



สวทช.
NSTDA

NAC2023
18th NSTDA Annual Conference
การประชุมวิชาการประจำปี สวทช. ครั้งที่ ๑๘



**สำนักงานพัฒนาวิทยาศาสตร์
และเทคโนโลยีแห่งชาติ**

28-31
มีนาคม 2566

Application of high-throughput phenotyping for irrigation schedule in Thai herbs

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National Center for Genetic Engineering and Biotechnology (BIOTEC),

National Science and Technology Development Agency (NSTDA)



Gotu kola



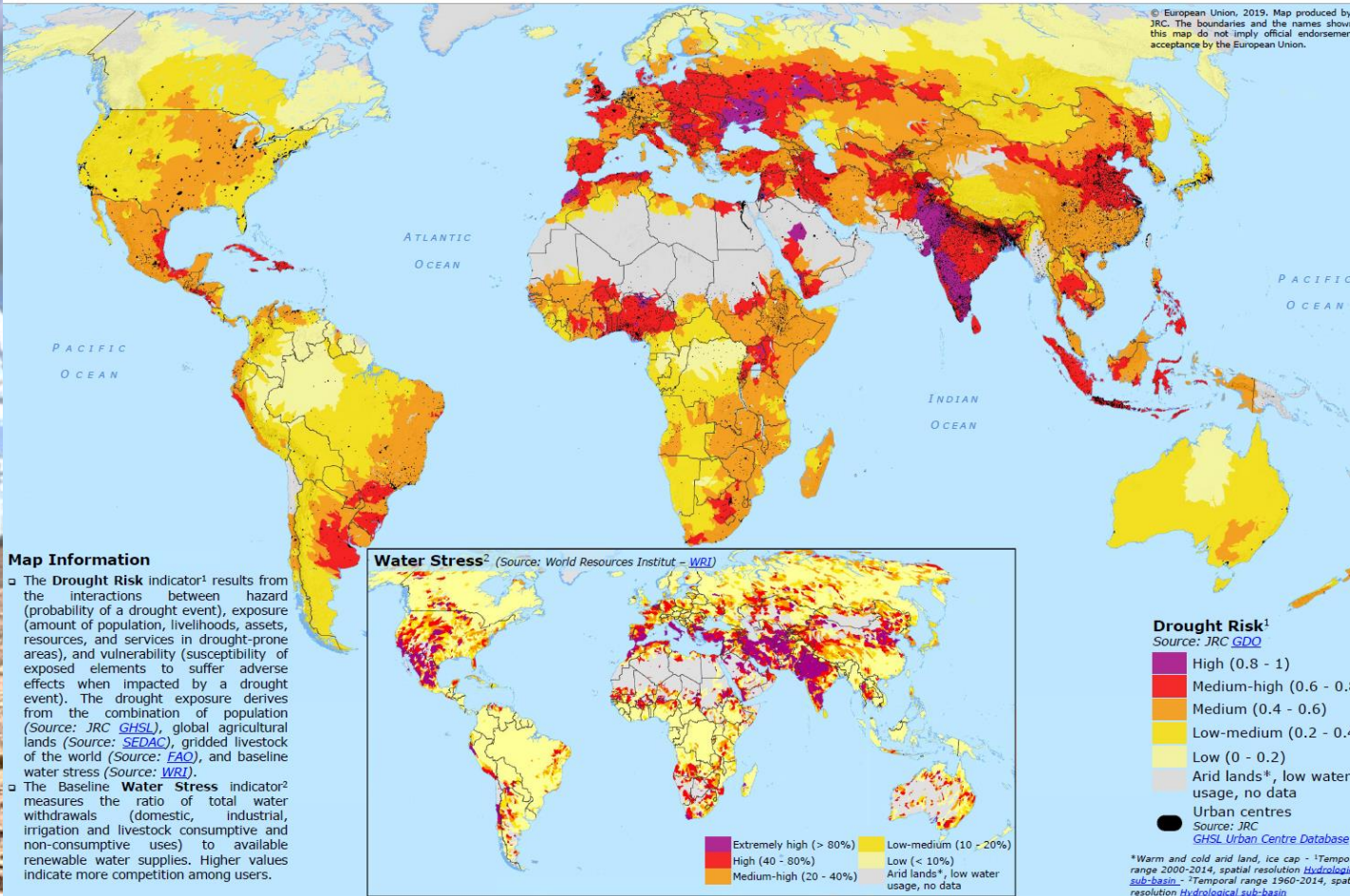
Andrographis paniculata



Turmeric

Emergency Response Coordination Centre (ERCC) – DG ECHO Daily Map | 11/10/2019

Global Drought Risk and Water Stress



- More than 10 million people died due to major drought.
- USD 27.8 billion in economic losses.
- Crop failures and other economic losses due to drought have totaled several hundred billion USD over the last century
- Over 1.4 billion people were affected by drought from 2000 to 2019.
- 12 million hectares of land lost each year.
- 14% of wetlands critical for migratory species.

<https://reliefweb.int/report/world/drought-numbers-2022-restoration-readiness-and-resilience>

Thai herbs:



http://acnews.net/detailnews.php?news_id=N256457940

- ประเทศไทยมีมูลค่าการบริโภคสมุนไพรอยู่ที่อันดับ 8 ของโลก ประมาณ 1,483.5 ล้านดอลลาร์สหรัฐ
- อัตราการขยายตัวของตลาดสมุนไพรร้อยละ 10.3
- ผลิตภัณฑ์ที่สร้างรายได้ 3 อันดับแรกคือ กลุ่มอาหารเสริมชนิดพร้อมดื่ม, กลุ่มเพื่อการรักษาอาการไอ หวัด แพ้อากาศ และกลุ่มอาหารเสริม
- สมุนไพร 5 ชนิด Thailand Champion Herbal Products : TCHP (2557) โดยกรมพัฒนาการแพทย์แผนไทยและการแพทย์ทางเลือก ทั้งภายในประเทศและต่างประเทศ ได้แก่ 1. กวาวเครือขาว 2. กระชายดำ 3. ลูกประคบ 4. ไพล และ 5. บัวบก
- 20 ชนิดสมุนไพรยอดฮิต ที่คนไทยทุกคนรู้จักชื่อดี มีประโยชน์มากมาย ได้แก่ 1. ว่านหางจระเข้ (วุ้นในใบสด) 2. **ขมิ้นชัน** 3. ทองพันชั่ง 4. กะเพรา 5. กระชายดำ 6. ว่านชักมดลูก 7. กระจับแดง 8. มะขามป้อม 9. **ฟ้าทะลายโจร** 10. ย่านาง 11. มะรุม 12. ชุมเห็ดเทศ 13. บอระเพ็ด 14. เสลดพังพอน 15. มะแว้ง(มะเขือพวงขม) 16. รางจืด 17. กระจวาน 18. กานพลู 19. หญ้าหนวดแมว และ 20. **บัวบก**



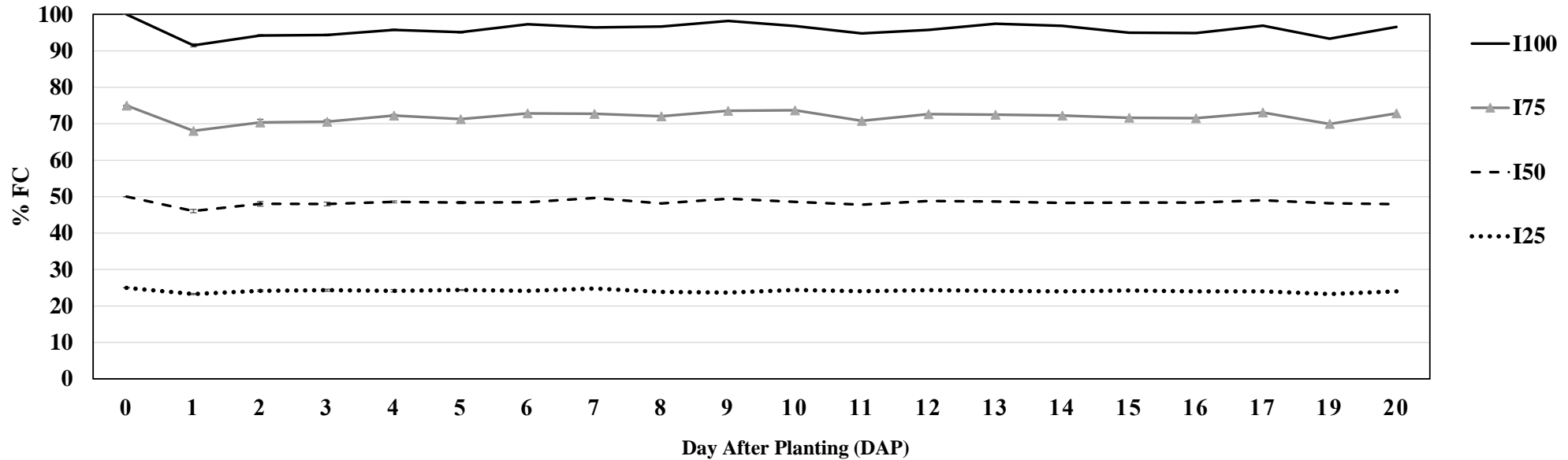
I_{100} = 100% Field capacity
 I_{75} = 75% Field capacity
 I_{50} = 50% Field capacity
 I_{25} = 25% Field capacity



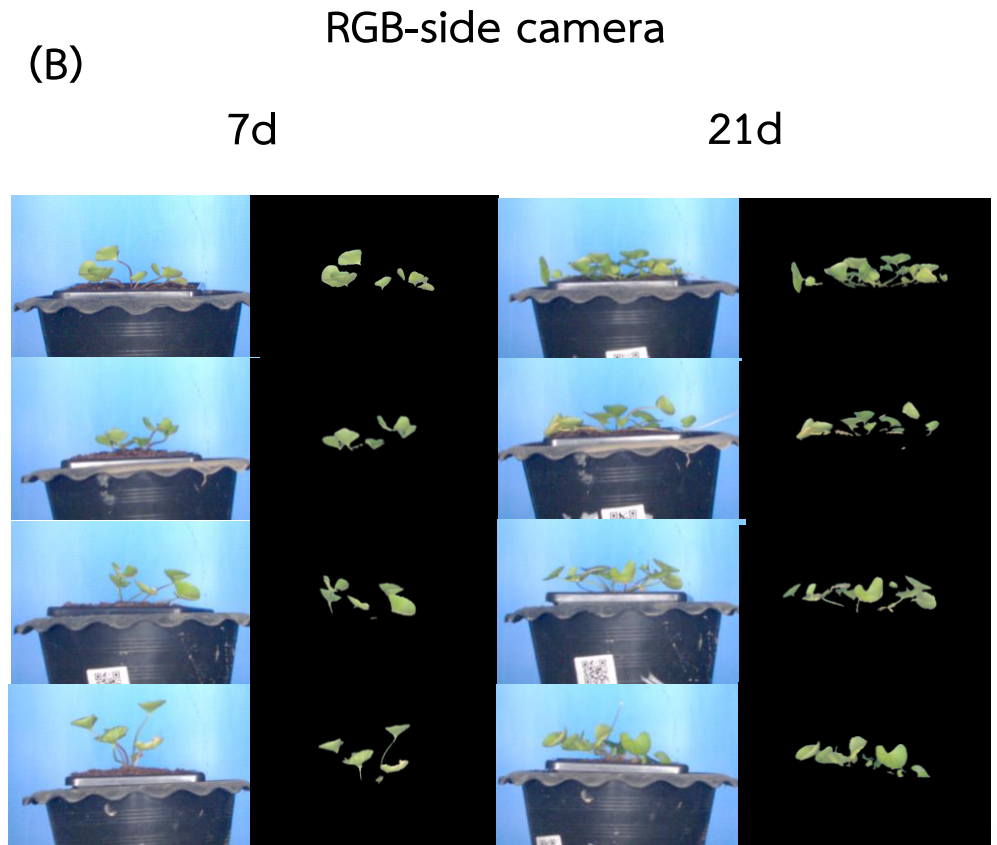
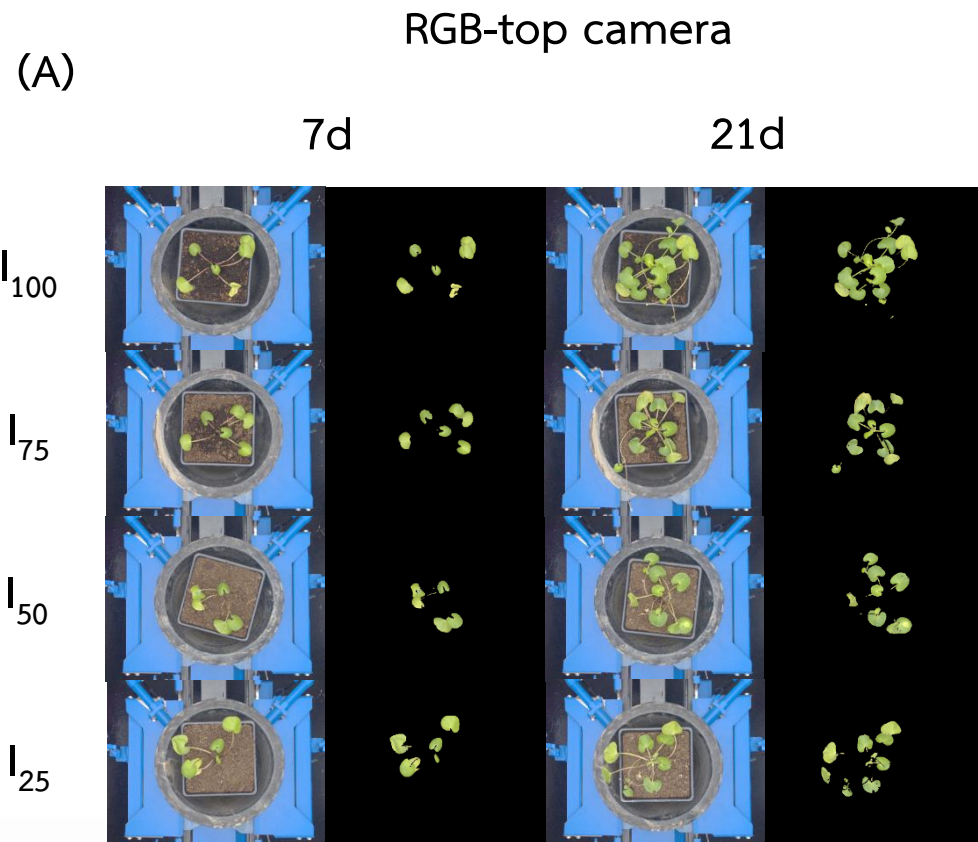
Plant-phenomics

- RGB
- FC

Field capacity percentage of irrigation schedule under I_{100} , I_{75} , I_{50} and I_{25}



RGB imageries of Indian pennywort under I_{100} , I_{75} , I_{50} and I_{25} for 7 and 21 days from RGB-top camera (A) and RGB-side camera (B)

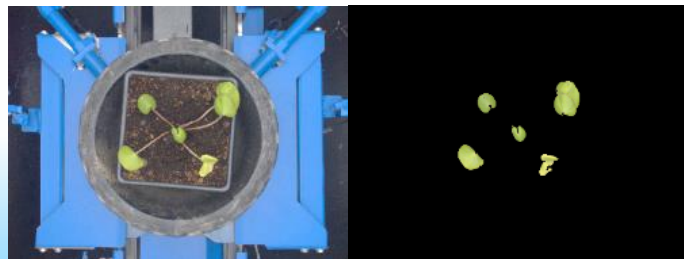


Canopy width, canopy height, perimeter, plant projected area and plant volume of Indian pennywort under different irrigation schedule

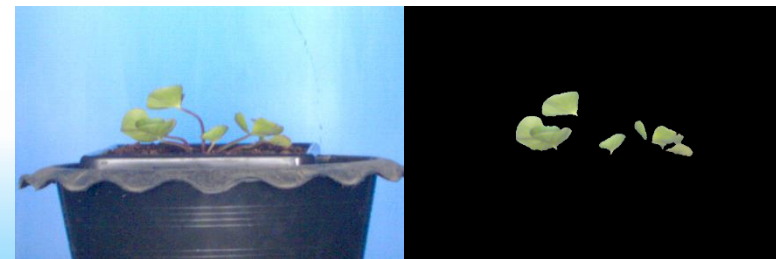
Tr.	Canopy width (cm)		Canopy height (cm)		Perimeter (cm)		Plant projected area (cm ²)		Plant volume (cm ³)	
	7d	21d	7d	21d	7d	21d	7d	21d	7d	21d
I ₁₀₀	14.8±0.5	18.3±0.6	5.0±0.8	5.6±0.4	86.9±8.1	242.7±11.8 a	60.4±4.9	193.0±15.5 a	105.4±11.5	493.3±59.1 a
I ₇₅	14.2±1.0	17.7±0.9	5.4±0.6	4.8±0.4	88.9±3.2	207.0±9.5 ab	56.3±1.8	131.9±13.1 b	102.8±12.6	325.5±59.5 ab
I ₅₀	13.5±1.1	17.9±0.9	7.3±0.6	5.8±0.5	106.6±9.9	195.0±13.5 b	70.7±6.7	131.3±9.6 b	134.0±19.8	315.8±40.7 ab
I ₂₅	13.3±0.7	17.1±0.7	6.1±0.9	5.5±0.6	90.8±7.9	170.6±9.0 b	53.5±6.7	112.8±12.0 b	90.0±20.2	252.7±28.8 b

Data presented as mean ± SE (n=6). Different letters in each column show significant difference at $p \leq 0.05$ according to Tukey's HSD test.

RGB-top camera



RGB-side camera

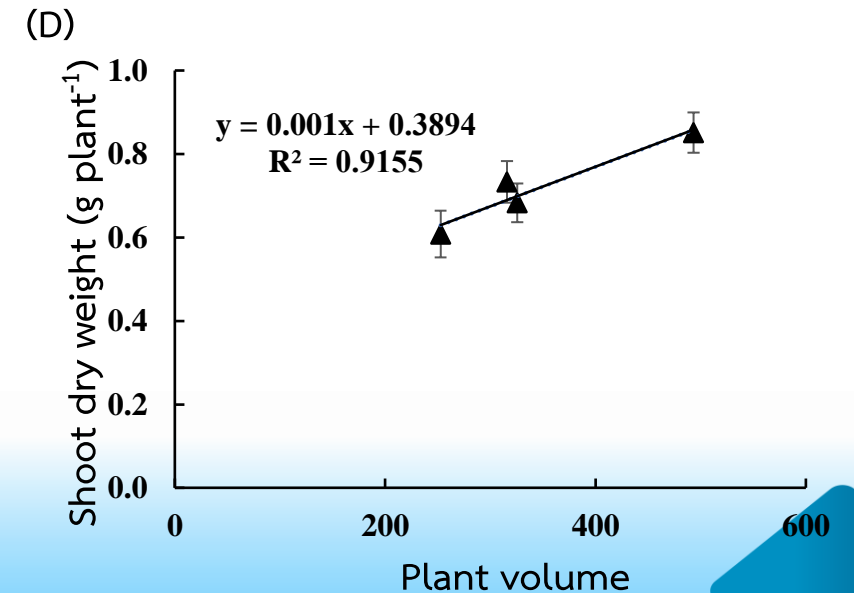
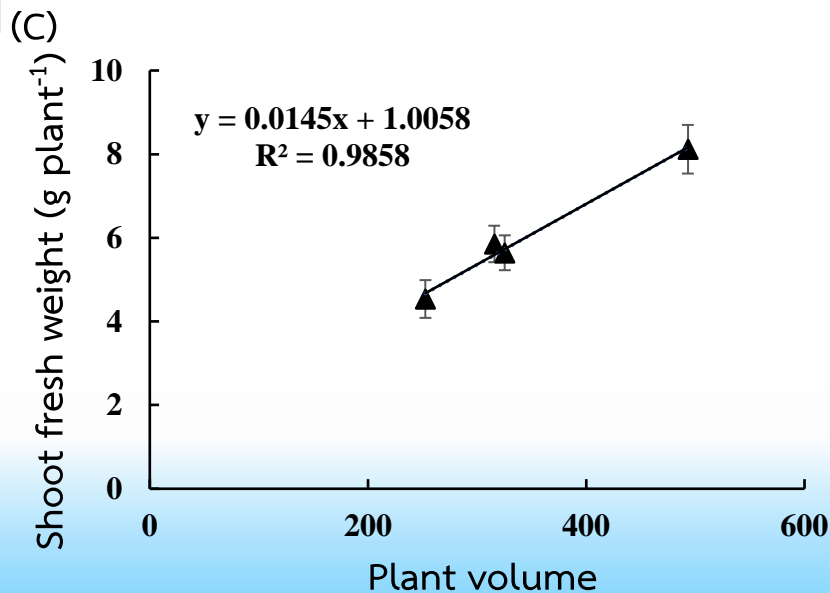
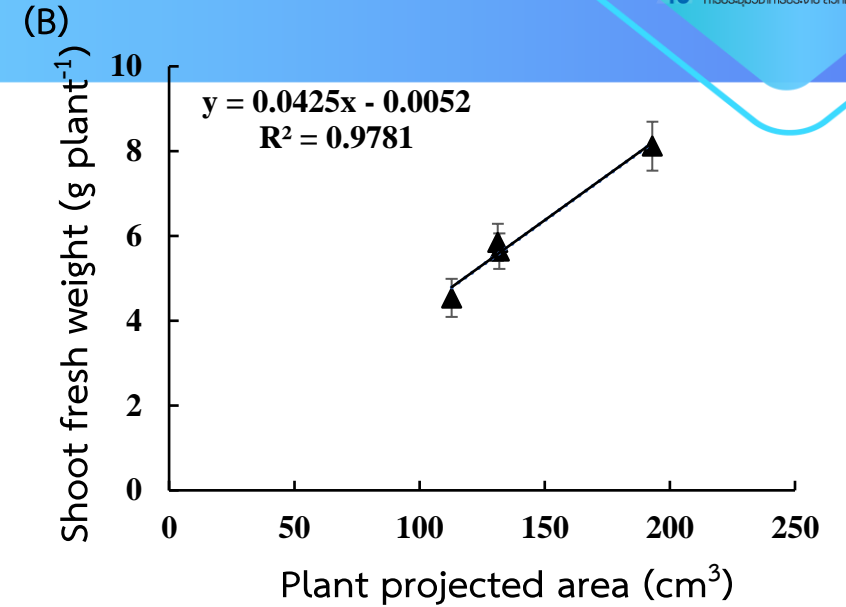
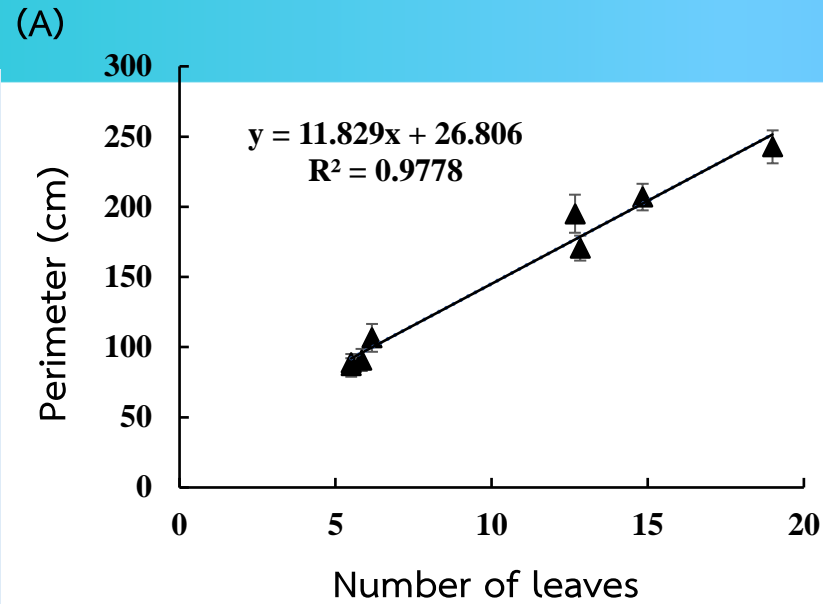
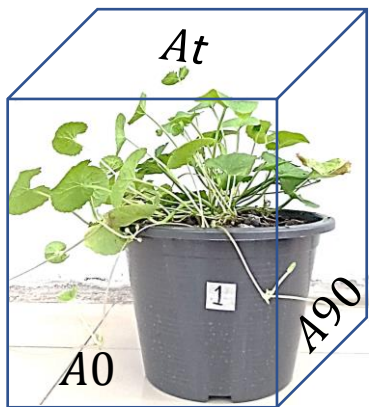


Relationship between number

- of
- leaf and perimeter (A)
- plant projected area and shoot fresh weight (B)
- plant volume and shoot fresh weight (C)
- plant volume and shoot dry weight (D)

$$V = \sqrt{At \times A0 \times A90}$$

Arend et al. (2016)

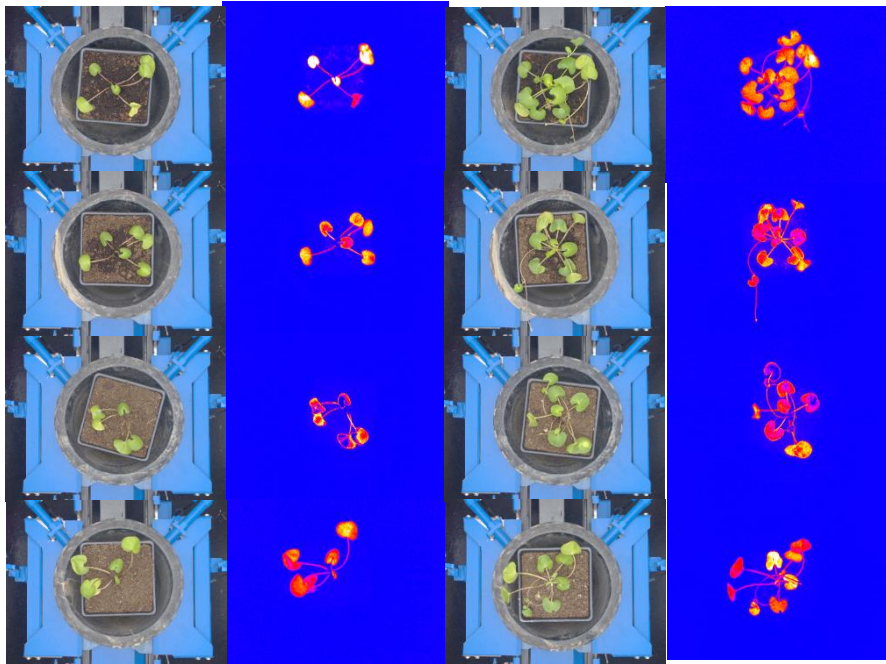


FC imageries (A), F_v/F_m from FC (B) and F_v/F_m from FC and FMS2 (Hansatec, UK) in Indian pennywort under I_{100} , I_{75} , I_{50} and I_{25} for 7 and 21 days

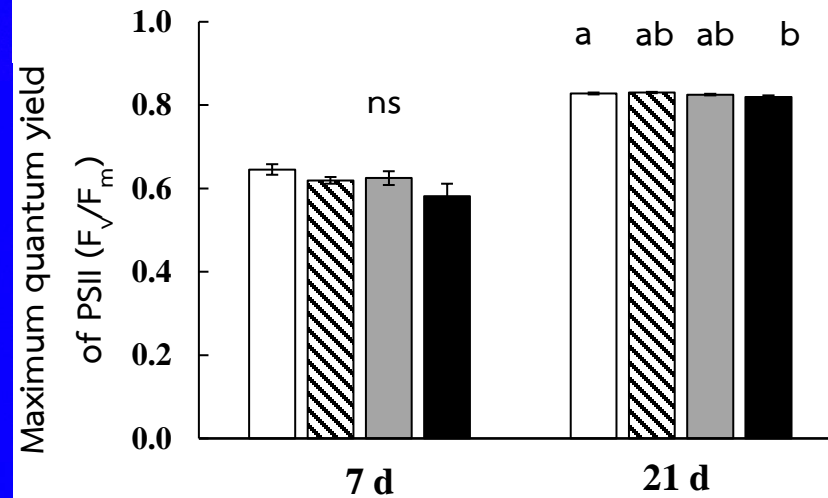
(A)

Week1

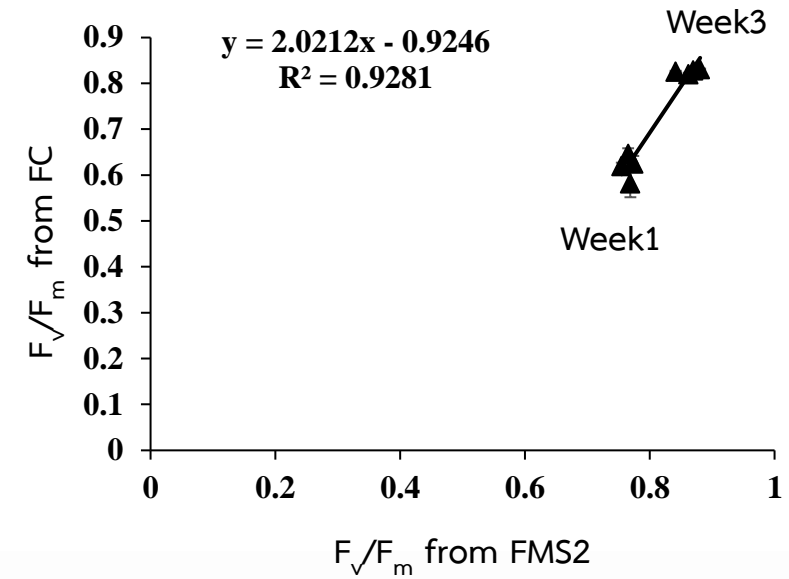
Week3



(B)



(C)



Andrographis paniculata (Burm. f.) Nees



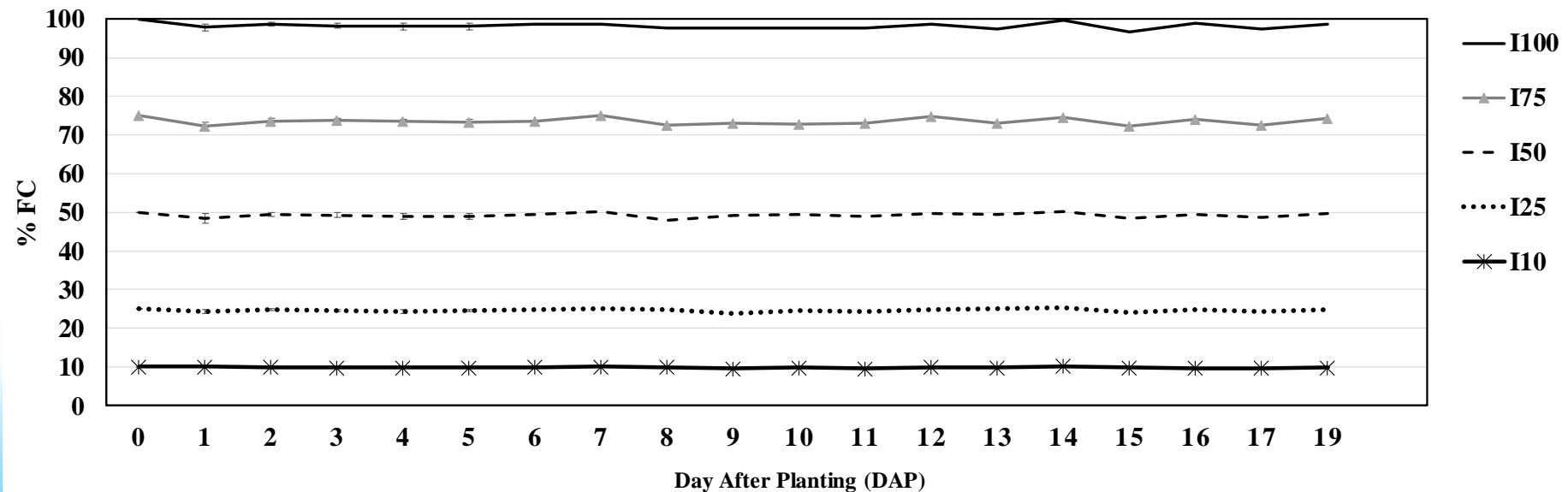
I_{100} = 100% Field capacity
 I_{75} = 75% Field capacity
 I_{50} = 50% Field capacity
 I_{25} = 25% Field capacity
 I_{10} = 10% Field capacity



Plant-phenomics

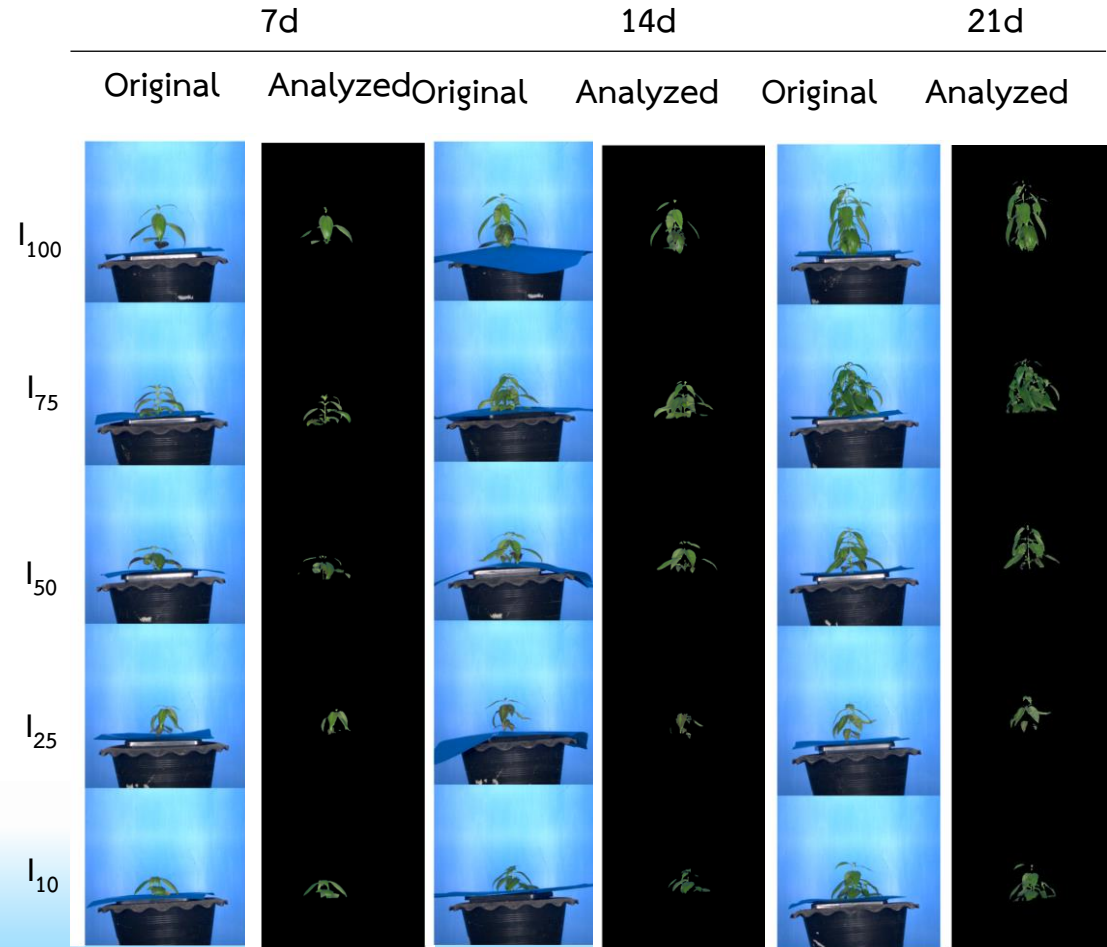
- RGB
- FC

Field capacity percentage of irrigation schedule at I_{100} , I_{75} , I_{50} , I_{25} and I_{10} from 0 to 19 days of experiment

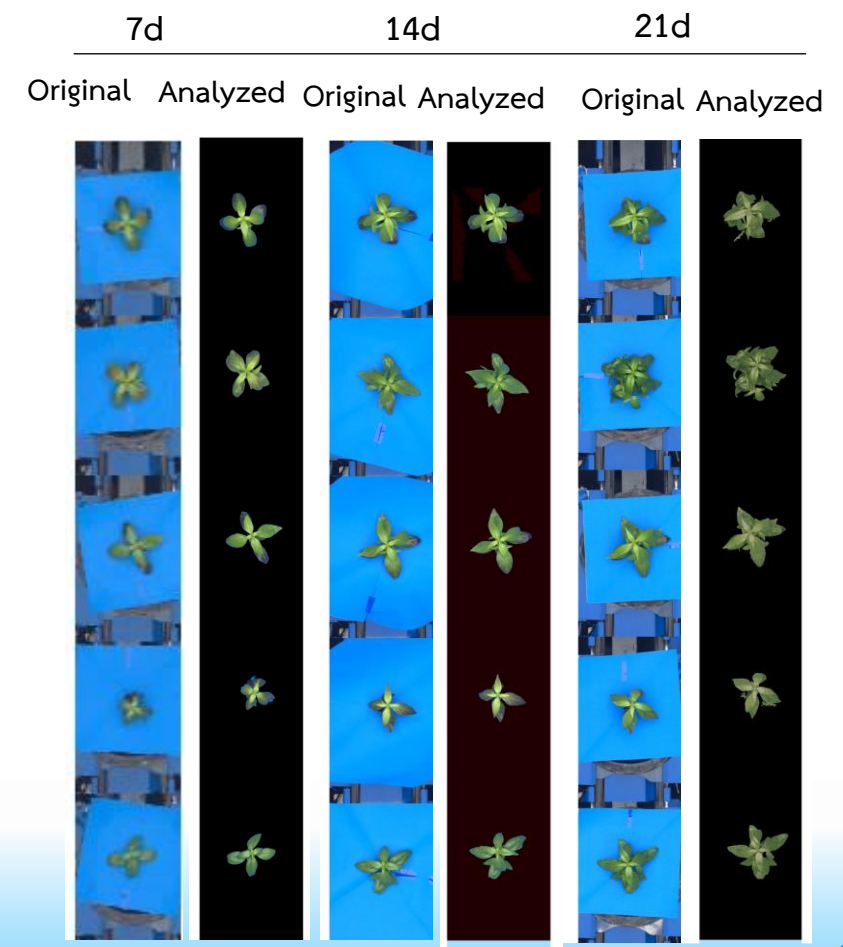


RGB imageries of *A. paniculata* under I_{100} , I_{75} , I_{50} , I_{25} and I_{10} for 7, 14 and 21 days from RGB-side camera (A) and RGB-top camera (B)

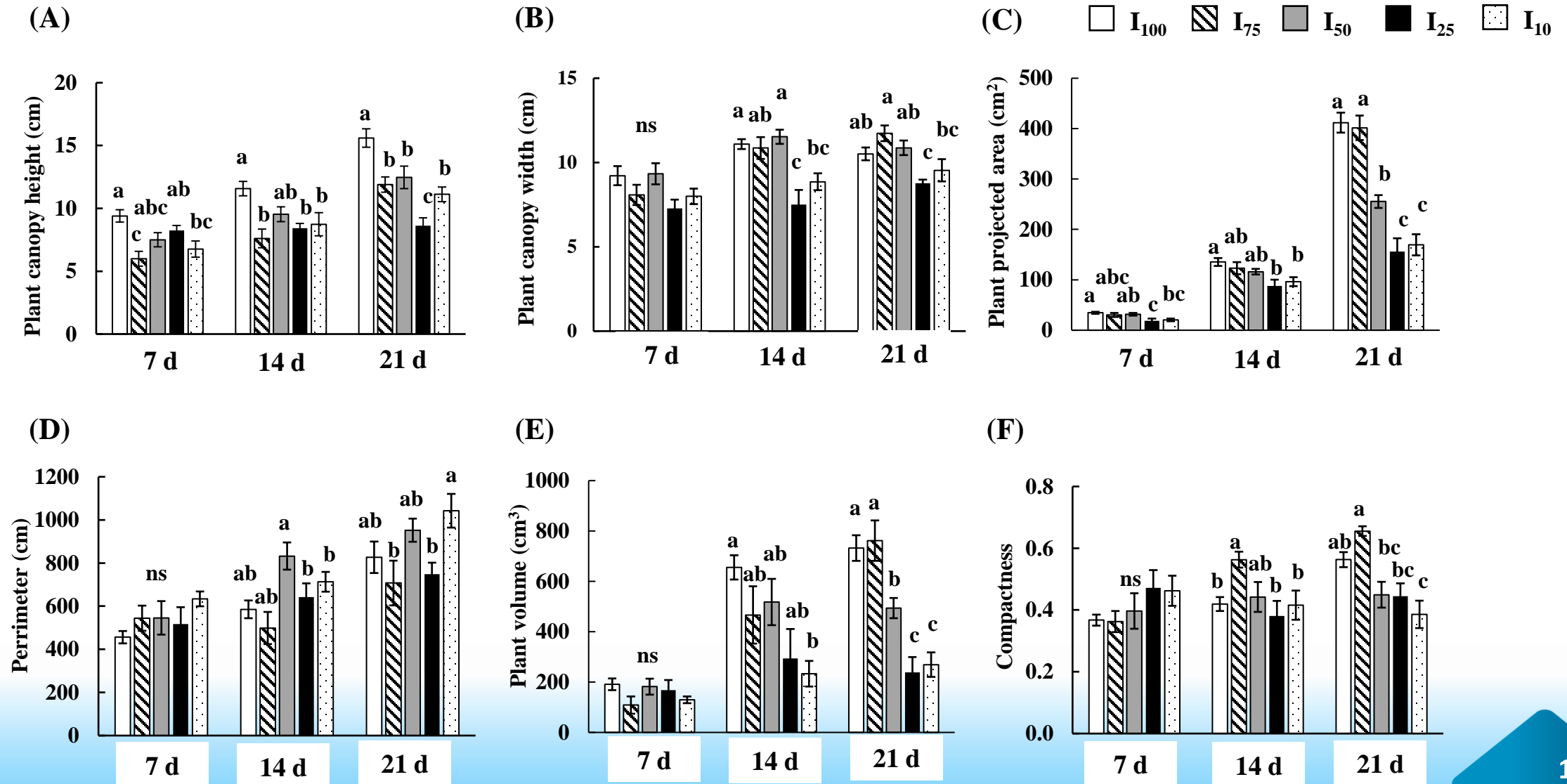
(A)



(B)

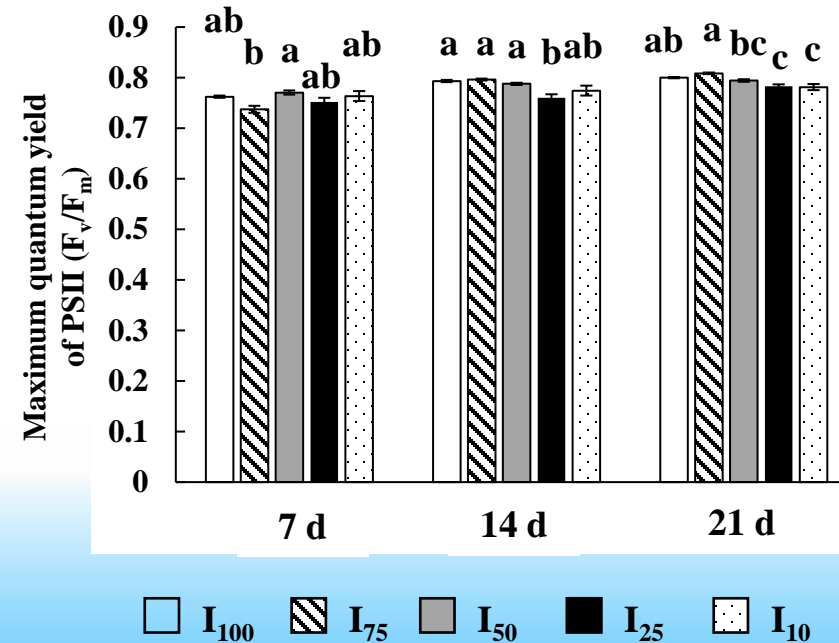
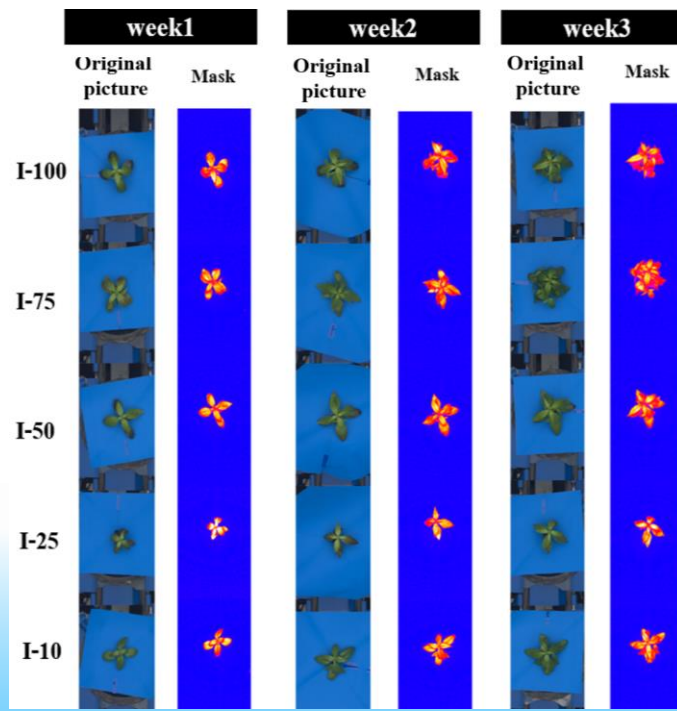


Plant morphology including plant canopy height (A), plant canopy width (B), plant projected area (C), perimeter (D), plant volume (E) and compactness (F) of *A. paniculata* under different irrigation schedule for 7, 14 and 21 days



Data set derived from Fluorocam imagery

Measuring Date	Measuring Time	Experiment ID	Round Order	Tray ID	Tray Info	Plant ID	Position	Plant Name	Plant Info	PID	Camera Position	Size	Fo	Fm	Fv	QY_max	Fp	Fm_L1	Fm_L2	Fm_L3	Fm_L4	Fm_Lss	Fm_D1	Fm_D2
2020-09-02	11:47:27	76	173	RSC2020_Tray_052		RSC2020_Tray_052	G0	T1R2		FC1	400	6456	104.8898	526.6838	421.794	0.800235	770.7974	985.5039	1008.061	1010.626	983.6795	972.5771	915.6606	921.9856
2020-09-02	11:51:20	76	173	RSC2020_Tray_053		RSC2020_Tray_053	G0	T1R3		FC1	400	5763	108.3859	550.4882	442.1023	0.803014	625.0131	766.5238	861.5393	934.946	940.5104	944.4737	838.8473	801.7364
2020-09-02	11:55:13	76	173	RSC2020_Tray_054		RSC2020_Tray_054	G0	T1R4		FC1	400	6687	103.7395	517.565	413.8255	0.799205	617.0487	933.1792	978.3224	987.7557	979.6216	978.485	889.2715	861.747
2020-09-02	11:59:06	76	173	RSC2020_Tray_055		RSC2020_Tray_055	G0	T2R1		FC1	400	5862	106.3675	526.617	420.2495	0.797596	733.3798	1090.469	1144.585	1102.358	1121.663	1128.605	992.1532	959.9841
2020-09-02	12:03:00	76	173	RSC2020_Tray_056		RSC2020_Tray_056	G0	T2R2		FC1	400	7615	113.919	592.5661	478.647	0.807175	598.5477	554.7263	638.2911	666.4186	672.2754	673.8197	662.6022	619.2853
2020-09-02	12:06:53	76	173	RSC2020_Tray_057		RSC2020_Tray_057	G0	T2R3		FC1	400	5740	115.1266	618.1158	502.9892	0.812376	611.3557	620.6835	679.5301	707.5728	722.707	733.6941	675.1494	637.1861
2020-09-02	12:10:46	76	173	RSC2020_Tray_058		RSC2020_Tray_058	G0	T2R4		FC1	400	6462	107.088	557.9373	450.8493	0.807623	642.5743	833.0473	916.3441	956.1968	963.1322	966.472	874.9302	830.9713
2020-09-02	12:14:40	76	173	RSC2020_Tray_059		RSC2020_Tray_059	G0	T3R1		FC1	400	6270	111.5016	579.3946	467.893	0.806653	575.0926	521.4556	603.1938	653.2682	655.7346	662.1176	620.1202	585.2064
2020-09-02	12:18:33	76	173	RSC2020_Tray_060		RSC2020_Tray_060	G0	T3R2		FC1	400	6161	115.196	565.0672	449.8712	0.795008	752.6888	519.9765	643.5472	647.8687	635.95	633.2545	594.3024	577.9917
2020-09-02	12:22:27	76	173	RSC2020_Tray_061		RSC2020_Tray_061	G0	T3R3		FC1	400	5740	113.503	548.2391	434.7361	0.791827	968.9136	1026.207	1095.561	1018.551	1071.752	1101.209	974.2127	941.4035
2020-09-02	12:26:20	76	173	RSC2020_Tray_062		RSC2020_Tray_062	G0	T3R4		FC1	400	6756	108.7168	519.661	410.9443	0.789323	861.1587	793.8536	856.3315	862.3537	854.6927	870.7531	778.276	763.4778
2020-09-02	12:30:13	76	173	RSC2020_Tray_063		RSC2020_Tray_063	G0	T4R1		FC1	400	4929	110.1641	555.8698	445.7057	0.800465	841.7624	874.5578	957.4195	975.8924	981.78	980.5399	814.7935	801.7472
2020-09-02	12:34:06	76	173	RSC2020_Tray_064		RSC2020_Tray_064	G0	T4R2		FC1	400	3739	111.7229	540.3312	428.6084	0.791658	873.6765	731.4103	777.9056	724.5538	758.3992	770.3636	691.0056	686.2507
2020-09-02	12:38:00	76	173	RSC2020_Tray_065		RSC2020_Tray_065	G0	T4R3		FC1	400	4450	109.7266	516.1636	406.437	0.785513	953.6789	839.0651	944.697	972.6194	951.2172	933.4257	793.7083	786.059
2020-09-02	12:41:53	76	173	RSC2020_Tray_066		RSC2020_Tray_066	G0	T4R4		FC1	400	4762	118.1395	538.3853	420.2458	0.778219	1036.525	762.5333	849.0686	844.9139	855.4291	847.8161	732.9873	730.3953
2020-09-02	12:45:46	76	173	RSC2020_Tray_067		RSC2020_Tray_067	G0	T5R1		FC1	400	3909	111.4255	505.7774	394.3519	0.776256	1119.904	1036.349	998.666	870.5871	952.3925	1043.569	908.2271	906.7605
2020-09-02	12:49:39	76	173	RSC2020_Tray_068		RSC2020_Tray_068	G0	T5R2		FC1	400	5106	122.0315	590.6854	468.6539	0.792693	537.1597	296.1578	323.945	343.1163	334.4415	330.6915	359.1013	363.8036





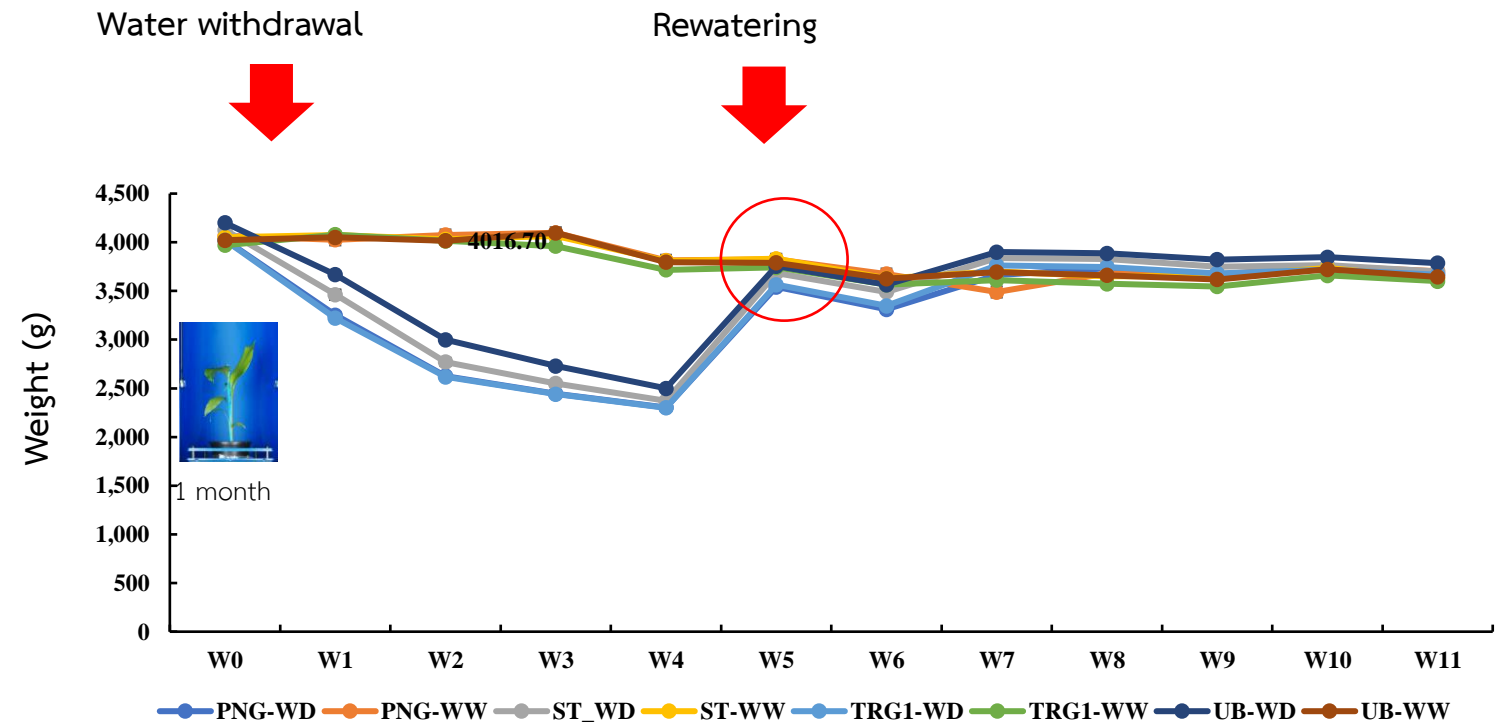
- PNG
- ST
- TRG1
- UB

1 months old



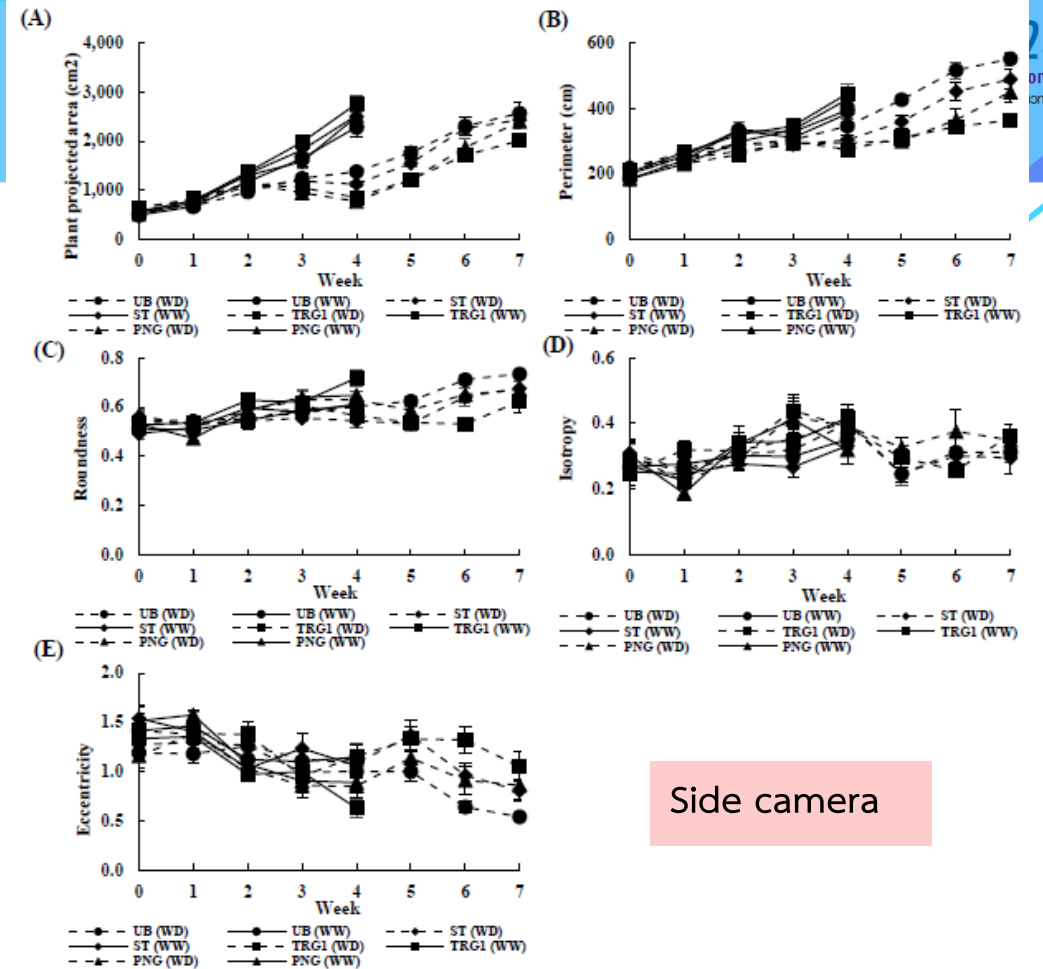
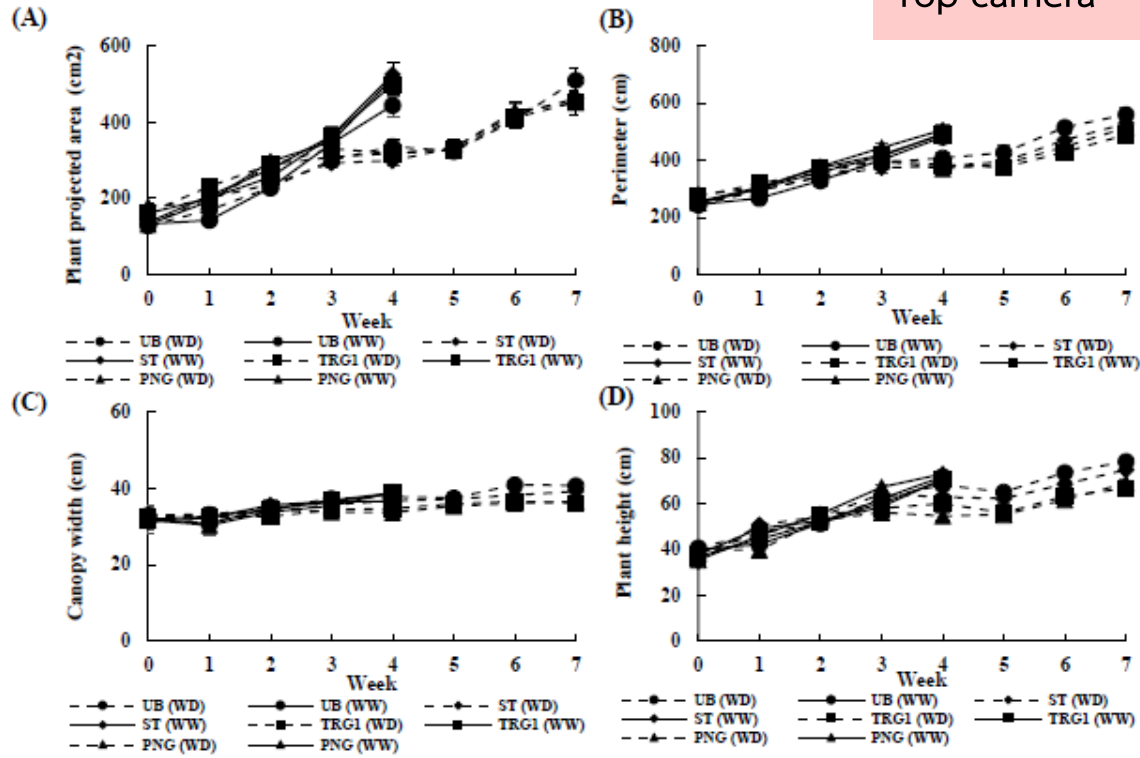
Water withdrawal

Plant watering schedule for turmeric

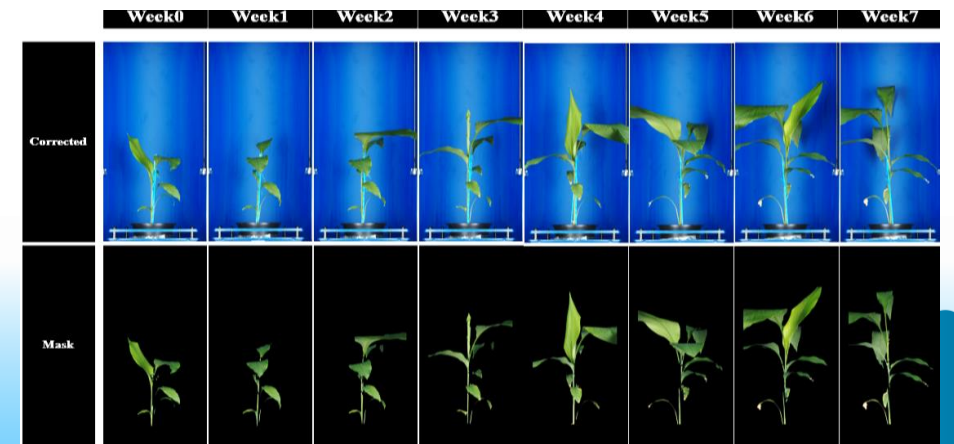


RGB camera

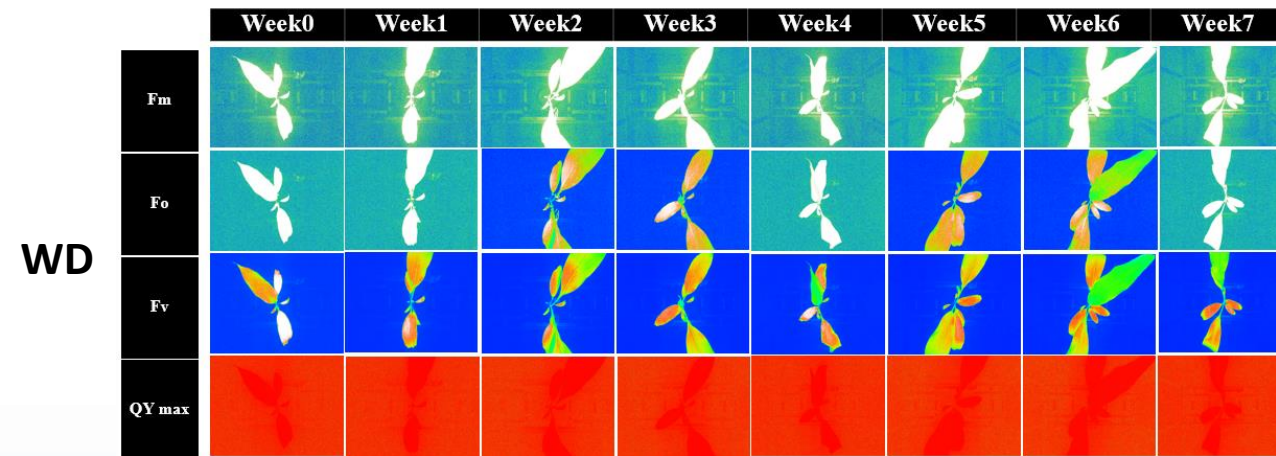
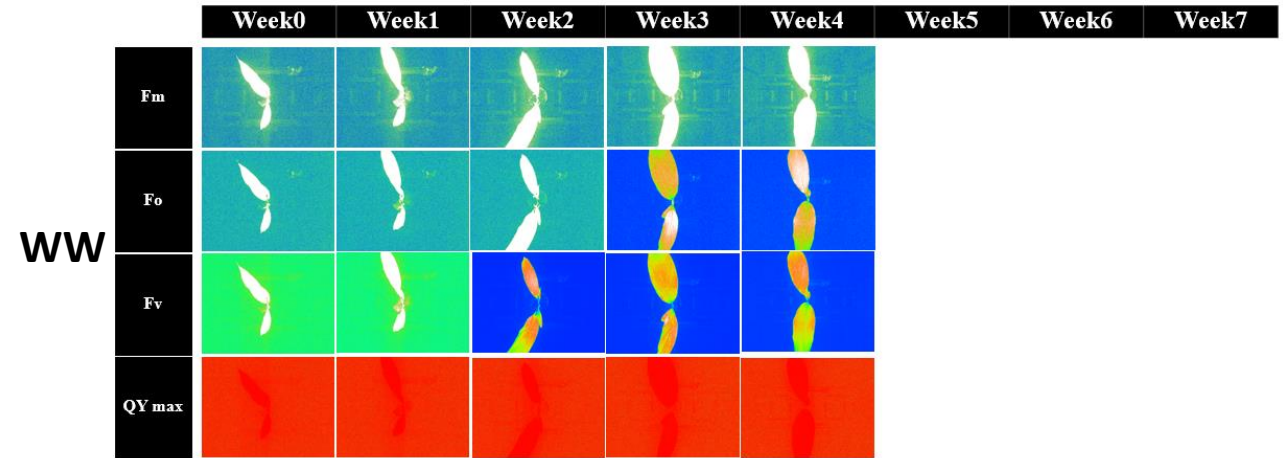
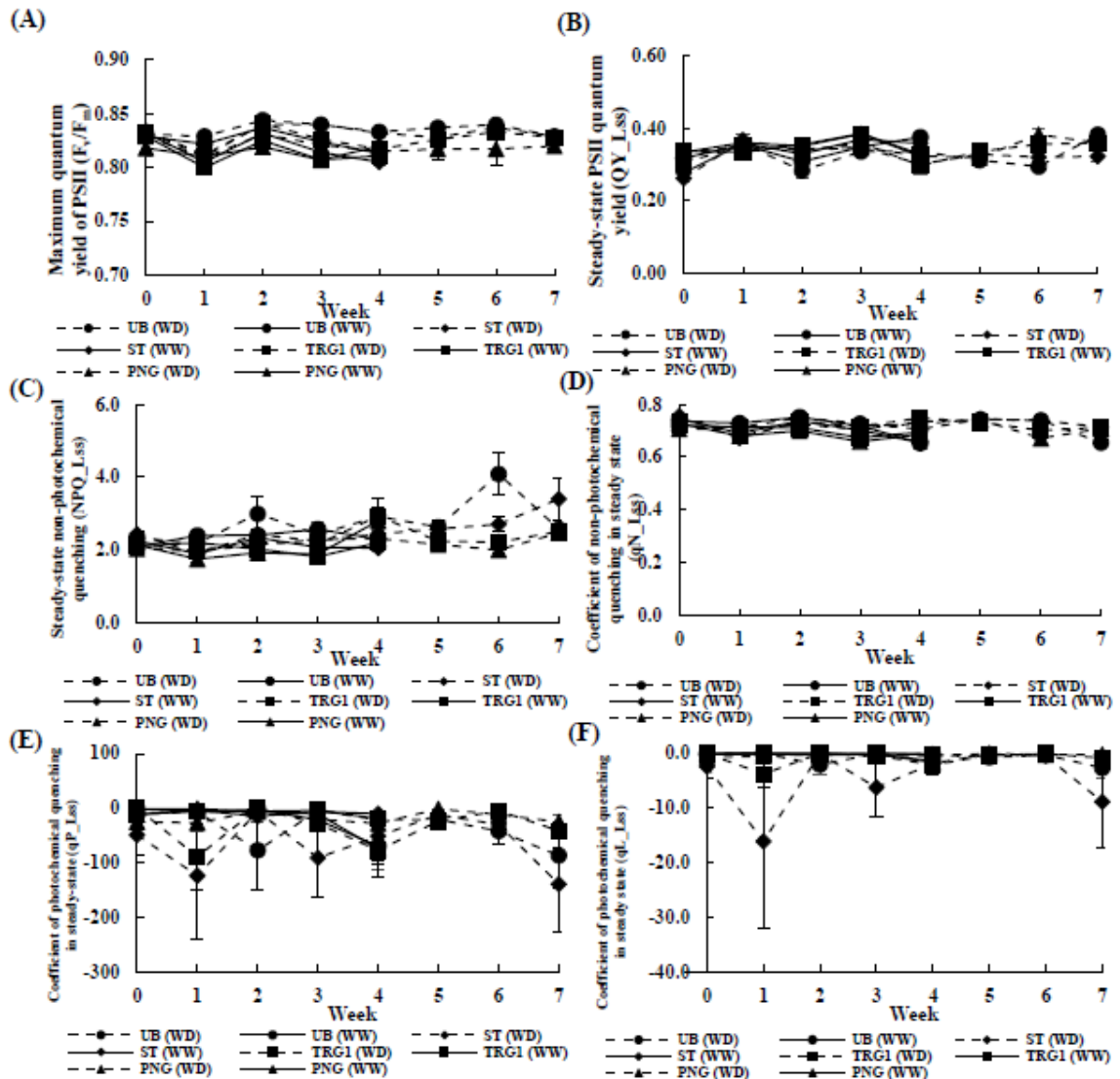
Top camera



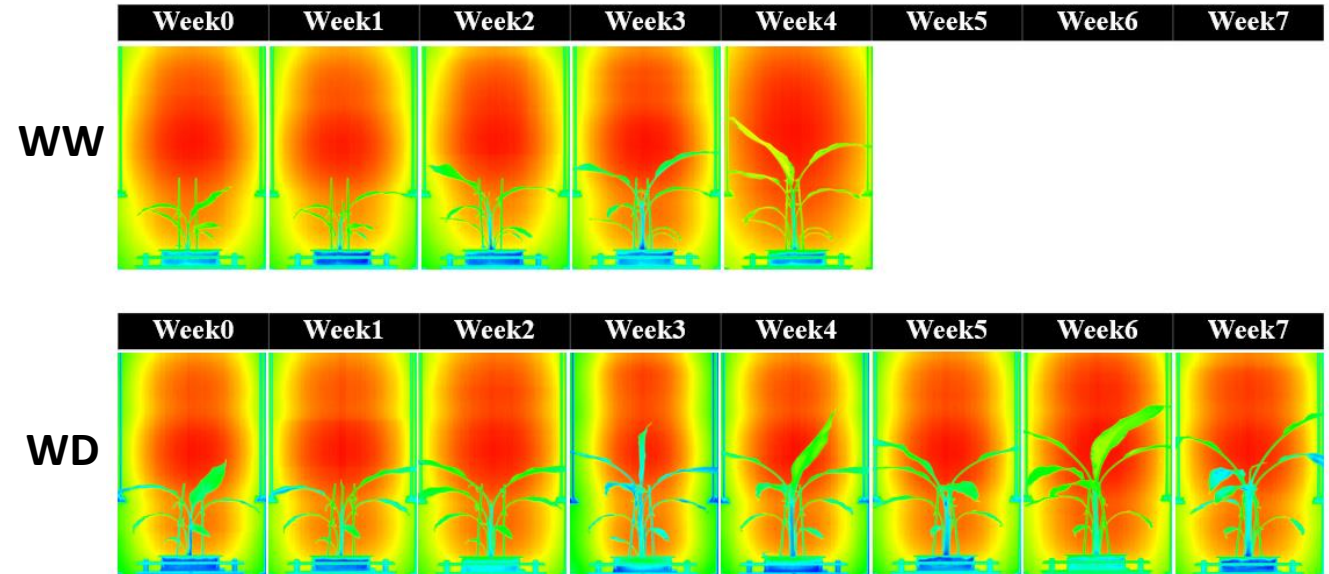
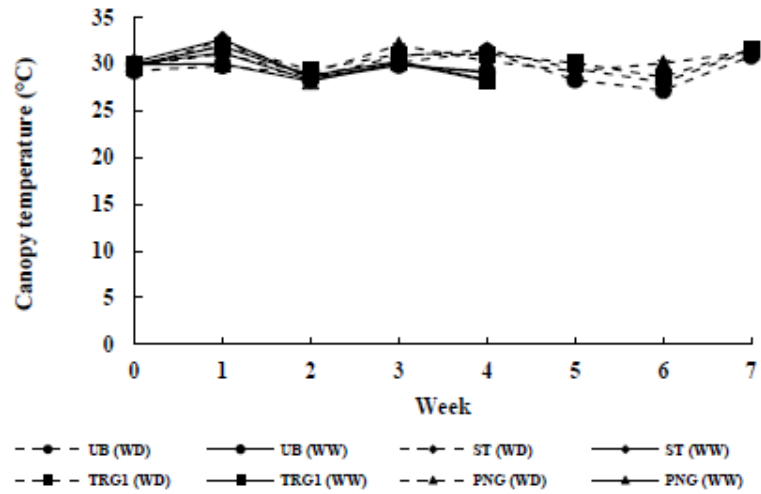
Side camera



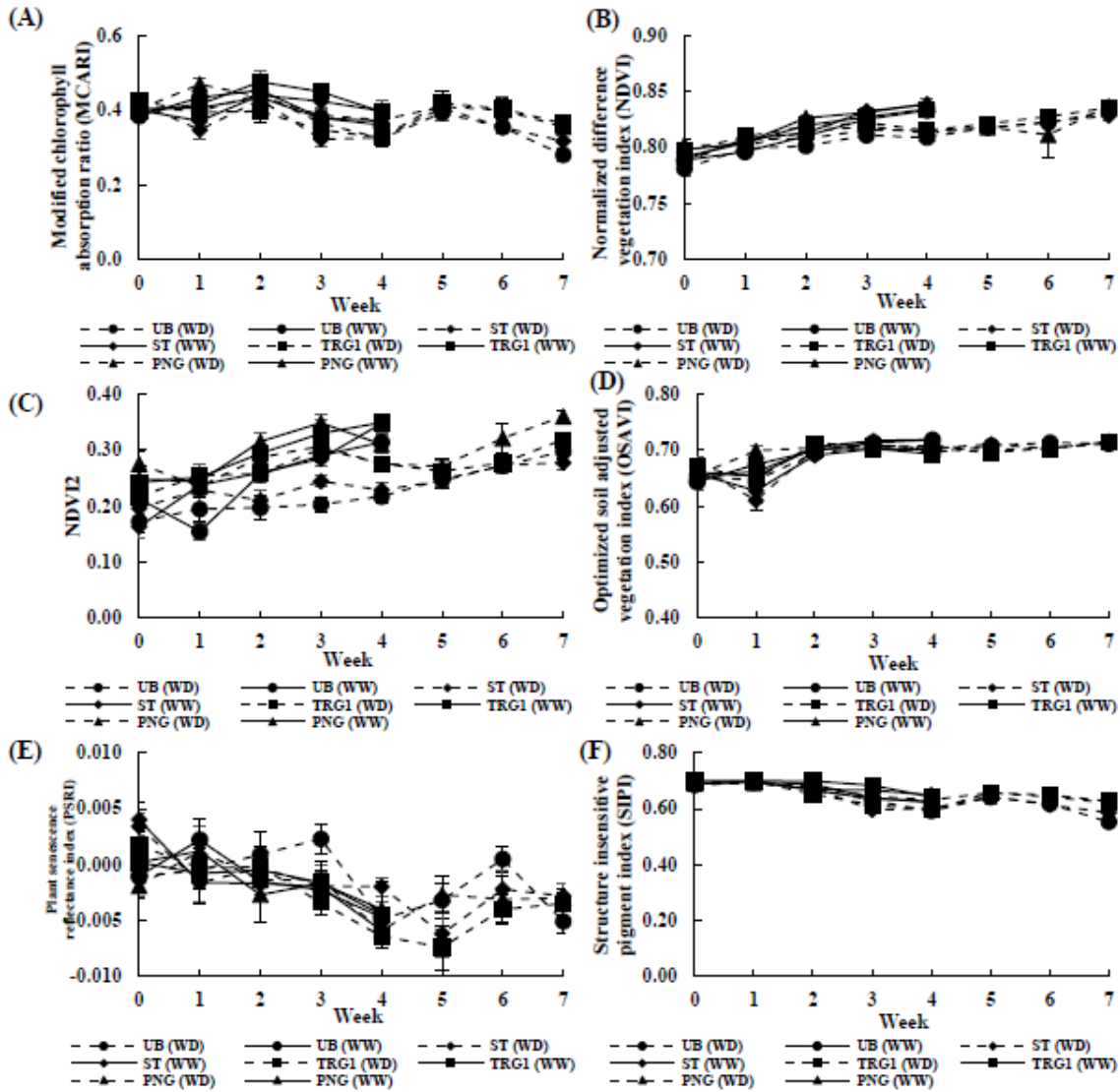
FluorCam



Thermal infrared camera

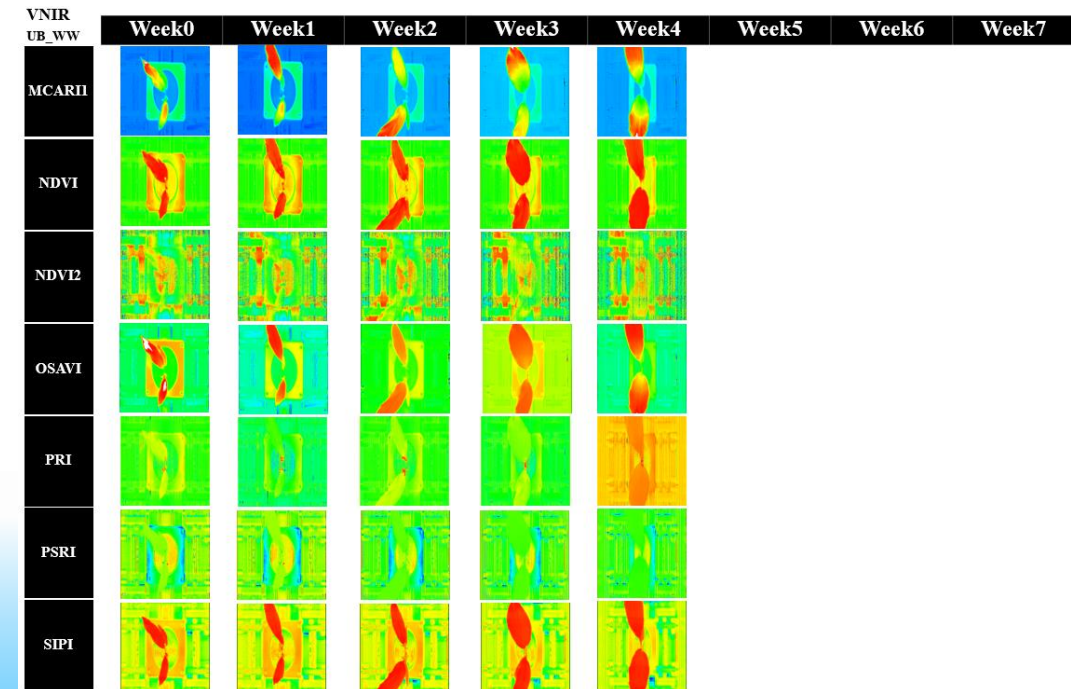
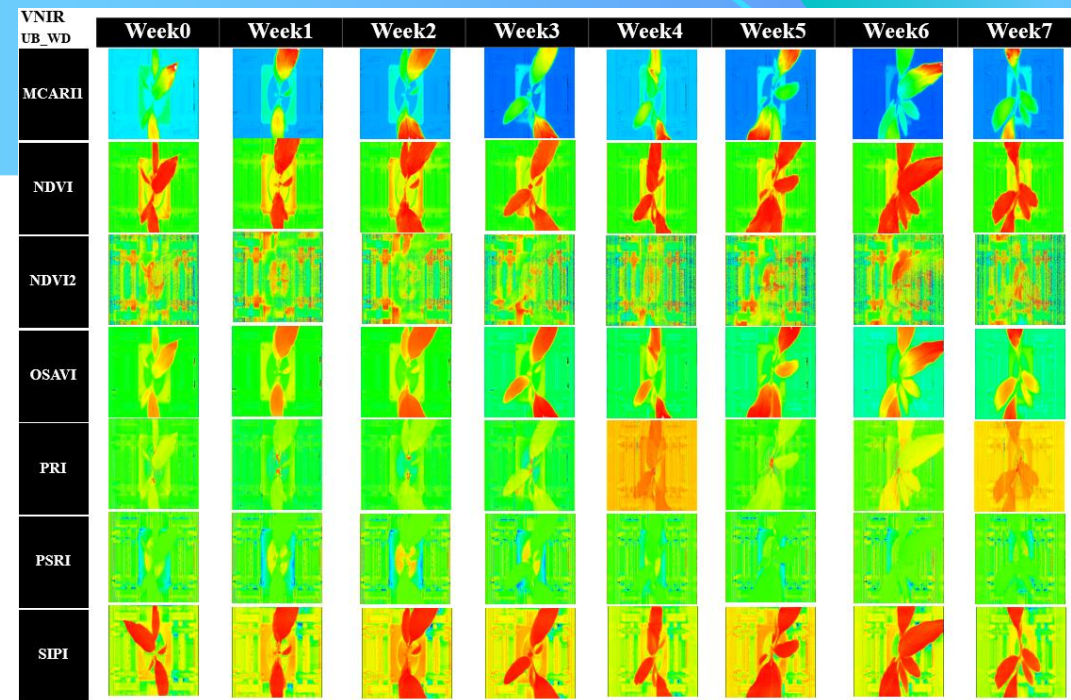


Hyperspectral camera: VNIR



WW

WD



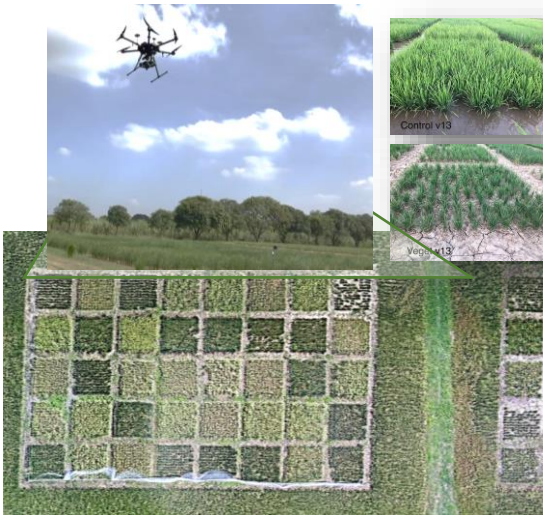
	Indian pennywort	<i>Andrographis paniculata</i>	Turmeric
Water requirement	I_{75} - RGB camera: Plant perimeter, plant projected area and plant volume - FC: $F\sqrt{F_m}$	I_{50} - RGB camera: Plant volume and plant projected area - FC: $F\sqrt{F_m}$	≤ 4 weeks - RGB camera: Plant volume and plant projected area - Thermal infrared: canopy temperature - HC: NDVI and water1

Greenhouse
HT3P

Ground-base HT3P

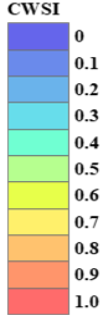
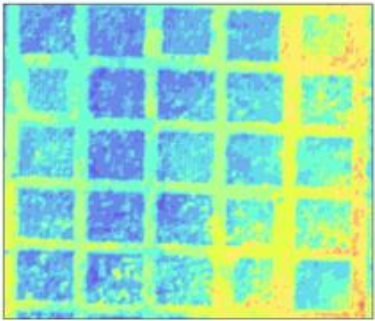
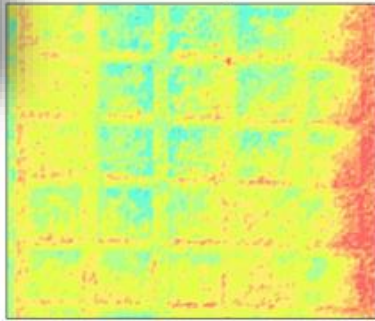
AI learning and automation system (SMART Farming)

Precision farming using UAV technology



Water withholding at vegetative stage (WD)

Well watering (WW)





Thank you

RGB camera parameters

Plant growth

Parameters

Plant projected area

Perimeter

Canopy width

Canopy height

Plant architecture

Roundness

Isotropy

Eccentricity

Parameter description

Total area covered the plant

Length of plant perimeter

Width of bounding box enveloping plant

Height of bounding box enveloping plant

Ratio between area and perimeter of plant surface

Isotropy of the plant, computed as a ratio of area and perimeter of the polygon created by object vertices

Parameter describing the degree of different between convex hull area and circle, which as center in plant centroid

