# Finding the needle in the haystack - Zegami – a new tool for visualizing phenotypic data sets

ICEC/AusPheno 2016 - Canberra

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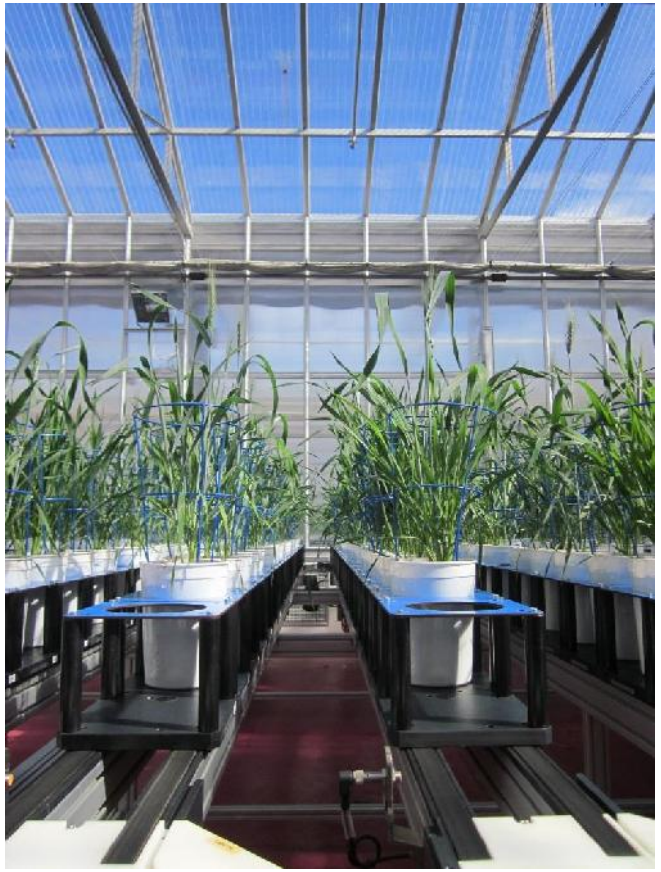
Australian Plant Phenomics Facility

NCRIS National Research Infrastructure for Australia An Australian Government Initiative

THE UNIVERSITY of ADELAIDE

zegami

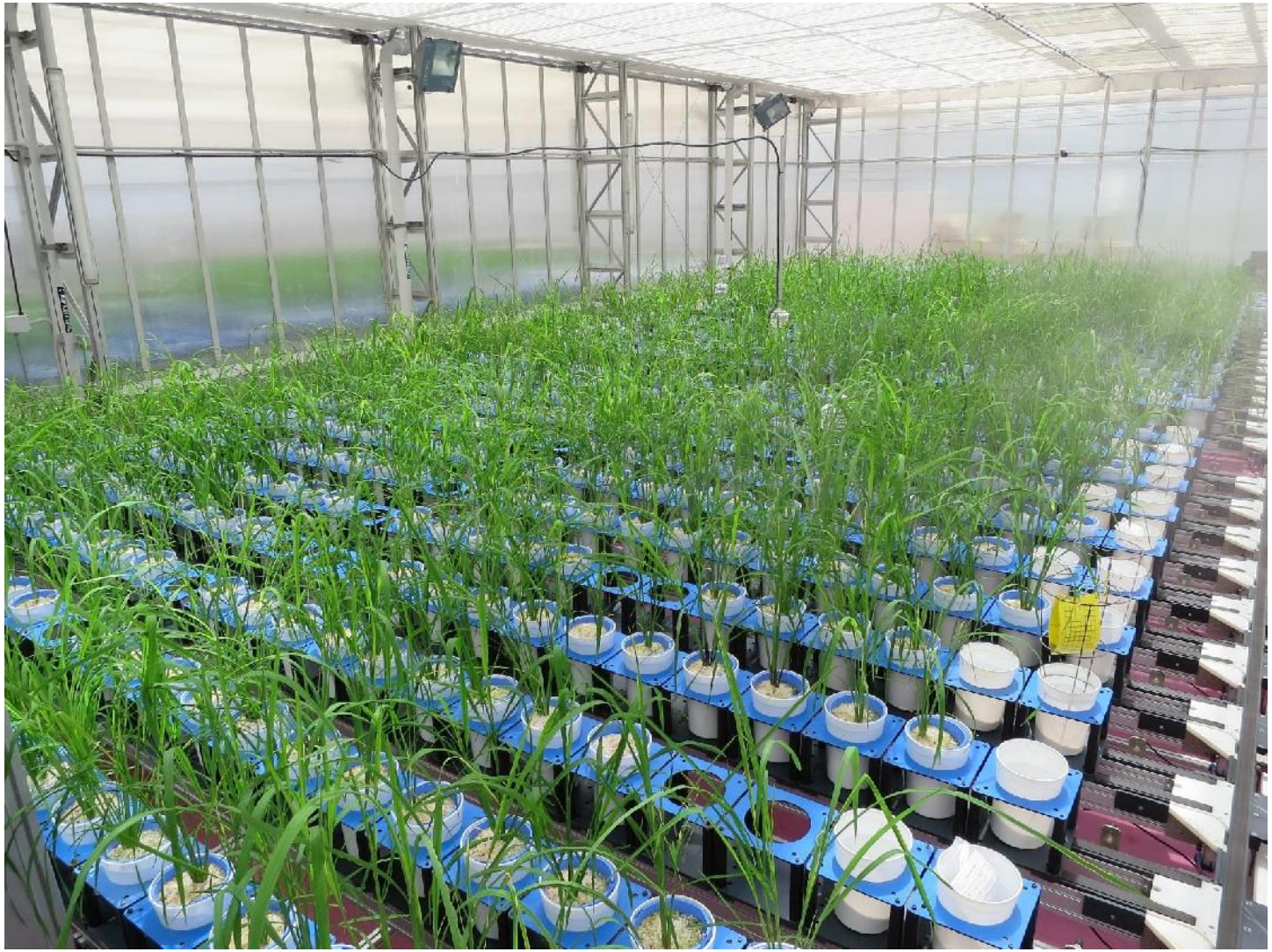
# The Plant Accelerator – from standard greenhouse to automation



# Phenotyping – past and present

- Manual measurements
- Direct contact with plants
- Relatively small data sets
- ‘simple statistics’ often sufficient

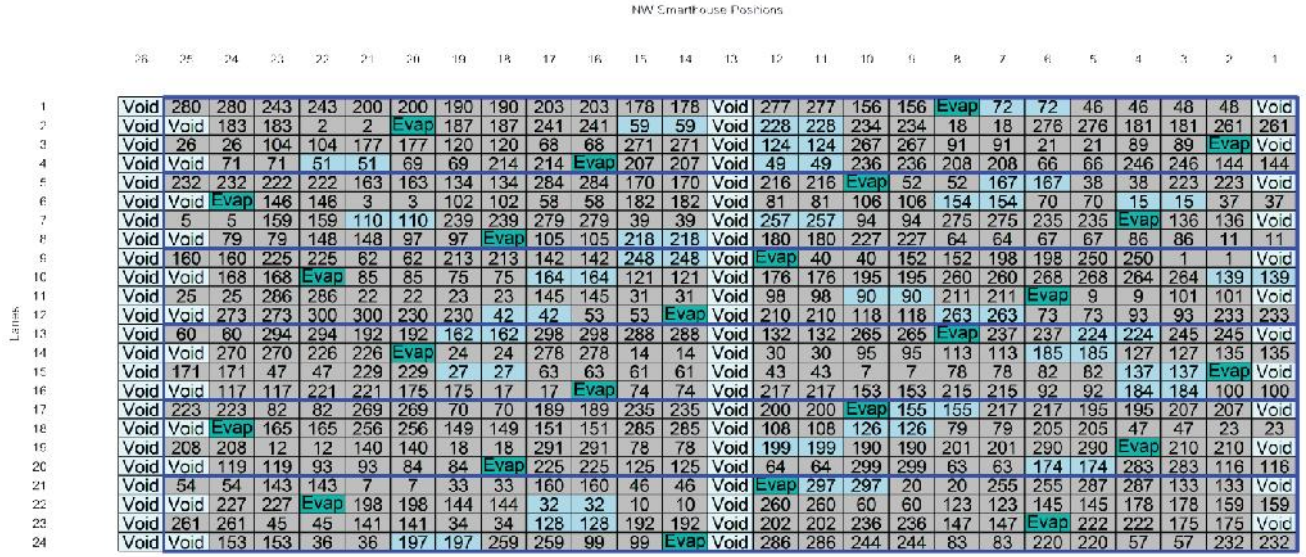
# Phenotyping – past and present



- Automated measurements
- Limited visual assessment of plants
- Large image-based datasets
- Need for multidisciplinary team of experts for experimental design, setup, image and data analyses

# A ‘typical’ high-throughput experiment

- Hundreds of genotypes
- Multiple treatments, uneven replication
- Over 1,000 plants, spread over two rooms
- 2 to 8 weeks of imaging
- 10,000s images
- Multiple traits per image
- Millions of cells in results file not uncommon



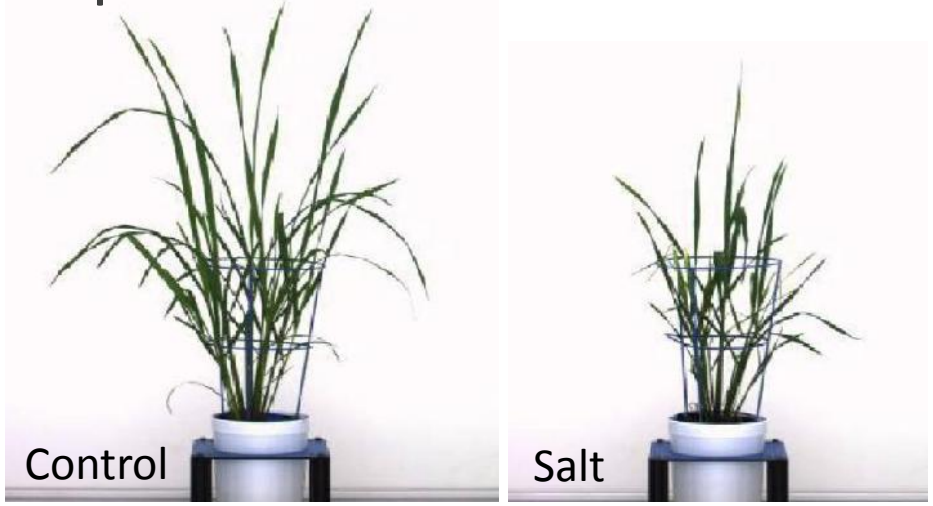

| | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Void | 280 | 280 | 243 | 243 | 200 | 200 | 190 | 190 | 203 | 203 | 178 | 178 | Void | 277 | 277 | 156 | 156 | Evap | 72 | 72 | 46 | 46 | 48 | 48 | Void |
| 2 | Void | Void | 183 | 183 | 2 | 2 | Evap | 187 | 187 | 241 | 241 | 59 | 59 | Void | 228 | 228 | 234 | 234 | 18 | 18 | 276 | 276 | 181 | 181 | 261 | 261 |
| 3 | Void | 26 | 26 | 104 | 104 | 177 | 177 | 120 | 120 | 68 | 68 | 271 | 271 | Void | 124 | 124 | 267 | 267 | 91 | 91 | 21 | 21 | 89 | 89 | Evap | Void |
| 4 | Void | Void | 71 | 71 | 51 | 51 | 69 | 69 | 214 | 214 | Evap | 207 | 207 | Void | 49 | 49 | 236 | 236 | 208 | 208 | 66 | 66 | 246 | 246 | 144 | 144 |
| 5 | Void | 232 | 232 | 222 | 222 | 163 | 163 | 134 | 134 | 284 | 284 | 170 | 170 | Void | 216 | 216 | Evap | 52 | 52 | 167 | 167 | 38 | 38 | 223 | 223 | Void |
| 6 | Void | Void | Evap | 146 | 146 | 3 | 3 | 102 | 102 | 58 | 58 | 182 | 182 | Void | 81 | 81 | 106 | 106 | 154 | 154 | 70 | 70 | 15 | 15 | 37 | 37 |
| 7 | Void | 5 | 5 | 159 | 159 | 110 | 110 | 239 | 239 | 279 | 279 | 39 | 39 | Void | 257 | 257 | 94 | 94 | 275 | 275 | 235 | 235 | Evap | 136 | 136 | Void |
| 8 | Void | Void | 79 | 79 | 148 | 148 | 97 | 97 | Evap | 105 | 105 | 218 | 218 | Void | 180 | 180 | 227 | 227 | 64 | 64 | 67 | 67 | 86 | 86 | 11 | 11 |
| 9 | Void | 160 | 160 | 225 | 225 | 62 | 62 | 213 | 213 | 142 | 142 | 248 | 248 | Void | Evap | 40 | 40 | 152 | 152 | 198 | 198 | 250 | 250 | 1 | 1 | Void |
| 10 | Void | Void | 168 | 168 | Evap | 85 | 85 | 75 | 75 | 164 | 164 | 121 | 121 | Void | 176 | 176 | 195 | 195 | 260 | 260 | 268 | 268 | 264 | 264 | 139 | 139 |
| 11 | Void | 25 | 25 | 286 | 286 | 22 | 22 | 23 | 23 | 145 | 145 | 31 | 31 | Void | 98 | 98 | 90 | 90 | 211 | 211 | Evap | 9 | 9 | 101 | 101 | Void |
| 12 | Void | Void | 273 | 273 | 300 | 300 | 230 | 230 | 42 | 42 | 53 | 53 | Evap | Void | 210 | 210 | 118 | 118 | 263 | 263 | 73 | 73 | 93 | 93 | 233 | 233 |
| 13 | Void | 60 | 60 | 294 | 294 | 192 | 192 | 162 | 162 | 298 | 298 | 288 | 288 | Void | 132 | 132 | 265 | 265 | Evap | 237 | 237 | 224 | 224 | 245 | 245 | Void |
| 14 | Void | Void | 270 | 270 | 226 | 226 | Evap | 24 | 24 | 278 | 278 | 14 | 14 | Void | 30 | 30 | 95 | 95 | 113 | 113 | 185 | 185 | 127 | 127 | 135 | 135 |
| 15 | Void | 171 | 171 | 47 | 47 | 229 | 229 | 27 | 27 | 63 | 63 | 61 | 61 | Void | 43 | 43 | 7 | 7 | 78 | 78 | 82 | 82 | 137 | 137 | Evap | Void |
| 16 | Void | Void | 117 | 117 | 221 | 221 | 175 | 175 | 17 | 17 | Evap | 74 | 74 | Void | 217 | 217 | 153 | 153 | 215 | 215 | 92 | 92 | 184 | 184 | 100 | 100 |
| 17 | Void | 223 | 223 | 82 | 82 | 269 | 269 | 70 | 70 | 189 | 189 | 235 | 235 | Void | 200 | 200 | Evap | 155 | 155 | 217 | 217 | 195 | 195 | 207 | 207 | Void |
| 18 | Void | Void | Evap | 165 | 165 | 256 | 256 | 149 | 149 | 151 | 151 | 285 | 285 | Void | 108 | 108 | 126 | 126 | 79 | 79 | 205 | 205 | 47 | 47 | 23 | 23 |
| 19 | Void | 208 | 208 | 12 | 12 | 140 | 140 | 18 | 18 | 291 | 291 | 78 | 78 | Void | 199 | 199 | 190 | 190 | 201 | 201 | 290 | 290 | Evap | 210 | 210 | Void |
| 20 | Void | Void | 119 | 119 | 93 | 93 | 84 | 84 | Evap | 225 | 225 | 125 | 125 | Void | 64 | 64 | 299 | 299 | 63 | 63 | 174 | 174 | 283 | 283 | 116 | 116 |
| 21 | Void | 54 | 54 | 143 | 143 | 7 | 7 | 33 | 33 | 160 | 160 | 46 | 46 | Void | Evap | 297 | 297 | 20 | 20 | 255 | 255 | 287 | 287 | 133 | 133 | Void |
| 22 | Void | Void | 227 | 227 | Evap | 198 | 198 | 144 | 144 | 32 | 32 | 10 | 10 | Void | 260 | 260 | 60 | 60 | 123 | 123 | 145 | 145 | 178 | 178 | 159 | 159 |
| 23 | Void | 261 | 261 | 45 | 45 | 141 | 141 | 34 | 34 | 128 | 128 | 192 | 192 | Void | 202 | 202 | 236 | 236 | 147 | 147 | Evap | 222 | 222 | 175 | 175 | Void |
| 24 | Void | Void | 153 | 153 | 36 | 36 | 197 | 197 | 259 | 259 | 99 | 99 | Evap | Void | 286 | 286 | 244 | 244 | 83 | 83 | 220 | 220 | 57 | 57 | 232 | 232 |

# Data analysis – the new phenotyping bottleneck

- A typical experiment takes ~ 4-12 weeks to run
- Basic image analysis with QC in parallel or ~ 1-2 weeks at completion
- Analysis of numeric data at the end can take months (or years)
  - Datasets are two large for basic stats approach
  - Time-course series
  - Plant scientists can feel overwhelmed with data sets
  - Exploration of data difficult with e.g. Excel, going through individual images impossible
  - QC required, outlier detection
  - Close collaboration between plant scientists and statisticians critical

# Basic questions asked during or after experiment

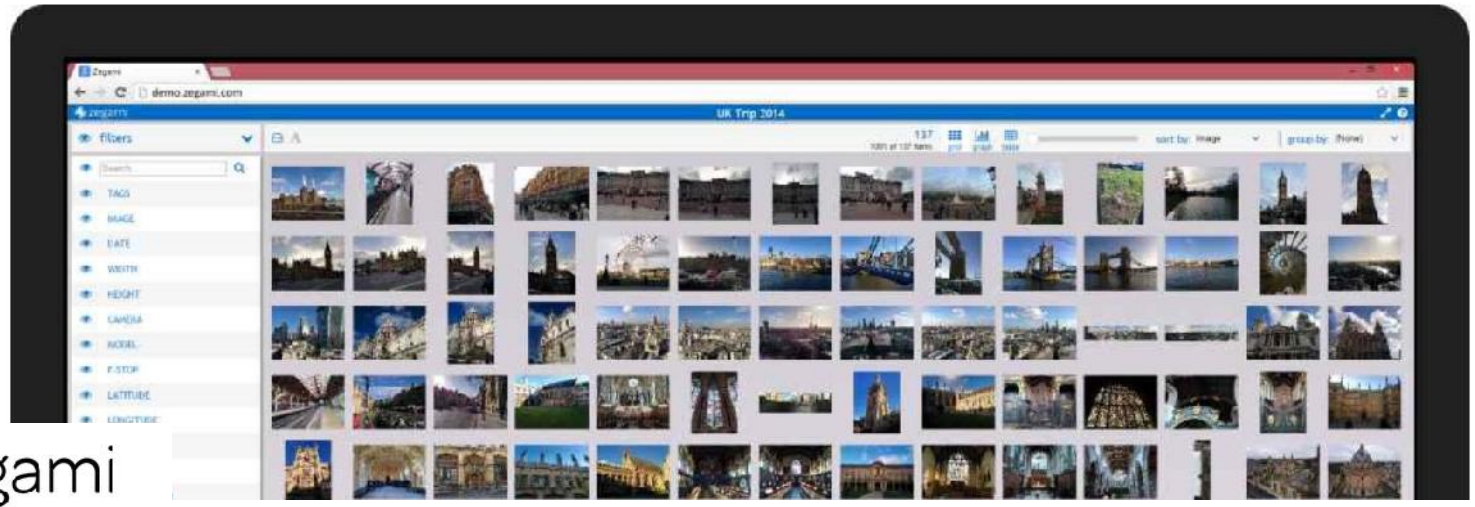
- Did the treatment work? Was it the right level?
- Are there trends between rooms, across a room?
- Are there outliers? What type?
  - Technical (e.g. image analysis)
  - Biological (e.g. poor seedling development)
- Apart from biomass over time, what other traits might be of interest?



# Ways to answer questions and address data-analysis bottleneck

- Tools for visual quality control by expert user
- Tools for easy exploration of dataset by plant scientists to get a feel for the data

Meet Zegami: The visual search tool




- Customized for plant phenotyping datasets
- Plotting tools
- Basic stats
- Login options

zegami

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Sign In

# Australian Plant Phenomics Facility: The Plant Accelerator

Message from eRSA: We will be performing an upgrade to our network infrastructure on **Wednesday, 21 September 2016** between **9.30am and 1.30pm.**

**Zegami will be unavailable during this time.**

## 0251 Nitrogen Use Efficiency and Water Use Efficiency in Wheat

Ten commercial wheat varieties were grown on the phenotyping platform of The Plant Accelerator from 22 to 74 days after the seedlings emerged and imaged every second day. The treatments consisted of three nitrogen levels (N1 (low), N2 (medium) and N3 (high) applied in the soil mix). For each of these nitrogen treatments there were four water availability treatments: D1, well watered; D2, restricted watering from day 22 but then well watered from day 48; D3, restricted water from day 22 onwards; and D4, well watered then restricted watering from day 48 onwards. There were 4 replicates per treatment with a total of 480 plants x 27 time points = 12960 image sets.

12960 items ✔ completed Processed: Tue Sep 22 2015 at 10:21am Duration: 62h 41m 9s

## 0184 Salinity stress response of rice diversity panel – Walia Lab – Uni Nebraska – Part I

A rice diversity panel consisting of 373 accessions (Zhao et al 2011, http://dx.doi.org/10.1038/ncomms1467) was exposed to 90 mM NaCl during the early tillering stage (8 days after transplanting). The salt treatment was applied in two steps of 45 mM at 10 and 13 days after transplanting. To assess natural variation for salinity tolerance, morphological and physiological responses were monitored over a period of 14 d after 90 mM NaCl treatment. The experiment was replicated three times from August to October 2013. Campbell et al. (2015) http://dx.doi.org/10.1104/pp.15.00450

15552 items ✔ completed Processed: Mon Aug 29 2016 at 9:46am Duration: 3h 9m 41s

## 0185 Salinity stress response of rice diversity panel – Walia Lab – Uni Nebraska – Part II

A rice diversity panel consisting of 373 accessions (Zhao et al 2011, http://dx.doi.org/10.1038/ncomms1467) was exposed to 90 mM NaCl during the early tillering stage (8 days after transplanting). The salt treatment was applied in two steps of 45 mM at 10 and 13 days after transplanting. To assess natural variation for salinity tolerance, morphological and physiological responses were monitored over a period of 14 d after 90 mM NaCl treatment. The experiment was replicated three times from August to October 2013. Campbell et al. (2015) http://dx.doi.org/10.1104/pp.15.00450

15552 items ✔ completed Processed: Mon Aug 29 2016 at 12:56pm Duration: 8h 38m 49s

## 0186 Salinity stress response of rice diversity panel – Walia Lab – Uni Nebraska – Part III

A rice diversity panel consisting of 373 accessions (Zhao et al 2011, http://dx.doi.org/10.1038/ncomms1467) was exposed to 90 mM NaCl during the early tillering stage (8 days after transplanting). The salt treatment was applied in two steps of 45 mM at 10 and 13 days after transplanting. To assess natural variation for salinity tolerance, morphological and physiological responses were monitored over a period of 14 d after 90 mM NaCl treatment. The experiment was replicated three times from August to October 2013. Campbell et al. (2015) http://dx.doi.org/10.1104/pp.15.00450

15768 items ✔ completed Processed: Tue Aug 23 2016 at 12:41pm Duration: 46h 26m 33s

## 0255 Rice response to salinity stress under waterlogged conditions - indica

Two rice diversity panels, indica and aus, containing a total of 553 genotypes, were phenotyped at The Plant Accelerator under waterlogged conditions. These panels were selected by breeders at the International Rice Research Institute (IRRI) and collaborating partners in the context of the Phenomics of Rice Adaptation and Yield Potential (PRAY) project, funded by the Global Rice Science Partnership (http://ricephenonetwork.irri.org/). Rice plants were exposed to salt stress (150 mM NaCl, applied to the flood water in which pots were immersed) when plants were 29 days old. Over a 13-day stress period, plant responses were monitored daily. The key traits analyzed were plant growth and transpiration, which allowed the calculation of transpiration use efficiency, a key index determined by the ratio of biomass produced per unit of water transpired.

filters

14784
100% of 14784 items
grid graph table

sort by: Barcode

group by: (None)

Search...

- TAGS
- BARCODE
- PLANT SPECIES
- GENOTYPE ID
- SALT TREATMENT
- REPLICATE
- SMARTHOUSE
- LANE
- POSITION
- SNAPSHOT TIME STAMP
- TIME AFTER PLANTING [D]
- WEIGHT BEFORE
- WEIGHT AFTER
- WATER AMOUNT
- PROJECTED SHOOT AREA [PIXELS]
- RGB_SV1 AREA
- RGB_SV1 AREA DISTRIBUTION ABOVE POT ABSOLUTE

Two rice diversity panels, *indica* and *aus*, containing a total of 553 genotypes, were phenotyped at The Plant Accelerator under waterlogged conditions. These panels were selected by breeders at the International Rice Research Institute (IRRI) and collaborating partners in the context of the Phenomics of Rice Adaptation and Yield Potential (PRAY) project, funded by the Global Rice Science Partnership (http://ricephenonetwork.irri.org/).

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Loading complete.

Close

filters

Search...

- TAGS
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- PLANT SPECIES
- GENOTYPE ID
- SALT TREATMENT
- REPLICATE
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14784
100% of 14784 items

grid graph table

sort by: Barcode

group by: (None)

filters

14784
100% of 14784 items
grid graph table

sort by: Salt Treatment
group by: (None)

Search...

- TAGS
- BARCODE
- PLANT SPECIES
- GENOTYPE ID
- SALT TREATMENT
- REPLICATE
- SMARTHOUSE
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- POSITION
- SNAPSHOT TIME STAMP
- TIME AFTER PLANTING [D]
- WEIGHT BEFORE
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- WATER AMOUNT
- PROJECTED SHOOT AREA [PIXELS]
- RGB_SV1 AREA
- RGB_SV1 AREA DISTRIBUTION ABOVE POT ABSOLUTE

5696

Data | Notes

tags

**Barcode**
044752-C

**Plant Species**
Oryza sativa

**Genotype ID**
66808

**Salt Treatment**
Control

**Replicate**
2

**Smarthouse**
NE

**Lane**
18

**Position**
16

**Snapshot Time Stamp**
03/23/2015 5:47:00 PM

**Time after Planting [d]**
40

**Weight Before**
3601

**Weight After**
4093

filters x

Search...

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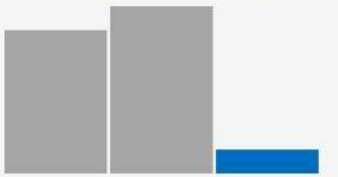

42 to 42

WEIGHT BEFORE
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PROJECTED SHOOT AREA

1056
7% of 14784 items
grid graph table

sort by: Salt Treatment
group by: (None)

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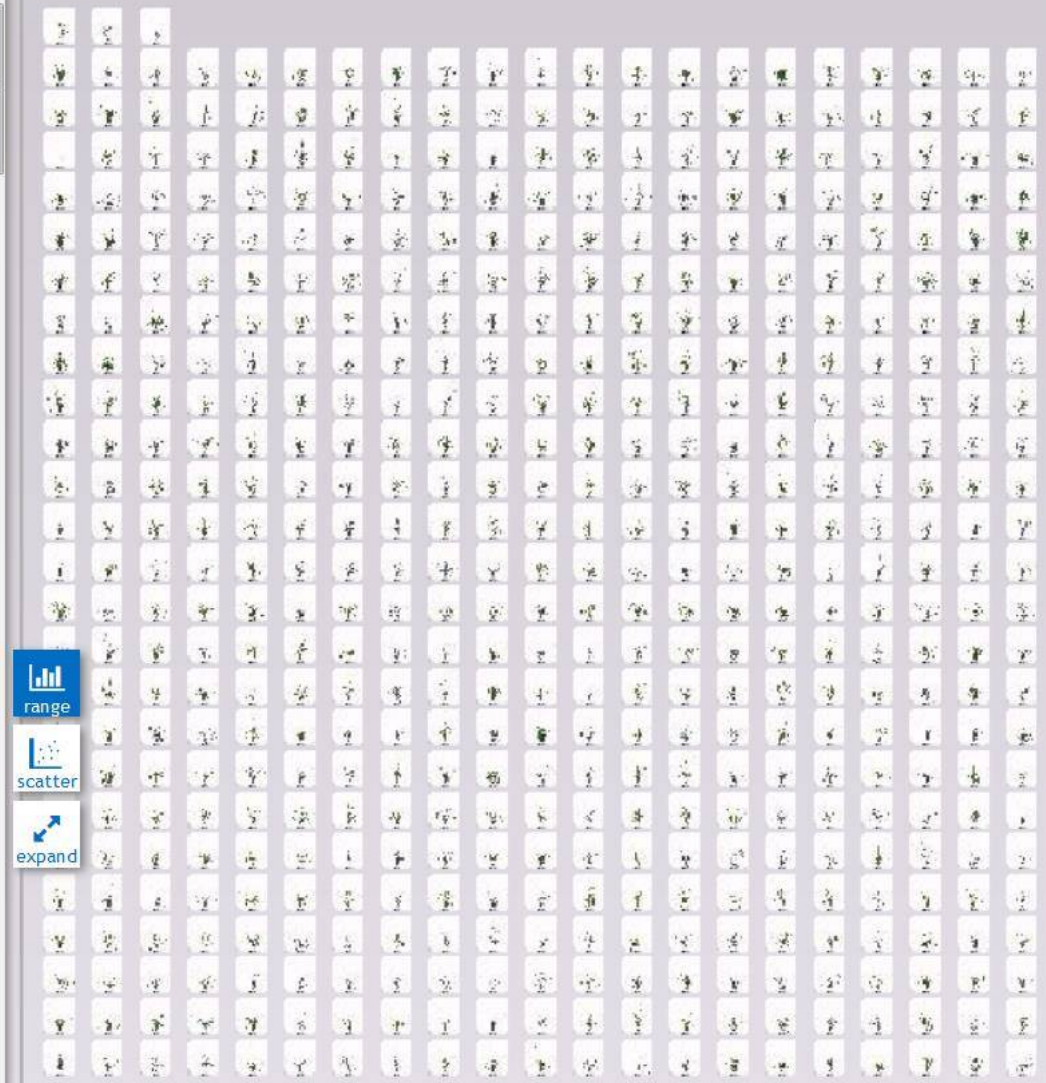
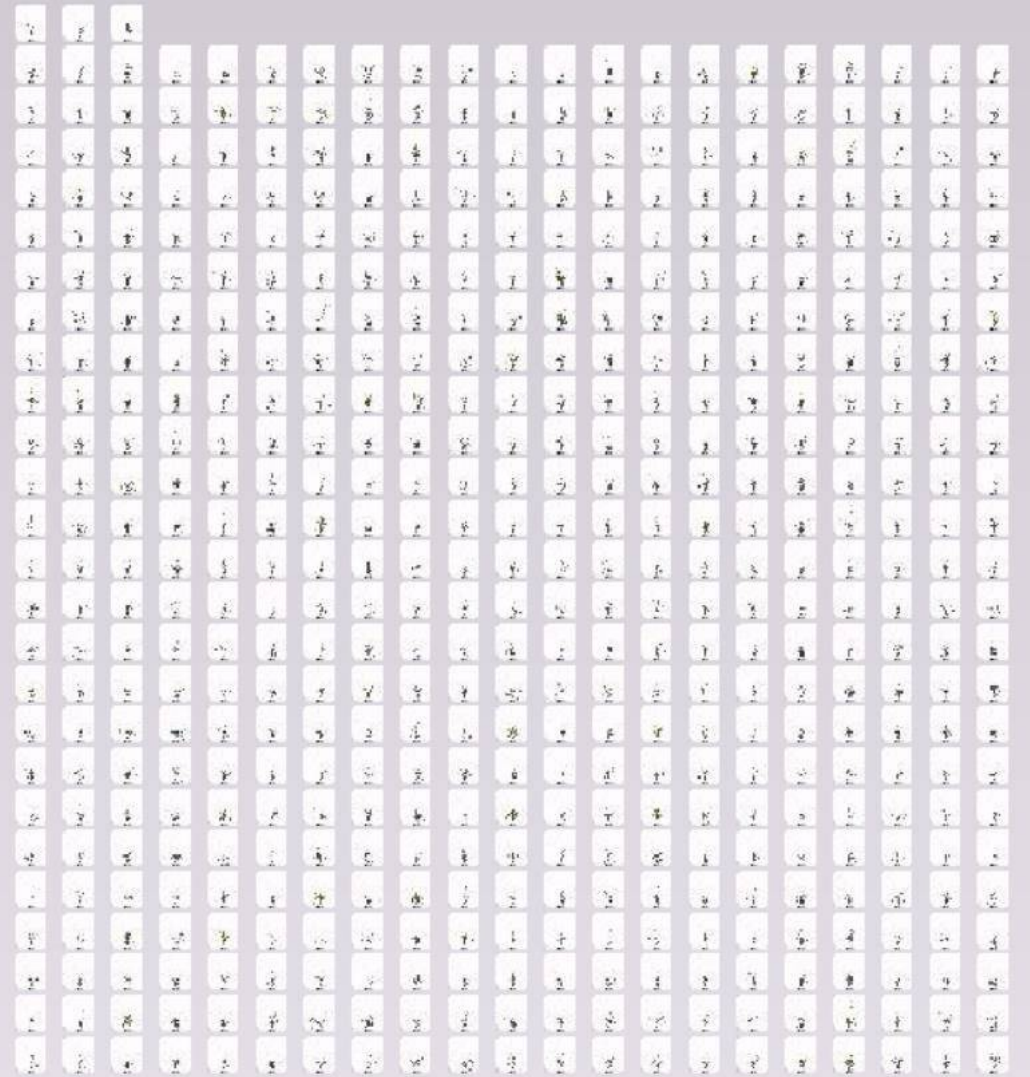
expand



528 (50%)

Control



528 (50%)

Salt

filters

Search...

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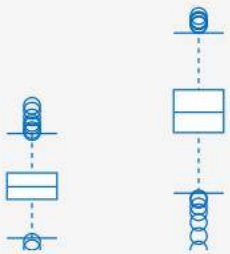
SALT TREATMENT



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TIME AFTER PLANTING [D]
42 to 42
WEIGHT BEFORE
WEIGHT AFTER
WATER AMOUNT

1056
7% of 14784 items
grid graph table
sort by: Salt Treatment
group by: (None)

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expand

Projected Shoot Ar

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Time after Planting [d]
Weight Before
Weight After
Water Amount
Projected Shoot Area [pixels]
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RGB_SV1 Area Distribution Above Absolut
RGB_SV1 Area Distribution Above Relative
RGB_SV1 Area Distribution Below Absolut
RGB_SV1 Area Distribution Below Relative
RGB_SV1 Boundary Point Count
RGB_SV1 Boundary Point Roundness
RGB_SV1 Boundary Points To Area Ratio
RGB_SV1 Caliper Length
RGB_SV1 Circumference
RGB_SV1 Center Of Mass X
RGB_SV1 Center Of Mass Y
RGB_SV1 Compactness
RGB_SV1 Convex Hull Area

528 (50%)
Control

528 (50%)
Salt

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0254 Rice response to salinity stress under waterlogged conditions - aus

filters

Search...

TAGS

BARCODE

PLANT SPECIES

GENOTYPE ID

SALT TREATMENT

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TIME AFTER PLANTING [D]

42 to 42

WEIGHT BEFORE

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WATER AMOUNT

1056

sort by: Salt Treatment

group by: (None)

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y axis: Projected Shoot Area [pixels]

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258,240
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Salt

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612,969
530,285
283,600
Control

Treatment 1

528 (50%)

528 (50%)

Control

Salt

zegami

# 0254 Rice response to salinity stress under waterlogged conditions - aus

filters

Search...

TAGS

BARCODE

PLANT SPECIES

GENOTYPE ID

SALT TREATMENT

REPLICATE

SMARTHOUSE

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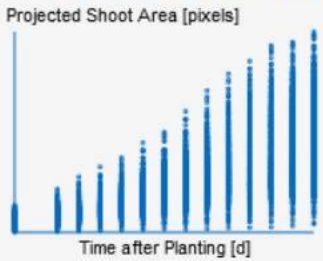
POSITION

SNAPSHOT TIME STAMP

TIME AFTER PLANTING [D]




WEIGHT BEFORE

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WATER AMOUNT

PROJECTED SHOOT AREA

14784
100% of 14784 items

grid graph table

sort by: Time after Planting

group by: (None)

Snapshot Time Stamp
Weight Before
Weight After
Water Amount
Projected Shoot Area [pixels]
RGB_SV1 Area
RGB_SV1 Area Distribution Above Absolut
RGB_SV1 Area Distribution Above Relative
RGB_SV1 Area Distribution Below Absolut
RGB_SV1 Area Distribution Below Relative
RGB_SV1 Boundary Point Count
RGB_SV1 Boundary Point Roundness
RGB_SV1 Boundary Points To Area Ratio
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RGB_SV1 Circumference
RGB_SV1 Center Of Mass X
RGB_SV1 Center Of Mass Y
RGB_SV1 Compactness
RGB_SV1 Convex Hull Area
RGB_SV1 Convex Hull Circumference

range

scatter

Projected Shoot Ar

expand

6336 (43%)

7392 (50%)

1056 (7%)

28 to 34

35 to 41

42

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0254 Rice response to salinity stress under waterlogged conditions - aus

filters

Search...

TAGS

BARCODE

PLANT SPECIES

GENOTYPE ID

SALT TREATMENT

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SMARTHOUSE

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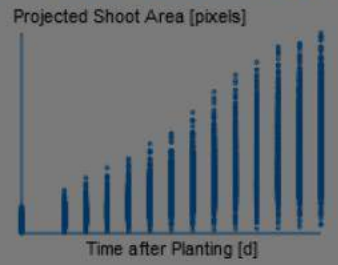
POSITION

SNAPSHOT TIME STAMP

TIME AFTER PLANTING [D]




WEIGHT BEFORE

WEIGHT AFTER

WATER AMOUNT

PROJECTED SHOOT AREA

14784

sort by: Time after Planting

group by: (None)

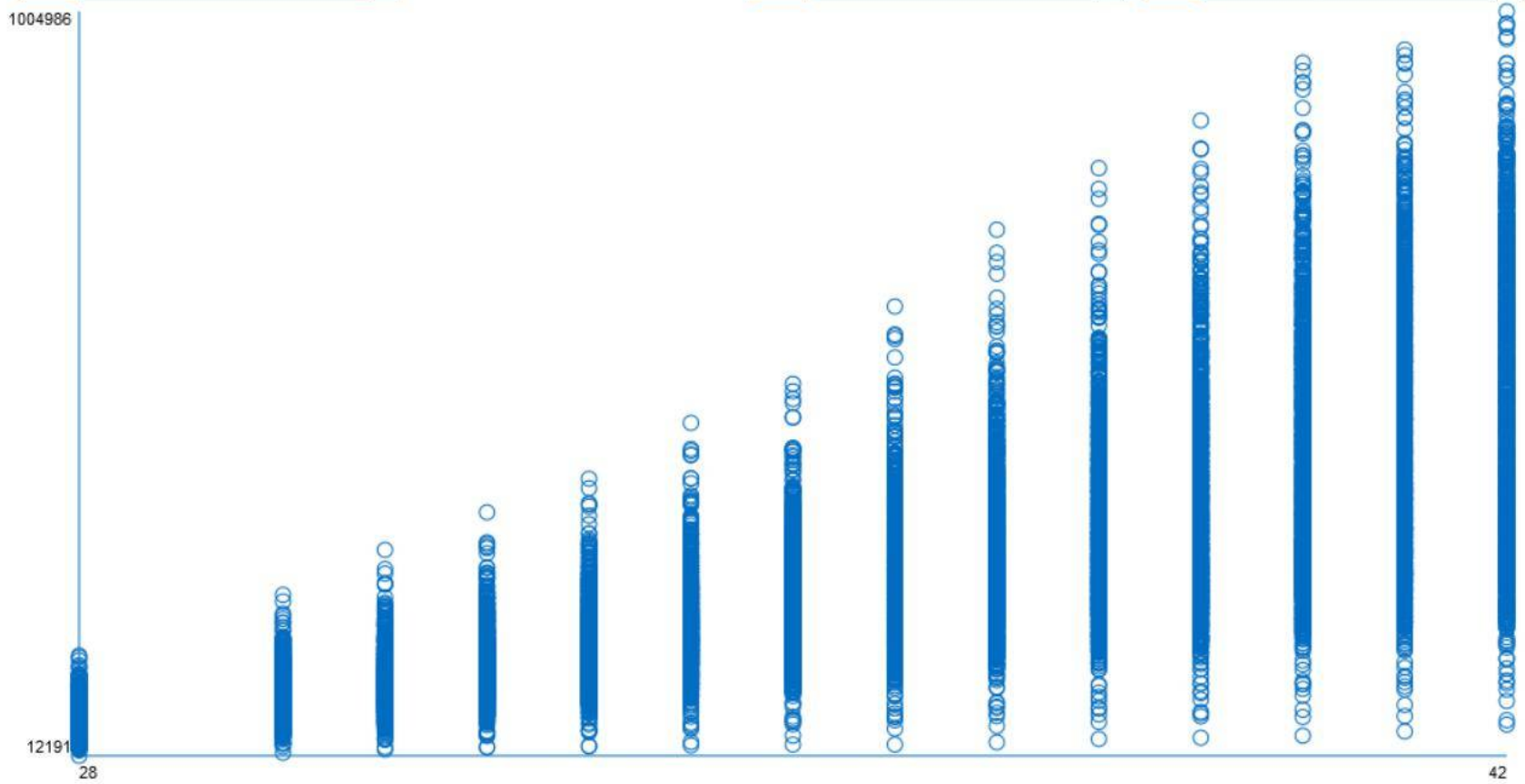
scatter

x

y axis Projected Shoot Area

series (None)

trellis (None)




x axis Time after Planting [d]

6336 (43%)

1056 (7%)

28 to 34

35 to 41

42

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Search...

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SALT TREATMENT

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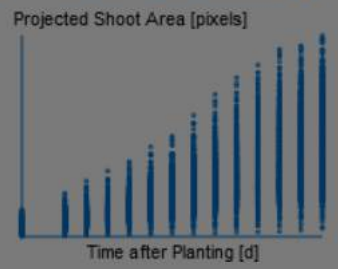
POSITION

SNAPSHOT TIME STAMP

TIME AFTER PLANTING [D]




WEIGHT BEFORE

WEIGHT AFTER

WATER AMOUNT

14784

sort by: Time after Planting

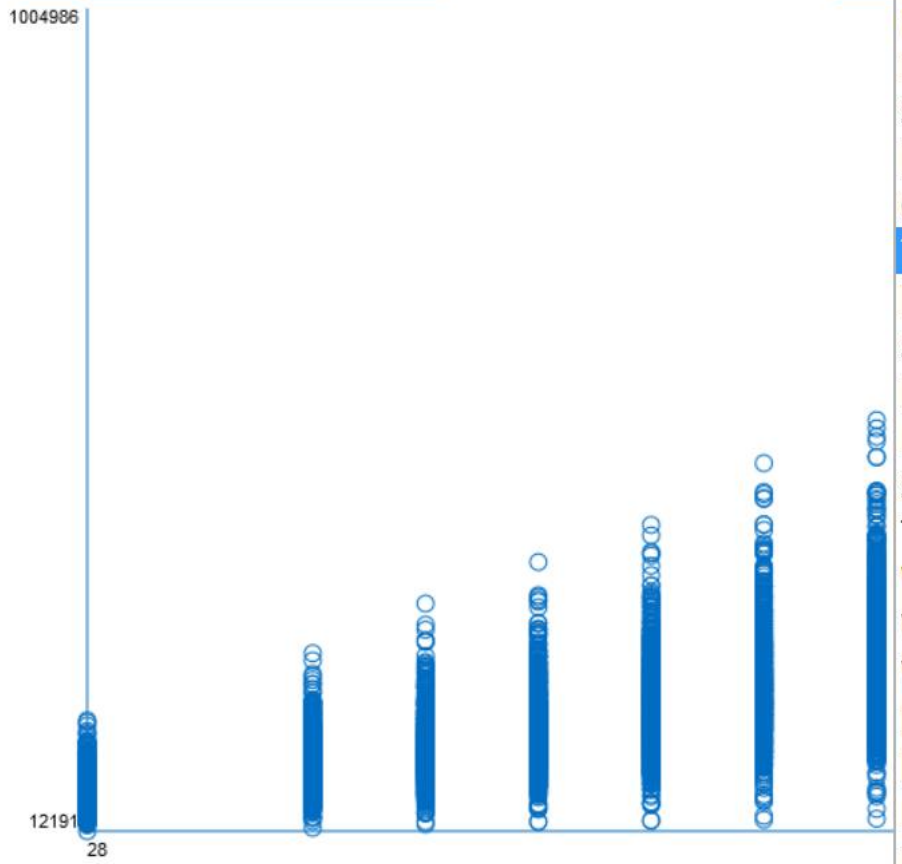
group by: (None)

scatter

y axis Projected Shoot Are

series (None)

trellis (None)




(None)
id
Snapshot ID Tag
Plant Species
Genotype ID
Treatment 1
Replicate
Smarthouse
Lane
Position
Snapshot Time Stamp
Time after Planting [d]
Weight Before
Weight After
Water Amount
Projected Shoot Area [pixels]
RGB_SV1 Area
RGB_SV1 Area Distribution Above Absolut
RGB_SV1 Area Distribution Above Relative
RGB_SV1 Area Distribution Below Absolut

x axis Time after Planting [d]

6336 (43%)

1056 (7%)

28 to 34

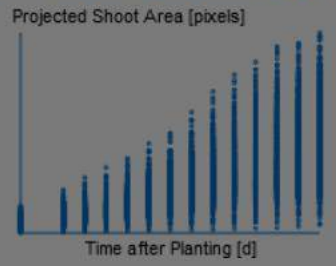
35 to 41

42

filters

Search...

TAGS
BARCODE
PLANT SPECIES
GENOTYPE ID
SALT TREATMENT
REPLICATE
SMARTHOUSE
LANE
POSITION
SNAPSHOT TIME STAMP
TIME AFTER PLANTING [D]

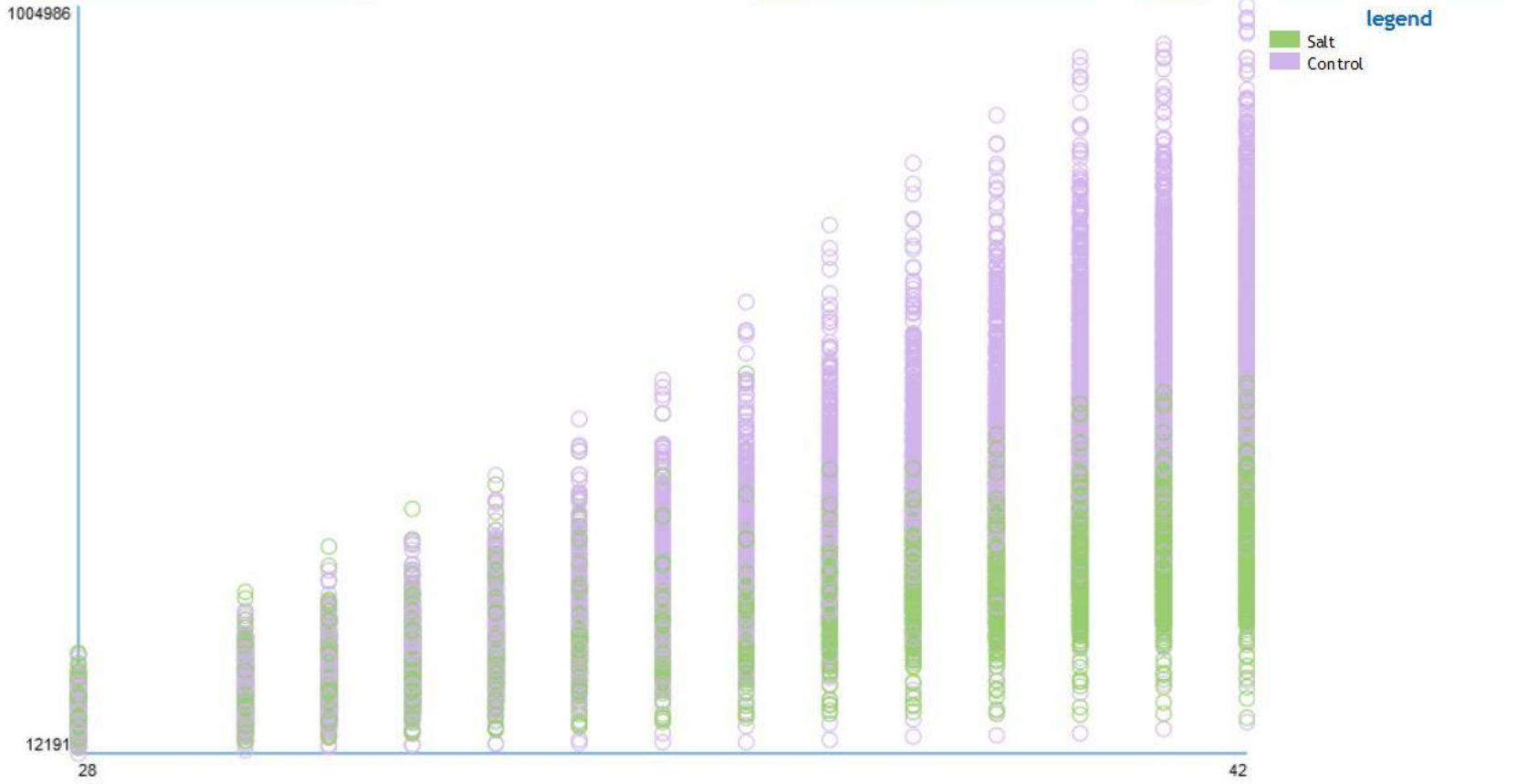



WEIGHT BEFORE
WEIGHT AFTER
WATER AMOUNT

14784
sort by: Time after Planting
group by: (None)

scatter

y axis Projected Shoot Are
series Treatment 1
trellis (None)




x axis Time after Planting [d]

6336 (43%)
1056 (7%)
28 to 34
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0254 Rice response to salinity stress under waterlogged conditions - aus

filters

Search...

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BARCODE

PLANT SPECIES

GENOTYPE ID

SALT TREATMENT

REPLICATE

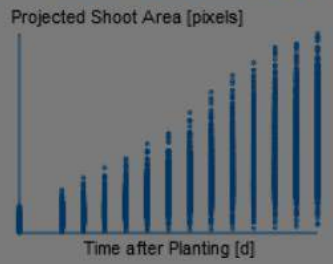
SMARTHOUSE

LANE

POSITION

SNAPSHOT TIME STAMP

TIME AFTER PLANTING [D]




WEIGHT BEFORE

WEIGHT AFTER

WATER AMOUNT

14784

sort by: Time after Planting

group by: (None)

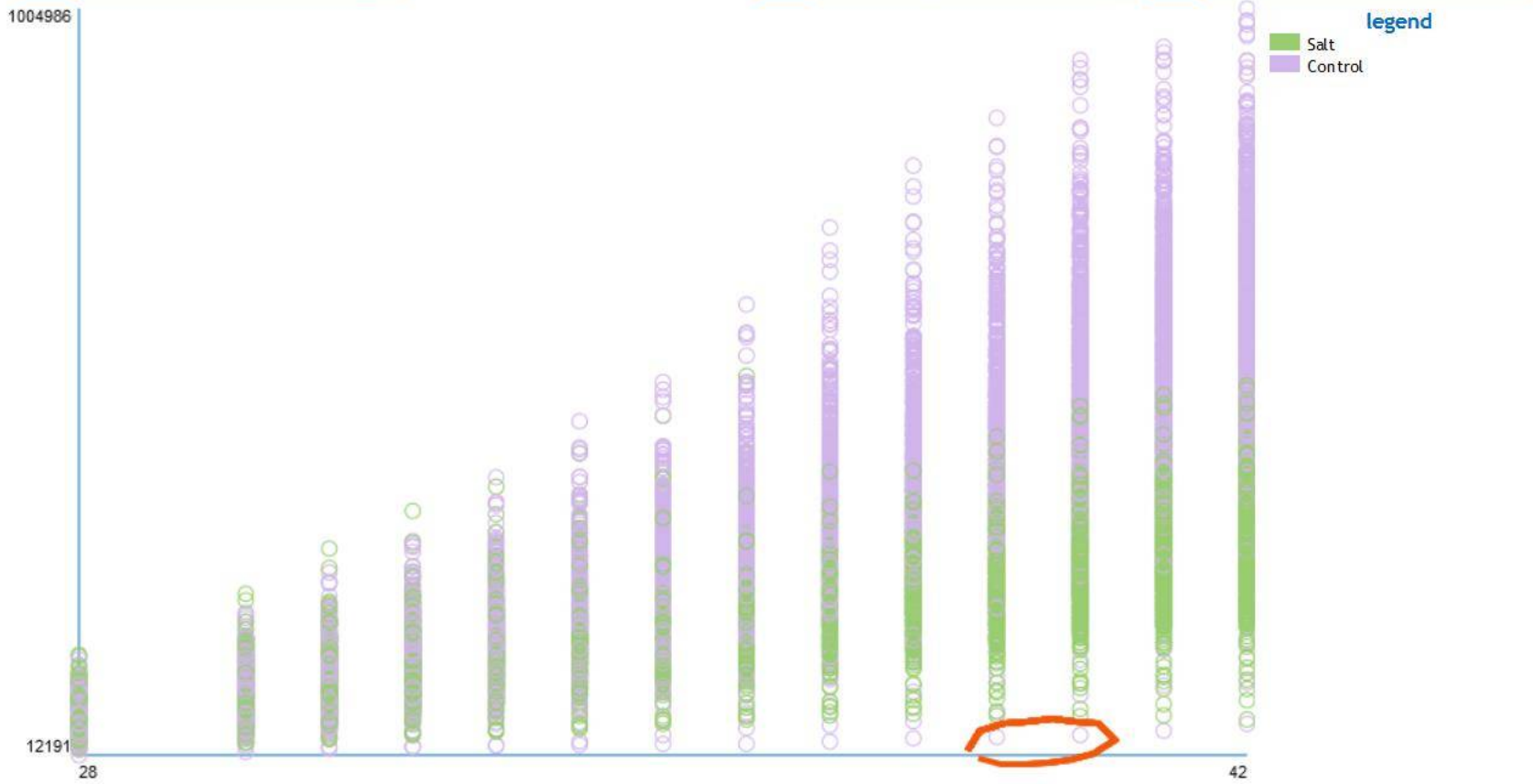
scatter

x

y axis Projected Shoot Are

series Treatment 1

trellis (None)




x axis Time after Planting [d]

6336 (43%)

1056 (7%)

28 to 34

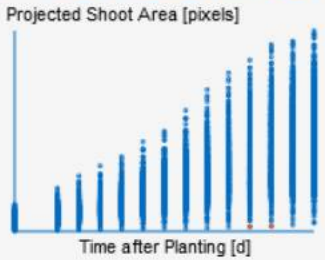
35 to 41

42

filters

Search...

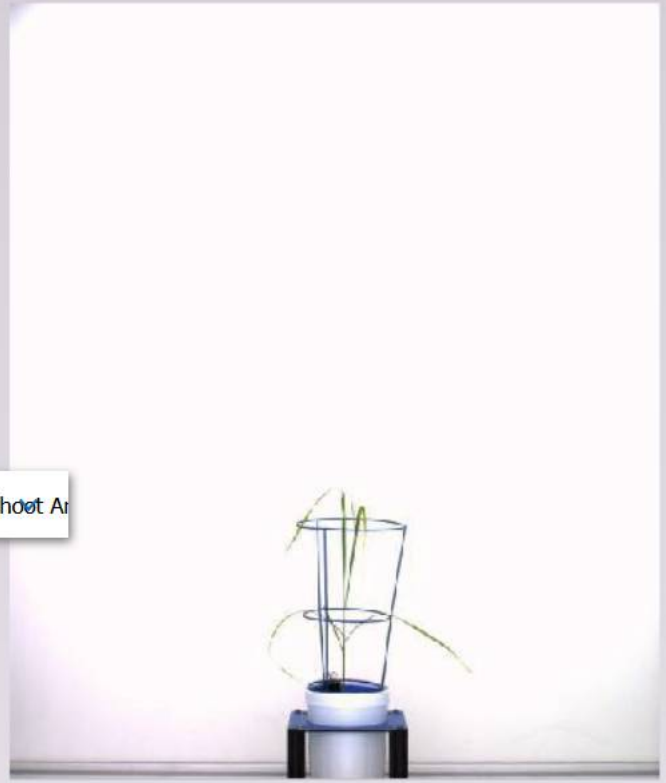
TAGS
BARCODE
PLANT SPECIES
GENOTYPE ID
SALT TREATMENT
REPLICATE
SMARTHOUSE
LANE
POSITION
SNAPSHOT TIME STAMP
TIME AFTER PLANTING [D]




WEIGHT BEFORE
WEIGHT AFTER
WATER AMOUNT

2
<1% of 14784 items
grid
graph
table
sort by: Time after Planting
group by: (None)

range
scatter
Projected Shoot Ar
expand



1 (50%)

39

1 (50%)

1342

Data
Notes

tags

Barcode
044441-C

Plant Species
Oryza sativa

Genotype ID
12282

Salt Treatment
Control

Replicate
1

Smarthouse
NE

Lane
5

Position
4

Snapshot Time Stamp
03/23/2015 12:42:00 PM

Time after Planting [d]
40

Weight Before
4055

Weight After
4095

zegami

0254 Rice response to salinity stress under waterlogged conditions - aus

filters

Search...

TAGS

BARCODE

PLANT SPECIES

GENOTYPE ID

SALT TREATMENT

REPLICATE

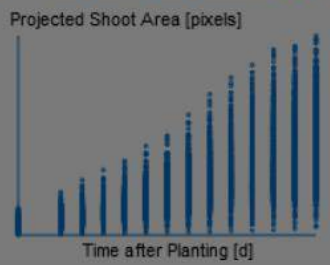
SMARTHOUSE

LANE

POSITION

SNAPSHOT TIME STAMP

TIME AFTER PLANTING [D]




WEIGHT BEFORE

WEIGHT AFTER

WATER AMOUNT

14784

sort by: Time after Planting | group by: (None)

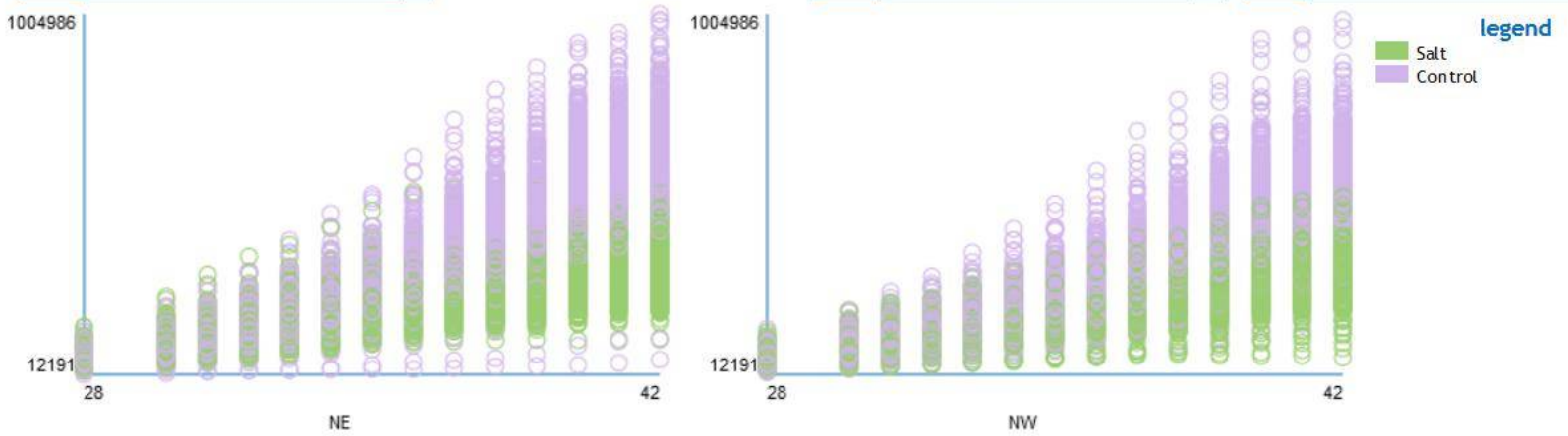
scatter

x

y axis Projected Shoot Are

series Treatment 1

trellis Smarthouse




x axis Time after Planting [d]

6336 (43%)

1056 (7%)

28 to 34

35 to 41

42

filters

AREA

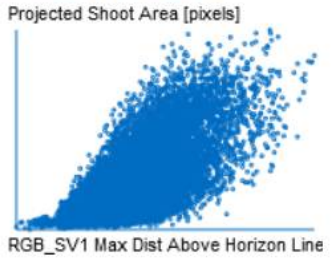
RGB_SV1 CONVEX HULL CIRCUMFERENCE

RGB_SV1 EXCENTRICITY

RGB_SV1 OBJECT EXTENT X

RGB_SV1 OBJECT EXTENT Y

RGB_SV1 HEIGHT




RGB_SV1 MEAN HUE

RGB_SV1 MEAN HUE VARIANCE

RGB_SV1 MIN ENCLOSING CIRCLE DIAMETER

RGB_SV1 MIN AREA RECTANGLE AREA

RGB_SV1 ROUNDNESS

RGB_SV1 HEALTHY AREA ABSOLUTE

14784
100% of 14784 items

grid graph table

sort by: Time after Planting | group by: (None)

range

scatter

expand

Projected Shoot Ar

Snapshot Time Stamp
Time after Planting [d]
Weight Before
Weight After
Water Amount
Projected Shoot Area [pixels]
RGB_SV1 Area
RGB_SV1 Area Distribution Above Absolut
RGB_SV1 Area Distribution Above Relative
RGB_SV1 Area Distribution Below Absolut
RGB_SV1 Area Distribution Below Relative
RGB_SV1 Boundary Point Count
RGB_SV1 Boundary Point Roundness
RGB_SV1 Boundary Points To Area Ratio
RGB_SV1 Caliper Length
RGB_SV1 Circumference
RGB_SV1 Center Of Mass X
RGB_SV1 Center Of Mass Y
RGB_SV1 Compactness
RGB_SV1 Convex Hull Area

6336 (43%)
7392 (50%)
1056 (7%)

28 to 34
35 to 41
42

zegami

0254 Rice response to salinity stress under waterlogged conditions - aus

filters

AREA

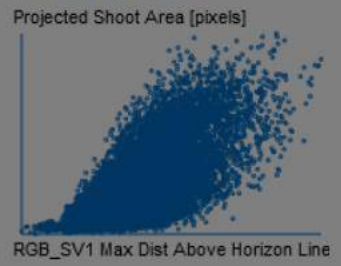
RGB_SV1 CONVEX HULL CIRCUMFERENCE

RGB_SV1 EXCENTRICITY

RGB_SV1 OBJECT EXTENT X

RGB_SV1 OBJECT EXTENT Y

RGB_SV1 HEIGHT




RGB_SV1 MEAN HUE

RGB_SV1 MEAN HUE VARIANCE

RGB_SV1 MIN ENCLOSING CIRCLE DIAMETER

RGB_SV1 MIN AREA RECTANGLE AREA

RGB_SV1 ROUNDNESS

RGB_SV1 HEALTHY AREA ABSOLUTE

14784

sort by: Time after Planting

group by: (None)

scatter

y axis Projected Shoot Are

series (None)

trellis (None)

1004986

12191

260

1907

x axis RGB_SV1 Height

Line

6336 (43%)

7392 (50%)

1056 (7%)

28 to 34

35 to 41

42

filters x

AREA

RGB_SV1 CONVEX HULL CIRCUMFERENCE

RGB_SV1 EXCENTRICITY

RGB_SV1 OBJECT EXTENT X

RGB_SV1 OBJECT EXTENT Y

RGB_SV1 HEIGHT x

scatter area selected

RGB_SV1 MEAN HUE

RGB_SV1 MEAN HUE VARIANCE

RGB_SV1 MIN ENCLOSING CIRCLE DIAMETER

RGB_SV1 MIN AREA RECTANGLE AREA

RGB_SV1 ROUNDNESS

RGB_SV1 HEALTHY AREA ABSOLUTE

RGB_SV1 HEALTHY AREA RELATIVE

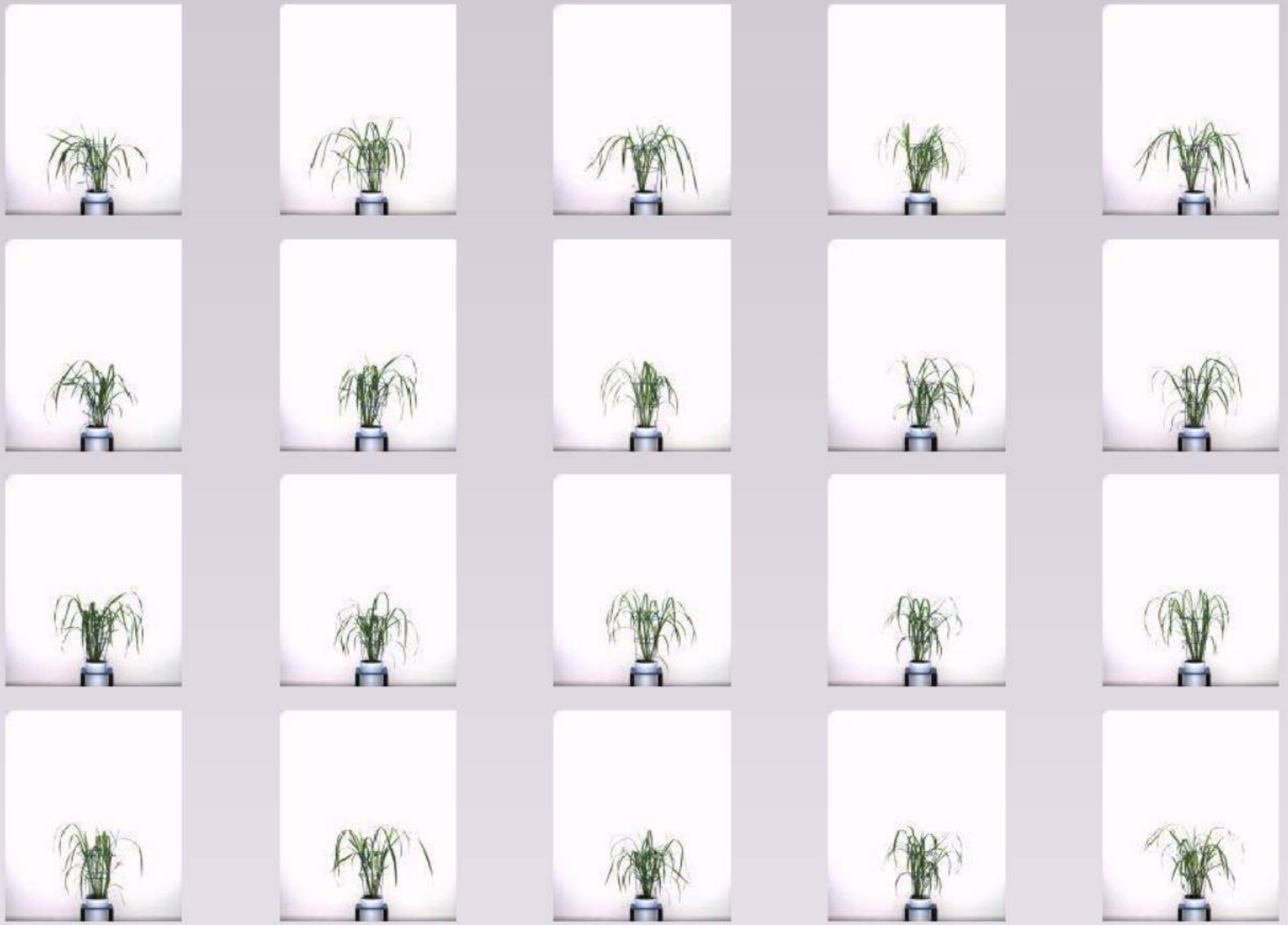
RGB_SV1 SENESCENT AREA ABSOLUTE

RGB_SV1 SENESCENT AREA RELATIVE

20
<1% of 14784 items

grid graph table

sort by: Time after Planting | group by: (None)



zegami

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filters

AREA

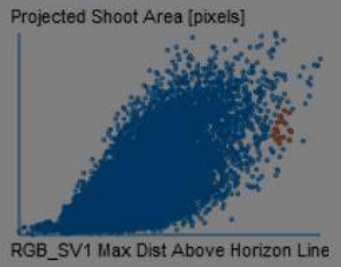
RGB_SV1 CONVEX HULL CIRCUMFERENCE

RGB_SV1 EXCENTRICITY

RGB_SV1 OBJECT EXTENT X

RGB_SV1 OBJECT EXTENT Y

RGB_SV1 HEIGHT




RGB_SV1 MEAN HUE

RGB_SV1 MEAN HUE VARIANCE

RGB_SV1 MIN ENCLOSING CIRCLE DIAMETER

RGB_SV1 MIN AREA RECTANGLE AREA

RGB_SV1 ROUNDNESS

RGB_SV1 HEALTHY AREA ABSOLUTE

18

sort by: Time after Planting

group by: (None)

scatter

y axis Projected Shoot Ar

series (None)

trellis (None)

1004986

12191

260

1907

x axis RGB_SV1 Height

Line

filters x

AREA

RGB_SV1 CONVEX HULL CIRCUMFERENCE

RGB_SV1 EXCENTRICITY

RGB_SV1 OBJECT EXTENT X

RGB_SV1 OBJECT EXTENT Y

RGB_SV1 HEIGHT x

scatter area selected

RGB_SV1 MEAN HUE

RGB_SV1 MEAN HUE VARIANCE

RGB_SV1 MIN ENCLOSING CIRCLE DIAMETER

RGB_SV1 MIN AREA RECTANGLE AREA

RGB_SV1 ROUNDNESS

RGB_SV1 HEALTHY AREA ABSOLUTE

RGB_SV1 HEALTHY AREA RELATIVE

RGB_SV1 SENESCENT AREA ABSOLUTE

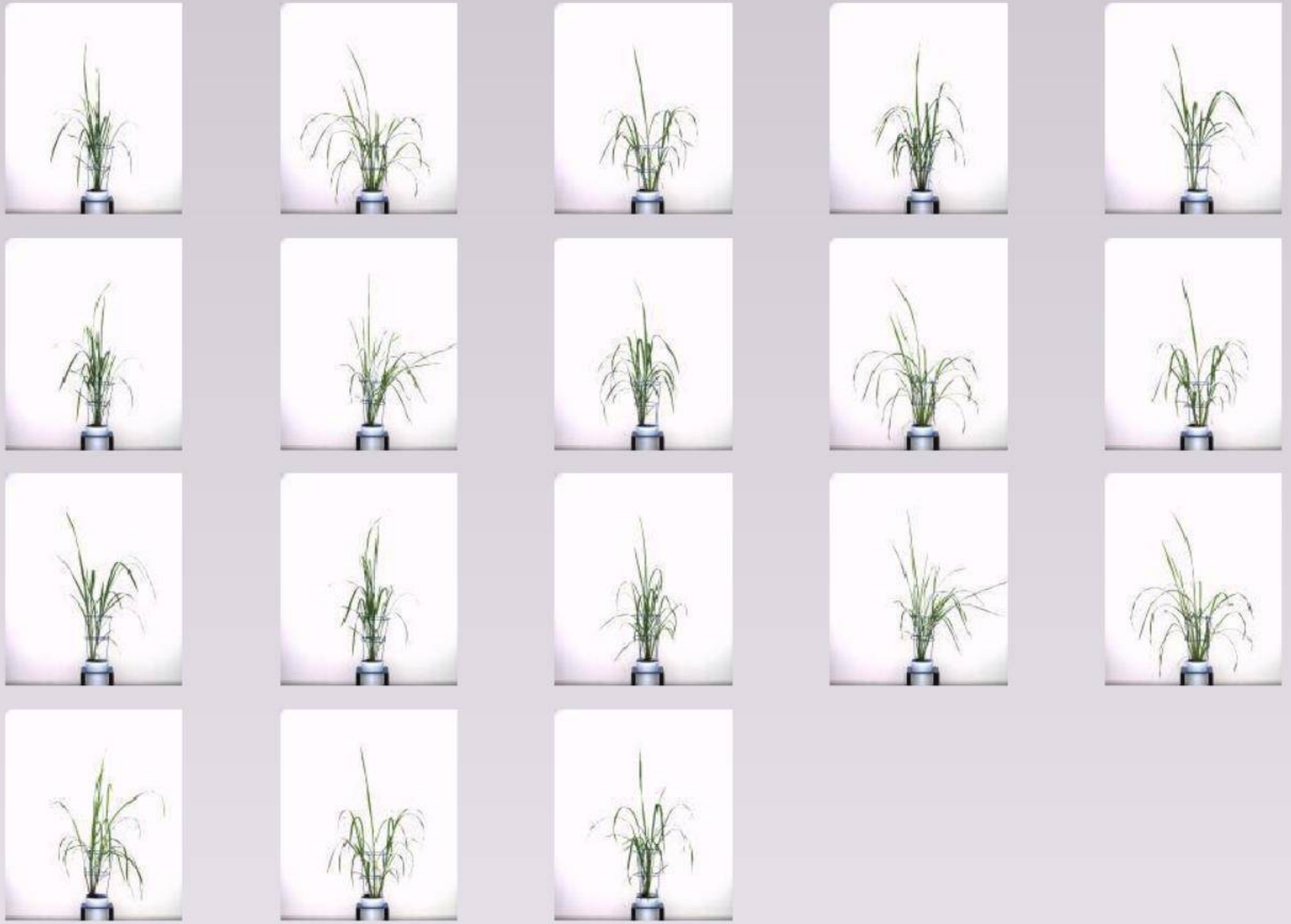
RGB_SV1 SENESCENT AREA RELATIVE

18
<1% of 14784 items

grid graph table

sort by: Time after Planting

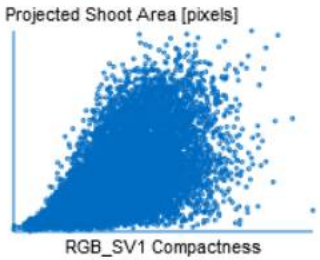
group by: (None)



filters

14784
100% of 14784 items
grid graph table
sort by: Time after Planting | group by: (None)

RGB_SV1 BOUNDARY POINTS TO AREA RATIO
RGB_SV1 CALIPER LENGTH
RGB_SV1 CIRCUMFERENCE
RGB_SV1 CENTER OF MASS X
RGB_SV1 CENTER OF MASS Y
RGB_SV1 COMPACTNESS




RGB_SV1 CONVEX HULL AREA
RGB_SV1 CONVEX HULL CIRCUMFERENCE
RGB_SV1 EXCENTRICITY
RGB_SV1 OBJECT EXTENT X
RGB_SV1 OBJECT EXTENT Y
RGB_SV1 HEIGHT

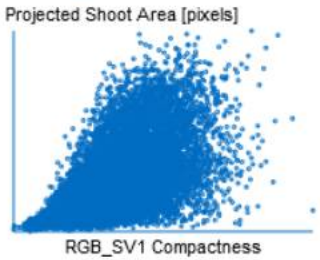
range
scatter
expand
Projected Shoot Ar

Snapshot Time Stamp
Time after Planting [d]
Weight Before
Weight After
Water Amount
Projected Shoot Area [pixels]
RGB_SV1 Area
RGB_SV1 Area Distribution Above Absolut
RGB_SV1 Area Distribution Above Relative
RGB_SV1 Area Distribution Below Absolut
RGB_SV1 Area Distribution Below Relative
RGB_SV1 Boundary Point Count
RGB_SV1 Boundary Point Roundness
RGB_SV1 Boundary Points To Area Ratio
RGB_SV1 Caliper Length
RGB_SV1 Circumference
RGB_SV1 Center Of Mass X
RGB_SV1 Center Of Mass Y
RGB_SV1 Convex Hull Area
RGB_SV1 Convex Hull Circumference

filters

14784
100% of 14784 items
grid graph table
sort by: Time after Planting | group by: (None)

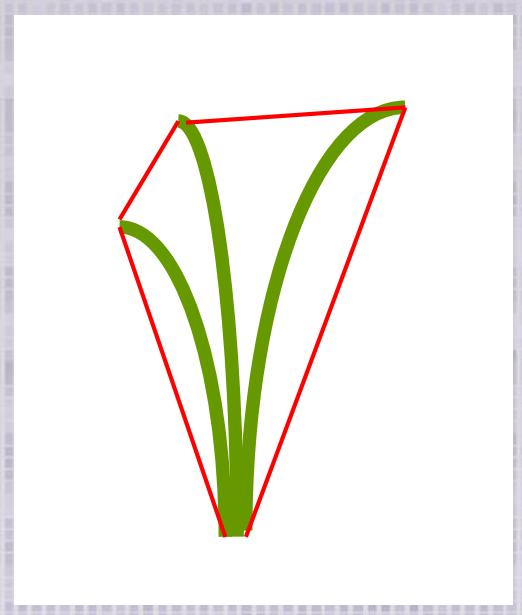
RGB_SV1 BOUNDARY POINTS TO AREA RATIO
RGB_SV1 CALIPER LENGTH
RGB_SV1 CIRCUMFERENCE
RGB_SV1 CENTER OF MASS X
RGB_SV1 CENTER OF MASS Y
RGB_SV1 COMPACTNESS




RGB_SV1 CONVEX HULL AREA
RGB_SV1 CONVEX HULL CIRCUMFERENCE
RGB_SV1 EXCENTRICITY
RGB_SV1 OBJECT EXTENT X
RGB_SV1 OBJECT EXTENT Y
RGB_SV1 HEIGHT

range
scatter
expand
Projected Shoot Ar

Snapshot Time Stamp
Time after Planting [d]
Weight Before
Weight After
Water Amount
Projected Shoot Area [pixels]
RGB_SV1 Area
RGB_SV1 Area Distribution Above Absolut
RGB_SV1 Area Distribution Above Relative
RGB_SV1 Area Distribution Below Absolut
RGB_SV1 Area Distribution Below Relative
RGB_SV1 Boundary Point Count
RGB_SV1 Boundary Point Roundness
RGB_SV1 Boundary Points To Area Ratio
RGB_SV1 Caliper Length
RGB_SV1 Circumference
RGB_SV1 Center Of Mass X
RGB_SV1 Center Of Mass Y
RGB_SV1 Convex Hull Area
RGB_SV1 Convex Hull Circumference



zegami

0254 Rice response to salinity stress under waterlogged conditions - aus

filters

14784

sort by: Time after Planting | group by: (None)

RGB_SV1 BOUNDARY POINTS TO AREA RATIO

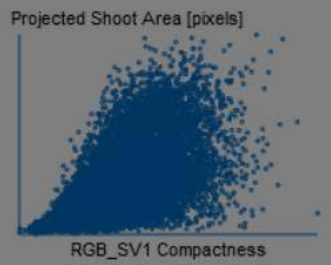
RGB_SV1 CALIPER LENGTH

RGB_SV1 CIRCUMFERENCE

RGB_SV1 CENTER OF MASS X

RGB_SV1 CENTER OF MASS Y

RGB_SV1 COMPACTNESS




RGB_SV1 CONVEX HULL AREA

RGB_SV1 CONVEX HULL CIRCUMFERENCE

RGB_SV1 EXCENTRICITY

RGB_SV1 OBJECT EXTENT X

RGB_SV1 OBJECT EXTENT Y

RGB_SV1 HEIGHT

scatter

x

y axis Projected Shoot Are

series (None)

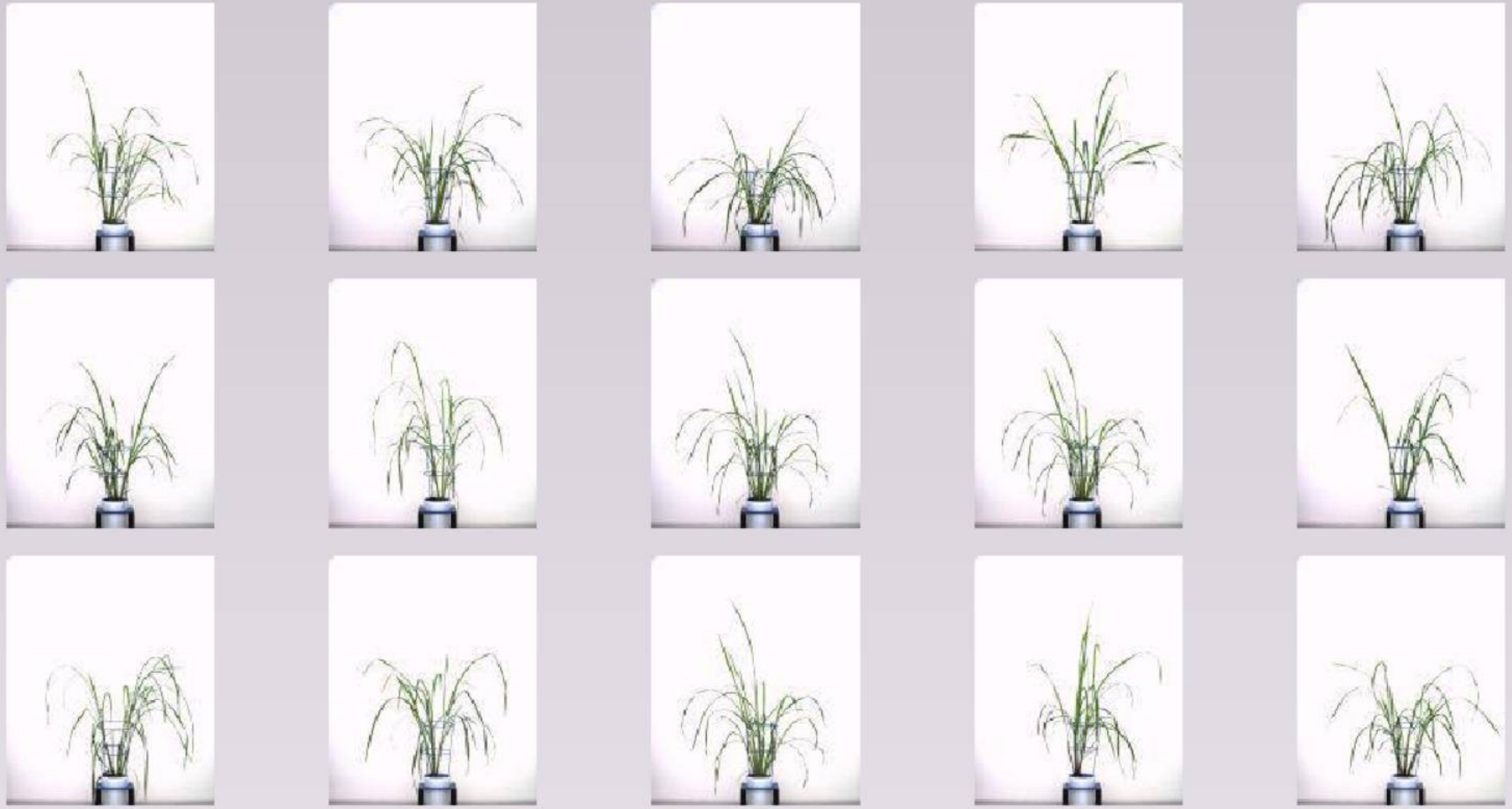
trellis (None)


x axis RGB_SV1 Compactness

filters x

RGB_SV1 BOUNDARY POINTS TO AREA RATIO
RGB_SV1 CALIPER LENGTH
RGB_SV1 CIRCUMFERENCE
RGB_SV1 CENTER OF MASS X
RGB_SV1 CENTER OF MASS Y
RGB_SV1 COMPACTNESS x
scatter area selected
RGB_SV1 CONVEX HULL AREA
RGB_SV1 CONVEX HULL CIRCUMFERENCE
RGB_SV1 EXCENTRICITY
RGB_SV1 OBJECT EXTENT X
RGB_SV1 OBJECT EXTENT Y
RGB_SV1 HEIGHT
RGB_SV1 MEAN HUE
RGB_SV1 MEAN HUE VARIANCE
RGB_SV1 MIN ENCLOSING CIRCLE DIAMETER

15
<1% of 14784 items
grid graph table
sort by: Time after Planting
group by: (None)



zegami

0254 Rice response to salinity stress under waterlogged conditions - aus

filters

RGB_SV1 AREA DISTRIBUTION BELOW POT RELATIVE

RGB_SV1 BOUNDARY POINT COUNT

RGB_SV1 BOUNDARY POINT ROUNDNESS

RGB_SV1 BOUNDARY POINTS TO AREA RATIO

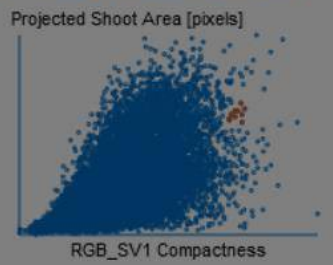
RGB_SV1 CALIPER LENGTH

RGB_SV1 CIRCUMFERENCE

RGB_SV1 CENTER OF MASS X

RGB_SV1 CENTER OF MASS Y

RGB_SV1 COMPACTNESS




RGB_SV1 CONVEX HULL AREA

RGB_SV1 CONVEX HULL CIRCUMFERENCE

10

sort by: Salt Treatment

group by: (None)

scatter

y axis Projected Shoot Are

series (None)

trellis (None)


x axis RGB_SV1 Compactness

8 (80%)

2 (20%)

Control

Salt

filters

RGB_SV1 AREA DISTRIBUTION BELOW POT RELATIVE

RGB_SV1 BOUNDARY POINT COUNT

RGB_SV1 BOUNDARY POINT ROUNDNESS

RGB_SV1 BOUNDARY POINTS TO AREA RATIO

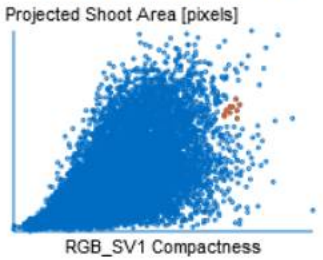
RGB_SV1 CALIPER LENGTH

RGB_SV1 CIRCUMFERENCE

RGB_SV1 CENTER OF MASS X

RGB_SV1 CENTER OF MASS Y

RGB_SV1 COMPACTNESS




RGB_SV1 CONVEX HULL AREA

RGB_SV1 CONVEX HULL CIRCUMFERENCE

10
<1% of 14784 items
grid
graph
table
sort by: Salt Treatment
group by: (None)

range
scatter
Projected Shoot Ar
expand

8 (80%)
Control
2 (20%)
Salt

filters x

RGB_SV1 AREA DISTRIBUTION BELOW POT RELATIVE

RGB_SV1 BOUNDARY POINT COUNT

RGB_SV1 BOUNDARY POINT ROUNDNESS

RGB_SV1 BOUNDARY POINTS TO AREA RATIO

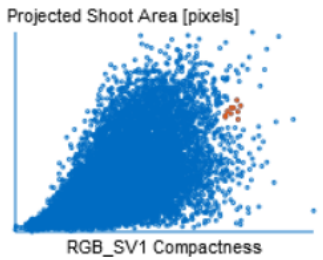
RGB_SV1 CALIPER LENGTH

RGB_SV1 CIRCUMFERENCE

RGB_SV1 CENTER OF MASS X

RGB_SV1 CENTER OF MASS Y

RGB_SV1 COMPACTNESS




RGB_SV1 CONVEX HULL AREA

RGB_SV1 CONVEX HULL CIRCUMFERENCE

10
<1% of 14784 items
grid graph table
sort by: Salt Treatment
group by: (None)

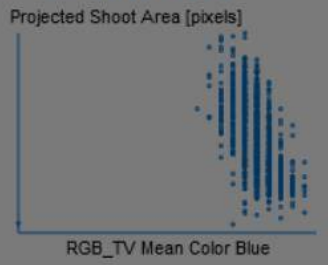
| id | Barcode | Plant Species | Genotype ID | Salt Treatment | Replicate | Smarthouse | Lane | Position |
|---|---|---|---|---|---|---|---|---|
| 223 | 044362-C | Oryza sativa | 8506 | Control | 1 | NE | 1 | 18 |
| 224 | 044362-C | Oryza sativa | 8506 | Control | 1 | NE | 1 | 18 |
| 3144 | 044570-C | Oryza sativa | 52441 | Control | 1 | NE | 10 | 18 |
| 7350 | 044870-C | Oryza sativa | 47381 | Control | 1 | NE | 23 | 20 |
| 11367 | 045157-C | Oryza sativa | 64775 | Control | 2 | NW | 12 | 6 |
| 11366 | 045157-C | Oryza sativa | 64775 | Control | 2 | NW | 12 | 6 |
| 12597 | 045245-C | Oryza sativa | 73127 | Control | 2 | NW | 16 | 2 |
| 15359 | 045442-C | Oryza sativa | 25925 | Control | 2 | NW | 24 | 16 |
| 531 | 044384-S | Oryza sativa | 54072 | Salt | 1 | NE | 2 | 16 |
| 532 | 044384-S | Oryza sativa | 54072 | Salt | 1 | NE | 2 | 16 |

range
scatter
Projected Shoot Ar
expand

sum: 62693

filters

RGB_TV COMPACTNESS
RGB_TV CONVEX HULL AREA
RGB_TV CONVEX HULL CIRCUMFERENCE
RGB_TV EXCENTRICITY
RGB_TV OBJECT EXTENT X
RGB_TV OBJECT EXTENT Y
RGB_TV MAX DIST TO POINT
RGB_TV MEAN HUE

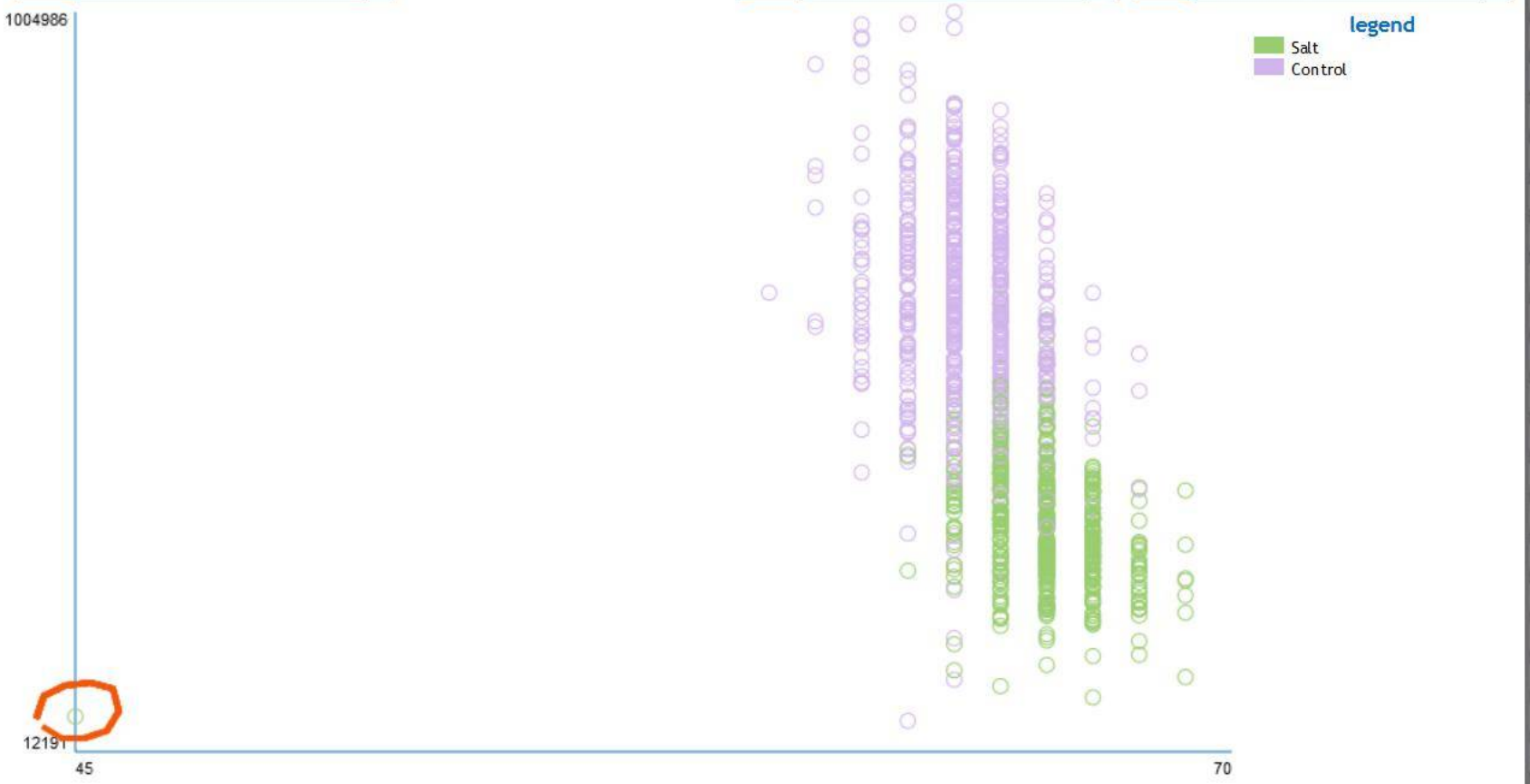



RGB_TV MEAN HUE VARIANCE
RGB_TV MIN ENCLOSING CIRCLE DIAMETER
RGB_TV MIN AREA RECTANGLE AREA
RGB_TV ROUNDNESS
RGB_TV HEALTHY AREA ABSOLUTE

1056
sort by: Barcode
group by: (None)

scatter

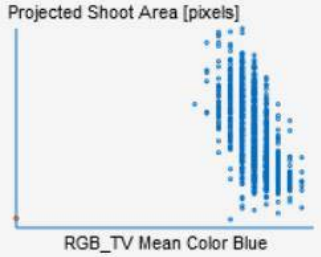
y axis: Projected Shoot Are
series: Treatment 1
trellis: (None)




x axis: RGB_TV Mean Hue

filters x

RGB_TV COMPACTNESS
RGB_TV CONVEX HULL AREA
RGB_TV CONVEX HULL CIRCUMFERENCE
RGB_TV EXCENTRICITY
RGB_TV OBJECT EXTENT X
RGB_TV OBJECT EXTENT Y
RGB_TV MAX DIST TO POINT
RGB_TV MEAN HUE




RGB_TV MEAN HUE VARIANCE
RGB_TV MIN ENCLOSING CIRCLE DIAMETER
RGB_TV MIN AREA RECTANGLE AREA
RGB_TV ROUNDNESS
RGB_TV HEALTHY AREA ABSOLUTE

range
scatter
Projected Shoot Ar
expand

1
<1% of 14784 items
grid graph table
sort by: Barcode
group by: (None)

9226

Data Notes

tags

Barcode
045004-S

Plant Species
Oryza sativa

Genotype ID
52696

Salt Treatment
Salt

Replicate
2

Smarthouse
NW

Lane
5

Position
16

Snapshot Time Stamp
03/25/2015 11:01:00 AM

Time after Planting [d]
42

Weight Before
4082

Weight After
4095

# Summary

- Zegami does not replace  detailed statistical analysis by experts
- But it allows plant scientists to explore large image datasets
- Brings together images and numeric values
- Allows to generate complex graphs on the fly
- Helps with quality control and outlier detection
- Allows plant scientists to ask new questions and query data easily
- Adaptable to other datasets (e.g. microscopy, germplasm bank,….)

# Acknowledgements


- Zegami Team (Roger Noble, Samuel Conway)
- Salt research lab at King Abdullah University of Science and Technology - KAUST (Nadia al-Tamimi, Sonia Negrao, Mark Tester)
- The Plant Accelerator Team – in particular George Sainsbury
- http://www.plantphenomics.org.au/projects/zegami/
- https://zegami.plantphenomics.org.au/#/