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Differential response of plant transpiration to uptake of rainwater-recharged soil water for dominant tree species in the semiarid Loess Plateau

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Tables and captions

Table S1. Plant height, trunk diameter, and estimated sapwood width for *H. rhamnoides* and *P. tomentosa* in both pure and mixed plantations.

Plantation type	No.	Height (m)	Trunk diameter (mm)	Sapwood width (mm)
***H. rhamnoides* in pure plantation**	1	3.95	45	9
	2	4.26	53	11
	3	4.05	51	10
	4	4.13	49	9
	5	3.98	50	10
	6	4.1	51	11
	7	4.3	57	12
	8	3.86	44	9
	9	3.92	53	11
***P. tomentosa* in pure plantation**	1	4.41	58	17
	2	3.9	52	9
	3	3.92	56	16
	4	4.35	56	17
	5	4.59	58	16
	6	4.2	53	13
	7	4.29	54	15
	8	3.86	51	9
	9	3.98	52	11
***H. rhamnoides* in mixed plantation**	1	4.36	52	12
	2	3.9	49	11
	3	4.23	51	12
	4	4.5	56	13
	5	4.73	55	14
	6	3.96	49	11
	7	4	51	12
	8	4.52	53	12
	9	4.39	52	12
***P. tomentosa* in mixed plantation**	1	4.12	53	11
	2	3.75	46	9
	3	4.5	57	13
	4	4.21	53	11
	5	4.2	53	11
	6	4.16	51	10
	7	3.8	45	9
	8	4.95	59	13
	9	4.16	51	10

The sapwood width was estimated through the equation established through 12 unmonitored individual core samples for specific species with different diameters. The core sample was obtained using an increment borer, and the colour difference between sapwood and heartwood was large. The equation between trunk diameter (mm) and sapwood width (mm) was $y=0.248x-2.296$ $R^2=0.84$ $p<0.01$ for *H. rhamnoides* in pure plantation; $y=0.348x-5.98$ $R^2=0.78$ $P<0.01$ for *H. rhamnoides* in mixed plantation; $y=1.126x-47.66$ $R^2=0.83$ $P<0.01$ for *P. tomentosa* in pure plantation; $y=0.317x-5.71$ $R^2=0.939$ $P<0.01$ for *P. tomentosa* in mixed plantation.

Table S2. Independent-sample *t*-test parameters for predawn (Ψ_{pd}), midday (Ψ_m), and gradient of leaf water potential ($\Psi_{pd} - \Psi_m$) between the first and second day after each rainfall amount.

	Rainfall amount (mm)	***df***	**Ψ_{pd}**		**Ψ_m**		**$\Psi_{pd} - \Psi_m$**	
			t	*p*	*t*	*p*	*t*	*p*
***H. rhamnoides* in pure plantation**	3.4	4	0.18	0.87	1.21	0.29	-2.5	0.07
	7.9	4	0.33	0.75	0.79	0.58	-8.01	0.47
	15.4	4	0.85	0.44	0.27	0.8	0.21	0.85
	24	4	0.97	0.39	-0.67	0.54	2.13	0.1
	35.2	4	-0.09	0.93	-7.1	0.52	0.28	0.79
***P. tomentosa* in pure plantation**	3.4	4	0.88	0.43	0.66	0.55	0.81	0.47
	7.9	4	0.34	0.08	0.75	0.49	-1.8	0.14
	15.4	4	0.23	0.83	0.73	0.51	-0.82	0.46
	24	4	-2.08	0.11	1.14	0.32	-0.85	0.45
	35.2	4	-1.67	0.17	1.15	0.31	-2.22	0.09
***H. rhamnoides* in mixed plantation**	3.4	4	2.53	0.07	1.4	0.24	-0.6	0.58
	7.9	4	1.24	0.28	2.02	0.11	-1.87	0.14
	15.4	4	-0.9	0.42	0.96	0.39	-1.29	0.27
	24	4	1.74	0.16	2.04	0.11	-1.22	0.29
	35.2	4	1.89	0.13	2.57	0.06	-0.29	0.78
***P. tomentosa* in mixed plantation**	3.4	4	0.07	0.95	1.9	0.13	-0.35	0.72
	7.9	4	0.81	0.46	0.96	0.39	-0.46	0.67
	15.4	4	0.7	0.52	2.12	0.1	-0.53	0.62
	24	4	1.85	0.14	0.74	0.49	0.48	0.66
	35.2	4	2.23	0.09	1.21	0.3	0.55	0.61

Table S3 The average (mean ± SD) and coefficients of variation (CVs, SD/mean) of soil water $\delta^{18}O$ and δD on the first day after 5 selected rainfall events, and daily soil water content (SW) from DOY 132 to 273 (11 May to 30 September) in *H. rhamnoides* pure plantation, *P. tomentosa* pure plantation, and *H. rhamnoides–P. tomentosa* mixed plantation.

	Soil depth	**Soil water $\delta^{18}O$ (‰)**		**Soil water δD (‰)**		**SW (m^3 m^{-3})**	
		average	CV	average	CV	average	CV
***H. rhamnoides* pure plantation**	0–30 cm	-5.79 ±1.26	21.6	-47.56 ±8.87	18.6	0.11 ±0.02	18.2
	30–100 cm	-6.80 ±1.27	18.7	-56.21 ±8.46	15.1	0.10 ±0.01	10.0
	100–200 cm	-9.27 ±0.79	8.5	-73.61 ±4.61	6.3	0.088 ±0.005	5.7
***P. tomentosa* pure plantation**	0–30 cm	-5.27 ±1.31	24.9	-43.73 ±9.47	21.7	0.12 ±0.02	16.7
	30–100 cm	-7.05 ±0.96	13.6	-57.69 ±6.69	11.6	0.09 ±0.009	10.0
	100–200 cm	-9.05 ±0.63	7.0	-70.98 ±3.90	5.5	0.085 ±0.005	5.9
Mixed plantation	0–30 cm	-5.59 ±1.44	25.8	-46.15 ±10.45	22.6	0.11 ±0.019	17.3
	30–100 cm	-6.55 ±1.15	17.6	-54.17 ±7.99	14.8	0.09 ±0.008	8.9
	100–200 cm	-9.03 ±0.59	6.5	-71.79 ±3.76	5.2	0.089 ±0.005	5.6

There are 45, 30, and 30 data for the average water $\delta^{18}O$ and δD of shallow, middle, and deep soil layer calculation in each plantation, respectively. The absolute value was used for CVs of soil water $\delta^{18}O$ and δD calculation.

Table S4. Repeated ANOVA (ANOVAR) parameters for the relative response of normalized sap flow (SF_R) and rainwater-recharged soil water uptake proportion (RUP) after rainfall pulses of *H. rhamnoides* and *P. tomentosa* (n = 30).

	Variation source	*df*	SF_R		RUP	
			F	*p*	*F*	*p*
Pure plantation	Rainfall	4	97.91	<0.001	385.02	<0.01
	Species	1	121.13	<0.001	21.02	<0.05
	Rainfall × Species	4	27.35	<0.001	0.83	0.52
Mixed plantation	Rainfall	4	489.9	<0.001	17696.38	<0.01
	Species	1	70.38	<0.001	4089.12	<0.01
	Rainfall × Species	4	249.17	<0.001	1776.62	<0.01
H. rhamnoides	Rainfall	4	42.63	<0.001	496.72	<0.01
	Plantation type	1	337.09	<0.001	360.16	<0.01
	Rainfall × Plantation type	4	215.43	<0.001	17.62	<0.01
P. tomentosa	Rainfall	4	10.05	<0.001	1969.3	<0.01
	Plantation type	1	32.36	<0.01	54.83	<0.01
	Rainfall × Plantation type	4	19.12	<0.001	208.06	<0.01

df = degree of freedom, Plantation type = pure and mixed plantation for each species. Pure and Mixed plantation indicate the result of SF_R and RUP for both species in different plantation types, respectively; *H. rhamnoides* and *P. tomentosa* indicate the mixed afforestation effect on SF_R and RUP for these species.

Table S5. Repeated ANOVA (ANOVAR) parameters for water uptake proportion from shallow (0–30 cm), middle (30–100 cm), and deep (100–200 cm) soil layer for *H. rhamnoides* and *P. tomentosa* (n = 30).

	Variation source	*df*	0–30 cm		30–100 cm		100–200 cm	
			F	*p*	*F*	*p*	*F*	*p*
Pure plantation	Rainfall	4	153.45	<0.01	145.04	<0.01	176.79	<0.01
	Species	1	8.69	<0.05	10.56	<0.05	11.08	<0.05
	Rainfall × Species	4	129.89	<0.01	112.46	<0.01	4.99	<0.01
Mixed plantation	Rainfall	4	1.5	0.41	2.3	0.11	18.34	<0.01
	Species	1	2.2	0.21	1.48	0.29	3.9	0.12
	Rainfall × Species	4	0.9	0.48	2.41	0.09	1.9	0.16
H. rhamnoides	Rainfall	4	2.05	0.14	1.51	0.25	85.46	<0.01
	Plantation type	1	1.07	0.36	1.32	0.32	10.08	<0.05
	Rainfall × Plantation type	4	0.62	0.66	1.39	0.28	5.59	<0.01
P. tomentosa	Rainfall	4	14.72	<0.01	71.59	<0.01	19.46	<0.01
	Plantation type	1	4.1	0.12	5.68	0.08	123.27	<0.01
	Rainfall × Plantation type	4	9.55	<0.01	85.29	<0.01	9.35	<0.01

df = degree of freedom, Plantation type = pure and mixed plantation for each species. Pure and Mixed plantation indicate the result of water sources from different soil layers for both species in different plantation types, respectively; *H. rhamnoides* and *P. tomentosa* indicate the mixed afforestation effect on water sources from different soil layers for these species.

Table S6. Repeated ANOVA (ANOVAR) parameters for predawn (Ψ_{pd}), midday leaf water potential (Ψ_m), and leaf water potential gradient (Ψ_{pd}–Ψ_m) for *H. rhamnoides* and *P. tomentosa* (n = 30).

	Variation source	***df***	Ψ_{pd}		Ψ_m		Ψ_{pd}–Ψ_m	
			F	*p*	*F*	*p*	*F*	*p*
Pure plantation	Rainfall	4	4.02	<0.05	24.44	<0.01	47.88	<0.01
	Species	1	182.74	<0.01	4.9	<0.05	969.97	<0.01
	Rainfall × Species	4	3.24	<0.05	2.08	0.13	18.68	<0.01
Mixed plantation	Rainfall	4	0.66	0.63	25.54	<0.01	82.49	<0.01
	Species	1	0.12	0.75	127.3	<0.01	3420.1	<0.01
	Rainfall × Species	4	1.8	0.18	3.7	<0.05	35.92	<0.01
H. rhamnoides	Rainfall	4	7.14	<0.01	19.64	<0.01	3.59	<0.05
	Plantation type	1	27.05	<0.01	496.66	<0.01	1278.96	<0.01
	Rainfall × Plantation type	4	1.69	0.202	3.32	<0.05	6.66	<0.01
P. tomentosa	Rainfall	4	30.78	<0.01	12.39	<0.01	7.38	<0.01
	Plantation type	1	792.77	<0.01	2.97	0.16	634.12	<0.01
	Rainfall × Plantation type	4	3.8	<0.05	0.09	0.98	3.83	<0.05

df = degree of freedom, Plantation type = pure and mixed plantation for each species. Pure and Mixed plantation indicate the result of leaf water potential for both species in different plantation types, respectively; *H. rhamnoides* and *P. tomentosa* indicate the mixed afforestation effect on leaf water potential for these species.

Table S7. The linear regression relationship between relative response of normalized sap flow (SF_R) and reference evapotranspiration (ET_0), net radiation (R_n), and vapor pressure deficit (VPD), and between SF_R and relative response of ET_0, R_n, and VPD from DOY 132 to 273 and from DOY 203 to 273.

Period	Independent factors	*H. rhamnoides* in pure plantation		*H. rhamnoides* in mixed plantation		*P. tomentosa* in pure plantation		*P. tomentosa* in mixed plantation	
		R^2	p	R^2	p	R^2	p	R^2	p
DOY 132–273	ET_0	0.18	0.47	0.11	0.59	0.44	0.22	0.39	0.26
	VPD	0.09	0.62	0.02	0.83	0.26	0.38	0.22	0.43
	R_n	0.06	0.68	0.04	0.74	0.04	0.75	0.03	0.8
	Relative response of ET_0	0.35	0.32	0.61	0.12	0.12	0.56	0.25	0.4
	Relative response of VPD	0.3	0.34	0.48	0.2	0.06	0.7	0.12	0.57
	Relative response of R_n	0.08	0.74	0.02	0.84	0.1	0.61	0.07	0.66
DOY 203–273	ET_0	0.15	0.75	0.25	0.67	0.009	0.98	0.003	0.97
	VPD	0.14	0.76	0.24	0.67	0.008	0.99	0.002	0.97
	R_n	0.31	0.63	0.44	0.54	0.04	0.87	0.06	0.84
	Relative response of ET_0	0.06	0.84	0.01	0.93	0.35	0.59	0.31	0.63
	Relative response of VPD	0.79	0.3	0.67	0.39	0.29	0.64	0.34	0.6
	Relative response of R_n	0.03	0.9	0.09	0.81	0.05	0.86	0.03	0.89

The regression equation is y=ax+b for all equations. Relative responses of R_n, VPD, and ET_0 are respectively calculated as for SF_R in Eq. (4), corresponding to before and the first day after rainfall event parameters for R_n, VPD, and ET_0.

Table S8. Parameters of allometric equation and average (mean ± SD) estimated biomass of leaf, branches, wood, and roots of *H. rhamnoides* and *P. tomentosa* in pure and mixed plantations (n=6).

Species		*a*	*b*	Biomass in pure plantation	Biomass in mixed plantation
H. rhamnoides	leaf	0.017	0.541	0.51 ±0.02	0.55 ±0.04
	branches	0.013	0.042	0.16 ±0.05	0.14 ±0.01
	wood	0.036	0.721	2.4 ±0.09	2.6 ±0.07
	roots	0.019	0.732	1.51 ±0.06	1.79 ±0.04
	total biomass			4.58 ±1.01	5.08 ±1.13
P. tomentosa	leaf	0.052	0.621	1.21 ±0.05	1.58 ±0.09
	branches	0.025	0.81	1.35 ±0.04	1.32 ±0.06
	wood	0.0492	0.832	4.22 ±0.11	4.73 ±0.13
	roots	0.031	0.791	2.02 ±0.06	2.75 ±0.1
	total biomass			8.8 ±1.39	10.38 ±1.55

The allometric equation is $Y=a(D^2H)^b$, *Y* is biomass (kg), *D* is trunk diameter measured at 1.3 m above the ground (cm), *H* is tree height (m). Six standard individuals of *H. rhamnoides* and *P. tomentosa* in pure and mixed plantations were selected for average *Y* calculation.

Figure Legends

Figure S1. The geographic location of (a) study area and (b) plantation sites in the Loess Plateau of China, and (c) monthly average (mean ± SD) rainfall amount and air temperature (Ta) during 2000-2017, and monthly rainfall amount and average Ta in 2018**.** Plantation types including *H. rhamnoides* pure plantation, *P. tomentosa* pure plantation, and mixed plantation. Three adjacent plots were selected (16 m × 10 m) for each plantation type, and the schematic diagram of these plantation types is in (b). The China basic map can be obtained from http://map.geoq.cn/arcgis/rest/services/ChinaOnlineCommunityENG/MapServer.

Figure S2. Independent-sample *t*-test for diurnal variation of average (mean ± SD) sap flow between the first and second day after rainfall amount of (a) 24 and (b) 35.2 mm for *P. tomentosa* in pure plantation. Error bars indicate the standard deviation (n = 3).

Figure S3. The linear regression relationship between $\delta^{18}O$ and δD for soil water at three soil layers (0–30, 30–100, and 100–200cm) in (a) *H. rhamnoides* pure plantation, (b) *P. tomentosa* pure plantation, and (c) Mixed plantation. The local meteoric water line (LMWL) is plotted in each panel for reference.

Figure S4. Variation in rainfall amount, net radiation (R_n), and vapor pressure deficit (VPD) from DOY 132 to 273 (11 May to 30 September). Arrows indicate dates of sample collection at the first day after rainfall events: DOY 157 (6 June), DOY 194 (12 July), DOY 204 (23 July), DOY 249 (6 September), and DOY 266 (23 September).

Figure S5. Independent-sample *t*-test for diurnal variation of average (mean ± SD) sap flow before and after 5 rainfall events for *H. rhamnoides* in pure (a–e) and mixed plantation (f–j). Before and after rainfall indicated the value in the day before and first day after a rainfall event. Error bars indicate the standard deviation (n = 3).

Figure S6. Independent-sample *t*-test for diurnal variation of average (mean ± SD) sap flow before and after 5 rainfall events for *P. tomentosa* in pure (a–e) and mixed plantation (f–j). Before and after rainfall indicated the value in the day before and first day after a rainfall event. Error bars indicate the standard deviation (n = 3).

Figure S7. Variation in average (mean ± SD) $\delta^{18}O$ and δD of rainwater, stem water, and soil water at seven soil depths for *H. rhamnoides* in (a–e) pure and (k–o) mixed plantations and for *P. tomentosa* in (f–j) pure and (k–o) mixed plantations after five rainfall events. Error bars indicate the standard deviation (n = 3). Date of stem and soil sample collection is followed the corresponding rainfall amount value. The average rainwater $\delta^{18}O$ and δD for each rainfall event is calculated with 3 rainwater subsamples, which is divided from one rainwater sample.

Figure S8. Relationship between rainfall amount and (a) relative response of normalized sap flow (SF_R) and (b) rainwater-recharged soil water uptake proportion (RUP) for *H. rhamnoides* in both plantation types, and these corresponding relationships for *P. tomentosa* (c–d) in both plantation types (n=3).

Figure S1.

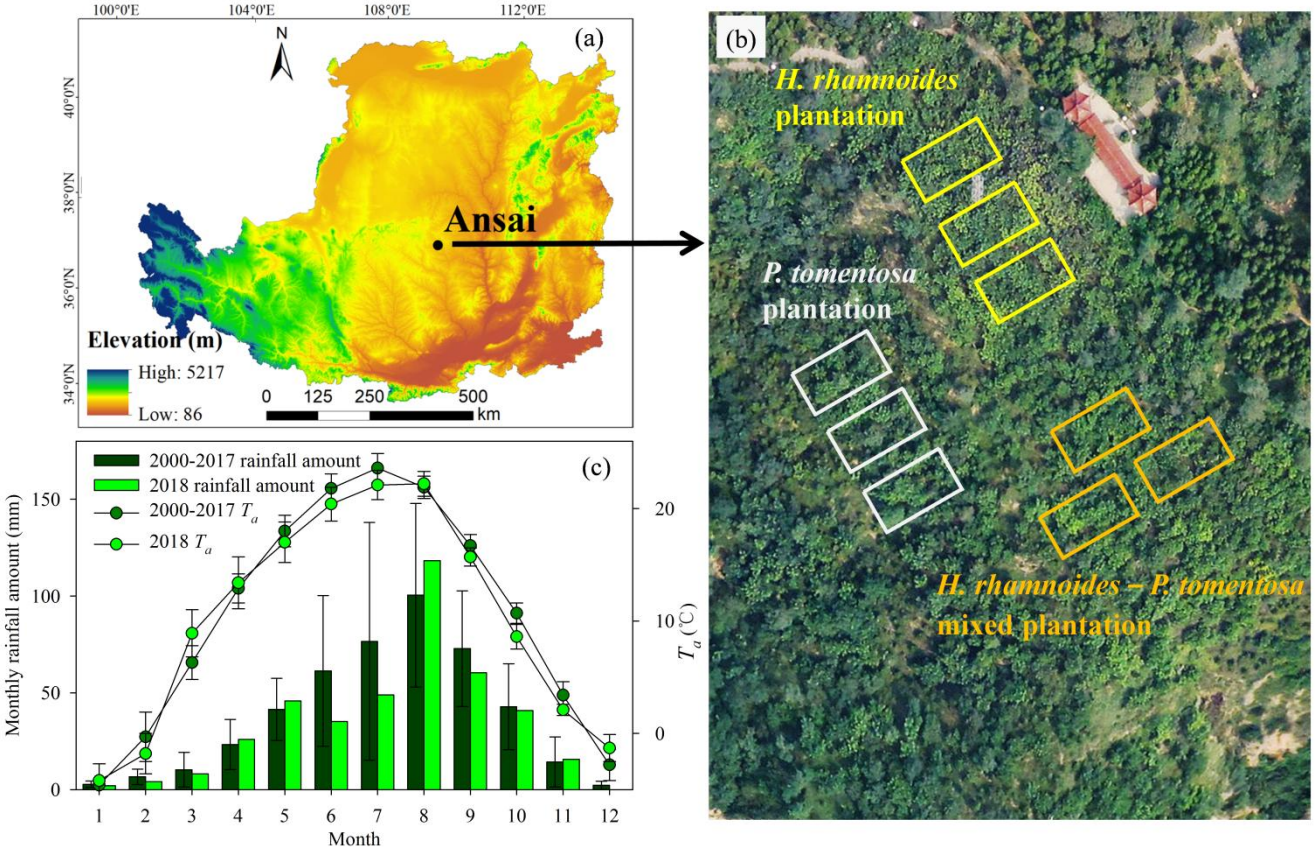

100°0'E
104°0'E
108°0'E
112°0'E
(a)
N
40°0'N
38°0'N
36°0'N
34°0'N
Ansai
Elevation (m)
High: 5217
Low: 86
0 125 250 500
km
(b)
H. rhamnoides plantation
P. tomentosa plantation
H. rhamnoides – P. tomentosa mixed plantation
(c)
2000-2017 rainfall amount
2018 rainfall amount
2000-2017 T_a
2018 T_a
Monthly rainfall amount (mm)
T_a (℃)
Month

Figure S2.

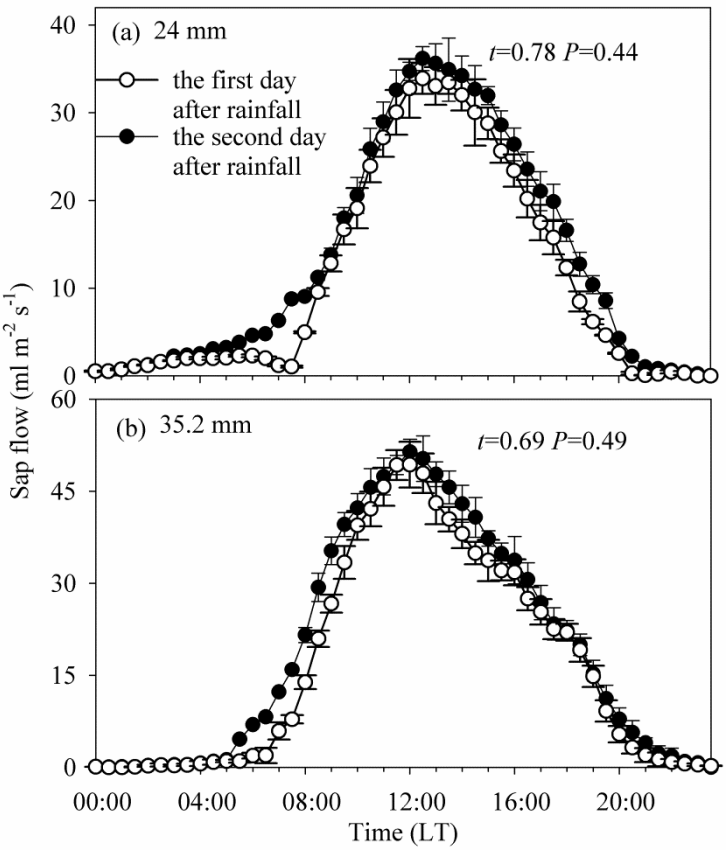

(a) 24 mm
t=0.78 P=0.44
the first day after rainfall
the second day after rainfall
(b) 35.2 mm
t=0.69 P=0.49
Sap flow (ml m-2 s-1)
Time (LT)
00:00
04:00
08:00
12:00
16:00
20:00

Figure S3.

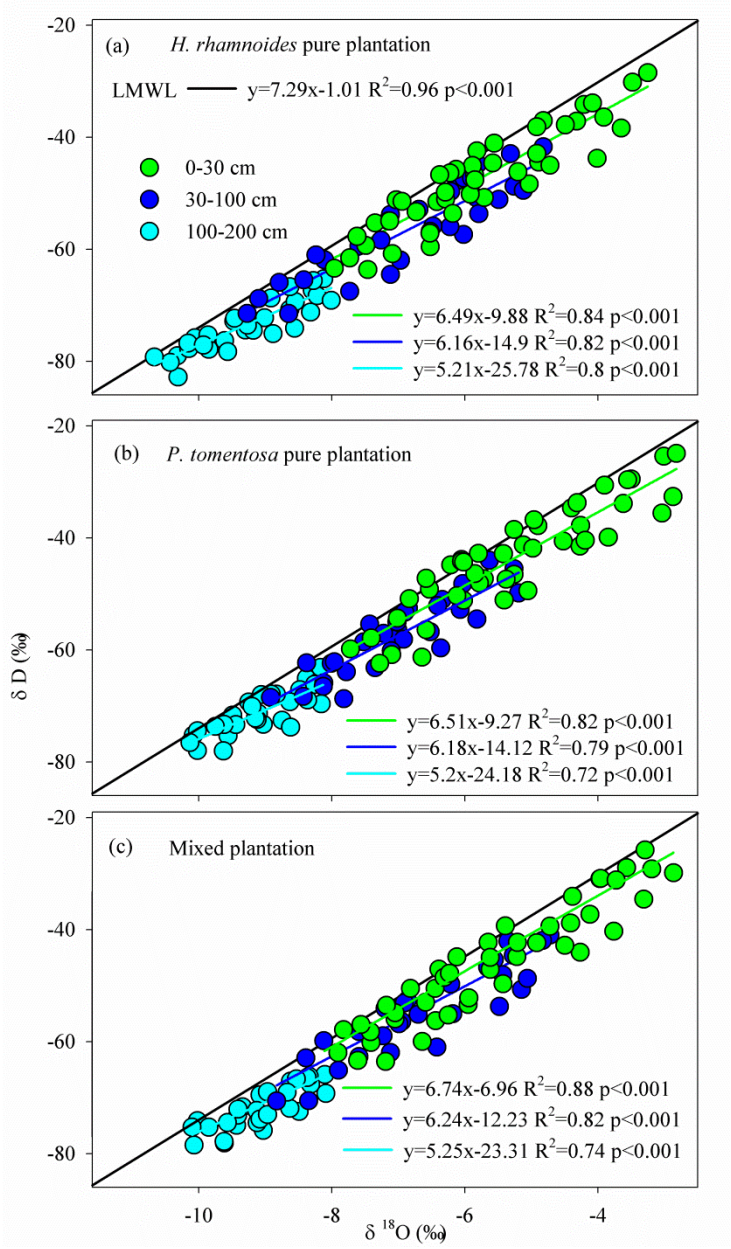

(a) H. rhamnoides pure plantation
LMWL y=7.29x-1.01 R2=0.96 p<0.001
0-30 cm
30-100 cm
100-200 cm
y=6.49x-9.88 R2=0.84 p<0.001
y=6.16x-14.9 R2=0.82 p<0.001
y=5.21x-25.78 R2=0.8 p<0.001
(b) P. tomentosa pure plantation
y=6.51x-9.27 R2=0.82 p<0.001
y=6.18x-14.12 R2=0.79 p<0.001
y=5.2x-24.18 R2=0.72 p<0.001
(c) Mixed plantation
y=6.74x-6.96 R2=0.88 p<0.001
y=6.24x-12.23 R2=0.82 p<0.001
y=5.25x-23.31 R2=0.74 p<0.001
δ D (‰)
δ 18O (‰)
-20
-40
-60
-80
-10
-8
-6
-4

Figure S4.

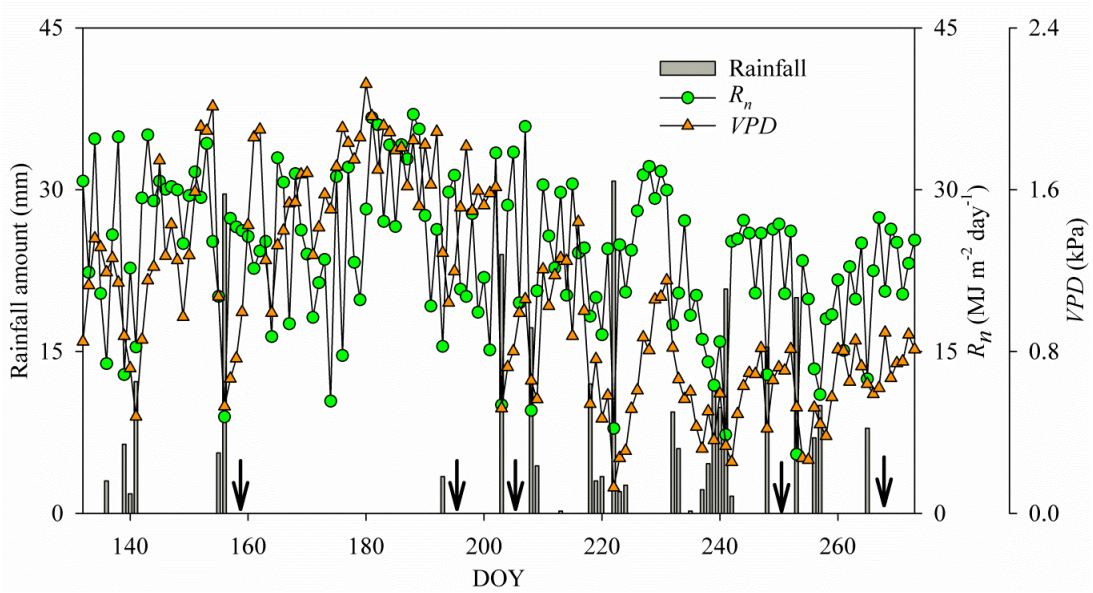

Rainfall
R_n
VPD
Rainfall amount (mm)
R_n (MJ m^{-2} day^{-1})
VPD (kPa)
DOY
0
15
30
45
0.0
0.8
1.6
2.4
140
160
180
200
220
240
260

Figure S5.

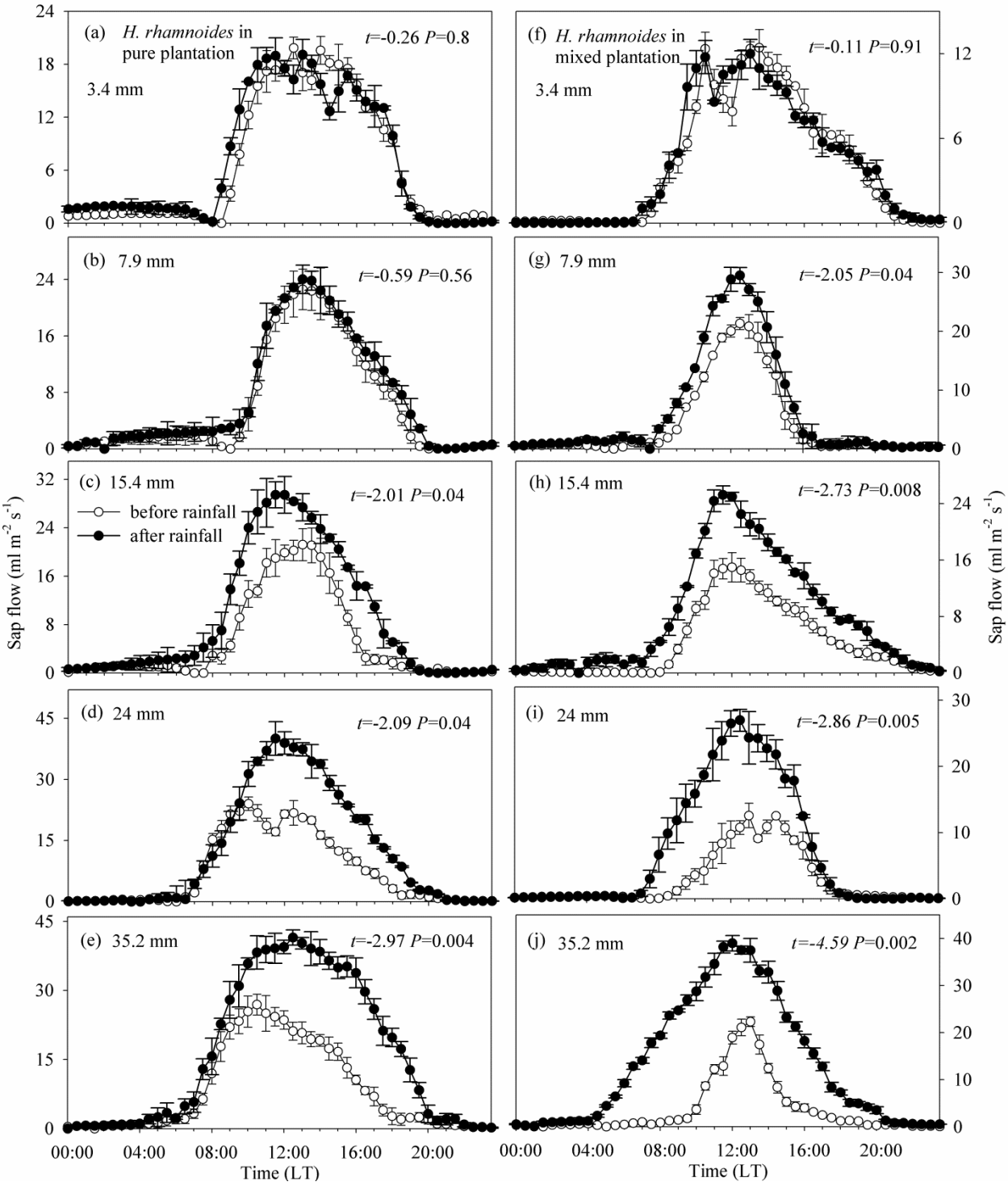

(a) H. rhamnoides in pure plantation
3.4 mm
t=-0.26 P=0.8
(b) 7.9 mm
t=-0.59 P=0.56
(c) 15.4 mm
t=-2.01 P=0.04
before rainfall
after rainfall
(d) 24 mm
t=-2.09 P=0.04
(e) 35.2 mm
t=-2.97 P=0.004
(f) H. rhamnoides in mixed plantation
3.4 mm
t=-0.11 P=0.91
(g) 7.9 mm
t=-2.05 P=0.04
(h) 15.4 mm
t=-2.73 P=0.008
(i) 24 mm
t=-2.86 P=0.005
(j) 35.2 mm
t=-4.59 P=0.002
Sap flow (ml m-2 s-1)
Sap flow (ml m-2 s-1)
00:00 04:00 08:00 12:00 16:00 20:00
Time (LT)
00:00 04:00 08:00 12:00 16:00 20:00
Time (LT)

Figure S6.

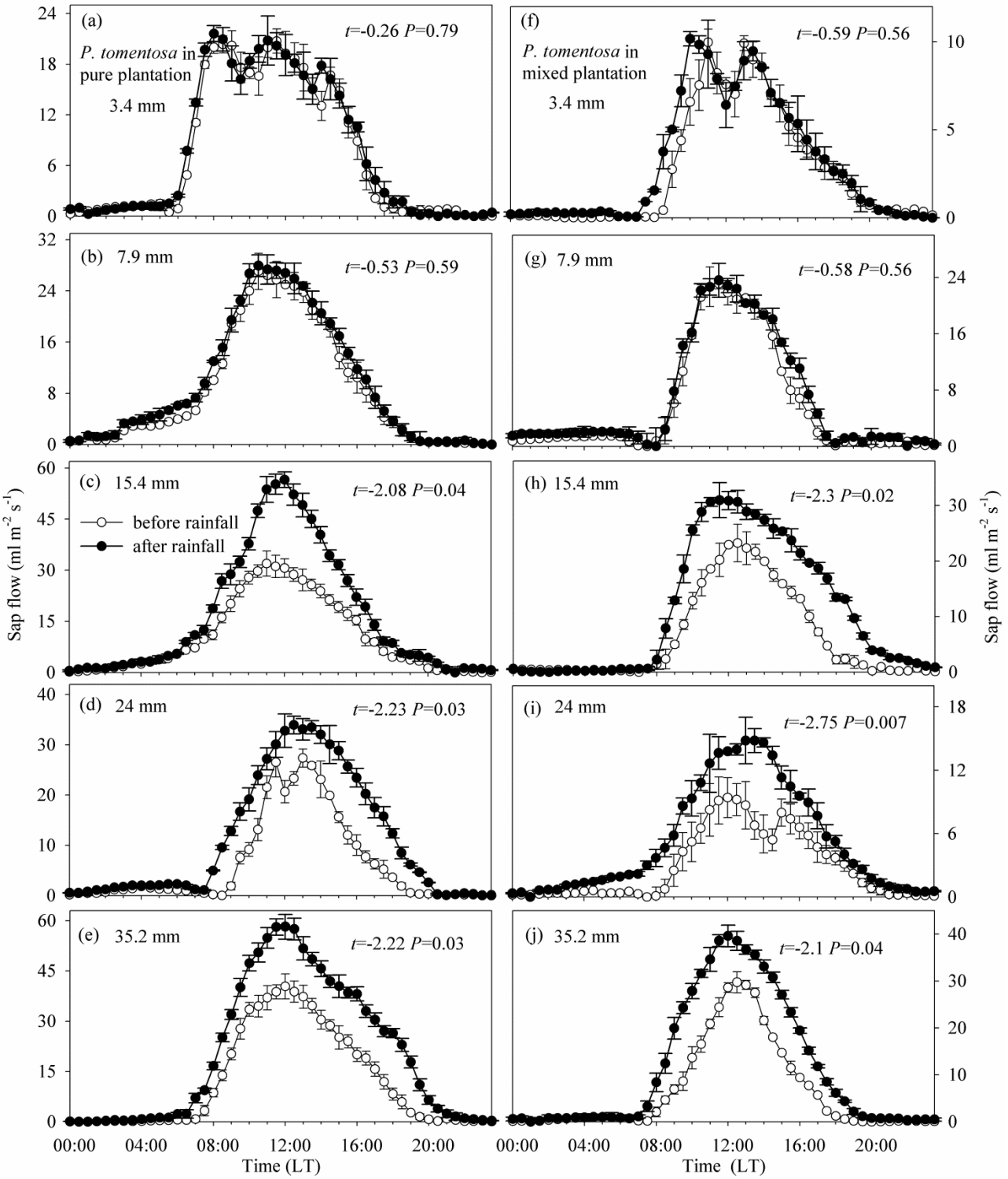

(a)
P. tomentosa in pure plantation
3.4 mm
t=-0.26 P=0.79
(b) 7.9 mm
t=-0.53 P=0.59
(c) 15.4 mm
t=-2.08 P=0.04
before rainfall
after rainfall
(d) 24 mm
t=-2.23 P=0.03
(e) 35.2 mm
t=-2.22 P=0.03
(f)
P. tomentosa in mixed plantation
3.4 mm
t=-0.59 P=0.56
(g) 7.9 mm
t=-0.58 P=0.56
(h) 15.4 mm
t=-2.3 P=0.02
(i) 24 mm
t=-2.75 P=0.007
(j) 35.2 mm
t=-2.1 P=0.04
Sap flow (ml m-2 s-1)
Sap flow (ml m-2 s-1)
00:00 04:00 08:00 12:00 16:00 20:00
Time (LT)
00:00 04:00 08:00 12:00 16:00 20:00
Time (LT)

Figure S7.

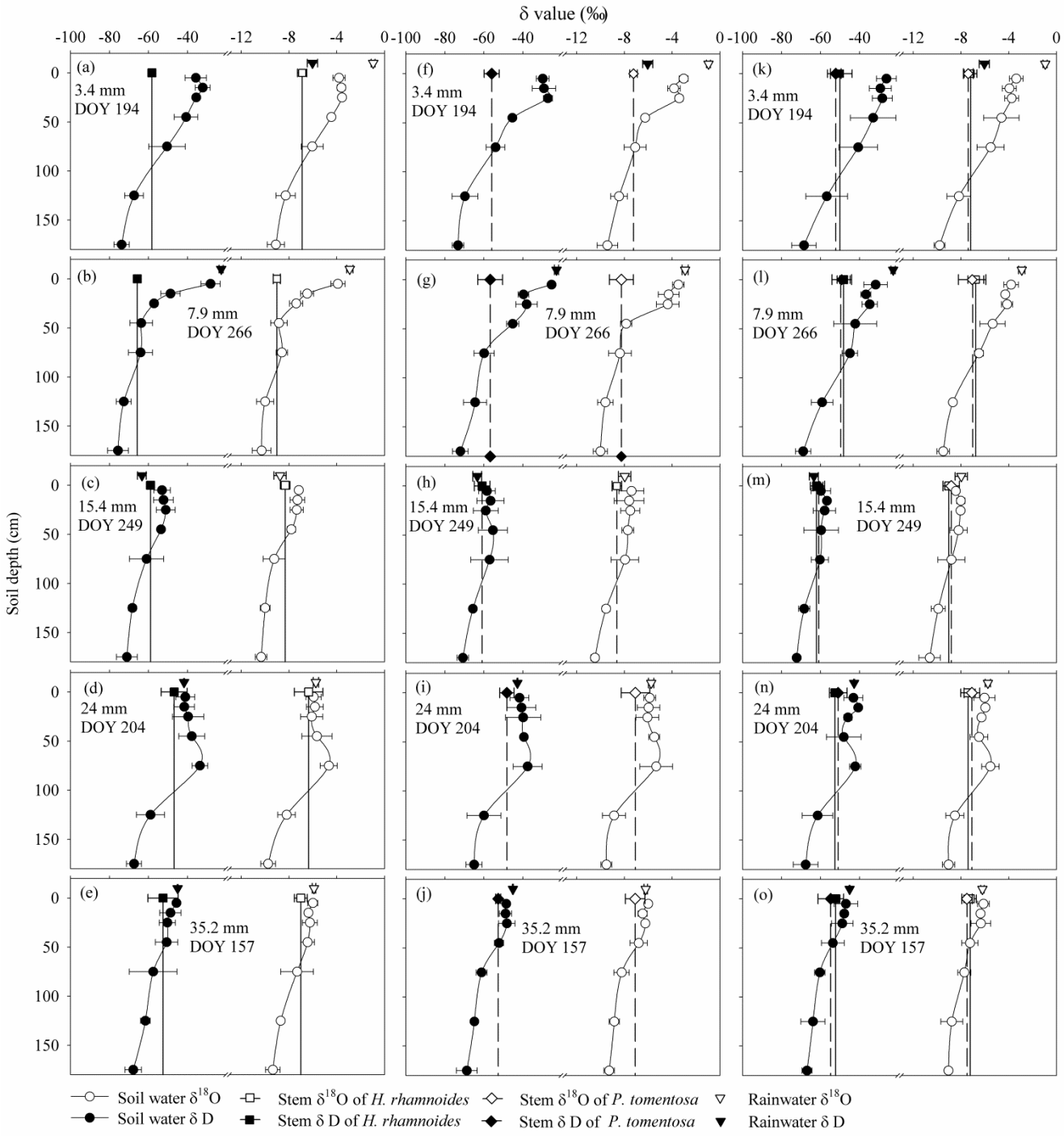
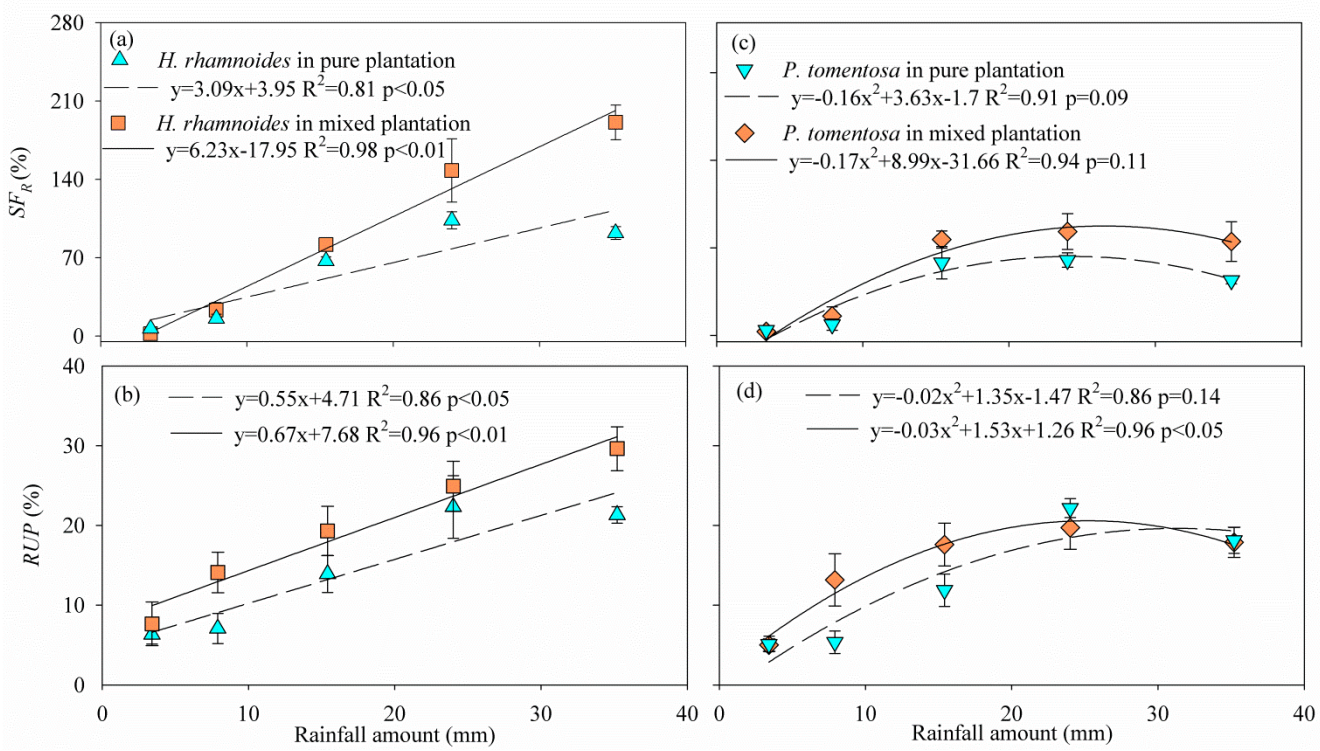

δ value (‰)
-100 -80 -60 -40 -12 -8 -4 0
Soil depth (cm)
0
50
100
150
(a) 3.4 mm DOY 194
(b) 7.9 mm DOY 266
(c) 15.4 mm DOY 249
(d) 24 mm DOY 204
(e) 35.2 mm DOY 157
(f) 3.4 mm DOY 194
(g) 7.9 mm DOY 266
(h) 15.4 mm DOY 249
(i) 24 mm DOY 204
(j) 35.2 mm DOY 157
(k) 3.4 mm DOY 194
(l) 7.9 mm DOY 266
(m) 15.4 mm DOY 249
(n) 24 mm DOY 204
(o) 35.2 mm DOY 157
Soil water δ18O
Soil water δ D
Stem δ18O of H. rhamnoides
Stem δ D of H. rhamnoides
Stem δ18O of P. tomentosa
Stem δ D of P. tomentosa
Rainwater δ18O
Rainwater δ D

Figure S8.


(a)
H. rhamnoides in pure plantation
y=3.09x+3.95 R2=0.81 p<0.05
H. rhamnoides in mixed plantation
y=6.23x-17.95 R2=0.98 p<0.01
SFR (%)
(c)
P. tomentosa in pure plantation
y=-0.16x2+3.63x-1.7 R2=0.91 p=0.09
P. tomentosa in mixed plantation
y=-0.17x2+8.99x-31.66 R2=0.94 p=0.11
(b)
y=0.55x+4.71 R2=0.86 p<0.05
y=0.67x+7.68 R2=0.96 p<0.01
RUP (%)
(d)
y=-0.02x2+1.35x-1.47 R2=0.86 p=0.14
y=-0.03x2+1.53x+1.26 R2=0.96 p<0.05
Rainfall amount (mm)
Rainfall amount (mm)