

# GENETIC VARIATION IN CASSAVA FOR DEVELOPMENTAL AND PHYSIOLOGICAL RESPONSES TO WATER STRESS

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# *Mechanism for Drought Tolerance*

Limited reports

- Osmotic adjustment
- Regulation of water use by stomatal control  
leaf fall
- Water storage in stem (pith)

# *Biomass production under drought*

- Biomass = Water Use (WU) x Water Use Efficiency (WUE)

# Hypothesis 1

- Water Use
- Developmental and morphological trait
  - Leaf (transpiration), root (water uptake) size
- Physiological traits
  - Midday leaf water potential
- Osmotic adjustment

# Hypothesis 2

- Water conservation

Under severer or prolonged drought

Stomatal closure

Leaf fall

water storage in pith

# Hypothesis 3

- Water Use Efficiency
  - more efficient photosynthesis
  - respiration regulation

# Genotypes examined 1

Variety	Variety Information				
	Origin	Maturity (months)	Plant Type	Root Yield (t/ha)	HCN Level
Golden Yellow	traditional variety	8月10日	medium tall & erect	20-30	low (edible)
Indang 2	traditional variety	10月12日	medium tall & moderately branching	-	low (edible)
Kadabao	traditional variety	10月12日	tall & erect	20-30	low (edible)
Kaplutan	traditional variety	8月10日	medium tall & erect	-	low (edible)
Namaya	traditional variety	10月12日	medium tall & moderately branching	-	moderate
Nito-nito	traditional variety	10月12日	medium tall & slightly branching	-	moderate
Pintuyan 3	traditional variety	10月12日	medium tall & moderately branching	-	moderate
Siasi	traditional variety	10月12日	medium tall & erect	-	moderate
Tandang 2	traditional variety	10月12日	tall & erect	-	moderate
Zapote	traditional variety	10月12日	medium tall & moderately branching	-	moderate
Datu 1	local selection from IPB,UPLB	10月12日	medium tall & slightly branching	30-40	moderate
Lakan 1	local selection from IPB,UPLB	8月10日	medium tall & erect	35-45	low (edible)

# Genotypes examined 2

Sultan 1	local selection from IPB,UPLB	9月11日	medium tall & slightly branching	35-45	moderate
Vassourinha	local selection from IPB,UPLB	10月12日	semi-dwarf & erect	25-35	moderate
Sultan 2	local selection from IPB,UPLB	10月12日	tall & slightly branching	25-35	moderate
VC-1	introduce hybrid from CIAT, Colombia	9月11日	medium tall & slightly branching	35-45	moderate
VC-2	introduce hybrid from CIAT, Colombia	8月10日	medium tall & moderately branching	35-45	low (edible)
VC-4	introduce hybrid from CIAT, Colombia	9月11日	medium tall & erect	35-45	moderate
PSB Cv-11	introduce hybrid from CIAT, Colombia	10月12日	medium tall & moderately branching	30-40	low (edible)
PSB Cv-12	introduce hybrid from CIAT, Colombia	10月12日	medium tall & moderately branching	25-35	moderate
PSB Cv-13	hybrid developed by PhilRootcrops	10月12日	medium tall & moderately branching	25-35	low (edible)
PSB Cv-14	hybrid developed by PhilRootcrops	8月10日	tall & slightly branching	30-40	moderate
PSB Cv-15	introduce hybrid from CIAT, Colombia	10月12日	medium tall & slightly branching	25-35	low (edible)
PSB Cv-16	hybrid developed by PhilRootcrops	10月12日	medium tall & moderately branching	25-35	low (edible)
PSB Cv-19	introduce hybrid from CIAT, Colombia	10月12日	medium tall & slightly branching	25-35	moderate
KU-50	introduce variety from Thailand	10月12日	medium tall & erect	25-35	moderate
Rayong 5	introduce variety from Thailand	10月12日	medium tall & slightly branching	25-35	moderate
Rayong 60	introduce variety from Thailand	10月12日	semi-dwarf & erect	20-30	high

# Experimental set-up



# Plant Growth at Later Stages



Fig. 8. Well-watered and Droughted Cassava Plants at Day 30 of Stress (60 DAP).



Fig. 9. Well-watered and Droughted Cassava Plants at Day 50 of Stress (80 DAP).

# Effects of Water Regimes and Genotypes

Parameters	Treatment		
	Water regime	Genotype	Interaction
Total plant biomass	**	**	**
Water use	**	**	**
Water use efficiency	*	**	**
Shoot biomass	**	**	**
Root biomass	**	**	**
Root-shoot biomass ratio	**	**	**
Plant height	**	**	**
Number of leaves developed	**	**	ns
Number of adventitious roots	**	**	**
Number of first order lateral roots	**	**	**
Number of second order lateral roots	*	**	**
Average length of adventitious roots	ns	**	**
Total length of roots	**	**	**
Midday LWP on day 7 of stress	ns	ns	ns
Midday LWP on day 21 of stress	ns	**	**
Midday LWP on day 35 of stress	ns	**	**
Predawn LWP on day 7 of stress	ns	*	ns
Predawn LWP on day 21 of stress	ns	**	**
Predawn LWP on day 35 of stress	*	**	**
Stomatal resistance on day 8 of stress	ns	ns	ns
Stomatal resistance on day 21 of stress	*	**	ns
Stomatal resistance of day 31 of stress	**	ns	ns
Leaf fall on day 51 of stress	*	**	ns

# Total Plant Biomass

Genotype	Total Plant Biomass (g)			
	Droughted	Well-watered	D/W Ratio	Rank
	(D)	(W)		
PSB Cv-19	3.13	19.57	0.160	1
Rayong 60	1.97	14.83	0.133	2
Rayong 5	2.30	17.37	0.132	3
Nito-nito	2.17	17.37	0.125	4
Sultan 1	2.27	19.13	0.119	5
PSB Cv-13	0.95	8.70	0.109	6
PSB Cv-16	2.00	18.27	0.109	6
Kaplutan	1.87	17.33	0.108	7
Namaya	1.20	11.20	0.107	8
Indang 2	1.27	12.00	0.106	9
G. Yellow	2.20	20.90	0.105	10
Kadabao	2.07	20.90	0.099	11
PSB Cv-14	2.10	21.70	0.097	12
Lakan 1	1.70	18.20	0.093	13
VC-1	1.77	19.20	0.092	14
Sultan 2	1.70	18.77	0.091	15
KU-50	1.50	16.67	0.090	16
VC-2	1.77	22.55	0.078	17
Tandang 2	1.60	21.10	0.076	18
PSB Cv-12	1.20	15.90	0.075	19
Datu 1	1.00	13.63	0.073	20
PSB Cv-15	1.43	19.83	0.072	20
Siasi	1.17	17.23	0.068	21
Pintuyan 3	1.67	26.67	0.063	22
Vassourinha	0.80	12.73	0.063	22
Zapote	1.23	19.70	0.062	23
PSB Cv-11	1.10	18.33	0.060	24
VC-4	1.43	24.25	0.059	25
Mean	1.66	18.00	0.094	

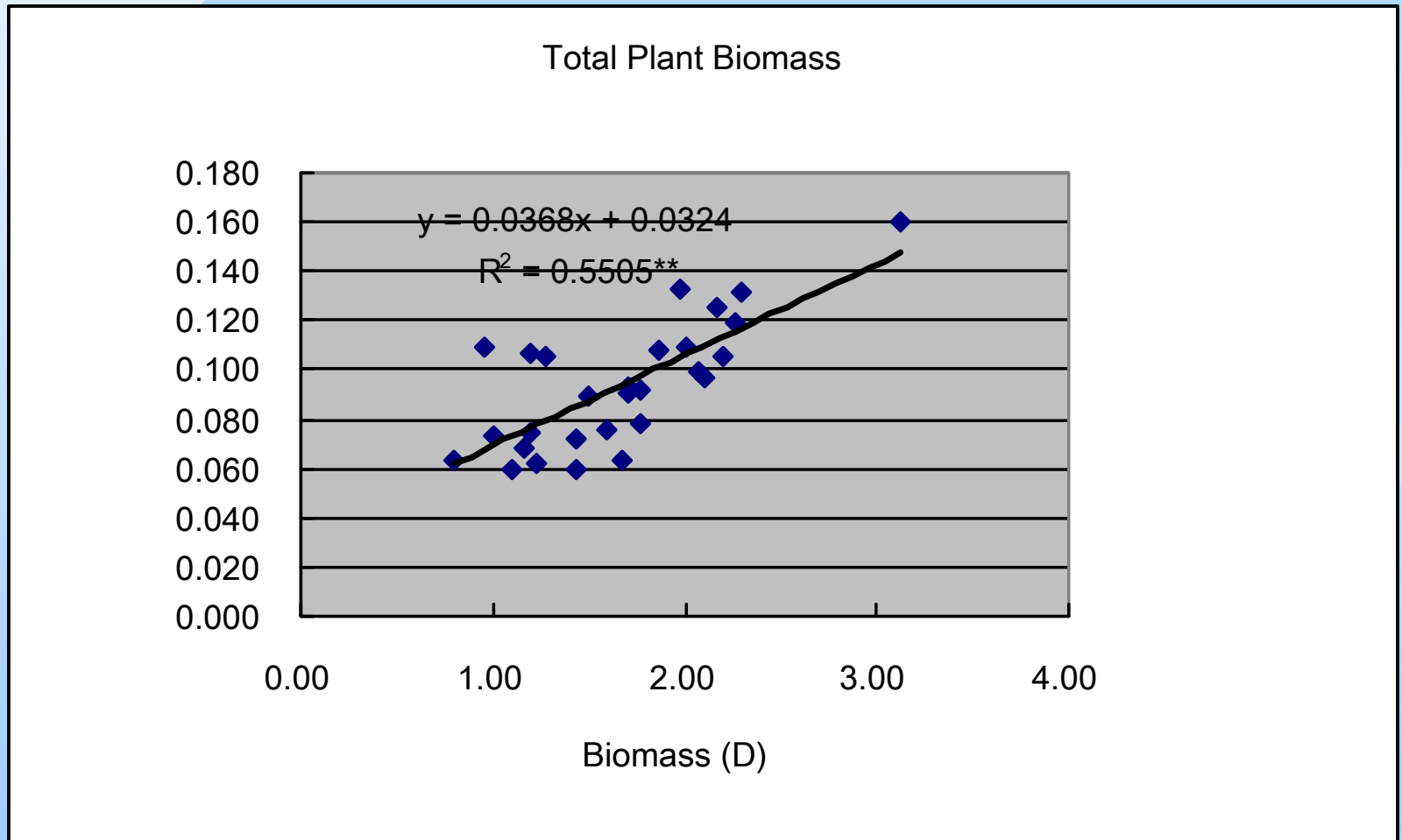
# Water Use

Genotype	Water Use (ml)			
	Droughted	Well-watered	D/W Ratio	Rank
	(D)	(W)		
PSB Cv-19	570.00	7175.00	0.079	10
Rayong 60	555.00	7250.00	0.077	12
Rayong 5	525.00	6275.00	0.084	7
Nito-nito	525.00	7115.00	0.074	15
Sultan 1	521.67	6095.00	0.075	14
PSB Cv-13	540.00	3140.00	0.172	1
PSB Cv-16	690.00	6020.00	0.115	2
Kaplutan	450.00	6530.00	0.069	18
Namaya	348.33	3680.00	0.095	4
Indang 2	480.00	4790.00	0.100	3
G. Yellow	540.00	7595.00	0.071	17
Kadabao	510.00	6410.00	0.080	9
PSB Cv-14	555.00	6965.00	0.080	9
Lakan 1	540.00	7385.00	0.073	16
VC-1	466.67	7850.00	0.059	22
Sultan 2	555.00	7205.00	0.077	12
KU-50	555.00	6230.00	0.089	6
VC-2	420.00	6635.00	0.063	20
Tandang 2	420.00	6890.00	0.061	21
PSB Cv-12	540.00	6005.00	0.090	5
Datu 1	390.00	4745.00	0.082	8
PSB Cv-15	450.00	6560.00	0.069	18
Siasi	525.00	6635.00	0.079	10
Pintuyan 3	585.00	7520.00	0.078	11
Vassourinha	345.00	4550.00	0.076	13
Zapote	360.00	5660.00	0.064	19
PSB Cv-11	510.00	6770.00	0.075	14
VC-4	555.00	7580.00	0.073	16
Mean	500.95	6330.71	0.081	

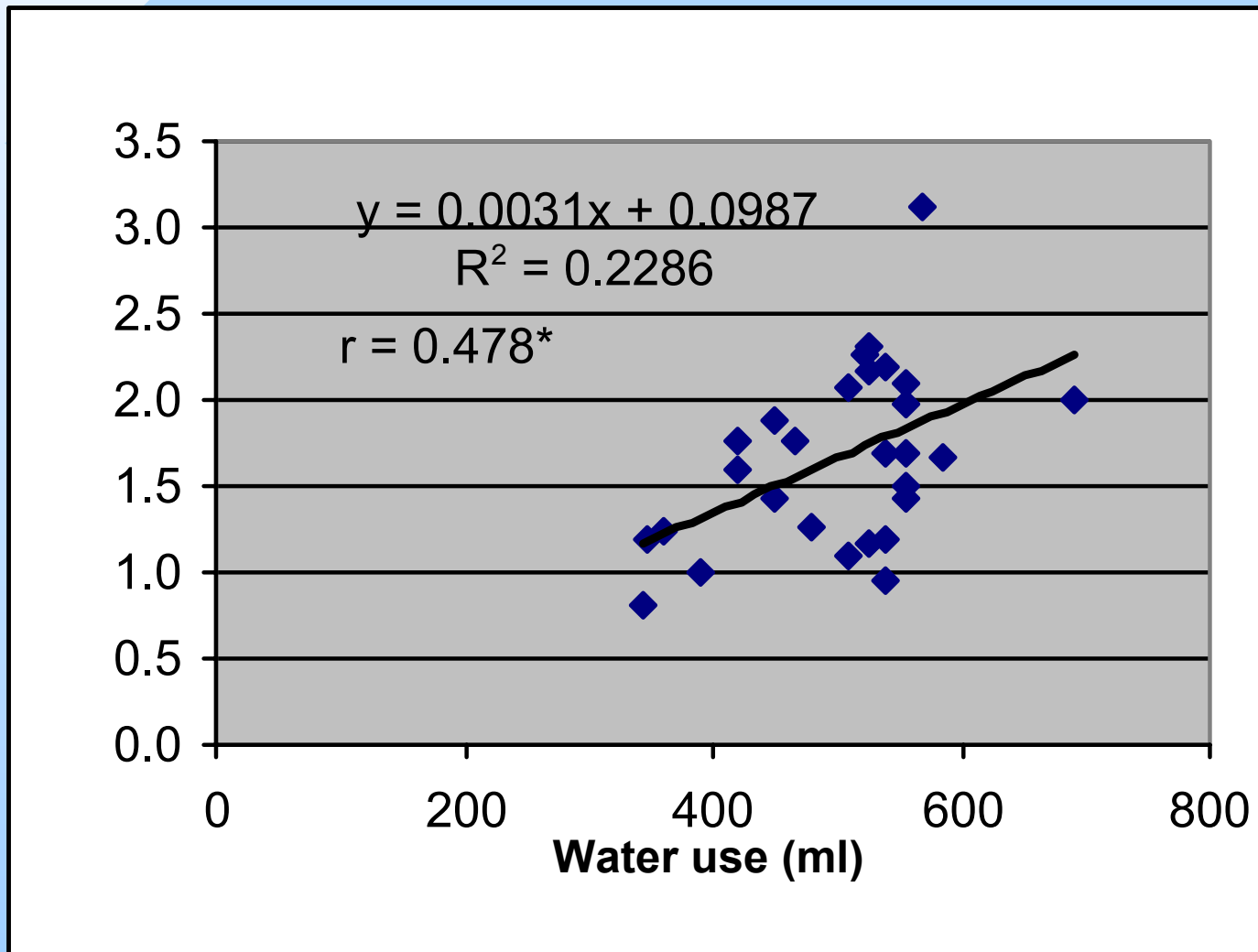
# Water Use Efficiency

Genotype	Water Use Efficiency (g kg <sup>-1</sup> )			
	Droughted	Well-watered	D/W Ratio	Rank
	(D)	(W)		
PSB Cv-19	5.49	2.73	2.011	1
Rayong 60	3.55	2.05	1.732	2
Rayong 5	4.38	2.77	1.581	5
Nito-nito	4.13	2.44	1.693	3
Sultan 1	4.35	2.73	1.593	4
PSB Cv-13	1.76	2.77	0.635	26
PSB Cv-16	2.90	3.03	0.957	18
Kaplutan	4.16	2.65	1.570	6
Namaya	3.45	3.04	1.135	13
Indang 2	2.65	2.51	1.056	14
G. Yellow	4.07	2.75	1.480	8
Kadabao	4.06	3.26	1.245	10
PSB Cv-14	3.78	3.12	1.212	11
Lakan 1	3.15	2.46	1.280	8
VC-1	3.79	2.45	1.547	7
Sultan 2	3.06	2.61	1.172	12
KU-50	2.70	2.68	1.007	16
VC-2	4.21	3.40	1.238	10
Tandang 2	3.81	3.06	1.245	9
PSB Cv-12	2.22	2.65	0.838	21
Datu 1	2.56	2.89	0.886	19
PSB Cv-15	3.18	3.02	1.053	15
Siasi	2.23	2.60	0.858	20
Pintuyan 3	2.85	3.55	0.803	24
Vassourinha	2.32	2.80	0.829	22
Zapote	3.42	3.48	0.983	17
PSB Cv-11	2.16	2.71	0.797	25
VC-4	2.58	3.20	0.806	23
Mean	3.32	2.84	1.171	

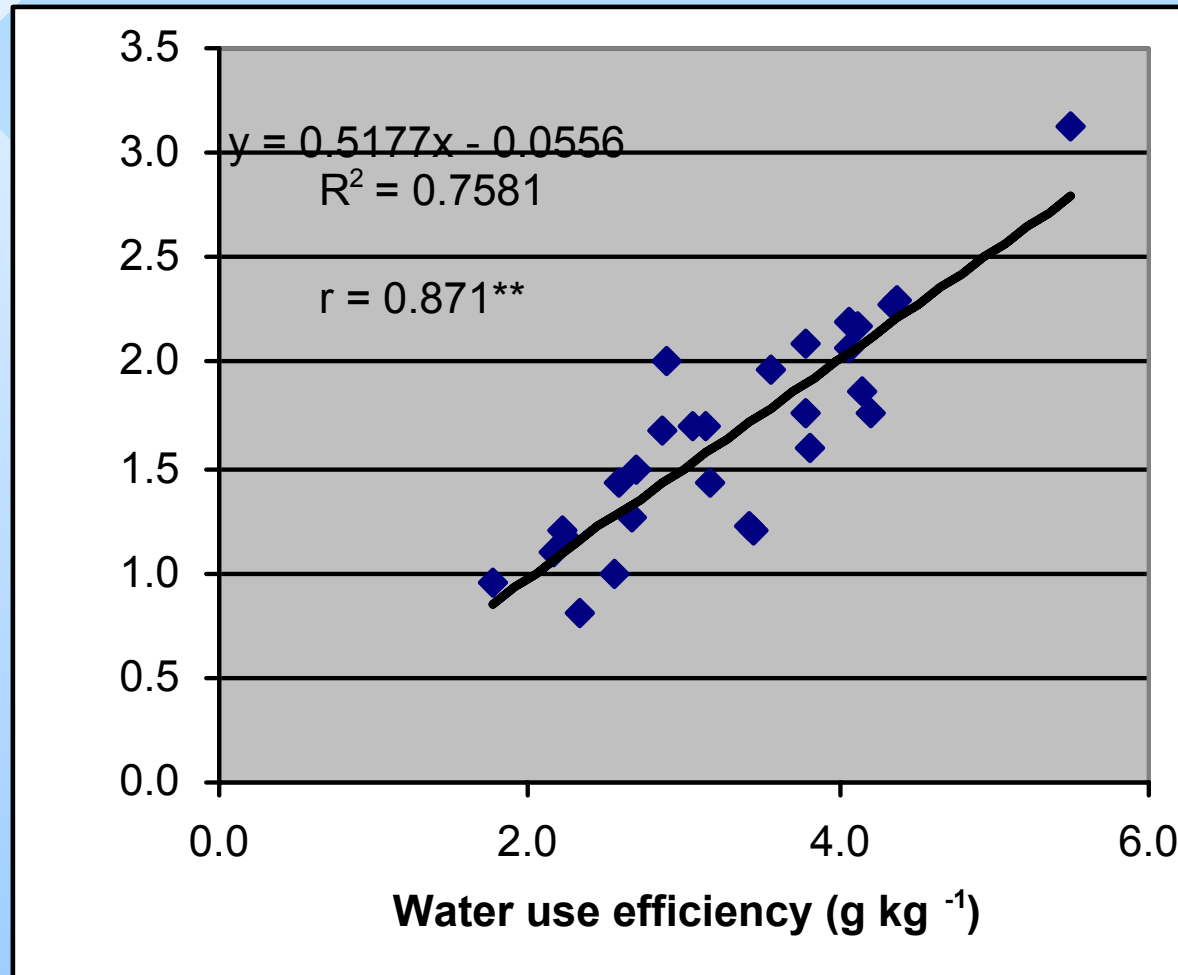
# Genetic variation in drought tolerance



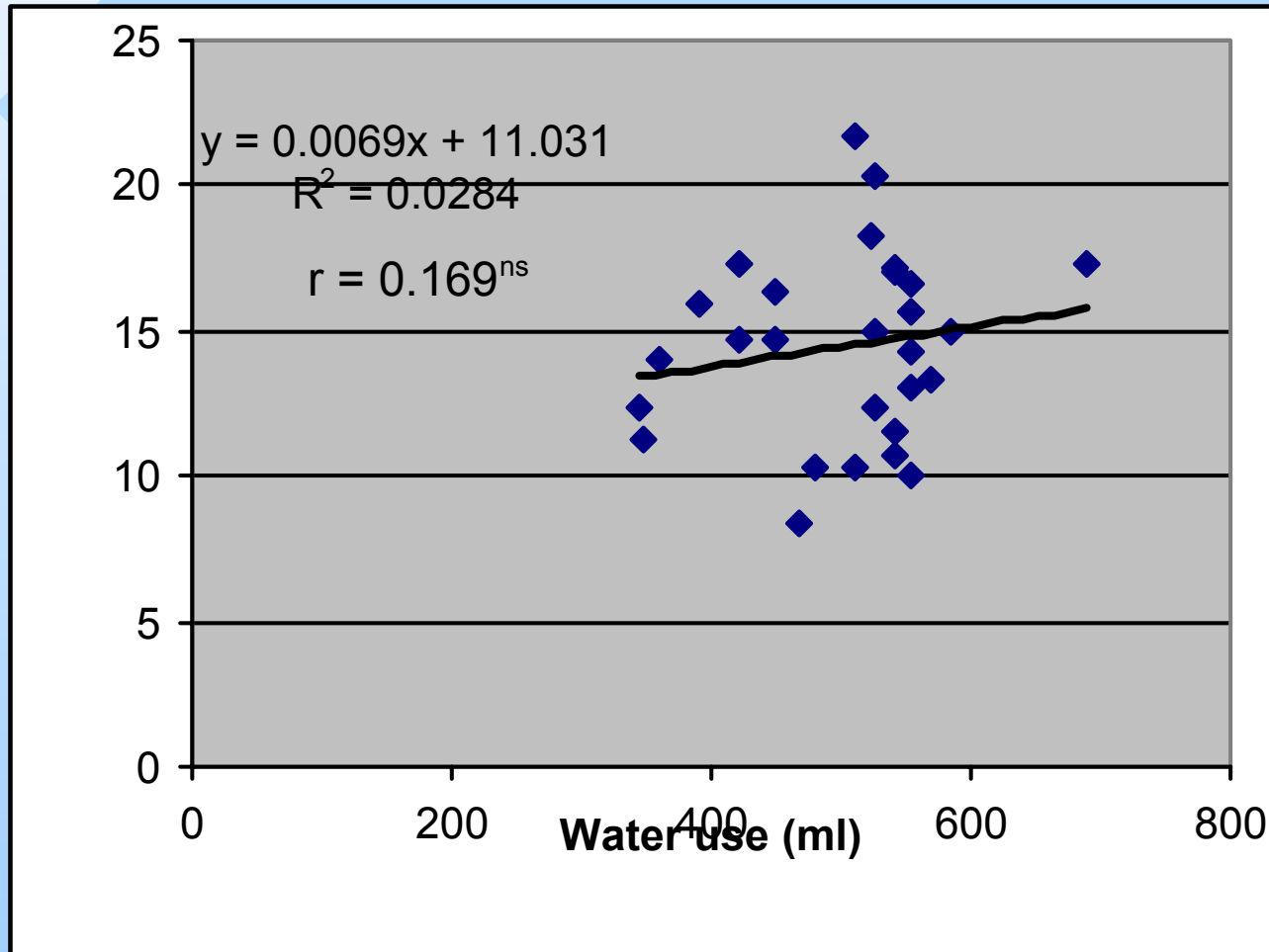
# Genetic variation in Water Use



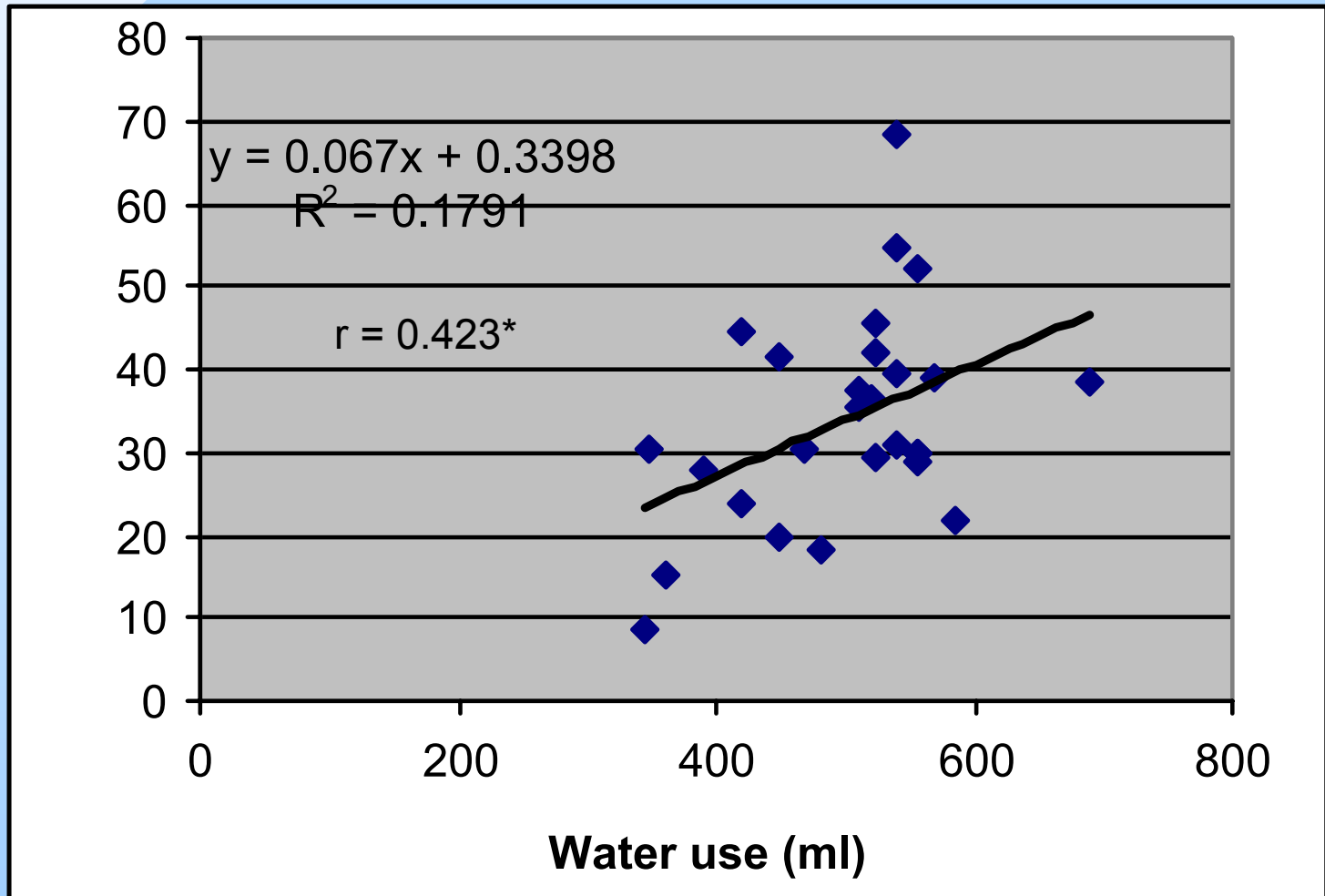
# Genetic variation in Water Use Efficiency



# Water Use x No. Leaves

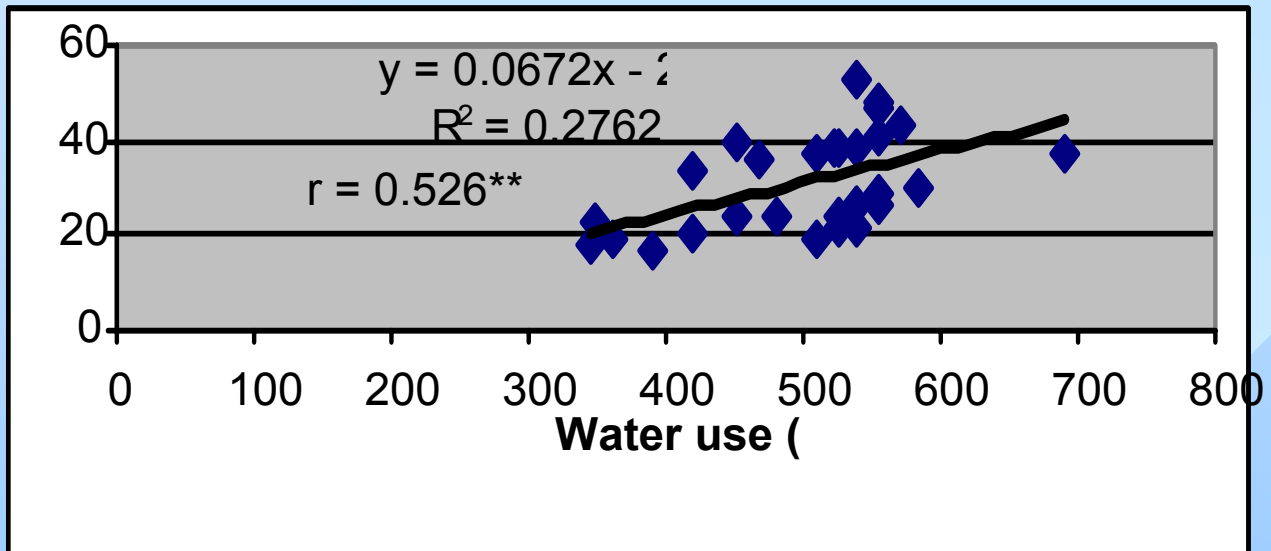
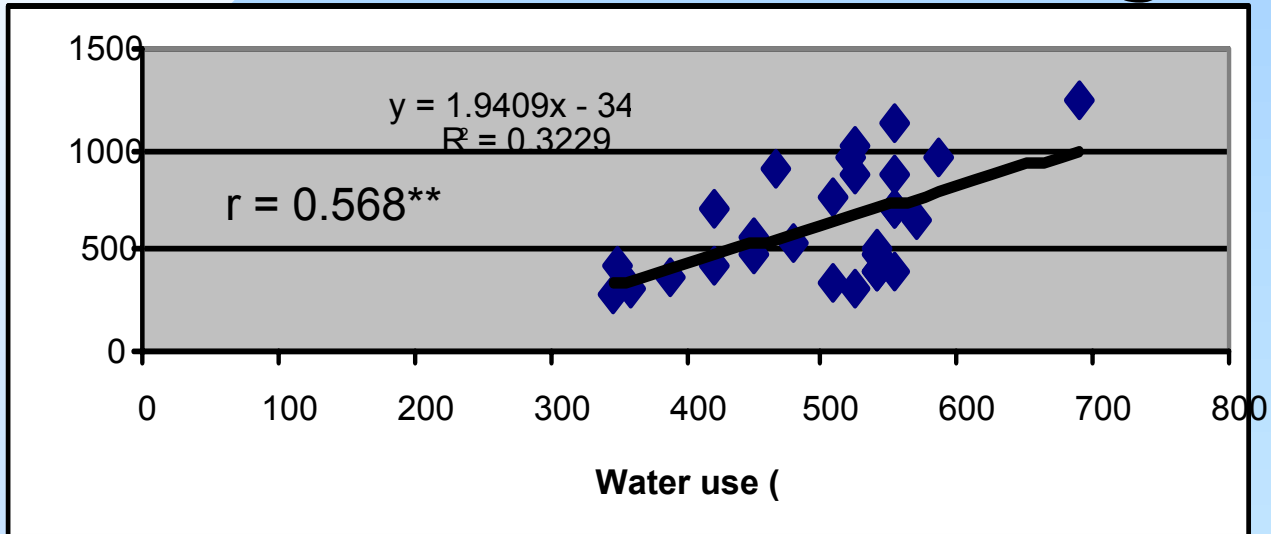


# Water Use x No. Adventitious roots

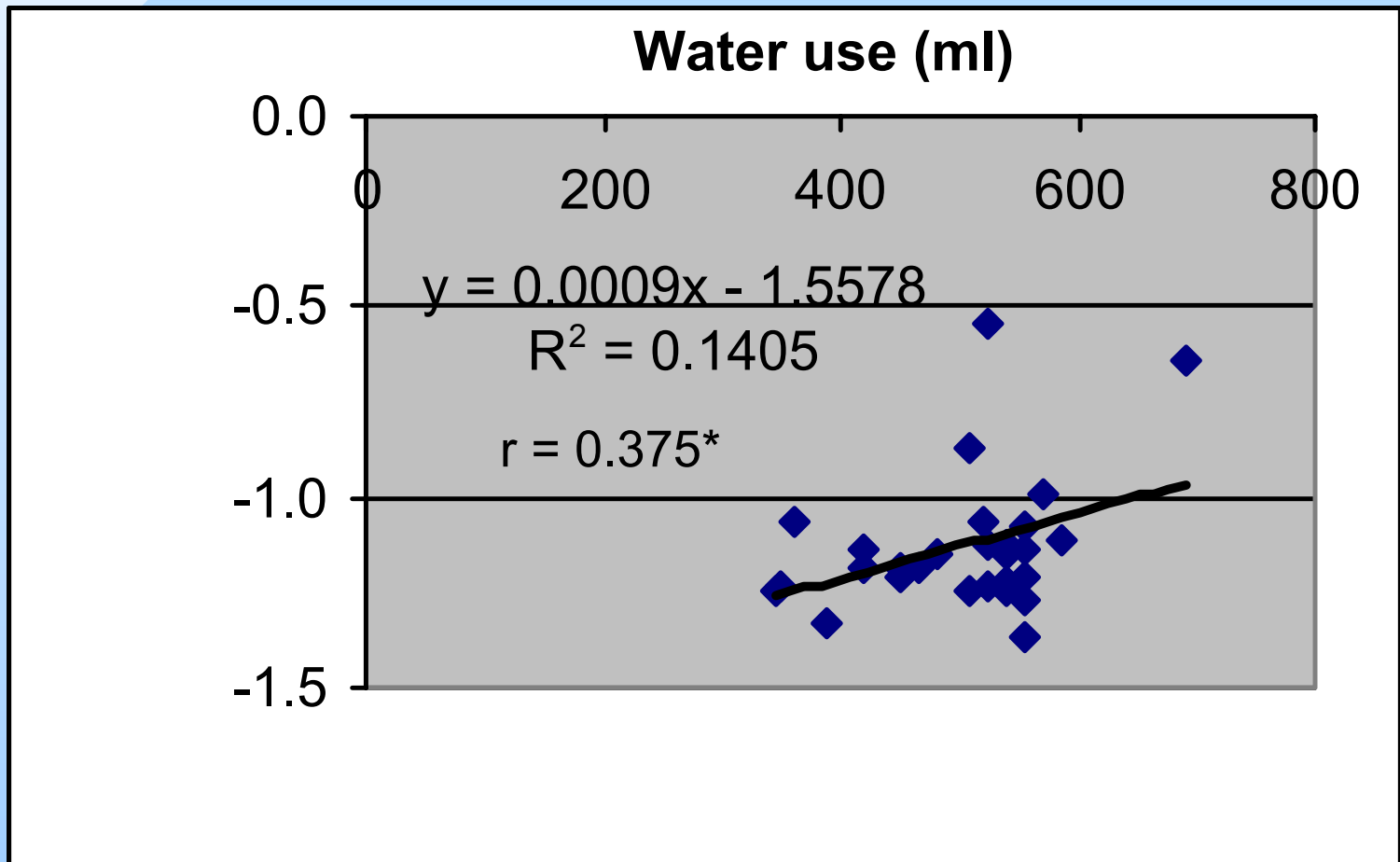


# Water Use x No. 2nd Laterals

## Water Use x Total Root Length



# Water Use x Midday Leaf Water Potential at day 21 of Stress



# Stomatal Response

Genotype	Stomatal Resistance (s cm <sup>-1</sup> ) at Day 31 of Stress			
	Droughted	Well-watered	Ratio	Rank
	(D)	(W)	D/W	
PSB Cv-19	13.63	0.87	15.67	13
Rayong 60	10.14	0.78	13.00	16
Rayong 5	15.29	0.52	29.40	6
Nito-nito	1.55	0.45	3.44	22
Sultan 1	9.26	1.10	8.42	18
PSB Cv-13	2.72	0.27	10.07	16
PSB Cv-16	7.28	0.39	18.67	11
Kaplutan	10.30	0.35	29.43	5
Namaya	30.57	0.34	89.91	1
Indang 2	9.59	0.30	31.97	2
G. Yellow	12.17	1.06	11.48	14
Kadabao	24.57	1.37	17.93	12
PSB Cv-14	10.01	0.43	23.28	8
Lakan 1	2.94	0.52	5.65	21
VC-1	7.96	0.88	9.05	17
Sultan 2	5.35	0.48	11.15	15
KU-50	9.23	0.71	13.00	16
VC-2	5.86	0.44	13.32	15
Tandang 2	6.63	0.93	7.13	20
PSB Cv-12	12.63	0.40	31.58	3
Datu 1	15.46	0.49	31.55	4
PSB Cv-15	6.61	0.46	14.37	14
Siasi	12.37	0.43	28.77	7
Pintuyan 3	12.07	1.50	8.05	19
Vassourinha	4.53	0.34	13.32	15
Zapote	7.12	0.34	20.94	10
PSB Cv-11	9.43	0.41	23.00	9
VC-4	1.60	1.29	1.24	23
Mean	9.89	0.64	15.51	

# Root-Shoot Ratio

Genotype	Root-Shoot Biomass Ratio			
	Droughted	Well-watered	D/W Ratio	Rank
	(D)	(W)		
PSB Cv-19	0.32	0.19	1.684	18
Rayong 60	0.52	0.23	2.261	8
Rayong 5	0.44	0.32	1.375	23
Nito-nito	0.31	0.15	2.067	13
Sultan 1	0.28	0.19	1.474	20
PSB Cv-13	0.58	0.40	1.450	22
PSB Cv-16	0.54	0.14	3.857	1
Kaplutan	0.70	0.29	2.414	5
Namaya	0.50	0.21	2.381	6
Indang 2	0.27	0.22	1.227	25
G. Yellow	0.24	0.21	1.143	28
Kadabao	0.55	0.19	2.895	3
PSB Cv-14	0.64	0.20	3.200	2
Lakan 1	0.38	0.17	2.235	9
VC-1	0.48	0.21	2.286	7
Sultan 2	0.38	0.18	2.111	11
KU-50	0.46	0.22	2.091	12
VC-2	0.32	0.13	2.462	4
Tandang 2	0.33	0.21	1.571	19
PSB Cv-12	0.64	0.30	2.133	10
Datu 1	0.37	0.21	1.762	16
PSB Cv-15	0.23	0.14	1.643	24
Siasi	0.46	0.27	1.704	17
Pintuyan 3	0.22	0.19	1.158	27
Vassourinha	0.19	0.16	1.188	26
Zapote	0.37	0.19	1.947	15
PSB Cv-11	0.38	0.26	1.462	21
VC-4	0.43	0.22	1.955	14
Mean	0.41	0.21	1.922	

# Drought Tolerance Mechanism

- Water Use

Less affected

Root development, high leaf water potential

- Water Use Efficiency

Enhanced

Stomatal control

Promoted allocation of dry matter to roots

**Water conservation during drought, recovery after rain**