4503	10.3768	11.8124
		Marker437663	-0.2463	10.9377	11.8946	17.0349
		Marker440827	-0.1933	7.8056	8.6925	10.4337
		Marker634711	0.1075	4.8703	5.6611	2.7471
		Marker5766843	-0.2232	7.2548	8.1267	13.7574
Dipentene	FASTmrEMMA	Marker258666	-0.6156	3.9525	4.7017	14.8534
		Marker701385	-0.6056	4.4791	5.2532	15.2663
	ISIS EM-BLASSO	Marker465298	-0.2141	3.9718	4.722	9.2497
		Marker614017	-0.2126	6.3115	7.1548	13.3737
		Marker626735	-0.1988	4.4377	5.2099	11.7168
		Marker704369	-0.2003	4.3761	5.1455	11.5935
		Marker842761	-0.254	4.8133	5.6018	19.0922
Neoabietic acid	mrMLM	Marker966639	1.3537	3.2265	3.935866	34.5227
	FASTmrEMMA	Marker339113	-1.5542	5.3985	6.2101	7.8646
		Marker611816	-0.0003	3.9426	4.6913	2.65E-07
		Marker966639	2.224	5.2374	6.0428	15.5729
	ISIS EM-BLASSO	Marker107060	-0.6358	3.1037	3.8055	7.0022
		Marker361854	0.7105	4.9663	5.7611	11.7684
		Marker371005	0.5997	3.8524	4.5965	7.6104
		Marker457568	-0.9575	6.9361	7.7987	17.6017
		Marker537352	0.5207	4.2726	5.0373	6.32
		Marker966639	1.157	12.4693	13.4535	24.9138
Pimaric acid	FASTmrEMMA	Marker224515	0.9111	3.91	4.657	6.1856
		Marker430961	-1.322	5.8314	6.6587	11.703
		Marker612397	1.4151	5.94	6.771	11.9273
		Marker750369	-1.323	4.7827	5.5699	9.0259
	ISIS EM-BLASSO	Marker175301	0.8194	6.8547	7.7149	12.5937
		Marker194568	0.3424	3.8099	4.5518	4.2803
		Marker430961	-0.2874	3.544	4.2717	2.1716
		Marker500036	-0.4464	8.3212	9.2213	9.0233
		Marker517726	0.6485	7.9474	8.838	17.7808
		Marker538322	-0.334	4.9108	5.7033	1.8606
		Marker573283	-0.4483	5.4576	6.2714	9.1022
		Marker612397	0.6419	10.5577	11.5073	14.0027
		Marker744766	0.543	7.0063	7.871	13.1496

Table S3. Details of loci associated with the content of compounds using mrMLM, FASTmrEMMA and ISIS EM-BLASSO

Table S4. Detected SNPs using EMMAX and FaST-LMM

Compounds	Marker	Position	EMMAX	P-value	FaST-LMM	P-value
Camphene	Marker399660	218	~	1.91E-07	~	1.91E-07
	Marker835695	231	~	1.75E-07	~	1.76E-07
Caryophyllene	Marker4848416	26			~	1.30E-07
Dipentene	Marker373310	191	~	1.74E-07	~	1.77E-07
Pimaric acid	Marker312204	202	~	6.59E-08	~	6.77E-08